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Investigation of Partial Replacement of Fine Aggregate and Cement with Polyethylene Terephthalate and GGBS in Concrete through Experimentation

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Abstract

Polyethylene terephthalate (PET) fiber, an incredible material, demands cautious handling and disposal to prevent groundwater contamination and adverse effects on human health. Derived from waste bottles, PET fiber is obtained by extracting fragments from empty transparent bottles. Ground granulated blast furnace slag (GGBS), a byproduct of the iron industry, possesses cementitious properties. Cement, widely acknowledged as a crucial material in construction, unfortunately contributes to environmental degradation due to carbon emissions and other pollutants during manufacturing. This paper explores the utilization of GGBS and PET fiber in concrete, both known for their strong bonding characteristics. Experimental trials involve substituting fine aggregate with PET fiber and cement with GGBS in concrete specimens. The trial mix comprises GGBS replacing a portion of OPC 53 grade cement at percentages of 30%, 40%, and 50%, and PET fiber substituting fine aggregate at 2%, 4%, and 6%, respectively. Observations are recorded after seven and twenty-eight days of testing the hardened concrete specimens.

Keywords—PET, GGBS, Trial Mix

Introduction

Concrete holds the title of being the most utilized construction material globally, boasting an annual production nearing six billion tons; only water exceeds its per capita usage. Nonetheless, the production of cement emits CO_2 and entails environmental concerns linked to raw material exploitation, prompting a push for researchers to reduce cement usage by incorporating alternative materials. These substitutes, sourced from nature, low-energy byproducts, or industrial waste, when combined with calcium hydroxide, exhibit cementation properties, known as pozzolonas.

Commonly utilized pozzolanas include ground granulated blast furnace slag (GGBS), fly ash, silica fume, and metakaolin. To fulfill the requirement for fine aggregate in concrete, Polyethylene Terephthalate (PET) bottles are finely powdered. The incorporation of plastic in concrete not only reduces the structure's weight but also enhances its resistance to seismic vibrations, making it more lightweight. Furthermore, employing Polyethylene Terephthalate (PET) in concrete has demonstrated a more efficient utilization of plastic waste, while GGBS has been substituted for Portland cement in varying proportions of 30%, 40%, and 50%, and PET bottles in proportions of 2%, 4%, and 6%, respectively.

Assessment of concrete's strength characteristics involves conducting compressive strength tests, splitting tensile strength tests, and flexural strength tests. Compression tests are carried out after 7 and 28 days of curing, while split tensile strength tests and flexural strength tests are conducted after 7 and 28 days of curing on M20 grade concrete.

Research Methodology

Sieve analysis of Coarse Aggregate)

According to IS 383:2016, the Indian Standard for Coarse and Fine Aggregates sourced from natural materials for concrete, the process of sieve analysis for coarse aggregate entails assessing the particle size distribution. This analysis is crucial for determining the aggregate's grading, a fundamental parameter in the design of concrete mixesMaintaining the Integrity of the Specifications

Compressive strength of concrete as per (456:2000)

The specimens for testing should be obtained in compliance with the applicable standards. Prior to conducting tests, it is necessary to fabricate cubic specimens from the concrete samples. The dimensions of these specimens, including diameter and height, must adhere to the specifications outlined in IS 516:1959

Split tensile strength of concrete as per (IS 5816:1999)

The split tensile strength test aims to ascertain the tensile strength of concrete. This involves subjecting a cylindrical concrete specimen to

diametric compressive loading until it fractures. The test protocol is outlined in the Indian Standard code IS 5816:1999. For this test, cylindrical concrete specimens with a diameter of 150 mm and a height of 300 mm are prepared. It is crucial to ensure that the specimens are thoroughly compacted and cured in accordance with standard curing procedures.

Flexural strength of concrete as per (IS 516:2018)

IS 516:2018 serves as the Indian Standard code governing the methods for testing the strength of concrete. The flexural strength of concrete is evaluated through a test commonly known as the "flexural strength test" or "modulus of rupture test."

Mix Design

The mix design for this study is based on the specifications outlined in IS 10262-2019. This standard provides combinations of materials for creating concrete that are both feasible and cost-effective. IS 10262:2009 offers guidelines for mix design, catering to various types of concrete such as mass concreting, self-compacting concrete, ordinary, standard, and high-strength concrete. The 2019 edition of the code further elaborates on mix design requirements. Additionally, IS 10262-2019 provides guidance on incorporating substitute materials that can partially replace aggregate and cement in concrete mixtures. Commonly used components include admixtures, fly ash, GGBS, rice husk ash, metakaolin, and superplasticizers. These materials are cost-effective and do not compromise the quality of concrete. For trial mixes, the design mix ratio adopted is Cement: Sand: Aggregate = 1: 2.123: 3.055. This ratio serves as a starting point for experimentation and optimization in accordance with IS 10262-2019 guidelines.

Results And DISCUSSION

The compression test, split tensile test, and flexural test are carried out on samples of ordinary concrete, with three specimens for each test. The dimensions of the specimens are as follows:

1. Compression Test: Specimen Size: 150mm x 150mm x 150mm (cubic)
2. Split Tensile Test: Specimen Size: 150mm in diameter and 300mm long (cylindrical)
3. Flexural Test: Specimen Size: 100mm x 100mm x 500mm (rectangular)

These specimen sizes are consistent with standard testing practices and are suitable for assessing the compressive strength, split tensile strength, and flexural strength of ordinary concrete according to testing standards.

A) Comparison between conventional concrete and GGBS plus PET reinforced concrete after 7 & 28 Days according to its compressive strength

The compression test are conducted on the sample specimen of the conventional concrete (3 specimen for each test) and Concrete Partially replacement of Cement by 30%, 40%, 50% GGBS & fine aggregate by 2%, 4%, & 6% PET respectively, having dimensions 150mm X 150mm X 150mm, 150mm in diameter & 300mm long & 100 mm X 100mm X 500mm respectively.

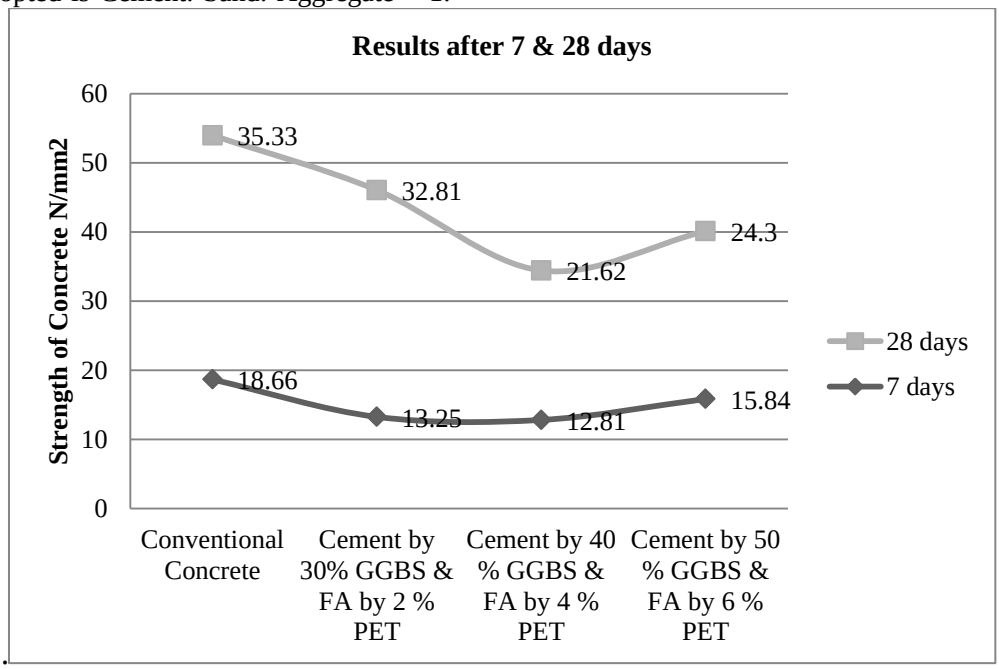

Fig. 1 Results of Compressive strength after 7 & 28 days

B) Comparison between conventional concrete and GGBS plus PET reinforced concrete after 7 days & 28 Days according to its Split tensile test

Split tensile tests are carried out on sample specimens of both conventional concrete (with three specimens for each test) and concrete partially replaced by 30%, 40%, or 50% GGBS, with fine aggregate replaced by 2%, 4%, or 6% PET, respectively. These specimens have varying

dimensions: 150mm x 150mm x 150mm for cubic samples, 150mm in diameter and 300mm long for cylindrical samples, and 100mm x 100mm x 500mm for other specified samples.

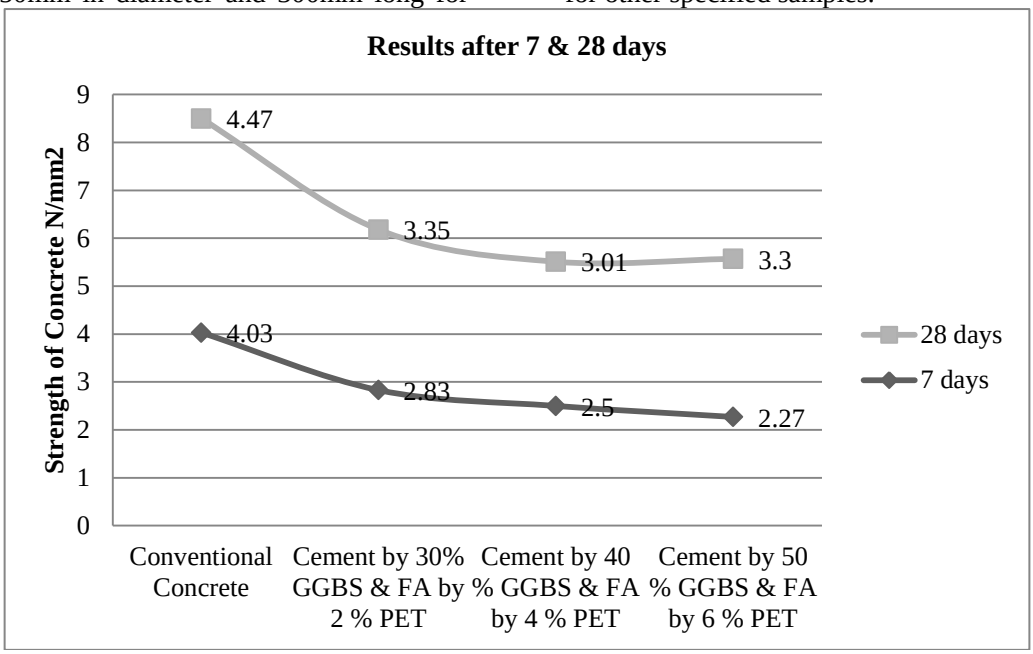

Fig. 2 Results of Split tensile test after 7 & 28 days

C) Comparison between conventional concrete and GGBS plus PET reinforced concrete after 7 days & 28 Days according to its Flexure test

The Flexure test are conducted on the sample specimen of the conventional concrete (3 specimen for each test) and Concrete Partially replacement of Cement by 30%, 40%, 50% GGBS & fine aggregate by 2%, 4%, & 6% PET respectively, having dimensions 150mm X 150mm X 150mm, 150mm in diameter & 300mm long & 100 mm X 100mm X 500mm respectively

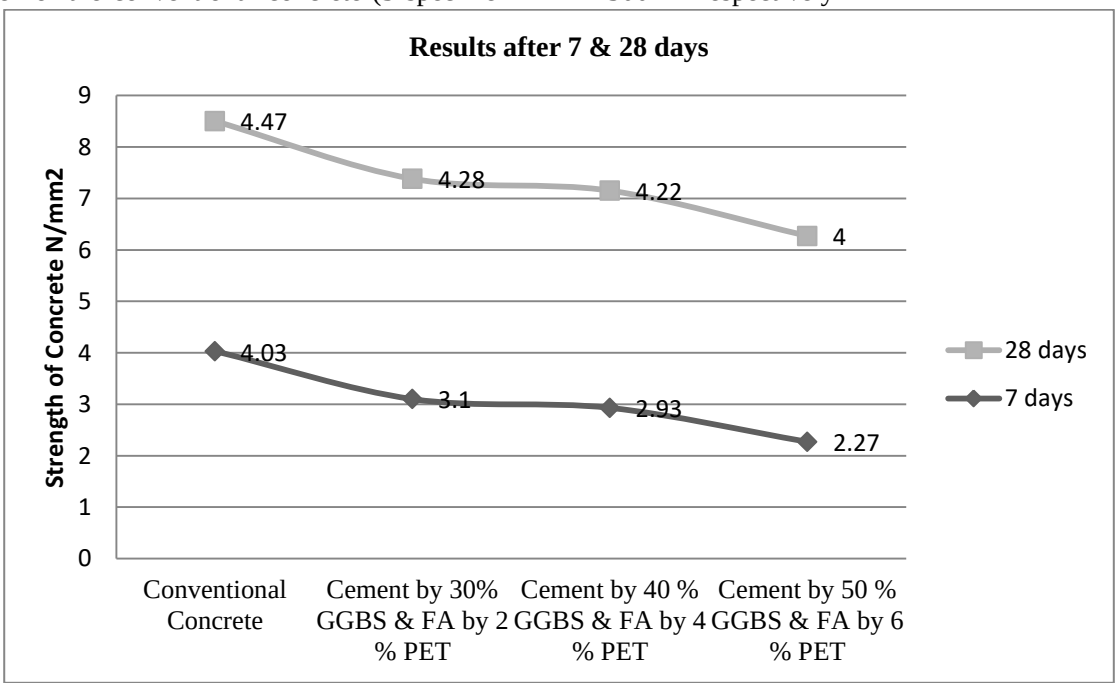

Fig. 3 Results of Flexure test after 7 & 28 days

Comparison between conventional concrete and GGBS plus PET reinforced concrete after 7 days

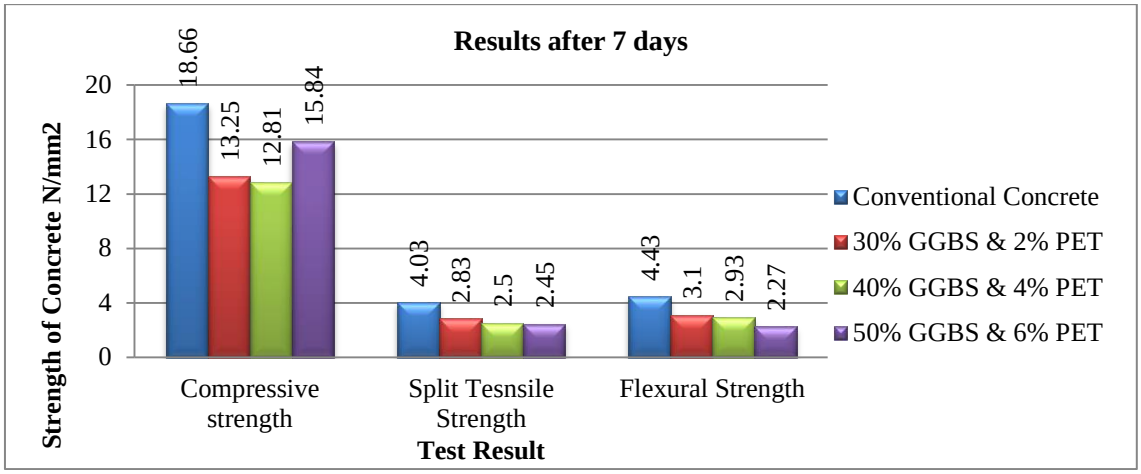

Fig. 4 Comparison of Conventional concrete and GGBS plus PET reinforced concrete after 7 days

D) Comparison between conventional concrete and GGBS plus PET reinforced concrete after 28 days

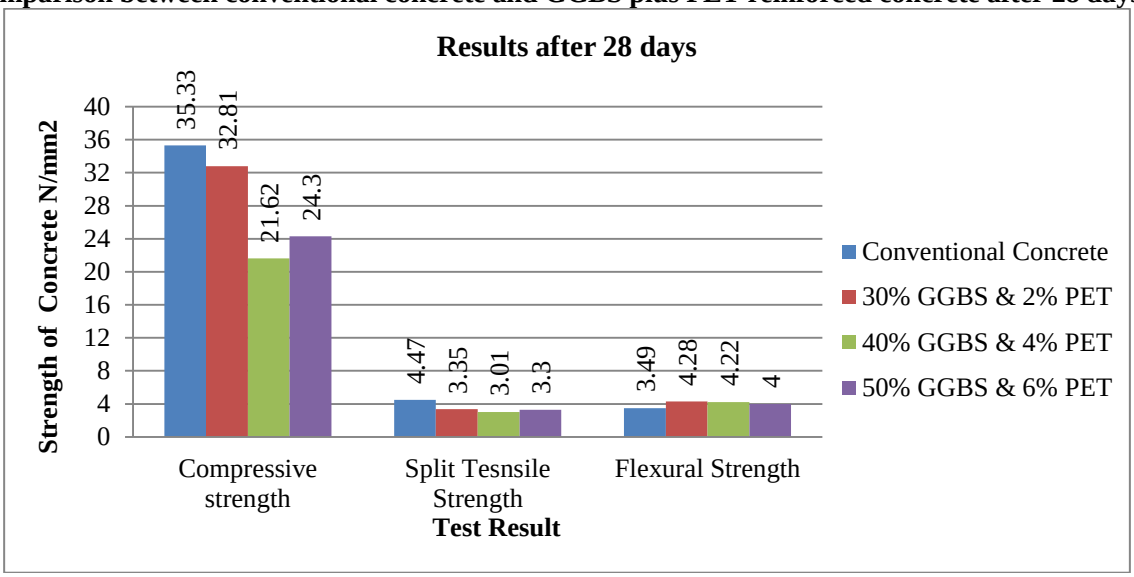

Fig. 5 Comparison of Conventional concrete and GGBS plus PET reinforced

Conclusion

Portland cement was partially replaced by 30%, 40%, and 50% of Ground Granulated Blast Furnace Slag (GGBS), while fine aggregates were substituted with Poly-Ethylene Terephthalate (PET) at rates of 2%, 4%, and 6% respectively. The concrete's strength characteristics were assessed through compressive strength, splitting tensile strength, and flexural strength tests.

The compression test was conducted after 7 and 28 days of curing, while the split tensile strength and flexural strength tests were carried out at the same intervals. These tests were performed on M20 grade concrete to evaluate its performance and durability under different curing durations.

Based on the observations from the experimental study:

Observations after 7 days of curing:

a) Conventional concrete exhibits higher compressive, split tensile, and flexural strength compared to the experimented mixtures.

b) Among the experimented mixtures, the combination of 50% GGBS replacement for cement and 6% PET replacement for fine aggregate yields the highest compressive strength.

c) The mixture with 30% GGBS replacement for cement and 2% PET replacement for fine aggregate shows the highest split tensile strength.

d) Similarly, the mixture with 30% GGBS replacement for cement and 2% PET replacement for fine aggregate exhibits the highest flexural strength.

Observations after 28 days of curing:

a) Conventional concrete continues to display higher compressive, split tensile, and flexural

strength compared to the experimented mixtures.

b) The combination of 30% GGBS replacement for cement and 2% PET replacement for fine aggregate results in the highest compressive strength among the experimented mixtures.

c) The mixture with 30% GGBS replacement for cement and 2% PET replacement for fine aggregate demonstrates the highest split tensile strength.

d) Similarly, the combination of 30% GGBS replacement for cement and 2% PET replacement for fine aggregate exhibits the highest flexural strength.

These observations provide insights into the effects of GGBS and PET replacements on the strength characteristics of concrete, with certain combinations showing promising results in terms of strength enhancement.

Acknowledgment

"I extend my heartfelt gratitude to the Principal and Head of the Civil Engineering Department, as well as to my guide, at SKN Sinhgad College of Engineering, Korti, Pandharpur, Maharashtra, India. Their unwavering support and provision of all necessary facilities have been invaluable in conducting the testing of specimens for the current study. Thank you for your guidance and encouragement throughout this endeavor."

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Energy-Efficient Lighting in Residential Spaces for Enhanced Holistic Well-Being

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DOI- 10.5281/zenodo.11076504

Abstract:

This research paper examines the potential of energy-efficient lighting in residential spaces to enhance holistic well-being. With a focus on the interplay between lighting design, sustainable technologies, and human-centric approaches, this paper explores how energy-efficient lighting solutions can positively impact various dimensions of well-being, including physical health, emotional comfort, and environmental sustainability. Through a comprehensive study of energy-efficient light fixtures and lighting systems this paper explains on the importance of optimizing residential lighting environments to promote overall wellness. By emphasizing the integration of energy-efficient lighting with user-centric design principles, this research features the transformative potential of lighting design in creating healthy and sustainable living spaces. This involves using energy-efficient light fixtures in a residential interiors that requires the lowest possible energy, such as LED lights, energy Star-approved fluorescent bulbs ,sensor LED tube lights are highly desirable because they are more durable and their maintenance cost is 70% less than traditional bulbs and tube lights .Also using a lighting control mechanism improves energy efficiency because it automatically turn on-off lights and eliminates waste of electricity, thus reduced energy consumption ,monthly electricity and finally reduces the carbon footprints .Finally understanding and implementing these energy-efficient light fixtures are creating environmentally responsible ,resource efficient and enhanced holistic approach in the field of residential interiors.

Keywords: Energy-efficient lighting, Residential spaces, Holistic well-being, Sustainable design, User-centric approach, LED light, Sensor tube light, Carbon footprints.

Introduction

Energy-efficient lighting refers to the use of lighting technologies that consume less energy while providing adequate illumination. These technologies include compact fluorescent lamps (CFLs), light-emitting diodes (LEDs), and occupancy sensors. Energy-efficient lighting not only reduces energy consumption but also leads to cost savings for homeowners and reduces greenhouse gas emissions, contributing to a more sustainable environment. Significance of lighting in residential spaces for occupant well-being Introduction to the concept of energy-efficient lighting, its potential benefit and understanding the relationship between lighting and holistic well-being in residential environments. LED (Light Emitting Diodes) panel at 10watt consumes 5 times less power and hence will reduce CO2 emission to 1/5th. LED has its advantages such as a very low energy consumption level which directly contributes to savings on the light bill. LED has much longer life than traditional lighting (up to 50,000 hours). There is no infrared lighting, UV radiation from LED lights and also it doesn't contain mercury making it safer. Also LED has high luminous efficiency (at least 90-100lm/W), lower losses in the distribution of the controlled luminous flux compared to traditional lamps (emitting only a beam of 120°, whilst traditional have about 360°). LED is fully dimmable without color variation. However, LED lighting is not nearly as immediately affordable as traditional lighting. The cost problem becomes worse to change the existing lights as opposed to starting new.

Aim and Objective of the study:

This review paper has been aimed to study the factors of energy-efficient lighting system and fixtures for understanding and creating environmentally responsible resource efficient and enhanced holistic approach in the field of residential interiors.

The objective of this review study:

To overview of the significance of lighting in residential spaces for occupant well-being

To analyze energy-efficient lighting technologies suitable for residential applications (LED, CFL, etc.)

Methodology

The research papers and data was collected by a thorough search using relevant search engines like Google, J STOR and Scopus indexed Journals, documents, images.

The collected data has been analyzed for practices followed by practicing architects, Interior designers to maintain the importance of optimizing residential lighting environments to promote overall wellness.

Energy-Efficient Lighting Technologies and Applications

Various energy-efficient lighting fixtures & technologies suitable for residential applications e.g. LED, CFL, etc. Lighting design principles for residential spaces, including task lighting, ambient lighting. Introduction to energy-efficient lighting and its potential impact on well-being Energy-efficient lighting refers to the use of lighting technologies that consume less energy while providing adequate illumination. These technologies can include, but are not limited to, compact fluorescent lamps (CFLs), light-emitting diodes (LEDs), and organic light-emitting diodes (OLEDs). The potential benefits of energy-efficient lighting in residential spaces include reduced energy consumption, lower electricity costs, and improved well-being for occupants. The interplay between lighting design and sustainable technologies Lighting design plays a crucial role in determining the effectiveness of energy-efficient lighting solutions. Lighting designers must consider factors such as the type of light source, color temperature, and luminous flux to create optimal lighting conditions that balance energy efficiency and visual comfort. Sustainable technologies, such as motion sensors, dimmers, and daylighting, can be integrated into the design to further enhance energy savings and occupant well-being. The impact of energy-efficient lighting on physical health Energy-efficient lighting can have a positive impact on occupants' physical health by reducing eye strain, improving sleep quality, and promoting better task performance. Adequate lighting is essential for maintaining good visual acuity and preventing eye strain, which can lead to headaches, dry eyes, and other vision-related issues. Furthermore, proper lighting can help regulate circadian rhythms, which in turn can improve sleep quality and overall health. The impact of energy-efficient lighting on emotional comfort Emotional well-being is closely linked to the quality of the environment in which we live and work. Energy-efficient lighting can contribute to emotional comfort by creating a visually appealing and functional space. Proper lighting can enhance the appearance of a room, reduce glare, and provide a sense of security and control. Additionally, energy-efficient lighting can help create a more productive environment, as adequate illumination is essential for effective task performance and reduced fatigue. The impact of energy-efficient lighting on environmental sustainability Energy-efficient lighting solutions contribute to environmental sustainability by reducing energy consumption, lowering greenhouse gas emissions, and decreasing the demand for non-renewable energy sources. This can help mitigate the effects of climate change and promote a healthier planet for future generations.

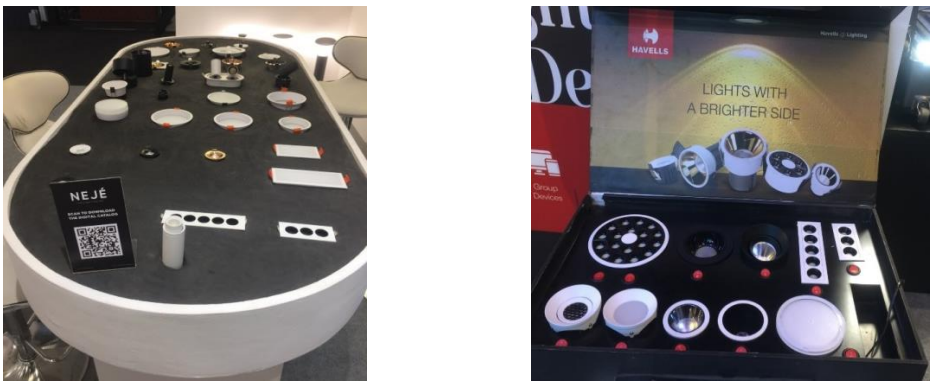

Fig.1- Different Types of LED light fittings

(Source: Actual photographs from lighting exhibition)

Sustainable Design Strategies for Residential Lighting

Integration of energy-efficient lighting with sustainable design principles, including passive design strategies and daylighting techniques Consideration of factors influencing lighting design decisions, such as energy efficiency, user preferences, and aesthetic considerations. Consideration of metrics such as energy savings occupant satisfaction, and health outcomes. Sustainable Design Strategies for Residential Lighting involve integrating environmental and social considerations into lighting design. This includes maximizing natural light, using energy-efficient light fixtures, and employing daylighting techniques. Some key strategies include orienting the building for optimal sun exposure, enhancing ventilation, and using advanced lighting solutions. Additionally, it's essential to avoid glare and spill light, as well as implementing passive sustainable design. By incorporating these strategies, residential lighting can become more sustainable and energy-efficient.

Fig 2-Lighting fixture stall at Exhibition & Interior ambient lighting of Kitchen, Dining area
(Source: Actual photographs from lighting exhibition stall & Internet)

Conclusion

Energy-efficient lighting in residential spaces can have a positive impact on the holistic well-being of individuals. It contributes to better physical, mental, and social health, as well as economic benefits. As the global community continues to prioritize energy conservation and environmental sustainability, the adoption of energy-efficient lighting technologies will become increasingly essential for creating healthier, more sustainable living environments.

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A Review on Performance Evaluation of Geopolymer Concrete

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DOI- 10.5281/zenodo.11076520

Abstract—
Ground Granulated Blast Furnace Slag (GGBS) is used to replace the cement. Increasing use of pervious concrete as a sustainable and environment -friendly paving materials is primarily owed to its ability to reduced pavement runoff. Pervious concrete is prepared by using the GGBS instead of cement also we replace water to sodium silicate with NaOH and Aggregate materials help to make concrete mixes more compact. During concreting Replacement of cement and water is 100 %. In comparison of ordinary Portland cement concrete and GGBS based Geopolymer pervious concrete is a more sustainable paving solution, also decrease in cost, heat island effect & reducing carbon dioxide emission.

Keywords—Ground Granulated Blast Furnace slag (GGBS), Sodium Hydroxide flakes, Sodium Silicate, Coarse Aggregates(10mm), Distilled water, Performance Evaluation, Mix Proportion, Compressive Strength and Permeability, geopolymer concrete, alkali activated concrete.

Introduction

Geopolymer Pervious concrete is a type of concrete manufactured without the addition of cement. In geopolymer pervious concrete along with an activator, cement as the concrete binder can be replaced by the GGBS. This will reduce global demand on cement, and therefore will reduce CO2 emission due to cement production. Thus, geopolymer concrete is commonly known as an eco-friendly concrete. This work mainly involves to reduce the CO2 emission when making of cement and to encourage the maximum utilization of manufacture by-product materials such as GGBS and fly ash etc.in order to make more eco-friendly concrete material.

The aim of the investigation is to assess the features of the utilization of a geo polymer binder for producing permeable geopolymer concrete. Materials used for producing pervious geopolymer concrete are ground granulated blast furnace slag with the Composition of 40, sodium silicate solution, sodium hydroxide and coarse aggregate. The Compressive strength, thermal curing at different temperature, functional characteristics and its relationship of the geo polymer pervious concrete were investigated. Compressive strength of geo polymer permeable concrete has enhanced along with the rise in density of Pervious geo polymer concrete. Permeability and voids exhibit a decreasing pattern with the increase in molarity and alkali binder ratio. Based on the strength attainment in the previous geo polymer concrete, it has used as a sub - base and base course of a flexible pavement layers.

Literature review

B. Sri Umniati, Puput Risdanareni, Fahmi Tarmizi Zulfikar Zein et.Al.(2017) "Workability enhancement of geopolymer concrete through the use of retarder"

In this Paper they Study that, after addition of Retarder Admixture initial setting time geopolymer concrete is increases. Geopolymer concrete with 0.6% retarder has the longest initial setting time (405 minutes), while concrete without retarder has the shortest initial setting time (225 minutes). Using retarder (Plastocrete RT6 Plus) increases the compressive strength of geopolymer concrete but not significant. In this experiment, geopolymer concrete with 0.6% of retarder is the strongest, with the compressive strength of 47.21 MPa, where the one without retarder is 38.29 MPa, both after 28 days.

S.Nagajothi, S.Elavenil (2018) "Compressive Strength of Geopolymer Concrete using Taguchi Method"

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M Uma Maguesvari et al (2020) "Experimental studies on pervious geopolymer concrete"

This investigation assesses the characteristics of pervious geo polymer concrete produced from utilisation of waste materials as geo polymeric binder. Compressive strength of geo polymer pervious concrete varies between 11.65 to 13.43 MPa. Compressive strength enhanced by the use of increment in AL/B for the mixes of same molar concentration. Permeability exhibits a converse pattern while contrast with compressive strength of pervious geo polymer concrete. Permeability of pervious geo polymer concrete varies between 0.654 to 1.742 cm/s.

The abrasion shows a similar trend to compressive strength and it ranges from 27% to 40 %. The voids of pervious geo polymer concrete decreases with increase in AL/B content. Based on the strength attainments in the previous geopolymer concrete, it satisfied the requirements of flexible pavement layers such as sub - base and base course according to Indian codes.

Padmanaban et al (2018) "Geopolymer Concrete with GGBS (Ground Granulated Blast Furnace Slag)"

Based on the experimental investigation he found that, Water absorption property is Water absorption property is lesser than the nominal concrete. The compressive strength and split tensile strength, flexural strength of geopolymer concrete higher than the normal concrete. For a given proportion of a mix, the compressive strength and split tensile strength increase with age.

The rate of gain in compressive strength and split tensile strength of geopolymer concrete is very fast at 7 days curing period and the rate gets reduces with age. Geo polymer concrete can be recommended as an innovative construction material for the use of construction. Apart from less energy intensiveness, the GPCs utilize the industrial wastes for producing the binding system in concrete. There are both environmental and economic benefits of using GGBS.

Srinisha K et al (2020) "Evaluation of Strength properties of GGBS based Geopolymer Concrete"

In this Paper Author have undertaken study and evaluation of strength and properties of Geopolymer concrete. The use of GGBS the service life of the concrete was increased to 40% on average, and with reduction in 30% cost as compared to the normal concrete made entirely with cement, was found to be more economically suitable which had better desirable property. The Compressive Strength properties of geopolymer concrete shows that, 3days strength for 8M of GPC gives a better result compare to 7days strength.

Hence for further studies 8M concentration is taken. The Split Tensile Strength properties shows that the 8M concentration of GPC gives higher strength in 7days test compare to 3days.The Flexural Strength properties shows that the 8M concentration of GPC gives higher strength in 7days test as compare to 3days. The addressed the project it can be concluded that the concrete structure made by GGBS geopolymer provided better results as compared to the normal concrete structure.

Anandh Babu Malayali et al (2019) "Experimental Study on the Compressive Strength and Permeable Properties of GGBS Based Geopolymer Pervious Concrete"

In this Paper the main Objective is to study compressive strength. Compressive strength is dependent on the aggregate size. Aggregate size 12mm shows better compressive strength than 6mm and 20mm aggregate. Permeability increases with respect to the increase in aggregate size. Aggregate 20 mm GGPC mixture showed higher permeability than other mixtures.

Ponalagappan Chokkalingam (2021) "Performance of cement-free geopolymer concrete made with ceramic waste powder using Taguchi Method"

In this Paper after performing this Method they found that, the water absorption was lowest in mixes that had a GGBFS replacement above 40%, AAS/binder ratio below 0.6, SS/SH ratio below 2, and SH molarity other than 12. Indeed, the highest absorption was for the control mix made with 100% CWP. It was apparent that the incorporation of GGBFS into CWP geopolymer mixes was critical to obtaining a dense matrix with low absorption

capacity. Similar findings were noted for the sorptivity. The compressive strength was affected by the GGBFS replacement, AAS/binder, SS/SH, and molarity of SH solution. In fact, respective values in the ranges of 20-60%, 0.50-0.55, 1.5-2, and 10-14 M led to superior compressive strength. The highest compressive strength was for mix T11 incorporating 60% GGBFS followed by the control made with 100% GGBFS. While geopolymer concrete mixes made 80% CWP could reach a cube compressive strength up to 53 MPa (f'c = 35 MPa), which is sufficient for most structural applications, cube strengths exceeding 60 MPa (f'c = 39 MPa) require at least 40% GGBFS replacement.

Hadi, M. N. S., Farhan, N. A. & Sheikh, M. Neaz (2017) "Design of geopolymer concrete with GGBFS at ambient curing condition using Taguchi method.

In this paper they have carried study, The geopolymer concrete with a binder content of 450 kg/m3, Al/Bi ratio of 0.35, SS/SH ratio of 2.5, and SH concentration of 14 M achieved the highest 7-day compressive strength (60.4 MPa) at ambient curing conditions.[8] The inclusion of FA, MK, and SF as partial replacement of GGBFS reduces the compressive strength of geopolymer concrete. Replacement of the GGBFS with FA, MK, and SF increases the initial and final setting time of the geopolymer paste and increases the slump of the fresh concrete as well. To increase the setting time of geopolymer concrete under ambient curing conditions, a combination of GGBFS with FA can be a possible solution, as the blend of GGBFS with FA achieved longer setting time compared with the blend of GGBFS with MK and SF.

Dilip Srinivas et al (2021) "Experimental Investigation on Bagasse ash Based Geopolymer Concrete Subjected to Elevated Temperature"

In this Paper they derived GPC mixes are more cohesive and stiffer and the setting time of GPC is very quick as compared toOPC concrete. The addition of super plasticizers increases its workability with limited dosage. It was found that due to the use of GGBS there was early strength gain in GPC and very small difference was found in 7- and 28-days strength. The geopolymer concrete has a better resistance against surface cracking and spalling up to 600oC. Addition of bagasse ash as a binder is applicable up to 30% without any retarding effect on compressive strength. The weight loss in geopolymer concrete increases as the elevated temperature increases.

S A Arafa et al (2018) "Optimum mix for fly ash geopolymer binder based on workability and compressive strength"

In this Research, The Alkaline solution to fly ash ratio 0.5, Molarity is 10M, Temperature 80^{o}c for 24 hr. Workability decreases, compressive strength increases with increasing in concentration. But in this result workability increase and decrease in compressive strength.AL to FA ratios 0.4,0.45,0.50,0.60; Molarity -6,8,10,12; Na_2SiO_3/NaOH-2.5.Result Gives Compressive strength for 12M highest strength 78.5 with 0.6 alkaline to fly ash ratio. [10] The Ratio of AL/FA increases the compressive strength is also increases

Nishant Mishra, Shyam Verma, V. Vasugi (2015) "Experimental Study on Geopolymer pervious Concrete"

This investigation shows that higher concentration of ground granulated blast furnace slag comparatively gives higher strength. In this research three trial mix were prepared of 80% GGBS, 20% fly ash similarly for 60/40% and 50/50% in which PGC1 was having good strength as compared to other mix as in this mix GGBS was used about 80% of total mix and 20% fly ash of total mix, as molarity also plays an important role but it was kept same throughout the test i.e 12M gives good strength. The permeability is also good as compared to normal concrete.

G. Srinivasa Rao, B. Sarath Chandra Kumar (2019) "Experimental Investigation of GGBS based Geopolymer Concrete with Steel Fibers"

In this Paper, After Experiment performing and studied, they found that, the compressive strength of the geopolymer concrete made with steel fibers are higher than the geopolymer concrete made without steel fibers.[12] It was clear that as the NaOH concentration increases the compressive strength also increases.

Farah Farhana (2020) "Effect of Geopolymer Paste on compressive strength, water absorption and porosity"

Based on this research, it can be said that the fly ash geopolymer paste has achieved it optimum quality. This paste has good compressive strength and also gave a good result in term of water absorption and porosity testing. It has low water absorption due to lower porosity percentage. [13] This also can prevent cracking from occur. Hence, it can be said

that the geopolymer paste give a good compressive strength, low water absorption and low porosity percentage.

Salaheddin Abdulsalam Arafa, Ahmad Zurisman Mohd Ali,Siti Nazahiyah Rahmat, and Yee Loon Lee (2016) "Optimum Mix for Pervious Geopolymer Concrete (GEOCRETE) Based on Water Permeability and Compressive Strength"

In this Paper they study on the compressive strength and water permeability measurement of pervious geopolymer concrete made with class F fly ash, activate alkali, and CA (with different sizes that range from 5 mm to 20 mm),

Compressive strength and water permeability of pervious geopolymer concrete depend primarily on the porosity of the concrete; age, binder material type, FA/CA ratio, and CA size showed marginal influence on the strength and water permeability of pervious geopolymer concrete. Reduction in the aggregate size decreased the porosity and water permeability of pervious geopolymer concrete, and thus, the strength of pervious concrete is increased. a pervious geopolymer concrete with FA/CA ratio of 1:7, CA of 5–10 mm, NaOH molarity of 10, Na2SiO3/NaOH ratio of 2.5, and AL/FL ratio of 0.5 when cured for 24 h at 80 °C gave optimum ratios for compressive strength of 19.8 MPa after temperature curing for 24 h and water permeability of 2.29 cm/s. The workability of the pervious geopolymer concrete in fresh state increases with the increase of AL/FL ratio, but it decreases with the increasing sodium hydroxide concentration.

Anandh Babu Malayali et al (2020) "Effect of Molar Content on GGBS based Geopolymer Pervious Concrete"

In this Paper results give; Compression strength increases with respect to molar content increases but molar content increases workability decreases due to that molar ratio limited up to M12.Compression strength directly proportion to Split tension value and density value increases by increase in molar content M12.Water absorption decreases with increase in molar content up to M12 Geopolymer pervious concrete properties of three values. ANOVA Analysis F-Stat, P-Value 0.0001 which will shows the difference is nearly close value. When compare all the parameter the molar of M12 which show higher compression strength and split tension strength and lower water absorption. From this study suggested go for GGPC. Other parameters are also had to study in further.

Fatheali A. Shilar , Sharanabasava V. Ganachari , Veerabhadragouda B. Patil , Syed Javed , T M Yunus Khan , and Rahmath Ulla Baig (2022) "Assessment of Destructive and Nondestructive Analysis for GGBS Based Geopolymer Concrete and Its Statistical Analysis"

In this Paper assets that, the effect of temperature on the compressive strength parameter using destructive and non-destructive testing was analyzed. Some important observations were reported in this work. The A/B ratio plays a vital role in strength development; an A/B ratio of 0.45 shows maximum compressive strength when the specimens are exposed to a curing temperature of 70 °C. Furthermore, the A/B ratio of 0.45, under a 70 °C temperature, performances of GPC reduces due to the evaporation of the liquid content in the mixture prior to the completion of the reaction duration, and even increases in silica coagulation.

Observation from Literature Review

1. The Performance based on Geopolymer pervious concrete is based on replacement on cementitious material like fly ash, bagasse ash and GGBS. Its Study shows that replacement of cement is important as environmental point of view and economically is also favorable.
2. The literature also discussed after the casting the thermal curing under different temperature and different molarity is help for increasing the strength and permeability
3. Effect of supplementary materials such as fly ash and GGBS, which further improve the strength and durability properties of Geopolymer Pervious concrete.
4. It is also observed that, GGBS partial replacement like 50%,40%,30% also use of fly ash and cement for making pervious concrete. But after adding the cement then it has low permeability and high strength.
5. Performance of GGBS based Geopolymer Pervious concrete by varying Molarity of NaOH
6. Performance of GGBS based Geopolymer Pervious concrete by varying Curing temperature.
7. The permeability & Mechanical properties of GGBS based Geopolymer Pervious concrete obtained above. Optimum mix of GGBS based Geopolymer Pervious concrete based on results obtained.

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Power Generation through Speed Breaker

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Abstract

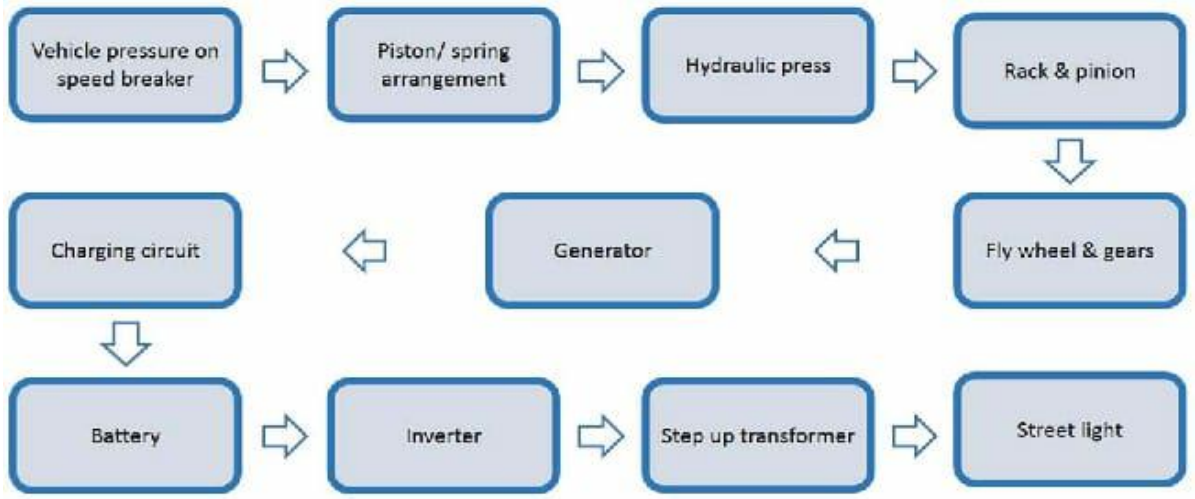
In this research, we purpose a renewable non-conventional energy sources based on speed breaker mechanism. Our project is to enlighten the streets utilizing the jerking pressure which is wasted during vehicles passes over speed breaker in roadside. We can tap the energy generated by moving vehicles & produce power by using speed breaker as a power generating unit. The kinetic energy of the moving of the moving vehicle can be converted into mechanical energy by rack and pinion Abstract In this research, we purpose a renewable non-conventional energy sources based on speed breaker mechanism. Our project is to enlighten the streets utilizing the jerking pressure which is wasted during vehicles passes over speed breaker in roadside. We can tap the energy generated by moving vehicles & produce power by using speed breaker as a power generating unit. The kinetic energy of the moving vehicles can be converted into mechanical energy by rack and pinion mechanism and this mechanical energy will be converted to electrical energy using generator which will be used for lightning of street lights. Therefore; using this mechanism we can save lot of energy which can fulfill our future demands.

Introduction

This paper attempts to show how energy can be tapped and used at a commonly used system, the road speed breakers. The number of vehicles passing over the speed breaker in roads is increasing day by day. A large amount of energy is wasted at the speed breakers through the dissipation of heat and also through friction, every time a vehicle passes over it. There is great possibility of tapping this energy and generating power by making the speed-breaker as a power generation unit. The generated power can be used for the lamps, near the speed breakers. The present work an attempt has been made to fabricate a ramp, which can utilize the kinetic energy of vehicles in power generation. This type of ramp is best suited for the places where the speed breaker is a necessity. The places like Toll bridges or on vehicle parking stands are best for its utilization. The work also discusses the shortcomings of existing methods and the ways it is countered by this method. The paper is organized as following. Section II describes the methodology of the project. Section III describes the energy crises is a bottleneck in the supply of energy resources to an economy. Section IV gives an in-depth explanation of each part and then the assembly as a whole with theoretical analysis. Section V explains the experimental procedure of power generation in this setup. Section VI includes the advantages of the power generation through speed breaker. Section VII explain about the result of the experiment. Section VIII describes the conclusion of our approach.

Methodology

Power can be produced from conventional and non-conventional energy sources. In this paper, we show energy conversion from kinetic energy to rotational energy and rotational energy to electrical energy respectively. This project explains the mechanism of electricity generation from speed breakers. It is a simple but optimum process to generate energy from speed breaker arrangements. There are a large number of vehicles running on a road. The vehicles are ongoing over a number of speed breakers present on a road. We want to replace this traditional speed breakers with our purposed speed breaker. It is an Electro-mechanical unit. This system utilizes both mechanical technologies and electrical techniques for the power generation and its storage. This generation will be proportional to the traffic density.



Literature Review

1. "Experimental Study on Power Generation from speed breaker" by S. Soundarrajan, R. Ananthakumar, and P. Pugazhavadivu: This study investigated the feasibility of using speed breakers to generate electricity. The authors designed and implemented a prototype system to convert kinetic energy from vehicles passing over speed breakers to electrical energy.

2. "Design and development of power generation from speed breaker" by S.D. Kshirsagar and S.B. Thombare: This paper presents a detailed design of a power generation system using speed breakers. This system utilizes Rack and pinion mechanism to convert vertical motion of speed breaker into rotary motion, which is then converted into electrical energy.

3. "Feasibility study of Electricity generation through speed breakers and utilization" by M.A. Khan, S.A. Sheikh, and N.M. Sheikh:

System construction

1.speed breaker:-

It is top portion of system which is made of iron in curved shape. The main function of speed breaker is to sustain the pressure of vehicle and squeezes it when vehicle passes through it.

2. spring arrangement:-

A spring is an elastic body whose function is to distort when loaded and to recover it's original shape when the load is removed.

3. Hydraulic press :-

In a hydraulic press a small force is applied on a column of liquid is converted into a much greater force available to another column of liquid.It is an application of pascale law.

$$F2=(f1/a)*A$$

4. Rack and pinion:-

Rack and pinion can convert rotary to linear of from linear to rotary motion. Rack is a linear gera and pinion is a circular gear.

5. fly wheel:-

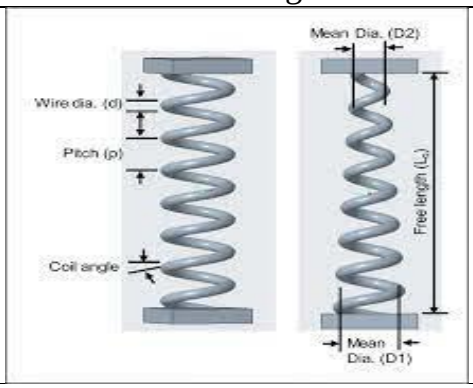
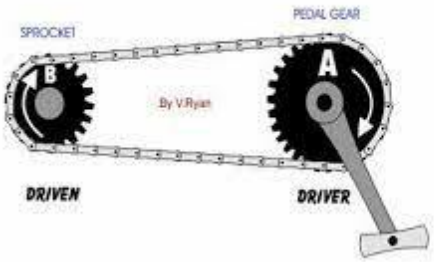
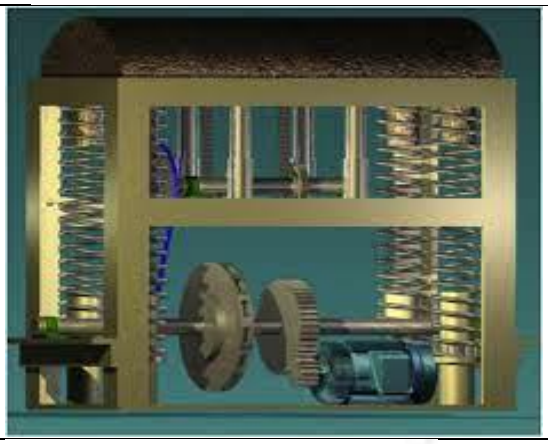
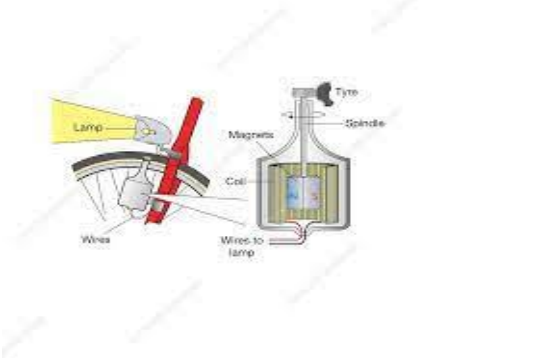
The primary function of flywheel is to act as an energy accumulator. It reduces the fluctuations in speed.It absorbs energy when demand is less and releases the same when it is required.

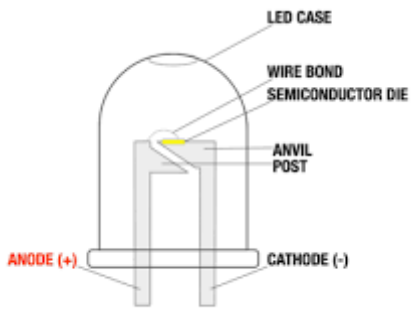
6. Generator:-

The device which convert mechanical energy into electrical energy is called generator.An AC generator is used for producing alternating current which contains assembly of stationary and moving parts.

7. Charging circuit:- The charging circuit is used to charge the battery.

Experimental Procedure Power ramp fabrication consists of various types of parts with different specifications. The components of Power Ramp used in construction are listed below and explain its function

Sr no.	Part name	Part image
1	Helical coil spring	
2	Chain drive	
3	Helical speed breaker surface	
4	Bicycle dynamo	

5	LED	

Advantages

1.Renewable energy source :- the power generation system using speed breaker is a renewable energy source that does not emit any harmful pollutants or greenhouse gases making it an eco friendly solution.

2.Cost effective:- the installation and maintainance cost of the power generation system using sped breaker is relatively low compared to other renewable energy sources like solar or wind power.

3. Reduce traffic speed:- The installation of speed breaker can help reduce traffic speed which can lead to a safer driving environment and fewer accident.

Result

A DC motor is an electric motor that runs on direct current (DC) electricity. DC motors were used to drive machines which eliminated the need for a local steam engine or internal combustion engine. DC motors can operate directly from rechargeable batteries, providing the motive power for the first electric vehicles. Today DC motors are still found in applications as small as toys and disk drives, or in large sizes to operate steel rolling mills and paper machines. Modern DC motors are nearly always operated in conjunction with power electronic devices. Energy conversion As stated above, mechanical energy is changed into electrical energy by movement of conductor through a magnetic field. The converse of this is also true. If electrical energy is supplied to a conductor lying normal to a e-ISSN: 2582-5208 International Research Journal of Modernization in Engineering Technology and Science (Peer-Reviewed, Open Access, Fully Refereed International Journal) Volume:05/Issue:05/May-2023 Impact Factor-7.868 www.irjmets.com www.irjmets.com @International Research Journal of Modernization in Engineering, Technology and Science [2931] magnetic field, resulting in current flow in the conductor, a mechanical force and thus mechanical energy will be produced. Producing mechanical force Like the generator, the motor has a definite relationship between the direction of the magnetic flux, the direction of movement of the conductor or force, and the direction of the applied voltage or current since the reverse motor of the generator. Fleming's left-hand rule can be used. If the thumb and first two fingers of the left hand are extended at right angles to each other, the thumb indicates the direction of movement. Teacher the index finger indicates the direction of the magnetic field and the middle finger the direction of the current. In a motor or generator, if the directions of any two factors are known, the third can be easily determined. The project is concerned with generation of electricity from speed breakers-like set up. The load acted upon the speed breaker-setup is there by transmitted to roller chain arrangements. Here the reciprocating motion of the speed-breaker is converted into rotary motion using the roller chain arrangement. The axis of the pinion is coupled with the sprocket arrangement. The sprocket arrangement is made of two sprockets. One is of the larger size and the other is smaller size. Both the sprockets are connected by means of a chain which serves in transmitting power from the larger sprocket to the smaller sprocket? As the power is transmitted from the larger sprocket to the smaller sprocket, the speed that is available at the larger sprocket is relatively multiplied at the rotation of the smaller sprocket. Electricity from Speed Breaker First of all what is electricity? Electricity is a form of energy. It is the flow of electricity. Electricity is a fundamental part of nature and is one of our most widely used forms of energy.

Conclusion

Energy is a key input for sustaining a country's industrial development and standard of living and is directly related to per capita energy consumption. Traditional sources like coal, oil, uranium etc.. are depleting very rapidly and by the turn of the century man will have to depend on non-conventional sources of energy for power generation. Different types of non-conventional energy sources like solar energy, wind energy, biogas etc... Now we can generate power without using the previously mentioned external sources by creating a "power ramp". Due to heavy vehicular traffic in big cities, people suffer.But this vehicular traffic can also be used for power generation through a new technology called "power ramp".If placed on high traffic roads, the weight and kinetic energy of the vehicles can generate mechanical power in the shafts, and this mechanical power is converted back into electrical power. The main drawback of this power curve is the design of the springs. When we have low traffic and intermittent power generation when we have difficulty designing springs, we need to smooth out these variations.

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Automatic Street Light

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Abstract

The primary consideration in the present field of technologies is Automation, Energy. Night travel has always been troublesome and considered unsafe because of the lingering darkness. Consumption, and cost-effectiveness. Automation is intended to reduce manpower with the help of intelligent systems. Energy saving is the primary consideration forever as the energy sources are getting diminished for various reasons. As we all know that energy consumption has been increasing day by day so, to overcome these consequences we are using IoT devices. These traditional lights also have their pros and cons. These lights are switched ON and OFF manually. Hence sometimes mistakes happen. Like light remains ON even during the day. And by mistake sometimes lights remain OFF even during the nights. Street lights also run using the electricity supplied by the respective electric boards. And so when in the night, the supply is cut off due to any reason, the surrounding is completely engulfed in darkness as street lights and also the lights from our homes go OFF. This also leads to confusion and accidents. To overcome these shortcomings the idea of smart street lights was proposed. These lights are equipped with sensors, microcontrollers, etc. which makes this system smart. LDRs (Light Dependent Resistors) are the trigger to turn ON and OFF the smart street lights at Twilight. IR (Infrared) sensors sense the presence of vehicles and humans and switch ON and OFF the street lights in the dead of the night. LEDs are used in place of Sodium lights which are both energy and cost-efficient. Overall this system is costly to install but is profitable in the long run.

Introduction:

We need to save or conserve energy because most of the energy sources we depend on, like coal and natural gas can't be replaced. Once we use them up, they are gone forever. Saving power is very important, instead of using the power in unnecessary times it should be switched off. In any city "STREET LIGHT" is one of the major power consuming factors. Most of the time we see streetlights are on even after sunrise thus wasting lot of energy. Over here we are avoiding the problem by having an automatic system which turns on and off the streetlights at given time or when ambient light falls below a specific intensity. LDR is used to detect the ambient light. If the ambient light is below a specific value the lights are turned on. These traditional lights also have their pros and cons. Automatic Street Light Control System is a simple and powerful concept, which uses transistor as a switch to switch ON and OFF the street light automatically. By using this system manual works are removed. It automatically switches ON lights when the sunlight goes below the visible region of our eyes. It automatically switches OFF lights under illumination by sunlight. This is done by a sensor called Light Dependant Resistor (LDR) which senses the light actually like our eyes. These traditional lights also have their pros and cons. These lights are switched ON and OFF manually. Hence sometimes mistakes happen. Like light remains ON even during the day. And by mistake sometimes lights remain OFF even during the nights. Street lights also run using the electricity supplied by the respective electric boards. And so when in the night, the supply is cut off due to any reason, the surrounding is completely engulfed in darkness as street lights and also the lights from our homes go OFF. This also leads to confusion and accidents. Several mishaps happen due to the darkness that engulfs our surroundings. To overcome these shortcomings the idea of smart street lights was proposed. These lights are equipped with sensors, microcontrollers, etc. which makes this system smart. LDRs (Light Dependent Resistors) are the trigger to turn ON and OFF the smart street lights at Twilight. IR (Infrared) sensors sense the presence of vehicles and humans and switch ON and OFF the street lights in the dead of the night. LEDs are used in place of Sodium lights which are both energy and cost-efficient. Overall this system is costly to install but is profitable in the long run.

Working:-

LDR sensor is used for detecting the presence of surrounding light so that during the day time when sun is bright, the street light is switched off automatically. And during the night time when there is no light, the LDR sends signal to microcontroller to turn on the street light. When light falls on the LDR then its resistance

decreases which results in increase of the voltage at pin 2 of the IC 555. IC 555 has got comparator inbuilt, which compares between the input voltage from pin2 and 1/3rd of the power supply voltage. When input falls below 1/3rd then output is set high otherwise it is set low. Since in brightness, input voltage rises so we obtain no positive voltage at output of pin 3 to drive relay or LED, besides in poor light condition we get output to energize. The automatic street light working is dependent on the presence or absence of light in the atmosphere, LDR works extremely well in managing light. LDR is usually reasonably priced, and this is a clever way of bringing automation into the street light system. This also enhances the street light's overall operation efficiency and power consumption. Visibility and natural light levels begin to decline as the sun sets. As a result, as visibility decreases, automatic street lights are expected to kick on. Automatic street lights turn on by assessing visibility data provided by a sensor. Because of the presence of natural light in the sky, visibility begins to increase at sunrise. The street light is obviously unnecessary during the day, and the only way to save energy is to turn it off. When a solar street light detects the presence of sunlight, it immediately turns off the light. An automatic street light circuit requires an LDR, a transistor, resistors, a breadboard, a battery, and wires. The transistor, in conjunction with a light-dependent resistor, functions as a controller, controlling the operation of the solar street light. The operation of a transistor is dependent on the operation of a light-dependent resistor. The transistor's input should be the LDR's output. The transistor transmits a signal to turn off the light, and if no signal is received, the light goes on. When the available light in the atmosphere falls below the threshold required for the LDR to operate, the resistor is unable to supply input to the transistor. When there is enough light, the LDR sends a signal to the transistor, which subsequently sends a signal to turn off the street light.

Components mostly Used :

1. Light-Dependent Resistor (LDR)

When different levels of light strike an LDR its resistance changes. They work on the photoconductivity concept, which gives less resistance in bright light and more resistance in dim light.

2. Microcontroller

It is a small integrated circuit that governs a specific operation in an embedded system. On a single chip, a typical microcontroller contains a CPU, memory, and input/output (I/O) peripherals.

3. Buzzer

It is an output device that is turned on whenever there is a transition in the relay. It will be turned on for a couple of seconds whenever the relay is turned on or off.

4. Relay

It is an electromechanical device that can be used to join or disconnect an electrical circuit. A relay is similar to a mechanical switch, but it can be controlled with an electronic signal rather than manually turning it on or off.

Fig :Automatic Street Light

Merits

Street lights provide a lot of benefits. It can be used to accumulate security in urban areas. In urban area helps to reduce crime and provide a sense of safety i. The risk of accidents in those areas are reduced. Moreover, it consumes low electricity and its operating cost is less when compared with other conventional lights. Street light is Eco-friendly and reducing Carbon dioxide. Moreover, street light artificially extending the hours in which it's light so

that activity can take place. It also improves safety for drivers, riders, and pedestrians.

By using this automatic system for street light controlling we can reduce energy consumption because the manually operated street lights are not switch off properly even the sun light comes and Also not switched on earlier before sunset. Normal street lights are turned ON and OFF manually. They are turned ON as soon as the sun sets and darkness takes over and switched OFF as the sun rises.

Demerits

The installation of smart street lights is costly when compared to normal street lights. Since it includes sensors, microcontrollers, memory units, and several other devices. However, when looking at it in the long time run, it is cost-effective High cost of energy-efficient products: Energy-efficient products and appliances Generally have a high initial capital cost.

There is a higher initial investment required for an automatic street light system compared to a conventional street light system. Energy generation for solar-powered automatic street lights is solely dependent on climatic conditions. There is also limited availability of potential financing mechanisms for energy efficiency.

Conclusion

The Streetlight controller using IDR based light intensity& traffic density, in the todays up growing countries will be more effective in case of cest, manpower and security as compare with today's running complicated and complex light controlling systems Automatic Street Light Controlling System puts up a very user friendly approach and could increase the power, This paper elaborates the design and construction of automatic street control system circuit Circuit works properly to turn street lamp ONOFF, After designing the circuit which controls the light of the street as illustrated in the previous sections IDR sensor and the photoelectric sensors are the twe main conditions in werking the circuit If the two conditions have been satisfied the circuit will de the desired werk according to specific program Each senser controls the turning ON or OFF the lighting column The street lights has been successfully controlled by microcontroller, With commands from the controller the lights will be ON in the places of the movement when it's dark Further more the drawback of the street light system using timer controller has been evercome, where the system depends on photoelectric sensor.

Future Scope-

We can save the energy for the future use and we can control the losses of the power . We can implemented this project for the home lamp or night lamp of the room. This is also used for the signals.

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Review on Performance Evaluation of High Performance Concrete using GGBS, Alccofine & Fly Ash for Durability and Strength Aspects

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Abstract:
High Performance Concrete (HPC) has gained significant attention in the construction industry due to its enhanced durability and strength characteristics. This review paper examines the performance evaluation of HPC incorporating Ground Granulated Blast Furnace Slag (GGBS), Alccofine, and Fly Ash as supplementary cementitious materials. The paper provides an overview of the properties of these materials and their effects on the durability and strength aspects of concrete. Various research studies and experimental findings related to the incorporation of GGBS, Alccofine, and Fly Ash in HPC mixes are analyzed and synthesized to assess their impact on durability parameters such as permeability, chloride ingress, sulfate attack, and carbonation resistance, as well as strength properties including compressive strength, tensile strength, and flexural strength. The review also discusses the optimization of mix proportions, curing regimes, and testing methodologies for evaluating the performance of HPC mixes.

Keywords: High Performance Concrete, GGBS, Alccofine, Fly Ash, Durability, Performance Evaluation, Mix Proportion, Supplementary Cementitious Materials.

Introduction:

The research focuses on evaluating the performance of high-performance concrete that incorporates three supplementary cementitious materials: GGBS (Ground Granulated Blast Furnace Slag), Alccofine, and fly ash. These materials are added to the concrete mix to enhance both its durability and strength characteristics. GGBS is a by-product of iron production that can improve the concrete's strength development and reduce heat of hydration. Alccofine is a type of silica fume that enhances the concrete's mechanical properties and durability by filling in pores and enhancing the paste-aggregate interface. Fly ash, a by-product of coal combustion, contributes to increased workability, reduced permeability, and improved long-term strength. The research aims to assess the combined impact of these materials on various aspects of concrete performance. These aspects include compressive strength, flexural strength, resistance to chloride penetration, sulphate attack, and overall durability. By analysing the effects of GGBS, Alccofine, and fly ash in high-performance concrete, the study seeks to provide valuable insights into the potential benefits of using these supplementary materials in construction projects. [1] High Performance Concrete (HPC) stands at the forefront of modern construction, offering superior durability and strength attributes vital for sustainable infrastructure development. With increasing demands for resilient and long-lasting structures, the incorporation of supplementary cementitious materials (SCMs) such as Ground Granulated Blast Furnace Slag (GGBS), Alccofine, and Fly Ash into concrete mixes has gained prominence. These SCMs not only enhance the mechanical properties of concrete but also contribute to environmental sustainability by reducing carbon emissions associated with traditional cement production. Despite the growing interest in HPC formulations utilizing GGBS, Alccofine, and Fly Ash, there remains a critical need for comprehensive evaluations of their performance concerning durability and strength aspects. Understanding the synergistic effects of these SCMs on concrete properties is essential for optimizing mix designs and ensuring the longevity of infrastructure projects.

Literature review

Genral :

The current research aims to understand the key factors contributing to the strength of concrete by incorporating Ground Granulated Blast Furnace Slag (GGBS), fly ash, and Alccofine. Through an extensive literature review, specific proportions of these materials are determined to replace portions of the cement content. By investigating the impact of these substitutions, the study seeks to optimize the composition of high-strength concrete, thereby improving its performance and durability characteristics.

Review of Literatures :

Narender Reddy, T. Meena (2018): Examined the compressive strength of concrete incorporating alccofine and GGBS reveals that better workability is attained. The greatest compression strength is obtained with a blend of cement, GGBS, and alccofine at proportions of 72%, 20%, and 8%, respectively. The findings distinctly illustrate that as the alccofine percentage rises, there is a decrease in compression strength, attributed to the incompatible nature of the materials employed.

Upadhyay SP, Jamnu MP (2014): In this investigation, the impact of Alccofine as both a supplementary cementing material and filling agent on concrete strength was examined. Utilizing 10% Alccofine alongside 30% Fly Ash yielded the highest compressive strength in concrete. Across all mixture proportions, concrete displayed robust strength gains within the first 3 days, followed by excellent gains between 3 to 7 days, yet strength increments slowed between 7 to 28 days. The inclusion of Alccofine enhanced self-compatibility attributes such as filling ability, flowability, and resistance to segregation. Moreover, Alccofine proves to be cost-effective compared to cement, offering higher strength. Variations in water-to-cement ratio (w/c) from 0.45 to 0.5 resulted in slightly higher compressive strength, with marginally superior strength observed with a higher w/c ratio at 3 days. On average, the compressive strength at 28 days was 73.8 MPa for a w/c ratio of 0.5 and 71.0 MPa for a w/c ratio of 0.45, indicating marginal increments in strength with aging.

Patel Y, Shah BK, Patel PJ (2013): In this investigation, the impact of locally sourced Alccofine as supplementary cementing materials and filling materials on the strength and durability of concrete was examined. Based on the findings of this study, the following conclusions can be drawn. As the water-to-cement (w/c) ratio increases, permeability also increases, leading to higher chloride penetration in all types of cement. The addition of Alccofine in Ordinary Portland Cement (OPC) systems results in a decrease in the RCPT value due to two main factors: proper particle size distribution leading to lower permeability and the reaction of alumina with chlorine, which preferentially reacts with alumina over calcium (Fidder reaction). The inclusion of fly ash in Alccofine-based cement further reduces the RCPT value, attributed to the higher amount of pozzolana and proper particle size distribution. It was concluded that the compressive strength achieved using Alccofine (8%) + Fly Ash (20%) is 54.89 MPa and 72.97 MPa at 28 and 56 days, respectively. The smaller particle size of Alccofine compared to cement helps reduce voids, indirectly contributing to increased strength. The use of Alccofine results in minimal loss of weight and compressive strength in concrete due to its greater compactness and lower permeability, reducing the effects of Sulphate Attack. This is attributed to the conversion of leachable calcium hydroxide into insoluble non-leachable cementitious products through pozzolanic action, leading to concrete impermeability. Additionally, the removal of calcium hydroxide reduces concrete susceptibility to magnesium sulfate attack. Similarly, Alccofine leads to minimal loss of weight and compressive strength in concrete, reducing the effects of alkali due to its finer mineral admixture properties. It was observed that it is possible to produce M70 concrete with an RCPT value lower than 500 coulombs, with Alccofine demonstrating lower RCPT values due to pore-filling and refining of particle size.

K Ashwini, P Srinivasa Rao. (2020): This paper presents a technical exploration of Alccofine's application in sustainable concrete development, focusing on mitigating the construction industry's environmental impact and utilizing industrial by-products efficiently. Through a comprehensive literature review, several key findings regarding Alccofine's role in concrete enhancement emerge. Notably, its high surface area enables consistent mixing and significantly reduces concrete permeability. Additionally, Alccofine accelerates hydration and pozzolanic reactions compared to conventional GGBS, leading to improved concrete properties. Its ability to refine pores in the concrete transition zone enhances the performance of fly ash-based Geopolymer concrete while bolstering strength and durability. Furthermore, Alccofine reduces water demand and admixture dosage, enhances paste density, and influences concrete fluidity, setting time, and the formation of calcium silicate hydrate, ultimately contributing to enhanced concrete strength and sustainability.

Mr. Pradyumna Sawant, Dr. Abhijit M. Zende

(2020): The technical analysis of High-Performance Concrete (HPC) emphasizes its superior material composition and properties compared to conventional concrete. Through rigorous experimentation and testing, it has been determined that specific mix formulations, such as Matrix 3, exhibit optimized strength characteristics surpassing other percentage mixes, including Matrix 1 and Matrix 2. Moreover, rate analysis reveals that Matrix 3 offers cost reductions of up to 16.59% compared to standard concrete, showcasing its economic viability. Additionally, Matrix 2 demonstrates enhanced workability, boasting a 13.61% increase over standard concrete, which is crucial for efficient construction practices. The controlled temperature maintenance during concrete curing eliminates the need for additional treatments, streamlining the construction process. Furthermore, the low water-cement ratio of less than 0.5 in HPC formulations mitigates carbonation effects, ensuring long-term durability and structural integrity. Lastly, HPC's significant reduction in concrete emissions by up to 48.50% underscores its environmental benefits and potential for sustainable construction applications.

Surendra Kumar, Mr. Rohit Kumar (2018): This paper investigates the influence of alccofine and fly ash on concrete properties, aiming to assess their impact on enhancing concrete performance. The literature review encompasses studies by various researchers on the durability of high-performance concrete incorporating alccofine and fly ash. With rising demands in the construction sector, there's a growing necessity for High Performance Concrete (HPC). Recent efforts in enhancing concrete performance indicate that incorporating cement replacement materials and mineral or chemical admixtures can bolster both strength and durability. Alccofine, a novel micro-fine concrete material, holds promise for high-strength concrete, offering improvements in both workability and strength. Notably, the cost of high-strength concrete mixes containing alccofine is found to be lower compared to those without alccofine, further highlighting its economic viability.

Kumar RS, Samanta AK, Singha Roy DK (2015): In the experimentation, substituting 15% of cement with alccofine yielded the highest compression test value, while for flexural strength, the optimal substitution was found to be 10%. Incorporating alccofine in the concrete mix enhanced early strength development across all tested properties. Water immersion curing exhibited the most favorable outcomes, followed by burlap curing. A 15% partial substitution of cement with alccofine resulted in a 17.14% increase in compressive strength, while a 10% substitution led to a 29.57% improvement in flexural strength.

Arjunkumar B, Geena George (2021): The classification of concrete based on strength includes conventional concrete (up to grade 60 MPa), high strength concrete (grades 60 – 90 MPa), and very high strength concrete (grades 90 – 130 MPa), among others. The utilization of high strength concrete has witnessed a notable uptick in the construction sector in recent years. This experimental investigation focuses on integrating mineral admixtures like alccofine 1203 and GGBS to enhance the mechanical properties of high strength concrete. Silica fume, derived from the silicon smelting process, serves as a pozzolanic material and is utilized in high-strength concrete either as a cement replacement or as an additive to augment concrete properties. High strength concrete offers a promising solution for large-scale construction projects requiring exceptional strength, flowability, and durability. Extensive research conducted over past decades has explored the efficacy of supplementary cementitious materials in enhancing concrete performance. Prior studies have underscored the significance of employing high-strength concrete to enhance both the strength and durability of structures against environmental degradation.

S. Kavitha and T. Felix Kala (2016): The combination of GGBS and Alccofine was observed to enhance the mechanical and rheological properties of SCC, potentially leading to the production of high-performance, high-strength concrete. The workability characteristics of SCC containing varying proportions of GGBS and Alccofine meet the EFNARC recommended values, enabling their utilization in SCC production. The difference in strength between SCC specimens with GGBS and Alccofine proportions and control specimens becomes significantly pronounced during the early stages of curing. Substituting 30% of cement with GGBS and 10% with Alccofine yields optimal results in terms of compressive and split tensile strength, with observed maximum strengths of 42.3 N/mm2 and 7.9 N/mm2 respectively. Incorporating GGBS and Alccofine enhances the flexural resistance of SCC, resulting in a maximum improvement of 8.3 N/mm2 in 28-day strength, highlighting the beneficial impact of these additives on flexural strength.

M. Vijaya Sekhar Reddy, K. Ashalatha and K. Surendra (2016): An Experimental investigation was conducted on the partial replacement of cement with fly ash and alccofine for M40 grade concrete. Cement was substituted with fly ash and alccofine at rates of 5%, 10%, 15%, and 20%. The findings

conclude that incorporating alccofine exhibits early strength development and is environmentally friendly. Alccofine demonstrates superior long-term strength properties compared to fly ash.

K. Gayathri, K. Ravichandran and J. Saravanan (2016): Alccofine-based concrete demonstrates lower RCPT values due to particle pore filling and refining, leading to enhanced durability. Beyond a 15% alccofine content, it acts primarily as a filler material, resulting in a gradual decrease in strength. The mix performs well in compressive strength during sulphate attack testing. Increasing alccofine content decreases weight loss but may compromise strength. Alccofine-based mixes exhibit resilience against chloride attack, with mix displaying superior strength and lower weight loss. In acid resistance tests, alccofine concrete exhibits slightly higher compressive strength and significantly less weight loss compared to conventional concrete, indicating effective resistance against acid attack. RCPT results demonstrate that concrete with alccofine outperforms control mixes in terms of performance. Elevating the alccofine percentage in concrete as a substitute for cement enhances the cementing efficiency. It is inferred that alccofine 1203 serves as a commendable replacement for cement up to a certain threshold, particularly up to 15%, exhibiting favorable performance in terms of durability.

Abhijitsinh Parmar, Dhaval M Patel, Dron Chaudhari, Harpalsinh Raol (2014): The sorptivity rates reveal that Silica Fume exhibits a higher sorptivity compared to Alccofine, indicating a greater rate of capillarity rise in Silica-Fume. In the Accelerated Corrosion Test, Silica-Fume specimens show more susceptibility to corrosion compared to Alccofine specimens. Results from the RCPT test indicate that Silica-Fume specimens have a higher average coulomb passing rate compared to Alccofine specimens at both 28 days and 56 days, suggesting higher Chloride Ion Permeability in Silica-Fume specimens, despite their good resistance to chloride ion permeability. In alkali attack tests, the percentage weight and strength losses for both materials show higher values for Silica-Fume specimens compared to Alccofine specimens. Similarly, in Chloride Attack Tests, Silica-Fume specimens exhibit higher percentage weight and strength losses compared to Alccofine specimens. Overall, the findings suggest that Alccofine demonstrates better resistance to Chloride Attack compared to Silica-Fume. From the Sea Water Test Results it can be concluded that the Alccofine possess the better resistant to the Sea Water than Silica-Fume.

Seethalakshmi T, Sakthieswaran N (2015): Cement stands as the second most consumed product globally, contributing to approximately 7% of total carbon dioxide emissions. Geopolymer concrete (GPC), crafted from industrial waste such as fly ash and GGBS, emerges as a promising eco-friendly alternative to Ordinary Portland Cement (OPC)-based concrete. GPC, distinguished by its inorganic alumino-silicate binder system, offers rapid strength gain, negates the need for water curing, and boasts commendable mechanical and durability properties, aligning with sustainability objectives. The construction sector, primarily reliant on Portland cement production, faces environmental challenges due to air pollutant emissions. This study delves into the strength development of various grades of GPC, exploring different molarities of sodium hydroxide (NaOH) and sodium silicate (Na2SiO3) as alkaline liquids for geopolymerization. Test specimens, including cubes and cylinders, are oven-cured and subjected to compressive strength tests at 7, 14, and 28 days. GPC formulations with compressive strengths ranging from 12.33 to 82.10 MPa are developed, with results indicating the viability of fly ash and GGBS combinations in GPC production.

Bhanavath Sagar &M V N Sivakumar (2018): In the realm of construction, the integration of supplementary cementitious materials (SCMs) has revolutionized concrete manufacturing by either partially replacing or supplementing conventional binder mass. This paper aims to synthesize and analyze reported findings concerning the mechanical and durability aspects of concretes incorporating alccofine-1203. By exploring the behavior and impact of alccofine-1203 as an SCM across various concrete types, a comprehensive understanding is sought. Alccofine-1203, characterized by ultra-fine particles and a unique chemical composition, facilitates improved hydration and pozzolanic reactions, thereby enhancing concrete properties. Its incorporation leads to enhanced workability, reduced segregation, diminished heat of hydration, lowered permeability, accelerated hydration rates, and improved pozzolanic reactions, resulting in early-stage high-strength concrete. The presence of calcium (CaO) and silica (SiO2) within alccofine-1203 further enhances mechanical and durability properties compared to other SCMs. Literature review suggests an optimal alccofine-1203 dosage ranging between 8% to 12%, demonstrating maximal improvements in concrete mechanical and durability characteristics at these levels.

Saurabh Gupta, Sanjay Sharma, Devinder Sharma (2015): Ensuring sustainability in the concrete industry is imperative to mitigate its environmental impact. The adoption of eco-friendly materials is crucial in this endeavor. Alccofine, an

ultra-fine slag by-product from the steel industry, possesses cementitious properties and can serve as a sustainable alternative to cement, reducing environmental pollution. In a study assessing its efficacy, mechanical properties such as compressive, split tensile, and flexural strengths were evaluated at 7, 14, and 28 days. Results revealed that blended concrete incorporating Alccofine exhibited superior qualities, including quick setting and enhanced workability, surpassing those of conventional concrete. These findings underscore the potential of Alccofine as a cement replacement to enhance the properties of blended concrete, thereby contributing to sustainability efforts in the construction industry.

Observation from literature review

1. Studies have consistently shown that alccofine contributes to early strength gains in concrete, particularly within the initial curing period. Water immersion curing has been identified as the most effective curing method.
2. The literature also discusses the combined effects of alccofine with other supplementary materials such as fly ash and GGBS, which further improve the strength and durability properties of concrete. Alccofine-based concrete exhibits resilience against various environmental factors such as chloride attack, sulphate attack, and acid attack, resulting in lower weight loss and higher compressive strength compared to traditional concrete mixes.
3. There are limitations to increasing the percentage of alccofine beyond a certain threshold, as it may begin to compromise the strength of the concrete, primarily acting as a filler material rather than a strength-enhancing additive.
4. The performance of fly ash and alccofine 1203 as partial substitutes for cement varies across different proportions: 10%, 20%, and 30% for fly ash, and 0%, 4%, 8%, 12%, and 14% for Alccofine 1203. Tests were conducted for compressive strength on cubes, split tensile strength on cylinders, and flexural strength on prisms, with curing durations of 7, 14, and 28 days. Durability tests included rapid chloride penetration, water absorption, water permeability, and carbonation attack.

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Harnessing Solar Power for Sustainable Transportation: A Comprehensive Study on Solar-Based Electric Bicycles

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Abstract:

Today with the increasing concerns surrounding climate change and the need for sustainable transportation solutions, this research paper explores the integration of solar power technology into electric bicycles (e-bicycles). The study investigates the technological advancements, environmental implications, and real-world applications of solar-based e-bicycles. This study investigate the making of a sustainable solar-powered electric bicycle. As reserves of coal, natural gas, and petroleum deplete, it is becoming ever more imminent to switch to renewable sources of energy. The objective of this study was to determine the reliability and cost efficiency of a solar-powered electric bicycle in daily life. This is quite useful for warm environments such as the Middle East and Mid-Asia, where sunlight is abundantly available

Introduction:

The introduction provides an overview of our solar-powered bicycle is a product of the transition to sustainable sources of energy. A bicycle is already sustainable, however this project makes it more efficient and creates awareness amongst the masses. The idea to begin this project was influenced by existing socio-economic factors of bringing affordable and efficient. Considering a landscape such as rural India, where the land is covered mostly with steep hills, bicycles are the cheapest mode of transport but the rugged terrain is a major obstacle. It is from here where we got our inspiration to build the solar bike - by utilizing electricity and solar power, a bicycle can be effectively transformed and upgraded. Subsequently,

it introduces the concept of solar-powered e-bicycles as a sustainable and energy-efficient mode of personal transportation, setting the stage for the research questions addressed in the study.

Literature Review

Certainly! The literature review section of a research paper on solar-powered bicycles provides an overview of existing knowledge and research related to the topic. In this paper, during these researches ebike literature survey is conducted by reviewing various research papers. In that number of research papers & patents are collected then analyzed by which we have get the information are: In 2007, Annette Muetze at all[1], work on changing electric bicycle System as a platform to improve electric bicycle performance by using new drive systems. It also provides brief idea about power requirement, speed & load (Weight of rider & bicycle). In 2012, Ian Vince Mcloughlin at all[9], were inventing the electric bicycle for the campus mobility in which they inculpated brushless DC motor which is mounted on either front or rear wheels for producing electricity. They also come with a modern technology that they provided navigation facilities for each system for the campus they invented for with android touchscreen. This is because bikes require 200-250 watts of sustained pedaling force. In this paper, during these researches ebike literature survey is conducted by reviewing various research papers. In that number of research papers & patents are collected then analyzed by which we have get the information are: In 2007, Annette Muetze at all[1], work on changing electric bicycle System as a platform to improve electric bicycle performance by using new drive systems i.e. key parameters that will result in improvement of the system performance. It also provides brief idea about power requirement, speed & load (Weight of rider & bicycle). In 2012, Ian Vince Mcloughlin at all[9], were inventing the electric bicycle for the campus. They also come with a modern technology that they provided navigation facilities for each system for the campus they invented for with android touchscreen. This is because bikes require 200-250 watts of sustained pedaling force.

Methodology:

The Solar powered bicycle is a first of its kind vehicle with an overhead solar panel which can be used to recharge the Lead acid battery during commute as well as when the cycle is parked outside. Also, it can be charged by plugging in to the grid electricity at homes. The solar bicycle consists of 250W DC hub motor to drive the rear wheel when the rider wishes to use the electric assist

, a 24V x 6 Ah lead acid battery, a 120W solar panel on top, The solar panel needs to be welded to the bicycle frame at key locations to hold it firmly in place. The battery will need to be protected from the elements by placing it in a sheet-metal box. The size of a solar panel and the battery may vary during testing in order to increase or decrease range keeping cost in mind. Overall, more than 30km of range from a single charge and yet be affordable to the average consumer especially in rural places to promote green energy vehicles

Components

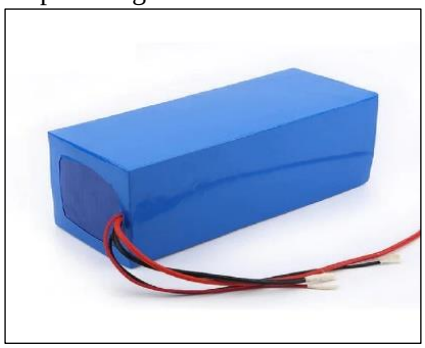
For a solar-based electric bicycle, the components typically include:

Frame:

The main structural component of the bicycle, providing support for other components.

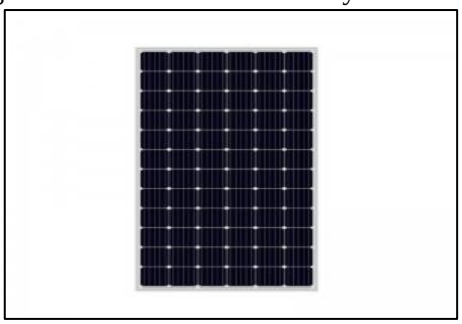
Battery:

Rechargeable lithium-ion battery to store the solar energy for powering the electric motor.



Solar Panels:

Photovoltaic panels mounted on the bike to capture sunlight and convert it into electricity.

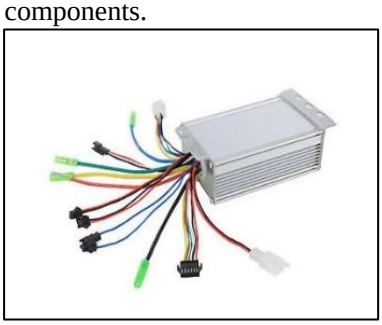


Electric Motor:

DC motor, either hub motor, to assist pedaling or provide propulsion.

Controller:

Electronic component that regulates the flow of electricity between the battery, motor, and other electrical components.



Display Panel:

Interface for the rider to monitor and control various parameters such as speed, battery level, and assistance level.

Throttle or Pedal Assist System:

Mechanism for controlling the electric motor's assistance level, either through a throttle or a pedal-assist sensor.

Wiring and Connectors:

Cables and connectors to link the electrical components together.

Brakes:

Mechanical or hydraulic braking system to control the bike's speed and safety.

Wheels and Tires:

Components for rolling and traction, including rims, spokes, hubs, and tires.

Gears and Drivetrain:

Components for transmitting power from the pedals to the wheels, including chain, cassette, derailleur, and crankset.

Environmental Impact:
The environmental impact analysis assesses the ecological benefits of solar-powered e-bicycles.

Carbon Emissions and Energy Consumption:
Solar-based e-bicycles exhibit a substantial reduction in carbon dioxide primarily due to the harnessing of renewable energy. Through solar panels mounted on the e-bicycle, riders can charge their batteries using clean energy. This section employs life cycle analysis to compare the total carbon emissions associated with the manufacturing, use, and disposal of solar-based e-bicycles against conventional electric bicycles.

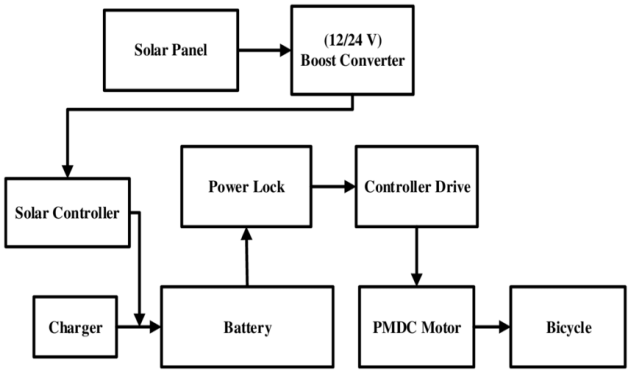
Energy Efficiency and Resource Utilization:
Solar-powered electric bicycles contribute to improved energy efficiency by utilizing sunlight, a readily available and renewable resource. This reduces the demand for grid electricity and lessens the strain on traditional energy sources. The overall energy efficiency, considering the production and maintenance processes, provides insights into the sustainable resource utilization of solar-based e-bicycles.

Lifecycle Sustainability:
Examining the entire lifecycle of solar-based e-bicycles, including raw material extraction, manufacturing, operation, and disposal, helps evaluate their overall sustainability. This includes assessing the environmental impact of solar panel production, battery manufacturing, and end-of-life disposal.

Reduction in Non-Renewable Resource Dependence:
Solar-based e-bicycles contribute to a decreased dependence on non-renewable energy sources, aligning with global efforts to transition towards sustainable energy alternatives. By harnessing solar power, these bicycles mitigate the environmental impact associated with the extraction and consumption of finite fossil fuels, thereby promoting a more sustainable transportation system.

Challenges And Considerations:
While the environmental benefits of solar-based e-bicycles are evident, it is essential to acknowledge challenges such as the environmental impact of solar panel production, the recycling of electronic components, and the overall lifecycle assessment. This section discusses these challenges and proposes avenues for addressing them to optimize the environmental performance of solar-powered electric bicycles.

Block Diagram of Solar Based E Bicyle:



Design And Callculation:
Power as per calculation:
Normal reaction on each tyreWn = Wt/2 = 40 kg
Force F = Wn * g = 392.4 N
Considering static friction
Static friction coefficient :
Fs = u * F =11.77N
Torque Ts = Fs * r = 3.88 Nm
Considering dynamic friction:
Static friction coefficient

Fd = u * F = 1.567 N
Torque Td= Fd* r = 0.517 Nm
Angular Speed:
w = velocity/radius = 25.25 rad/sec
Power Requirements:
1. on plane Ground
For static condition
Ps = Ts*w = 3.88 * 25.25 = 97.97 W
For dynamic condition
Pd = Td * w = 13.05 W
Overall power requirement = 97.97 * 2 = 195.94 W.
2. On inclined surface
a]Power required = F*V = 447.33 W
Extra power required = 447.33 – 195.94 = 251 W
b] Considering dynamic friction
F = u * m*g * cos (a) + m*g sin (a)= 27.34 N
Power P = F*V = 262 W

By considering the above calculations we require 250W hub motor.

Charging adapter selection:

10% Ah rating of the battery.

We select 36V 2.2A charging adapter.

Conclusion:

The conclusion concludes with recommendations for future research directions and practical applications to encourage further exploration of solar-powered electric bicycles as a sustainable transportation solution.The integration of solar power into electric bicycles represents a significant stride toward sustainable transportation. The assessment reveals compelling advantages, including a substantial reduction in carbon emissions, heightened energy efficiency, and a diminished reliance on finite resources

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Geography, Well-being, and Mental Health: Exploring the Intersection of Place and Mind

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Abstract:

This research paper is a study on the intricate connection between geography and mental health, showing how location affects individual well-being. By following medical geography, circadian rhythms, and seasonal affective disorder (SAD) ideas, this research maps issues of mental health geographically. Various factors influence the geographic distribution of mental health outcomes including populations' latitudinal locations. At lower latitudes or closer to the equator, there are usually fewer rates of mental disorders than at higher latitudes as a result of differences in sunlight exposure and circadian rhythms. In regions with extreme variations in daylight hours such as during winter months, it may be possible that changes can worsen SAD leading to mood disturbances and depression. Water bodies and green spaces are important for improving an individual's mental well-being while proximity to natural environments is positively associated with better mental health outcomes. Green space availability provides psychological restoration, stress reduction, and social cohesion that counteracts urbanization-related impacts on people's lives as well as environmental stressors. By understanding the complex interplay between geographical factors and mental health, policymakers, urban planners, and healthcare professionals can develop targeted interventions to promote mental well-being. Incorporating considerations of geographical context, such as access to natural amenities and mitigation of seasonal variations, can contribute to creating healthier and more resilient communities. Through interdisciplinary collaboration and holistic approaches, geography can serve as a valuable tool in navigating the landscape of mental health and fostering well-being for all.

Keywords: Circadian Rhythms, Psychological, Recreational, Seasonal affective disorder (SAD).

Introduction:

The geographical context of an area has been increasingly recognized as a determinant of mental health outcomes. This research paper explores the multifaceted relationship between geography and mental health, examining how physical, environmental, and social factors in a given location can impact psychological well-being. Drawing on a diverse range of studies, the research delves into the various geographical factors affecting mental health. The physical environment, including natural landscapes, climate and proximity to water bodies plays a crucial role in mental health. Research by Frumkin (2001) and Kaplan (1995) highlights how exposure to nature positively influences mental well-being. Access to green spaces, parks, and natural settings has been associated with reduced stress, improved mood, and enhanced cognitive function. Conversely, urban environments with high population density, noise pollution, and limited green spaces can contribute to stress and mental health challenges. Evans (2003) has reflected on the effects of the physical environment on stress underscores the importance of considering geographic features in understanding mental health disparities.

Further, climate of a region has profound effects on mental health. A study by Rocklöv and Forsberg (2008) suggests that extreme weather events and climate-related stressors contribute to mental health challenges. Communities exposed to frequent natural disasters or those facing climate change-related impacts may experience higher rates of anxiety, depression, and post-traumatic stress disorders. Moreover, seasonal variations in climate, such as sunlight exposure, can contribute to Seasonal Affective Disorder (SAD). The social and economic geography of an area also influences mental health outcomes. Kawachi and Berkman (2007) in his research on social capital, highlights how community interconnection and social networks contribute to positive mental health. Communities with strong social ties and support systems exhibit better mental health outcomes compared to socially fragmented areas. Economic disparities across regions can also affect mental health. Understanding the economic landscape of an area is crucial for comprehending mental health challenges within different communities.

The characteristics of a community, including its cultural diversity, social norms, and built environment, shape mental health outcomes. Kessler et al. (2007) in his cross-cultural studies depicts how community factors influence the prevalence of mental health disorders. Cultural stigma, social acceptance, and community attitudes towards mental health can significantly impact the well-being of residents. Brashears (2013) also highlights the importance of the structure of social connections within a community and its influence on mental health. Examining community-level factors provides valuable insights into the geographic determinants of mental health. The inter-relation of geographical factors and mental health are discussed as follows:

Latitudinal Location and Mental Health

The relationship between latitudinal location and mental health has been a subject of growing interest in recent research. This exploration stems from the recognition that environmental factors, such as sunlight

exposure, temperature variations, and seasonal changes, can influence mental health outcomes. One prominent aspect of the latitudinal mental health gradient is the prevalence of Seasonal Affective Disorder (SAD). SAD is a subtype of major depressive disorder that typically occurs in the fall and winter months when sunlight exposure is reduced. Researchers like Rosenthal et al. (1984) and Wirz-Justice (2009) have conducted seminal studies highlighting the connection between reduced sunlight, disrupted circadian rhythms, and the onset of depressive symptoms in individuals living at higher latitudes.

The geographical distribution of SAD corresponds to regions with less sunlight during the winter months, emphasizing the role of light exposure in maintaining mental well-being. Light therapy, as studied by Lam and Terman (2007), has emerged as an effective intervention for mitigating SAD symptoms, further underscoring the importance of environmental factors in mental health.

Sunlight exposure at higher latitudes affects not only mood but also the production of vitamin D in the skin. Vitamin D has been linked to various aspects of mental health, including the regulation of neurotransmitters and neuroprotective effects. Research by Penninx et al. (2008) and Schoor et al. (2013) has explored the association between vitamin D deficiency, prevalent at higher latitudes, and an increased risk of depression and cognitive decline.

Apart from sunlight, temperature extremes associated with certain latitudes can also impact mental health. Rocklöv et al. (2014) in his work on the effects of extreme heat on mental well-being highlights the potential mental health challenges posed by climate-related factors, especially in tropical and subtropical regions. Similarly, extreme cold temperatures, prevalent at higher latitudes, have been linked to increased rates of mood disorders and decreased overall mental well-being.

Proximity to Water Bodies and Mental Health

The relationship between water bodies and mental health has become a subject of increasing interest within the realm of environmental psychology and public health. There are multifaceted connections between exposure to water bodies, such as oceans, lakes, rivers, and mental well-being. Various studies have found presence of water can positively impact mental health outcomes. Numerous studies, including those conducted by Frumkin (2001), highlight the therapeutic benefits of nature exposure, often termed as ecotherapy or nature-based therapy. Research by Kuo and Sullivan (2001) shows proximity to water bodies amplifies positive outcomes in mental health. The sound of water, visual aesthetics, and the calming effects of waterfront environments contribute to stress reduction and mood enhancement. Further. coastal environments have been associated with improved mental health. Research by White et al. (2013) demonstrates that living in areas with greater visibility of blue spaces, such as oceans and rivers, is linked to lower levels of psychological distress. Thus, water bodies contribute uniquely to the restorative qualities of natural environments.

The concept of "Blue Mind," popularized by marine biologist Dr. Wallace J. Nichols (2014), explores the cognitive, emotional, psychological, and social benefits of being near, in, on, or under water. Thus, water promotes a meditative state, reducing stress and increasing overall well-being. Studies by White et al. (2019), Depledge and Bird (2009) further support the idea that exposure to blue spaces is associated with positive mental health outcomes, including improved mood and cognitive performance. In addition, engaging in water-related activities, such as swimming, or walking along the shore, provides both physical exercise and mental relaxation. Research by Thornton and Tarrant (2006) highlights the positive impact of aquatic activities on mental health, for individuals with anxiety and depression.

The biophilia hypothesis, proposed by Edward O. Wilson, postulates that humans possess an innate affinity for nature. Water bodies evoke positive emotional responses, as they are integral components of natural environments. Research by Kaplan and Kaplan (1989) supports the idea that exposure to water enhances cognitive restoration

and stress recovery, aligning with the principles of the biophilia hypothesis. Furthermore, waterfront areas provide settings for social cohesion, reducing feelings of isolation and promoting mental well-being.

Green Spaces and Mental Health

The association between green spaces and mental health has gained significant attention in recent years. As urbanization continues to rise, understanding the impact of access to nature on mental well-being becomes crucial. Numerous studies, including research by Ulrich (1984), Kuo and Sullivan (2001), consistently demonstrate the stress-reducing effects of exposure to natural environments. The concept of "restorative environments" suggests that nature, particularly green spaces, can mitigate mental fatigue and alleviate stress. Natural settings, provides individuals with opportunities for psychological restoration. Studies by Berman et al. (2008) demonstrate that spending time in nature can improve attention, concentration, and working memory. This cognitive restoration effect is particularly relevant in urban environments, where mental fatigue and attentional fatigue are prevalent. Furthermore, the role of physical activity in green spaces contributes to mental health benefits. Research by Pretty and Barton (2008) highlights the positive impact of green spaces on mood and self-esteem through activities like walking, jogging, or gardening. In addition, green spaces often serve as communal hubs, fostering social interactions and a sense of community. The positive social interactions facilitated by green spaces contribute to overall mental health by providing social support networks.

Seasonal Changes and Mental Health

The impact of seasonal changes on mental health, often referred to as Seasonal Affective Disorder (SAD). SAD is a type of depression that occurs at specific times of the year, typically during fall and winter when daylight hours are shorter. Individuals with SAD often experience symptoms such as low energy, changes in sleep patterns, and a persistent low mood during specific seasons.

The prevalence of SAD varies with geographical location, with higher latitudes experiencing a more significant impact. The relationship between light exposure and circadian rhythms plays a crucial role in seasonal mental health. A study by Wirz-Justice (2009) highlights the importance of natural light in regulating the body's internal clock. Reduced exposure to natural light during the darker months can disrupt circadian rhythms, impacting sleep-wake cycles and contributing to mood disturbances. Further, the hormone melatonin, which plays a crucial role in regulating sleep-wake cycles, exhibits seasonal variations. Rosenthal (1984) in his research on melatonin and its relation to SAD highlights how changes in melatonin production may contribute to seasonal mood disturbances.

Seasonal changes also impact vitamin D levels, as sunlight is a primary source of vitamin D synthesis. Research by Penninx et al. (2008) and Schoor et al. (2013) suggests an association between vitamin D deficiency and an increased risk of depression in certain populations. The role of vitamin D in mental health has broader implications of seasonal variations in sunlight exposure.

Urban-Rural Disparities in Mental Health

The association between urban and rural environments and mental health has emerged as a significant area of research. Urbanization is a global trend, however, studies by Hardyns and Pauwels 2014) suggest that urban living is associated with stressors, including noise, pollution, social isolation, and high population density. These stressors contribute to the higher prevalence of mental health issues such as anxiety and mood disorders in urban populations. rural areas may provide more opportunities for outdoor activities and a closer connection to nature. Kuo (2015) in his work on the benefits of nature exposure suggests that living in rural environments may offer protective factors for mental health through increased access to natural environments.

Conclusion:

In conclusion, the relationship between seasonal changes and mental health is a multifaceted interplay of biological, psychological, and environmental factors. From the identification of SAD to exploring the role of light exposure, melatonin, and vitamin D, researchers have made significant strides in unraveling the mechanisms underlying seasonal mood variations. Acknowledging the impact of seasonal changes on mental health is crucial for developing treatment strategies, and public health initiatives aimed at supporting individuals affected by seasonal mood disturbances. Further, the relationship between water bodies and mental health is a nuanced interplay of psychological, physiological, and social factors. Identifying the therapeutic potential of water bodies is crucial for urban planning, healthcare, and public health initiatives aimed at promoting mental health in diverse populations. By recognizing the influence of geographic features on mental well-being is crucial for developing targeted interventions and policies that address the diverse challenges faced by different communities. Future research should continue to explore the nuanced interactions between geography and mental health,

fostering a comprehensive understanding of the geographical landscape of well-being.

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Unveiling the Power of Latent Heat: Applications and Challenges in Thermal Energy Storage

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Abstract:
Latent heat is a fundamental concept in thermodynamics. It plays a vital role in various thermal energy storage systems. This paper explores the significance of latent heat, its applications, challenges and future directions in energy storage technologies across the globe. The amount of latent heat in phase change materials (PCM) is much higher than sensible heat. Therefore, this significant latent heat supply can partially fulfil the energy demand for certain applications. Through an analysis of latent heat storage mechanisms, phase change materials and integration strategies, this paper aims to provide insights into harnessing latent heat for enhanced energy efficiency, sustainability and applications in thermal energy storage.

Keywords: *Latent Heat, Thermal Energy Storage, Phase Change Materials, Energy Efficiency, Sustainability*

Introduction

Latent heat, a fundamental aspect of thermodynamics, refers to the heat absorbed or released during a phase transition at constant temperature. This unique property enables the efficient storage and release of thermal energy, making latent heat an indispensable element in various energy storage systems. This paper delves into the mechanisms, applications, challenges, and future prospects of latent heat in thermal energy storage, highlighting its importance in advancing sustainable energy solutions.

Latent heat storage relies on the phase changes of the medium, such as from solid to liquid, utilizing latent heat to store energy [1]. This method offers high storage density and an isothermal condition for a low to medium temperature range compared to sensible heat storage[2]. Latent heat storage has two main advantages. The first one allows for storing large amounts of heat with only small temperature changes, leading to high storage density and the second one smooths temperature variations due to the time taken for the phase change process to complete. Comparing latent and sensible heat storage, latent heat storage can achieve storage densities typically 5 to 10 times higher, with PCM storage volume being two times smaller than that of water. This method can be used in a wide temperature range, and the PCM chosen should meet specific thermophysical, kinetics, and chemical properties for effective thermal storage systems [3].

Types of Latent Heat

There are three phases of the substance: Solid, Liquid and Gaseous. Accordingly, there are three types of latent heats, which have been described below:

. *Latent heat of fusion*: Amount of heat required to melt the substance of unit mass from solid to liquid or the amount of heat required to be removed from the unit mass of substance to freeze it from liquid to solid is called as latent heat of fusion.

Latent heat of vaporization: The amount of heat required by the unit mass of substance to vaporize from liquid to gaseous state or the amount of heat required to be removed from the unit mass of substance to condense from the gaseous to liquid phase is called as latent of vaporization.

Latent heat of sublimation: The amount of heat required by the unit mass of substance to convert directly from solid to gaseous phase or the amount of heat required to be removed from the gaseous substance to change it to the solid phase is called as latent heat of sublimation.

Mechanisms of Latent Heat Storage

Latent heat storage relies on phase change processes, where energy is stored or released as a substance undergoes a transition between solid, liquid, or gaseous phases. During melting or solidification, substances absorb or release latent heat, maintaining a constant temperature until the phase change is complete. This mechanism allows for the efficient storage of large amounts of energy in relatively small

volumes, offering advantages over sensible heat storage methods. The use of phase change materials (PCMs) has enormous potential to store thermal energy.

Latent heat storage uses the phase transition of a material. Usually solid–liquid phase change is used, by melting and solidification of a material. Upon melting heat is transferred to the material, storing large amounts of heat at constant temperature; the heat is released when the material solidifies. Materials used for latent heat storage are called PCMs.

The amount of heat stored is calculated following the Equation:

$Q=m\cdot\Delta h$

Where,

Q is the amount of heat stored in the material (J), m is the mas of storage material (kg), and Δh is the phase change enthalpy (J/kg).[4]

Heat Storage Systems

The versatility of latent heat storage finds applications across various sectors including buildings, solar energy systems, refrigeration, and thermal management of electronics. In buildings, phase change materials integrated into walls, ceilings, or floors regulate indoor temperatures by absorbing excess heat during the day and releasing it at night, reducing reliance on mechanical heating and cooling systems. Similarly, in solar energy systems, latent heat storage enables the storage of solar thermal energy for later use, ensuring uninterrupted power supply even during periods of low solar irradiance.

Solid materials, like concrete and castable ceramics have low price and good thermal conductivities. Concerning liquid materials, a variety of fluids have been tested to transport the heat, including water, air, oil, and sodium, before molten salts were selected as best [5].

In India, various materials are used for storing heat in different applications, including thermal energy storage, cooking, and space heating. Here's a list of some commonly used materials for heat storage in India:

Water*:* Water is one of the most readily available and commonly used materials for storing heat. It has a high specific heat capacity, making it efficient for storing thermal energy in applications such as solar water heaters and domestic hot water systems.[6]

Bricks: Bricks have a relatively high thermal mass and can store heat effectively. They are often used in traditional building construction in India, contributing to thermal comfort by absorbing and releasing heat slowly.

Concrete: Concrete is another material with high thermal mass, making it suitable for heat storage applications. It is used in buildings, particularly in floors and walls, to regulate indoor temperatures and improve energy efficiency.[7]

Phase Change Materials (PCMs): PCM-based systems are gaining popularity in India for thermal energy storage applications. PCMs absorb and release latent heat during phase transitions, offering efficient and compact storage solutions. Common PCM materials include paraffin wax, fatty acids, and salt hydrates.[8]

Salt Hydrates: Salt hydrates, such as sodium sulphate decahydrate (Glauber's salt) and sodium acetate trihydrate, are used as PCMs for storing heat due to their high latent heat of fusion and relatively low cost. They find applications in solar thermal energy storage and space heating systems.

. **Paraffin Wax:** Paraffin wax is widely used as a PCM in thermal energy storage applications due to its high latent heat of fusion and thermal stability. It is encapsulated or incorporated into building materials for passive solar heating and cooling systems.[9]

Bio-based Materials: Agricultural residues and waste biomass are being explored as renewable and sustainable materials for thermal energy storage in India. These materials can be processed into other forms suitable for heat storage applications.

Molten Salts: Molten salts, such as nitrate and carbonate salts, are used in concentrated solar power (CSP) plants for high-temperature thermal energy storage. They have excellent thermal stability and heat transfer properties, enabling efficient energy storage and electricity generation.

Thermal Storage Fluids: Various fluids, including oils and glycols, are used as heat transfer and storage fluids in thermal energy storage systems. These fluids circulate through collectors or storage tanks, absorbing and delivering heat as required.

Phase Change Emulsions: Emulsions containing PCM droplets dispersed in a carrier fluid are being researched for thermal energy storage applications. These emulsions offer advantages such as enhanced heat transfer and compatibility with existing systems.

These materials are utilized across a range of applications in India, contributing to energy efficiency, sustainability, and thermal comfort in buildings, industries, and renewable energy systems.

Challenges

Despite its advantages, latent heat storage faces challenges such as limited thermal conductivity of phase change materials, phase transition temperature matching with application requirements, material degradation over cyclic operation, and cost-effectiveness. In India, there are different tropical and equatorial climate regions.

Because of the large temperature difference in the summer and winter season, one PCM is insufficient to provide latent heat storage in the various applications for both the summer and winter seasons. In the winter season the maximum temperature remains below the transition temperature range of the PCM resulting in no utilization of the latent heat of the PCM. Addressing these challenges necessitates advancements in material science, encapsulation techniques, and system design to optimize energy storage and release efficiency while ensuring long-term reliability and affordability.

Research Trends And Future Directions

Current research trends in latent heat storage focus on developing high-performance phase change materials with tailored properties, exploring advanced encapsulation methods to enhance material stability and durability, and integrating latent heat storage systems with renewable energy technologies for grid stabilization and demand management. Future directions include the development of smart materials capable of self-regulating phase change processes, and the integration of latent heat storage into emerging applications such as wearable technology and energy-efficient transportation.

Solar energy storage in the form of latent heat could reserve as a sustainable energy solution during the electricity shortage, fossil fuels depletion, and pollution crises. Solar energy storage aims to aid energy management by storing the heat in the form of latent heat during periods that the sun is abundant and releasing them when required. Energy storage in PCM is an eco-friendly approach with zero emissions.

Conclusion:

Latent heat storage represents a promising solution for efficient thermal energy storage, with applications spanning across diverse sectors. Despite existing challenges, ongoing research and technological advancements continue to improve the performance and scalability of latent heat storage systems, driving progress towards a sustainable energy future. Harnessing the full potential of latent heat requires interdisciplinary collaboration, innovative approaches, and sustained investment in research and Development.

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Future Era and Innovative Bio-inspired Solutions for Sustainable Biomass Conversion in Renewable Energy Systems

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Abstract:

As the world's energy needs and climate change mitigation become more pressing, the search for sustainable energy sources becomes more and more necessary. Given its availability, carbon neutrality, and capacity to be converted into a variety of energy forms, biomass has great potential as a renewable energy source. However, efficient and sustainable biomass conversion remains a critical challenge. This study examines bio-inspired strategies for the sustainable conversion of biomass in renewable energy systems, taking cues from the complex mechanisms and processes that occur in nature. In order to develop creative strategies for improving biomass conversion efficiency and sustainability, we delve into the fundamental ideas of biological systems, including enzyme processes, metabolic pathways, and structural frameworks. Developing microorganism-inspired bio-mimetic catalysts and enzymes with the goal of maximizing reaction conditions and reducing energy input is the main emphasis of the research. Additionally, it looks at how synthetic biology methods might be used to create microbial communities that can transform biomass feed stocks into high-value goods like bio-fuels and bio-chemicals. The study also looks at the creation of new materials and nano-scale structures for the conversion of biomass, drawing inspiration from artificial photosynthesis systems and photosynthetic animals. Bio-inspired solutions expedite the transformation to a bio-based economy by bringing about a paradigm change in sustainable biomass conversion

Introduction:

Renewable energy has become a vital pathway for sustainable development due to growing environmental concerns and the need to lessen dependency on fossil fuels. Because it is abundant, renewable, and has the capacity to be converted into many types of energy, biomass is one of these that have great promise. Still, converting biomass sustainably and efficiently is a significant task that calls for creative solutions modeled after the complex systems and processes found in nature. Biomass can be regarded as any organic material that originated from plants or animals. Thus, the United Nations Framework Convention on Climate Change UNFCCC in 2005(1), defined it as follows;

"A non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms. This shall also include products, by-products, residues and waste from agriculture, forestry and related industries as well as the non-fossilized and biodegradable organic fractions of industrial and municipal wastes".

renewable resources is essential. Among the numerous renewable resources, biomass is considered a better option for non-renewable fossil resources. It is abundant, cost-effective, and environmentally friendly [2]. The world's fourth largest source of energy is biomass, and it is competent to manage rural development and energy security [3]. Presently, biomass supplies approximately 8–15% of society's energy supplies as electricity, heat, and fuels for transportation, and about 40–50% in many developing countries. It is anticipated that nearly 33–50% of primary energy consumption in the world could be met in 2050 via biomass [3, 4, 5].

The study explores the future of biomass conversion in renewable energy systems, focusing on bio-inspired solutions that enhance efficiency, sustainability, and adaptability. Innovations like pyrolysis, gasification, and anaerobic digestion have improved biomass conversion efficiency. Biomass is crucial for sustainability, as it is a renewable, carbon-neutral energy source, encourages recycling, improves energy security, supports biofuel production, sequesters carbon, and promotes resource efficiency. Balancing environmental, social, and economic factors is essential for maximizing biomass's benefits.

Litrature Review

TABLE I.

S.N.	Details of the reviewed papers		
	Title of the Paper/Author	***Findings***	***Limitations***
1.	Biomass Conversion Technologies for Bioenergy Generation: An Introduction by Abdurrahman Garba	**1.** Biomass is a versatile and abundant renewable energy resource that can be converted into various forms of bioenergy, such as biofuels, biogas, and bioelectricity. **2.** Conversion technologies discussed include thermochemical processes like combustion, gasification, and pyrolysis, as well as biochemical processes such as anaerobic digestion and fermentation.	1. While environmental impacts are discussed, but might not comprehensively address all challenges associated with biomass conversion, such as feedstock variability, technological barriers, or policy constraints. May provide only a broad overview of biomass conversion technologies.
2.	Biomass conversion processes. Energy Conversion and Management. 1997, by Küçük M, Demirbaş A	1. The environmental implications of biomass conversion, including emissions of greenhouse gases and pollutants, as well as the potential for resource depletion and land use changes.	1. The paper may provide a narrow focus on biomass conversion processes prevalent at the time of publication, potentially overlooking newer or emerging technologies.
3.	Biomass-resource for sustainable development. International Journal of Advanced Research in Technology Pathak B, Chaudhari S, Fulekar M., 2013	1. The environmental advantages of utilizing biomass, such as reduced greenhouse gas emissions, mitigation of climate change, and promotion of carbon neutrality. 2. The paper highlights the availability and diversity of biomass resources, emphasizing their significance as renewable energy sources for sustainable development.	1. Study likely discusses the potential of biomass as a renewable energy source for sustainable development but the study is based on old data or research, it may not reflect recent advancements or changes in the field of biomass energy
4.	Barthlott, W., Rafiqpoor, M. D., & Erdelen, W. R. (2016). Bionics and biodiversity–bio-inspired technical innovation for a sustainable future.	• In order to create a more sustainable future, this work demonstrates how biomimetic research can spur technological advancements in architecture and building construction. To create more effective, flexible, and ecologically friendly designs, they stress how important it is to take inspiration from biodiversity.	• "Bionics and biodiversity–bio-inspired technical innovation for a sustainable future" may oversimplify or idealize the biological systems under study.

Biomass Can Be Converted To Energy In Different Ways

A. Direct combustion (burning)= produce heat, electricity

B. Thermochemical conversion = produce solid, gaseous, and liquid fuels

C. Chemical conversion = liquid fuels

D. Biological conversion = produce liquid and gaseous fuels

Direct combustion is the most common method for converting biomass to useful energy. All biomass can be burned directly for heating buildings and water, for providing industrial process heat, and for generating electricity in steam turbines.

Thermochemical conversion of biomass includes pyrolysis and gasification. Both processes are thermal decomposition processes wherein biomass feedstock materials are heated in closed, pressurized vessels called gassifiers at high temperatures. The processes mainly differ in the temperatures and in the amount of oxygen present during conversion.

a. Pyrolysis entails heating organic materials to between 800° F and 900° F (400° C and 500° C) in the nearly complete absence of free

oxygen. Biomass pyrolysis produces fuels such as charcoal, bio-oil, renewable diesel, methane, and hydrogen.

b. Hydrotreating is used to process bio-oil (produced by *fast pyrolysis*) with hydrogen under elevated temperatures and pressures in the presence of a catalyst to produce renewable diesel, renewable gasoline, and renewable jet fuel.

c. Gasification entails heating organic materials to between 1,400° F and 1,700 F (800° C and 900° C) with injections of controlled amounts of free oxygen or steam into the vessel to produce a carbon monoxide- and hydrogen-rich gas called synthesis gas or *syngas*. Syngas can be used as a fuel for diesel engines, for heating, and for generating electricity in gas turbines. It can also be treated to separate the hydrogen from the gas, and the hydrogen can be burned or used in fuel cells. The syngas can be further processed to produce liquid fuels using the Fischer–Tropsch process.

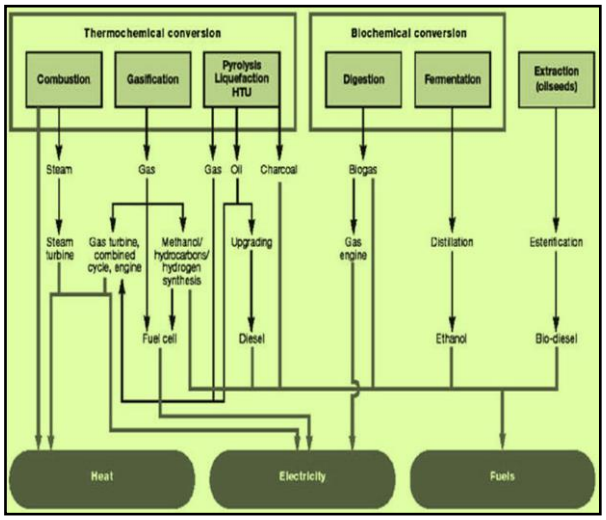


Fig.1 Main biomass conversion

Source- Peixoto Basso, T., Olitta Basso, T., & Carlos Basso, L. (Eds.). (2021). Biotechnological Applications of Biomass. IntechOpen. doi: 10.5772/intechopen.89320io-inspired Desgin

A chemical conversion process known as transesterification is used for converting vegetable oils, animal fats, and greases into fatty acid methyl esters (FAME) to produce biodiesel.

Biomass is converted into ethanol through fermentation and anaerobic digestion, which is used as a vehicle fuel. Biogas, also known as biomethane, is produced in anaerobic digesters at sewage treatment plants, dairy and livestock operations, and solid waste landfills. Properly treated renewable natural gas has the same uses as fossil fuel natural gas.

Bio-inspired solutions

Numerous solutions to difficult issues can be found in nature, and bio-mimicry has become a viable strategy for innovation across a range of fields. Bio-inspired solutions can be used to build more sustainable and effective biomass conversion systems by taking cues from biological structures and processes. Examples include reproducing photosynthetic processes for energy absorption, simulating enzyme systems for biomass degradation, and copying biological metabolic pathways for the synthesis of bio-fuels. Innovative Bio-Inspired Solutions are-

Biomimetic Catalysts and Enzymes

Bio-mimetic catalysts and enzymes, which are modeled after natural biological systems, are one way to improve the efficiency of biomass conversion. Many enzymes found in nature possess exceptional catalytic activity and selectivity, making them valuable resources for the conversion of biomass. Researchers can create synthetic analogs with higher stability and performance by examining the structure and activity of these enzymes. Enzymes that originate from microorganisms that thrive in severe environments and extremophiles, for example, have special qualities that make them ideal for biomass conversion in difficult situations. High efficiency and specificity biomass degradation and conversion reactions can be catalyzed by bio-mimetic catalysts, which are designed to resemble the structural characteristics and catalytic mechanisms of these enzymes.

Bio-Inspired Reactor Designs

1. Apart from biomimetic catalysts, bio-inspired reactor designs present inventive approaches to enhance biomass conversion procedures. Biochemical systems frequently display self-regulation and compartmentalization, allowing for effective and regulated reactions to take place in small areas.
2. These concepts are serving as a source of inspiration for scientists as they create reactor designs that resemble the structural makeup and operation of biological systems.
3. One way to achieve better conversion efficiency and product yields is by precisely controlling reaction conditions and substrate concentrations through the use of compartmentalized reactors equipped with microfluidic channels and immobilized enzymes.
4. Real-time process parameter monitoring and modification is made possible by self-regulating reactor systems with feedback mechanisms, guaranteeing peak performance and efficient use of resources.

Microbial consortium

Microbial consortium is usually referred as group of diverse microorganisms that have the

ability to act together in a community. Microbial communities are ubiquitous in their natural environment and key players in global carbon and nitrogen cycles (Stolyar et al., 2007).

Increasing Biomass Conversion Efficiency through Microbial Consortia Design-

1. Utilizes synthetic biology techniques to design microbial consortia.
2. Microorganisms cycle nutrients and break down organic matter, crucial to ecosystems.
3. Engineered consortia can transform diverse biomass feedstocks into valuable products.
4. Genetic engineering and synthetic biology techniques can engineer metabolic pathways and enzymatic reactions.
5. This allows synthesis of Biofuels, Biochemicals, electricity and other high-value molecules from renewable biomass resources.

Innovative Substances and Nanostructures

Biomimicry principles guide the design of materials and nanostructures for biomass conversion applications. By simulating natural photosynthetic systems, researchers can create artificial photosynthesis systems and materials for light gathering. Nanoscale structures, modeled after photosynthetic pigment organization, enable efficient light absorption and energy transmission, promoting photochemical reactions leading to biomass destruction and conversion. Bio-inspired materials offer new possibilities for enzyme separation, immobilization, and catalysis

Fig.2 Production of Bioelectricity from Microbes

Source: Microbial fuel cell: Venkatesh et al, 2016

Ecologically Integrated Biomass Conversion Systems:

To reduce environmental impact and improve sustainability, develop biomass conversion systems based on ecological principles. This method entails planning systems that coexist peacefully with natural processes and taking into account the wider ecological effects of using biomass.

Current Challenges in Biomass Conversion

Before delving into bio-inspired solutions, it is crucial to understand the existing challenges in biomass conversion. These include issues related to feedstock variability, inefficient conversion processes, and environmental impacts such as greenhouse gas emissions and waste generation. Addressing these challenges is essential for the widespread adoption of biomass-based renewable energy.

Fig.2 Production of Bioelectricity from Microbes

Source: Microbial fuel cell: Venkatesh et al, 2016

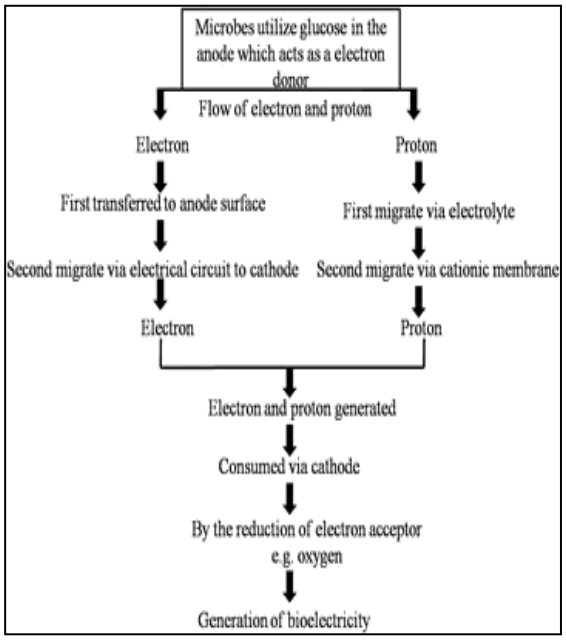


Fig.2 Production of Bioelectricity from Microbes

Source: Microbial fuel cell: Venkatesh et al, 2016

Recognizing the chemistry of practical biomass feedstocks

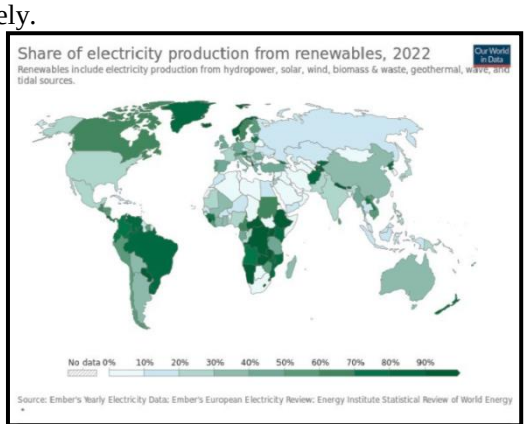
Obtaining process-relevant catalytic information

Improving catalytic stability

Understanding the role of solvents (Fundamental catalytic challenges to design improved biomass conversion technologies, Walker et al, 2019)

Utilizaton Of Renewable Energy Sources

For sustainable development to occur and to lessen our reliance on fossil fuels, it is imperative that renewable resources be used efficiently. According to the IEA (International Energy Agency) in 2017, 13.9% of the world's total primary energy supply was provided by renewable energy sources and high consumption was 41.7% by residential/commercial & public services sector. Along with the increasing population, the consumption of renewable energy increased by the sector is 42.40% in 2020. To mitigate climate change and to promote sustainability renewable resources are meet our energy requirements effectively.



Conclusion

The future of sustainable biomass conversion in renewable energy systems holds immense promise, driven by advancements in bio-inspired solutions and emerging technologies. As we transition into the future era, it is evident that a multifaceted approach integrating biology, engineering, and innovation will be crucial in addressing the global energy challenge. To fully harness bio-inspired sustainable biomass conversion, researchers, policymakers, and industry stakeholders must collaborate, invest in research, and establish supportive regulatory frameworks, accelerating the deployment of innovative technologies towards renewable energy. The future of biomass conversion in renewable energy systems depends on nature-inspired innovation, fostering collaboration and embracing bio-inspired solutions. This can unlock new opportunities for sustainable energy production, mitigate climate change, and build a resilient future.

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A Review on Solar Dryers for Agricultural Products

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Abstract:-

Solar drying is a sustainable and environmentally friendly method for preserving agricultural products. This paper provides a comprehensive review of solar dryers used in the agricultural sector. It examines various types of solar dryers, including direct, indirect, and mixed-mode designs, highlighting their principles of operation, advantages, and limitations. Furthermore, the paper discusses the influence of design parameters such as airflow, temperature control mechanisms, and drying chamber configurations on the performance of solar dryers.

Additionally, the review explores recent advancements in solar drying technologies, including hybrid systems and integration with energy storage solutions, to enhance efficiency and reliability.

Moreover, the paper discusses challenges associated with solar drying, such as intermittent solar availability, weather dependency, and the need for proper maintenance and monitoring. Strategies to overcome these challenges, including optimization techniques, material selection, and incorporation of intelligent control systems, are examined.

Keywords: - Solar drying, agricultural products, solar dryers, design parameters, advancements, challenges.

Introduction:-

Despite being one of the oldest methods of utilizing solar energy for preserving agricultural and horticultural products, its significant potential in food processing industries has yet to be fully explored from a scientific standpoint.In recent years, the world has faced numerous challenges related to food security, intensified by factors such as population growth, climate change, and socio-economic imbalance. These challenges have led to periodic food crises, characterized by shortages, price volatility, and inadequate access to nutritious food. The occurrence of food crises highlights the vulnerability of global food systems and underscores the importance of adopting strategies to ensure food security and reduce the risk of hunger and malnutrition.

One critical aspect of addressing food security concerns is the preservation of agricultural products. Food preservation plays a vital role in extending the shelf life of perishable foods, reducing food waste, and ensuring a stable food supply throughout the year. Among various preservation methods, food drying has been practiced for centuries as a simple yet effective technique for preserving a wide range of agricultural products, including fruits, vegetables, grains, and meat.Conventional food drying systems typically rely on air dryers powered by fossil fuels such as coal, natural gas, or diesel. While these systems are capable of efficiently removing moisture from food products, they come with significant environmental drawbacks. The combustion of fossil fuels releases greenhouse gases and pollutants into the atmosphere, contributing to climate change and air pollution. Moreover, the reliance on non-renewable energy sources poses economic challenges, particularly in regions where fuel costs are high or supplies are unreliable. In contrast, solar drying offers a sustainable and environmentally friendly alternative for preserving agricultural products. By harnessing solar energy, solar dryers can effectively remove moisture from food products without emitting harmful pollutants or depleting finite energy resources. Solar drying systems utilize solar collectors to capture sunlight and convert it into heat, which is then used to facilitate the drying process. This reliance on clean, renewable energy sources not only reduces operational costs but also minimizes the carbon footprint associated with food preservation. The significance of solar drying extends beyond environmental considerations. By enabling farmers to preserve their harvests efficiently and cost-effectively, solar drying contributes to food security, income generation, and economic flexibility in rural communities. Moreover, solar drying systems can be adapted to local conditions and scaled to meet the needs of smallholder farmers, empowering them to add value to their produce and access higher-value markets.

Types of Solar Dryers:-

Solar drying systems come in various designs, each with its own operational principles, advantages, and limitations. Understanding these different types of solar dryers is essential for selecting the most appropriate system based on specific requirements and environmental conditions. The following are the main types of solar dryers:

Direct Solar Dryers:

Direct solar dryers, also known as natural convection dryers, rely on the direct exposure of agricultural products to sunlight for drying. These dryers typically consist of a transparent cover (such as glass or plastic) to trap solar radiation and create a greenhouse effect inside the drying chamber. The harvested crops or food items are spread out on trays or racks within the chamber, allowing them to be heated directly by the sun's rays. As the temperature inside the chamber rises, moisture evaporates from the agricultural products, promoting drying

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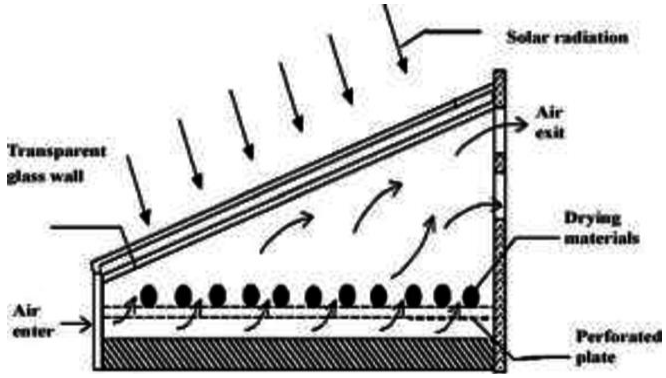

Fig 1 Direct Solar Dryer.

Advantages:

1. Simple design and construction.
2. Low cost, especially for small-scale applications.
3. Relatively high efficiency in sunny conditions.

Limitations:

1. Vulnerable to fluctuations in weather conditions, such as cloud cover or rainfall.
2. Limited control over temperature and airflow, leading to potential overheating or uneven drying.

Indirect Solar Dryers:

Indirect solar dryers utilize solar energy to heat air or another medium, which is then circulated through the drying chamber to remove moisture from agricultural products. Unlike direct solar dryers, indirect dryers separate the drying process from direct exposure to sunlight, providing greater control over temperature and airflow.

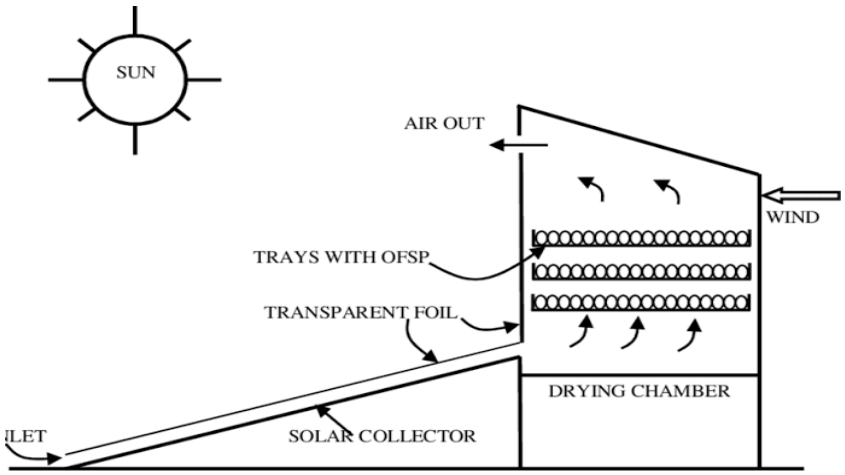

Fig 1 Indirect Solar Dryer.

Advantages:

1. Improved control over drying conditions, resulting in more uniform drying and higher product quality.
2. Reduced risk of contamination from dust, insects, or other external factors.
3. Suitable for drying sensitive or high-value products that require precise temperature control.

Limitations:

1. Higher initial investment costs compared to direct solar dryers.

2. Dependency on auxiliary heating sources (e.g., solar collectors or heat exchangers) for maintaining consistent temperatures.
3. Complexity of design and operation, requiring careful maintenance and monitoring.

Mixed-Mode Solar Dryers:

Mixed-mode solar dryers combine features of both direct and indirect drying systems to optimize drying efficiency and flexibility. These dryers may incorporate elements of direct solar heating, supplemented by auxiliary heating or airflow control mechanisms to enhance performance under varying weather conditions.

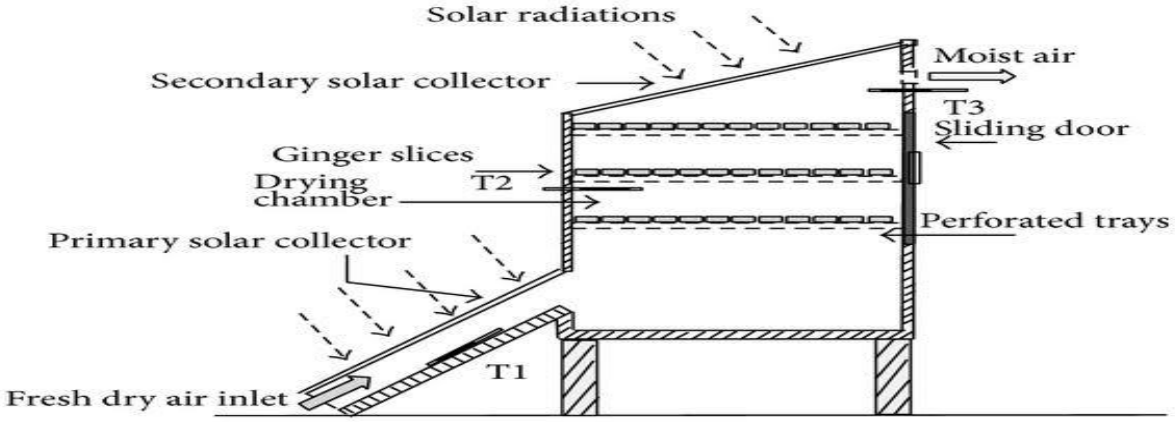

Fig. 3 Mixed-Mode Solar Dryer.

Advantages:

1. Versatility in adapting to different drying requirements and environmental conditions.
2. Enhanced energy efficiency through the integration of multiple drying modes.
3. Potential for higher throughput and faster drying rates compared to conventional solar dryers.

Limitations:

1. Increased complexity of design and operation, requiring skilled maintenance and troubleshooting.
2. Higher initial costs associated with additional components and control systems.
3. Optimization may be challenging, requiring careful calibration and adjustment to achieve desired drying outcomes.

In summary, understanding the characteristics and capabilities of different types of solar dryers is essential for selecting the most suitable system for specific agricultural drying applications. While each type has its own advantages and limitations, solar drying offers a sustainable and environmentally friendly alternative to conventional drying methods, contributing to food security, economic development, and environmental sustainability.

Literature Review:

Pangavhane et al[1] This research paper presents a comprehensive exploration of a natural convection solar dryer designed for preserving agricultural produce, focusing specifically on grape dehydration. The dryer comprises several components, including a flat plate solar air heater, a drying chamber with chimney, and instrumentation for temperature and airflow monitoring. The study evaluates the thermal performance of the solar air heater and the drying chamber under both no-load and grape load conditions. Additionally, it highlights the efficiency of the dryer in reducing drying time compared to traditional methods such as open sun drying. The results indicate that the developed solar dryer maintains an optimal temperature range for dehydration and enhances drying rates through the generation of hot air flow. The collector efficiencies achieved by the system are found to be sufficient for heating the drying air effectively. Overall, the research underscores the potential of solar drying technology in improving agricultural preservation practices and reducing drying time, thus contributing to enhanced efficiency and sustainability in food processing.

P. Gbaha et al[2] The research paper explores the design and experimental analysis of a direct type natural convection solar dryer constructed from locally sourced materials. It focuses on assessing the dryer's thermal performance through empirical correlations and kinetics analysis during the drying of various foodstuffs such as cassava, bananas, and mangoes. The study emphasizes the influence of key parameters, including solar radiation, drying air mass flow, and temperature, on the dryer's effectiveness in reducing moisture content. Furthermore, it highlights the significance of solar drying technology in addressing food shortage challenges, particularly in regions prone to post-harvest losses. The literature review contextualizes the study within the broader field of solar drying, referencing previous works that have explored different types of solar dryers and their technical performance. Notably, the paper underscores the

urgent need for accessible and cost-effective drying solutions to mitigate food losses and enhance food supplies, particularly in famine-stricken regions. Additionally, the research contributes to the understanding of drying kinetics and thermal processes, providing empirical correlations for modeling and simulating the drying of tropical farm products.

Ho-Hsien Chen et al [3] this paper represents a significant advancement in the field of agri-food dehydration through the development of an experimental closed-type dryer integrated with a photovoltaic system (PV). In traditional open-sun drying, the drying process is influenced by various external and internal factors, leading to challenges in controlling product quality. Recognizing these limitations, researchers have explored alternative drying systems utilizing solar energy. The experimental closed-type solar dryer described in this study addresses these challenges by incorporating PV technology and a transparent drying cabinet designed to optimize solar heating while minimizing energy loss. This innovative approach allows for greater control over drying parameters, resulting in improved product quality compared to traditional methods. Additionally, the gradual temperature modulation strategy and dehumidification system further enhance the system's efficiency, demonstrating its potential as a sustainable solution for high-quality agri-food dehydration while reducing environmental impact.

B.M.A. Amer et al [4] This paper represents a pioneering effort in the development of a hybrid solar dryer, which combines direct solar energy utilization with a sophisticated heat exchanger system. Through this innovative approach, the dryer effectively operates as both a solar dryer on sunny days and a hybrid system during periods of reduced solar radiation or at night, leveraging stored heat energy. The incorporation of a heat exchanger cum heat storage unit significantly enhances the dryer's efficiency, allowing for continuous operation and improved drying performance. With the ability to recycle up to 65% of the drying air, this hybrid solar dryer demonstrates a notable advancement in agri-food dehydration technology. Tested with ripe banana slices, the dryer exhibits impressive capacity and efficiency, showcasing its potential for sustainable food processing. Through comparative studies, the paper highlights the superior product quality achieved with this hybrid drying method, underscoring its importance as a sustainable solution for high-quality agri-food dehydration.

Bukola O. Bolaji et al [5]This paper presents a comprehensive study on the design, construction, and performance evaluation of a mixed-mode solar dryer tailored for food preservation. The utilization of solar energy in agricultural applications, particularly in developing countries, has gained significant attention due to its renewable nature and potential for enhancing productivity. Solar air heaters, such as the one described in this study, offer a viable solution for crop drying and space heating, contributing to post-harvest loss reduction and food availability. Traditional drying methods, often conducted in open air, are plagued by various challenges, including exposure to weather elements, infestation, and inconsistent drying rates. In contrast, solar dryers provide a controlled environment for drying, enhancing product quality and reducing losses. This study focuses on a mixed-mode solar dryer, which combines direct solar radiation absorption with heated air from a separate solar collector, optimizing the drying process efficiency. By evaluating parameters such as temperature rise, drying rate, and system efficiency, the study demonstrates the effectiveness of the mixed-mode solar dryer in rapidly drying food items to safe moisture levels. The findings underscore the potential of solar dryers in addressing post-harvest challenges and improving food security in resource-constrained settings.

O.V. Ekechukwu et al [6] The reviewed paper offers an insightful overview of solar drying technology, covering a spectrum of designs, construction details, and operational principles of solar-energy drying systems. Through a systematic classification, two main groups of solar dryers are identified: passive or natural-circulation solar-energy dryers, and active or forced-convection solar-energy dryers, which are often termed as hybrid solar dryers. Within these groups, three sub-categories are delineated based on structural arrangement: integral-type, distributed-type, and mixed-mode solar dryers. The discussion delves into the suitability of each design type for application in rural farming contexts of developing countries, considering factors such as climate, crop losses, and economic viability. The paper underscores the growing attractiveness of solar-energy crop dryers as commercial propositions, particularly in mitigating crop losses arising from inadequate drying, fungal attacks, and weather-related challenges. By elucidating the underlying principles of drying, including heat and mass transfer processes, the review elucidates the fundamental objectives of solar drying: to reduce moisture content to ensure safe storage, thereby addressing the critical need for effective drying methods in diverse agricultural settings. Moreover, it highlights the diverse approaches to heat transfer in solar drying, emphasizing the role of solar radiation in supplying the energy necessary for vaporization of water from the product. The classification provided offers a structured framework for understanding the myriad designs and operational modes of solar-energy drying systems, facilitating informed

decisions in selecting appropriate drying technologies for specific agricultural contexts.

Vinay Narayan Hegde et al [7] The research paper presents the design and experimental evaluation of an indirect, active-type solar dryer tailored for drying bananas, a high-production crop in India with significant losses. Recognizing the pressing need to reduce postharvest losses and enhance food availability, especially in regions like India with inadequate storage and processing infrastructure, the study emphasizes the relevance of solar drying as an environmentally friendly and cost-effective preservation method. By leveraging locally available, biodegradable materials and incorporating innovative features such as different airflow configurations and mounting schemes, the dryer aims to optimize drying efficiency while maintaining product quality. Experimental results reveal that the bottom flow configuration outperforms the top flow, exhibiting higher chamber temperatures and greater energy efficiency. Moreover, the use of wooden skewers enhances the drying rate and facilitates loading and unloading of bananas, resulting in improved product quality. Through meticulous thermal analysis and experimentation, the study provides valuable insights into the design considerations and operational parameters essential for the effective utilization of solar energy in agricultural drying applications.

A. O. Adelaja et al [8]The research paper focuses on addressing the challenges faced by tropical and sub-Saharan African countries in preserving agricultural produce due to inadequate electrical energy supply and the need to compete in the international market. To tackle these issues, a cost-effective natural convection solar dryer was developed and evaluated, specifically targeting the drying of plantain fillets. The system, designed in an *L*-shaped configuration, operates on the principle of natural convection, with a collector made of mild steel painted black for maximum heat absorption. Unlike some indirect-mode solar dryers that utilize glass covers, this dryer receives radiant heat energy indirectly, preventing exposure of the produce to harmful ultraviolet rays. Through thorough thermal and drying analyses, the system's efficiency was determined, with collector and system efficiencies of 46.4% and 78.73%, respectively. Additionally, a significant percentage moisture removal of 77.5% was achieved within 20 hours, maintaining the integrity of the dried plantain fillets. The cost analysis revealed that the system, with a total cost of approximately $195.00, is affordable for small- and medium-scale enterprises, as well as for domestic use in rural communities. These findings underscore the potential of solar drying technologies to address postharvest losses and enhance food security in resource-constrained regions.

Design Parameters and Performance:

The performance of solar dryers is intricately linked to a range of design parameters that collectively influence their efficiency, effectiveness, and reliability in preserving agricultural products. These parameters encompass various aspects of the dryer's construction and operation, each playing a critical role in shaping the drying process. A deeper exploration of these key design parameters provides insights into their interplay and their impact on the overall performance of solar dryers:

1. Airflow: Airflow dynamics within the drying chamber are fundamental to achieving uniform drying and efficient moisture removal from agricultural products. Proper airflow ensures that moisture-laden air is continually replaced with dry ambient air, preventing the formation of stagnant zones and facilitating optimal drying conditions. Factors such as airflow velocity, directionality, and distribution patterns influence heat and mass transfer rates, affecting the rate of moisture evaporation and the uniformity of drying. [12] Design considerations such as the placement and size of inlet and outlet vents, the use of baffles or diffusers to control airflow, and the incorporation of fans or blowers for forced convection can all impact airflow dynamics and, consequently, drying performance.[13]
2. Temperature Control Mechanisms: Effective temperature control is essential for maintaining optimal drying conditions and preventing thermal damage to the product. Temperature control mechanisms regulate the heat input to the drying chamber, ensuring that temperatures remain within the desired range for efficient moisture removal while minimizing the risk of overheating. Passive control methods, such as adjustable vents or louvers, allow for natural ventilation and temperature regulation based on ambient conditions. Active control systems, including thermostatic controllers or temperature sensors coupled with actuators, offer precise temperature control by modulating heat input or airflow as needed.[14] Additionally, insulation materials and reflective surfaces can help minimize heat loss and optimize thermal performance, particularly during periods of low solar radiation or at night.[15]
3. Drying Chamber Configurations: The design and configuration of the drying chamber significantly influence heat and mass transfer processes, directly impacting drying efficiency and product quality. Factors such as chamber size, shape, orientation, and insulation play key roles in determining heat distribution, airflow patterns, and residence time within the dryer. Optimal chamber design balances factors such as solar exposure, heat retention, and airflow dynamics to maximize drying rates while ensuring uniformity across the product. Insulation materials, such as expanded polystyrene or

fiberglass, help minimize heat loss and maintain stable internal temperatures, particularly during periods of fluctuating ambient conditions. Additionally, features such as adjustable trays or racks allow for flexible loading configurations and facilitate uniform exposure to solar radiation, further enhancing drying efficiency and product quality.[16]

Moreover, advancements in computational modeling and simulation techniques have enabled researchers to conduct detailed analyses of solar dryer designs, allowing for optimization of key parameters such as airflow patterns, heat distribution, and product placement. Computational fluid dynamics (CFD) simulations, coupled with experimental validation, provide valuable insights into the complex interactions between design variables and drying performance, guiding the development of more efficient and reliable solar drying systems.

Recent Advancements:

Recent advancements in solar drying technologies have focused on enhancing efficiency, reliability, and scalability through innovative approaches and integration with complementary systems. A review of these developments sheds light on the evolving landscape of solar drying and its potential for further advancement. Key

advancements include:

A. Hybrid Solar Drying Systems: Hybrid solar drying systems combine solar energy with other renewable energy sources or conventional heating methods to overcome limitations associated with intermittent sunlight and varying weather conditions. Integration with biomass, geothermal, or waste heat sources allows for continuous drying operations, regardless of solar availability. For instance, studies by Li et al. [9] demonstrated the feasibility of integrating solar collectors with biomass boilers to provide reliable heat input for drying agricultural products, improving system resilience and energy efficiency.

B. Energy Storage Solutions: Integration of thermal energy storage (TES) systems with solar dryers enables heat capture and storage during periods of abundant sunlight for later use during cloudy or nighttime conditions. TES systems, such as phase change materials (PCMs) or sensible heat storage mediums, help mitigate the effects of intermittent solar availability and extend drying operations beyond daylight hours. Research by Vishnuvardhan Reddy Mugi et al explored the use of PCM-based TES systems in solar dryers for drying agricultural products, demonstrating improved energy efficiency and drying performance.[10]

C. Intelligent Control Systems: Advancements in control systems and automation technologies have enabled the implementation of intelligent control strategies to optimize drying processes and energy utilization. Real-time monitoring of environmental conditions, moisture content, and system performance allows for adaptive control and dynamic adjustment of drying parameters. Studies by Naji Abdenouri et al [11] investigated the use of fuzzy logic-based control systems in solar dryers for agricultural products, demonstrating improved efficiency and product quality through precise control of drying parameters.

Challenges and Solutions:

Solar drying, despite its numerous benefits, is not without its challenges, which can hinder its widespread adoption and effectiveness. However, various strategies have been proposed to address these challenges, leveraging advancements in technology and innovative approaches. A comprehensive understanding of these challenges and potential solutions is essential for maximizing the efficiency and reliability of solar drying systems. The following highlights key challenges associated with solar drying and corresponding solutions:

A. Intermittent Solar Availability and Weather Dependency:

Challenge: Solar drying systems rely on sunlight as the primary source of energy, making them susceptible to variations in weather conditions and seasonal changes. Intermittent cloud cover, rainy days, and shorter daylight hours can significantly impact drying rates and system performance.

Solution: Integration of hybrid systems with auxiliary heating sources or energy storage solutions helps mitigate the effects of intermittent solar availability. Hybrid systems combine solar energy with other renewable energy sources or conventional heating methods to ensure continuous drying operations, regardless of weather conditions. Additionally, incorporating thermal energy storage systems allows for heat capture and storage during periods of abundant sunlight for later use during cloudy or nighttime conditions.[10]

B. Maintenance Requirements:

Challenge: Solar drying systems require regular maintenance to ensure optimal performance and longevity. Components such as solar collectors, ventilation systems, and control mechanisms may be susceptible to wear and tear, dust accumulation, or mechanical failures over time, leading to decreased efficiency and reliability.

Solution: Implementation of proactive maintenance strategies and routine inspections can help identify and address potential issues before they escalate. Regular cleaning of solar collectors, inspection of ventilation ducts, and calibration of control systems are essential maintenance tasks to optimize system performance. Additionally, incorporating robust and durable materials in the construction of solar dryers can enhance resilience and minimize maintenance requirements over the system's lifespan.

C. Optimization Techniques and Intelligent Control Systems:

Challenge: Achieving optimal drying conditions and maximizing energy efficiency in solar drying systems requires precise control over key parameters such as airflow, temperature, and moisture content. However, variations in environmental conditions, product characteristics, and system dynamics pose challenges to achieving consistent and uniform drying outcomes.

Solution: Integration of intelligent control systems and optimization techniques enables real-time monitoring, analysis, and adjustment of drying parameters to optimize performance and energy utilization. Advanced control algorithms, such as fuzzy logic or model predictive control, can dynamically adjust drying parameters based on input data and system feedback, ensuring optimal drying conditions and product quality. Additionally, optimization techniques such as mathematical modeling, experimental design, and data analytics provide valuable insights into system behavior and help identify areas for improvement.[11]

Conclusion:

In conclusion, the exploration of key design parameters in solar drying systems underscores their critical role in optimizing performance and efficiency. Through an in-depth analysis of airflow dynamics, temperature control mechanisms, and drying chamber configurations, it becomes evident that the successful operation of solar dryers relies on a delicate balance of these factors. By carefully considering and integrating these design parameters, solar dryer designers and operators can develop systems that offer superior drying rates, enhanced product quality, and greater energy efficiency.

The literature review highlights the significant potential of solar drying systems to address both energy and environmental concerns in agricultural product preservation. By harnessing renewable solar energy, solar dryers offer a sustainable and environmentally friendly alternative to conventional drying methods powered by fossil fuels. The use of clean energy sources not only reduces greenhouse gas emissions and mitigates climate change but also helps alleviate dependence on finite energy resources, promoting energy security and resilience in agricultural production systems.

Furthermore, solar drying systems have the potential to contribute to food security, economic development, and poverty alleviation, particularly in rural and off-grid areas. By enabling farmers to preserve their harvests efficiently and cost-effectively, solar dryers can extend the shelf life of agricultural products, reduce post-harvest losses, and enhance market access and income generation opportunities. Moreover, the adoption of solar drying technology can foster local entrepreneurship and innovation, driving sustainable development and empowering communities to build more resilient food systems.

In summary, solar drying systems represent a promising solution for addressing energy and environmental challenges in agricultural product preservation. By leveraging clean and renewable solar energy, these systems offer a sustainable, economically viable, and socially inclusive approach to food preservation. Moving forward, continued research, innovation, and investment in solar drying technology are essential to unlock its full potential and accelerate its adoption on a global scale.

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A Review on Exploring the Impact of Cutting Parameters on Surface Roughness in Machining

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Abstract:
This research aims to provide a comprehensive review of the optimization of process parameters for turning operations on D3 Die Steel. The study focuses on improving surface roughness and the ultimate goal of enhancing the quality and efficiency of turning operations in the manufacturing industry. The study explores how variations in cutting parameters during the turning operation impact the product's surface roughness and the time taken for machining. Surface roughness is deemed a critical metric in assessing the product's quality. The primary cutting parameters, including cutting speed, feed rate, depth of cut, and spindle speed, are known to influence the quality of the material's surface finish. This research paper focuses on the use of the Taguchi method for optimizing these cutting parameters in the turning process. The Taguchi method serves as a robust optimization technique, employing a specially devised orthogonal array to examine the cutting parameters' effects via a limited set of experiments. The Analysis of Variance (ANOVA) technique is applied to identify which input parameters have a significant impact on performance outcomes.

Keywords—Turning Parameters, D3 die steel, ANOVA, Surface Roughness, Taguchi Method.

Introduction

For many years, it has been understood that machining conditions such as cutting speed, feed rate, and depth of cut (DOC) should be carefully selected to optimize the cost-effectiveness of machining operations. However, manufacturing industries in developing countries often face challenges in running machines at their optimal operating conditions. This is because they rely heavily on the experience and skills of machine tool operators to determine the best cutting conditions. In these industries, it's common to use conservative cutting conditions based on handbooks during process planning. Unfortunately, this unscientific approach leads to decreased productivity due to the underutilization of the machine's capabilities. To address this issue, researchers have worked on calculating optimal cutting conditions, particularly in turning operations [1]. Surface roughness holds significant importance for machined workpieces, particularly in scenarios where precision is critical. In turning operations, surface roughness is affected by several factors, including cutting speed, depth of cut, tool nose radius, workpiece hardness, feed rate, and tool angles. These variables collectively influence the quality of the machined surface, highlighting the complexity and multi dimensional nature of achieving desired surface finish in turning processes [2]. In metal cutting most regularly used method is turning in which a single point cutting tool does metal removal by giving feed in a parallel direction to the axis of rotation. Turning can be done in an automated lathe machine which does not require more labor or frequent supervision by operator. The turning operation is a basic metal machining operation that is used widely in industries dealing with metal cutting. The selection of machining parameters for a turning operation is a very important task in order to accomplish high performance. By high performance, we mean good machinability, better surface finish, lesser rate of tool wear, higher material removal rate, faster rate of production etc [3,5]. The surface finish of a product is usually measured in terms of a parameter known as surface roughness [4]. Improved surface finish can be attained by increasing cutting velocity and by decreasing feed [7,17].

The analysis of variance (ANOVA) is used to assess the primary effects on output parameters. The findings reveal that among the factors considered, both feed rate and cutting insert nose radius have the most significant influence on surface roughness. Additionally, tangential force and specific cutting force are primarily affected by the depth of cut, with feed rate also playing a notable role in their variations. This indicates the relative

importance of these factors in determining the observed outcomes in machining processes [14,16]
D3 die steel plays a crucial role in achieving optimal surface roughness due to its excellent wear resistance and toughness properties. Its high hardness and stability contribute to minimizing tool wear and maintaining consistent machining performance, resulting in improved surface finish. Incorporating D3 die steel in machining processes can lead to enhanced surface quality and dimensional accuracy, making it a valuable material for applications requiring high precision and surface integrity [18].

Taguchi Method

Taguchi method, developed by Genichi Taguchi, is a robust statistical approach aimed at improving the quality of manufactured products and processes. It's based on the concept of conducting experiments to optimize product and process parameters while minimizing variability and cost [13]. The Taguchi method is a highly effective optimization technique widely outputs such as performance, quality, and cost. One of its key strengths lies in its ability to set design parameters effectively while reducing sensitivity to deviations in system performance caused by various sources. This methodology is particularly valuable when dealing with qualitative and discrete design parameters.

In recent years, there has been a significant surge in interest and application of the Taguchi method across various industrial processes. Many researchers have embraced this method to optimize cutting process parameters through reduced design experiments, showcasing its versatility and effectiveness in improving manufacturing processes. [16] **Turning Process Parameters**

The turning process involves the removal of material from a workpiece to achieve desired dimensions, surface finish, and geometrical features by rotating the workpiece against a cutting tool. Turning process parameters refer to various factors that influence the performance and outcome of the turning operation.

1. Cutting Speed (Spindle Speed): It refers to the rotational speed of the workpiece in revolutions per minute (RPM). Higher cutting speeds generally result in better surface finish but can increase tool wear. The selection of cutting speed depends on the material being machined, tool material, and desired surface finish.

2. Feed Rate: Feed rate is the rate at which the cutting tool advances along the workpiece's surface, typically measured in millimeters per revolution (mm/rev) or millimeters per minute (mm/min). It affects the material removal rate, surface finish, and tool life. Higher feed rates lead to higher material removal rates but may compromise surface finish and tool life.

3. Depth of Cut: Depth of cut refers to the thickness of material removed in a single pass of the cutting tool. It influences the chip thickness, cutting forces, and heat generation. Optimal depth of cut balances material removal efficiency with surface finish and tool life considerations. [1]

Optimizing turning process parameters involves selecting the appropriate combination of cutting speed, feed rate, depth of cut, tool geometry, and workpiece material to achieve the desired machining objectives, such as dimensional accuracy, surface finish, and tool life, while minimizing production costs and cycle time. Experimentation, analysis, and continuous improvement are integral parts of optimizing turning processes to enhance productivity and quality in manufacturing operations.

Literature Survey

Thamizhmanii (2009) investigated the milling of Inconel 718, a nickel-based material, utilizing a minimum quantity lubrication (MQL) approach with vegetable oil. The study found that MQL did not yield significant improvements in milling performance at lower cutting speeds. However, when employing MQL at a cutting speed of 30 m/min, using super alloy tools resulted in superior surface roughness compared to dry milling. Furthermore, supplying MQL at a rate of 37.5 ml/hour led to enhanced surface roughness compared to rates of 12.5 ml/hour and 25 ml/hour, while also reducing flank wear. Overall, MQL increased tool life by 43.75% compared to dry cutting. It was observed that dry milling led to increased surface roughness and flank wear across all cutting speeds, with a notable escalation beyond a cutting speed of 30 m/min.[2]

Chavoshi and Tajdari (2010) According to, hard turning is characterized by machining workpieces with a minimum hardness of 45 HRC using appropriate inserts. Employing advanced tool materials like cubic boron nitride and mixed ceramic offers numerous advantages over grinding or polishing, including reduced cycle times, enhanced process flexibility, achieving compatible surface roughness, higher rates of material removal, and mitigating environmental concerns by eliminating the need for cutting fluids.[4]

Bartarya and Choudhury (2012) conducted hard turning experiments to explore the effects of various parameters on surface roughness. They employed cubic boron nitride (CBN) tools for turning AISI 52100 steel (60±2 HRC). Through a full factorial design of experiments, with cutting speed ranging from 167 to 261 m/min, feed rate from 0.075 to 0.15 mm/rev, and depth of cut from 0.1 to 0.2 mm, they developed a regression equation to predict surface roughness. The surface roughness ranged from an average of 1.11 µm to 6.19 µm. It was found that depth of cut, feed rate, and their interaction

significantly influenced surface roughness. Interestingly, increasing the feed rate at low depths of cut initially reduced surface roughness, followed by an increase. Cutting speed had a relatively minor impact on surface roughness compared to depth of cut and feed rate.[5]

Ozel et al. (2007) c**o**nducted machining of hardened steel (AISI D2 steels, 60 HRC) using ceramic tools with varying nose radii. They employed a full factorial design of experiments to systematically investigate the effects of three factors: feed rate, cutting speed, and cutting time, each at three different levels, on surface roughness. The findings revealed that the lowest surface roughness values (approximately 0.18 – 0.20 µm) were achieved at low feed rates and the highest cutting speeds. Furthermore, it was observed that reducing the feed rate resulted in improved tool longevity.[18]

Maheshwari Patil and R.J. Patil (2012) investigated the impact of the High-Speed Steel (HSS) single point cutting tool's nose radius on cutting angle strength and tool wear during the machining of EN9 steel. Their study highlighted that vibrations within the tool geometry affect tool wear and the integrity of the cutting edge during turning operations on plain carbon steel components.[6]

K. Venkatesan et al. (**2014)** investigated the effect of cutting parameters on the machinability of Ni-Cr alloy Inconel 625 using carbide inserts. Their study revealed that using PVD-coated inserts resulted in improved performance in terms of cutting force and surface roughness. They established a relationship between the independent variables (cutting parameters) and the dependent variables (cutting force and surface roughness).[7]

Co. Izelu et al. (2014) In their study, explored how varying turning parameters impact the surface roughness of 41Cr1 alloy steel. Their findings indicated that factors such as depth of cut, cutting speed, and workpiece material exerted a notable influence on the resultant surface roughness of the workpiece.[8]

NBV Laxmi Kumara et al. (**2015)** emphasized the significance of the cutting tool surface geometry as a critical parameter influencing manufacturing quality. Their study involved experimental analysis of machining processes, particularly focusing on understanding the chip formation process.[9]

Raman Kumara et al. (**2017)** concentrated on concurrently optimizing prime energy consumption response, surface roughness, and material removal rate to enhance the sustainability of machining operations. In their experiment, they concluded that during rough turning of EN353 alloy steel, employing multi-layer coated tungsten carbide inserts yielded favorable results. They utilized Taguchi's L27 orthogonal array in conjunction with Minitab 16 software for the design of experiments.[10]

Amritpal Singh et. al. (2020) The hard-turning procedure is gradually establishing itself in contemporary manufacturing technology, and with advancements in cutting tool materials, it can be utilized as an alternative machining technique to grinding, offering a more cost-effective approach to finishing hard surfaces. The primary concerns associated with hard turning include tooling expenses and the impact of the process on machinability properties. Inadequate selection of process parameters can lead to excessive tool wear and heightened surface roughness. Therefore, there exists a necessity to identify the appropriate parameters to attain precise dimensional accuracy, favorable surface quality, and maximum material removal rate. This article evaluates the influence of different process parameters such as cutting speed, depth of cut, and feed rate on response parameters like surface roughness, material removal rate, and chip reduction coefficient. This investigation delves into the primary cutting parameters that influence the turning operation.[11]

Saurabh Singhvi et al. (2020) address the contemporary challenge faced by machining industries: reducing lead time and increasing production rates to uphold competitiveness. This study delves into the machinability of mild steel in turning processes conducted on conventional lathe machines. Two parameters, namely tool rake angle and feed rate, are varied to assess their impact on material removal rate. An endeavor has been made to model a single response variable utilizing Taguchi and ANOVA methodologies, which are crucial techniques with widespread practical significance for statistical inference in various applications. The Taguchi L9 orthogonal array is employed for experimental design. The primary objective of this research is to conserve power and optimize production time during product manufacturing.[12]

S.Khrais et al. (2021) developed various regression models for surface roughness as a function of cutting parameters during the turning of fire-cemented medium carbon steel with TiN-Al2O3-TiCN coated inserts. An experimental design and signal-to-noise ratio (S/N) were employed to correlate the impact of turning parameters with the workpiece surface finish using the Taguchi method. The effects of turning parameters were analyzed using the analysis of variance (ANOVA) technique. Evaluated parameters included feed rate, cutting speed, and depth of cut.[13]

M. Vellibor et al. (2022) introduced a Taguchi robust parameter design for modeling and optimizing surface roughness in dry single-point turning of induction-hardened alloy steel 42CrMo4/AISI 4140 using TiN-coated tungsten carbide inserts. Three cutting parameters, namely cutting speed (80, 110, 140 m/min), feed rate (0.071,

0.196, 0.321 mm/rev), and depth of cut (0.5, 1.25, 2 mm), were employed in the experiment. All other variables were kept constant. The average surface roughness (Ra) was selected as a measure of surface quality.[14]

H. Yanda et al. (2023) investigated the influence of cutting speed, feed rate, and depth of cut on material removal rate (MRR), surface roughness, and tool life in conventional turning of ductile cast iron FCD700 grade using TiN-coated cutting tools under dry conditions. The machining parameters included cutting speeds of 220, 300, and 360 m/min, feed rates of 0.2, 0.3, and 0.5 mm/rev, while the depth of cut (DOC) remained constant at 2 mm. The impact of cutting conditions (cutting speed and feed rate) on MRR, surface roughness, and tool life was investigated. Experiments were conducted based on the Taguchi design of experiments (DOE) with a symmetrical L9 array, followed by the optimization of results using Analysis of Variance (ANOVA) to identify the maximum MRR, minimum surface roughness, and maximum tool life.[15]

J.S. Senthil Kumar and colleagues (2023) utilized Inconel 718 to enhance surface roughness and flank wear in comprehensive turning processes. Machining experiments were conducted using a full factorial design under dry cutting conditions. Taguchi's optimization analysis revealed the significant factors and their influence on surface roughness and flank wear in turning and facing operations. Validation tests were conducted under optimal conditions to compare the preliminary results predicted by the aforementioned models.[16]

Conclusion

The observation reveals that D3 die steel yields the minimum surface roughness among the materials studied. Analysis of the main effect plot elucidates that the surface roughness of the workpiece is primarily influenced by speed and feed rate, while the depth of cut exerts a negligible impact on surface roughness.

It is discerned that the roughness of the workpiece surface escalates with an elevation in feed rate, whereas it diminishes with an augmentation in cutting speed. Consequently, the optimal machining parameters are determined to be the speed and feed rate, as they facilitate the reduction of surface roughness in the workpiece.

This conclusion underscores the critical role played by speed and feed rate in the machining process, particularly in attaining desired surface finish characteristics. By optimizing these parameters, manufacturers can effectively mitigate surface roughness, thereby enhancing the overall quality of machined components.

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Advancements in Sustainable Materials for Energy Storage Applications: A Comprehensive Review

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Abstract:
This evaluate explores sustainable materials for strength garage, categorizing the dialogue into 5 key sections. It covers the historic evolution of substances, latest advancements in nanomaterials and eco-friendly options, and evaluates their overall performance in terms of electricity density and cycle life. The paper concludes with a forward-looking perspective on emerging traits, presenting treasured insights for researchers and enterprise professionals aiming to contribute to a greater sustainable future in energy garage technologies.

Keywords: *Sustainable energy storage, Nanomaterials, Eco-friendly alternatives, Energy density, Cycle life assessment, Renewable energy integration*

Introduction:

The transition to sustainable power sources has grow to be a paramount worldwide subject, necessitating improvements in power garage technologies. This section presents a contextual heritage, tracing the evolution of materials used in energy storage and highlighting the pressing want for sustainable alternatives[1]. The rationale underscores the pivotal function of substances innovation in addressing environmental challenges, power safety, and the pursuit of a resilient and coffee-carbon electricity destiny[2].

Clarifying the focal point and parameters of this complete review, this subsection outlines the particular technology and materials under scrutiny. By delineating the scope, readers advantage a clear expertise of the evaluate's breadth, consisting of batteries, supercapacitors, and emerging garage structures. The targets elucidate the goal to evaluate latest improvements, compare overall performance metrics, behavior lifestyles cycle analyses, and analyze the integration of sustainable substances inside the broader context of renewable power structures[3].

Emphasizing the vital position of sustainable substances inside the energy garage panorama, this subsection underscores their importance in mitigating environmental influences, enhancing energy efficiency, and contributing to ordinary sustainability dreams. By contextualizing the relevance of these materials inside the large discourse on smooth power, the introduction establishes the pivotal importance of exploring and knowledge the improvements in sustainable substances for strength garage.

Historical Perspective On Materials Used

The historical evolution of materials used in electricity storage offers a vital context for know-how the trajectory of advancements within the discipline. Early energy storage structures generally depended on conventional substances such as lead-acid for batteries and carbon-based substances for capacitors. These substances, though effective for his or her time, had obstacles in terms of electricity density, cycle lifestyles, and common performance[4].

The mid to late twentieth century witnessed extensive strides with the arrival of lithium-ion batteries, introducing a pivotal shift in the direction of greater green and compact strength storage[5]. The use of lithium as an anode fabric marked a turning factor, permitting better power densities and longer cycle lives compared to traditional opposite numbers. This breakthrough spurred the speedy development of transportable electronics and electric cars.

As research continued, the 21st century delivered forth an technology of exploration into nanomaterials. Nanotechnology allowed for the manipulation of substances at the atomic and molecular tiers, unlocking extraordinary opportunities for strength storage. Nanomaterials which include graphene and carbon nanotubes emerged as frontrunners, presenting greater conductivity, surface region, and structural integrity[6].

Simultaneously, an elevated emphasis on sustainability prompted the exploration of green options. Materials derived from natural resources, which includes bio-based polymers and natural

compounds, won attention for his or her renewable nature and decreased environmental impact. This shift aligned with a broader movement in the direction of circular economy principles, aiming to decrease waste and promote the sustainable use of resources.

In precis, the ancient attitude on substances utilized in electricity garage displays a journey from conventional materials to the era of nanotechnology and sustainable alternatives[7]. Understanding this evolution is vital for appreciating the motivations behind the ongoing pursuit of materials that now not most effective meet power storage demands but additionally align with modern sustainability goals. The ancient context units the level for evaluating the existing nation and looking forward to the destiny trajectory of materials within the dynamic area of strength storage.

Sustainable Materials For Energy Storage

This segment offers a comprehensive evaluation of diverse energy garage technology, laying the muse for information the diverse applications of sustainable substances[8]. Encompassing batteries, supercapacitors, and emerging garage structures, a detailed exploration of every era's ideas and functionalities is supplied. This units the level for a nuanced exam of the substances used within these technology and their pivotal role in shaping the panorama of sustainable strength storage[9].

Delving into the historic evolution of materials employed in energy storage, this subsection traces the pivotal milestones and shifts in material alternatives. From early traits to modern materials, a retrospective analysis gives insights into the factors driving cloth choice over the years. Understanding this historical context is important for appreciating the motivations at the back of the ongoing quest for sustainable substances and the advancements shaping the current electricity storage paradigm[10].

Focusing on the present day aspects of sustainable materials, this segment explores current developments and developments. It highlights innovations in nanomaterials, natural compounds, and different eco-friendly alternatives that show promise in enhancing the performance and sustainability of power garage structures. By synthesizing modern-day studies, this subsection provides a forward-looking angle, paving the manner for a greater sustainable and green future in electricity storage technologies.

Current Developments In Sustainable Material

In the rapidly evolving landscape of energy storage, large strides had been made in the realm of sustainable substances, ushering in a new generation of innovation and efficiency. Nanomaterials, with their unique structural and functional residences, have emerged as key players in enhancing power garage performance. Researchers are exploring their ability for progressed charge/discharge prices, better energy density, and extended cycle lifestyles. Simultaneously, a noteworthy consciousness is on natural compounds and green alternatives, presenting a shift in the direction of materials that decrease environmental impact all through their life cycle.

Recent research have unveiled novel packages of nanocarbon materials, along with graphene and carbon nanotubes, demonstrating top notch conductivity and balance, that are essential factors for advancing power storage capabilities. The integration of those nanomaterials into electrode designs for batteries and supercapacitors showcases their capacity to address longstanding challenges in energy garage systems.

Furthermore, the usage of sustainable materials derived from herbal assets, including biodegradable polymers and natural compounds, is gaining traction. These materials no longer best contribute to decreasing reliance on finite sources however additionally showcase promising houses for power garage programs. Bio-based polymers, as an instance, provide a renewable and environmentally friendly alternative for manufacturing electrode substances.

This section delves into the specifics of those modern-day trends, exploring the nuanced packages and performance improvements facilitated by means of nanomaterials and green options. As researchers retain to get to the bottom of the entire capability of those materials, the ongoing developments mark a critical step towards attaining a sustainable and efficient future in power garage technology.

Performance And Sustainability Assessment

In the dynamic landscape of strength garage, the effectiveness of sustainable materials is carefully evaluated thru a multifaceted performance and sustainability evaluation. At the forefront of this evaluation is the vital exam of electricity density, a parameter pivotal for figuring out the garage capability of substances. Nanomaterials, specifically graphene and carbon nanotubes, have validated outstanding strides in improving electricity density, enabling greater compact and effective energy storage answers.

Cycle life is a paramount attention, gauging the sturdiness of substances over repeated charge-discharge cycles. Sustainable substances, characterised by means of their durability and balance, frequently exhibit extended cycle lives as compared to standard counterparts. This section delves into the nuanced improvements in cloth design that make a contribution to extended cycle lives, addressing worries associated with the longevity and reliability of power garage systems.

Beyond person metrics, the assessment extends to the general performance of power garage answers using sustainable materials. Considerations

encompass price-discharge performance and self-discharge costs, dropping light on how those materials together enhance the general performance of strength garage technologies. Sustainable substances no longer only aspire to improve efficiency however additionally attempt to lessen environmental affects at some point of their life cycle, aligning with broader dreams of sustainability.

Furthermore, the section delves into the environmental sustainability of those substances, scrutinizing their sourcing, manufacturing processes, and give up-of-lifestyles disposal. Sustainable substances frequently present advantages including a reduced carbon footprint, useful resource conservation, and recyclability[11]. This exam underscores the importance of considering the complete life cycle of substances to limit ecological footprints.

In conclusion, this comprehensive performance and sustainability evaluation illuminates the pivotal position of sustainable materials in advancing energy garage technology[12]. By excelling in key metrics and aligning with sustainability principles, these substances contribute notably to the evolution of electricity garage structures, promising more efficiency and decreased environmental impact.

Future Perspectives And Outlook

Looking in advance, the future of sustainable materials in strength garage guarantees transformative tendencies and innovations. The integration of advanced nanomaterials is predicted to strengthen, with a focus on scalable manufacturing for broader industrial packages. Novel eco-friendly options, along with bio-primarily based polymers and natural compounds, are poised to play a pivotal function, emphasizing sustainability in the course of the strength storage life cycle. The synergy of artificial intelligence and system mastering is emerging as a key street, supplying possibilities for shrewd manipulate systems to optimize electricity garage performance. As energy storage remains relevant to the shift closer to sustainability, this phase outlines key guidelines for future research, including scalability enhancement, price-effectiveness, and novel material mixtures to propel the sphere towards a greater sustainable and greener strength future.

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Advances in Mechanical Behavior Analysis of 3D Printed ABS Components: A Comprehensive Review

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Abstract:

This study aims to review research progress on factors that affect the mechanical behavior of 3D printed ABS components. By examining recent studies and experimental findings, the review seeks to identify and analyze key factors that influence the mechanical properties of ABS components, including tensile strength, compressive strength, Young's modulus, impact resistance and fatigue behavior. The study aims to explore the impact of various parameters such as infill patterns, layer thickness, printing speed & material composition on the mechanical performance of 3D printed ABS components.

Moreover, the review intends to investigate the role of advanced modeling and simulation techniques, such as finite element analysis, in predicting and understanding the mechanical responses of 3D printed ABS components under different loading conditions. By synthesizing the current research landscape, the study aims to provide valuable insights into optimizing the design, material selection, and manufacturing processes to enhance the mechanical performance and reliability of 3D printed ABS components across a range of industrial applications.

Keywords: *Additive Manufacturing, 3D Printing, ABS Material, Tensile Properties, Compressive Properties, Process Parameters, FDM, FEA*

Introduction:

Since the advent of rapid manufacturing, additive manufacturing (AM) has emerged as a notable and widely embraced fabrication method within the manufacturing industry [1]. Additive manufacturing, originally developed in the 1980s, has seen significant growth and adoption in the last 20 years. This technology, commonly known as 3D printing, has gained widespread acceptance and popularity across various sectors including manufacturing, education, and residential domains [2] 3D printing, represents a cutting-edge and revolutionary technology within the realm of manufacturing. Its progressive nature allows for the creation of intricate, unique, and innovative designs that were previously constrained by traditional subtractive methods. This progressive approach to additive manufacturing enables the production of free-form shapes without limitations, facilitating the rapid implementation of new designs. These capabilities have positioned additive manufacturing processes as crucial components of Industry 4.0, surpassing traditional subtractive methods in terms of adaptability and efficiency [3]. Additive manufacturing methods, commonly referred to as 3D printing, are envisioned as the future of manufacturing. These techniques, also known as Additive Manufacturing (AM) or Rapid Prototyping (RP), offer the ability to create intricate components while minimizing material wastage and eliminating the necessity for fixtures. These results in cost-effectiveness and faster production compared to traditional methods [4]. This layered manufacturing technology that involves the creation of a three-dimensional object by depositing successive layers of material. The process of material extrusion additive manufacturing (AM), also referred to as FDM [5]. Using a solid-based rapid prototyping technique called fused deposition modeling (FDM), a sample is produced by repeatedly depositing polymeric layers from a print head [6]. The diagram illustrating the process of 3D printing using fused deposition modeling can be seen in Figure 1. FDM presents various benefits like affordable equipment expenses, high precision in mold dimensions, and time efficiency [7]. Due to its benefits, FDM is extensively utilized in manufacturing sectors, aiding in enhancing

product design and expediting commercialization processes. [8]. Amorphous polymers are well-suited for FDM due to their low temperature requirement, rapid solidification capability, and the relationship between temperature and viscosity, which allows
the influence of for efficient printing. [9].

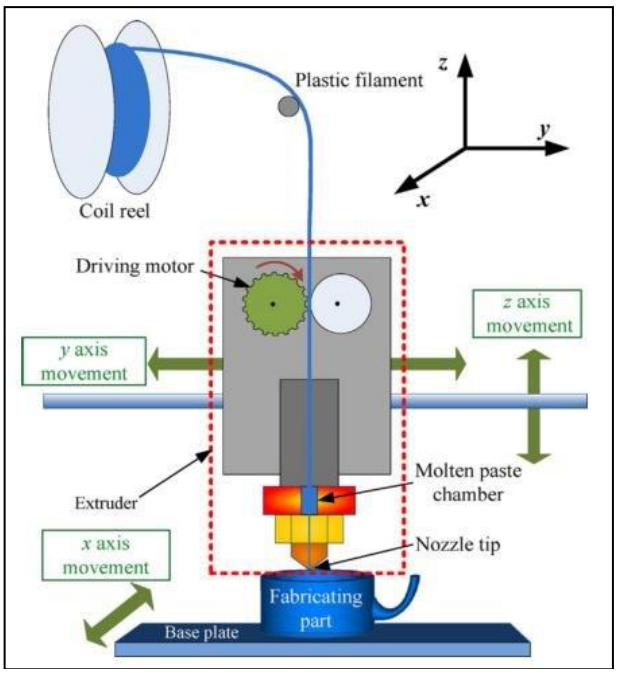

Fig. 1 Schematic of 3D printing by the fused deposition modeling [1]

As FDM components are increasingly utilized as final products in critical performance applications, it becomes essential to simulate and analyze these parts during the design phase [10].
Finite Element Analysis (FEA) is a widely used tool for engineering analysis, including structural, vibrational, and thermal assessments. It is based on the Finite Element Method (FEM), a numerical technique for solving boundary value problems in partial differential equations. FEM divides a large body into smaller elements, each represented by equations that are combined to create a system representing the entire body. Through calculus-based methods, FEA provides approximate solutions for these analyses. [11,12]

Acrylonitrile Butadiene Styrene (ABS) is a thermoplastic known for its impact resistance and amorphous nature. ABS is favored across multiple industries due to its unique attributes, such as its robust mechanical properties, resistance to chemicals, superior surface finish, and high-quality processing capabilities [13]. ABS is a strong, long-lasting resin that resists chemicals, yet it is susceptible to polar solvents. Compared to HIPS, it has slightly greater thermal distortion temperature and superior compressive properties. Acrylonitrile butadiene styrene can be processed using a variety of equipment and has a broad processing window. There are three options: blow molding, injection molding, and extrusion. Because of its low melting point, it is perfect for fused deposition modeling methods in additive manufacturing [14]. Often referred to as fused filament fabrication (FFF) or fused deposition modeling (FDM), this is the most widely used additive manufacturing (AM) technique. This is because of its inexpensive cost, ease of use, and large selection of materials that are readily available for purchase. Polymers like polylactic acid (PLA), polycarbonate (PC), acrylonitrile butadiene styrene (ABS), and polyether ether ketone (PEEK) are commonly used in FFF [15].

Existing Research Work:

Over the years, researchers have been focusing on optimizing various process parameters and advancing different additive manufacturing techniques. Recent studies in this field have explored and discussed new developments and improvements.

Agrawal et al. (2023) The study focused on varying parameters such as printing temperature and infill density to determine their influence on the mechanical properties of the printed specimens. The researchers conducted static tensile tests in accordance with the ASTM D638-14 standard to evaluate the tensile strength and Young's modulus of the printed ABS samples [3].

Ahmad M. N., et al (2023) The goal of the paper was to investigate the effects of various 3D printing parameters on the mechanical properties of ABS samples produced through fused deposition modeling. By studying factors like infill patterns, orientations, layer thicknesses, and speeds, the researchers aimed to understand how these parameters influence the tensile strength and modulus of the printed

samples. Through their experiments and analyses, they were able to determine the optimal printing conditions that resulted in the highest mechanical performance, such as the highest tensile strength and modulus. Additionally, they found a direct correlation between the orientation of the printed parts and their tensile strength, highlighting the importance of selecting appropriate build orientations and printing speeds to enhance the microstructure of the specimens. [15]

Ali H. B., et al (2022) The goal of the paper was to investigate the mechanical characteristics of printed ABS components after the 3D printing process. The study aimed to analyze how various process parameters such as layer thickness, infill density, and infill pattern affect the compressive and tensile properties of ABS material produced through fused deposition modeling (FDM) 3D printing. By examining these parameters, the researchers sought to determine the optimal combination that would result in improved mechanical properties of the printed ABS components. Ultimately, the study aimed to provide insights into optimizing 3D printing process parameters to enhance the mechanical performance of ABS material in additive manufacturing. [12]

Rasiya G., et. al., (2022) provided an overview of additive manufacturing techniques. They discussed various processes, including Fused Deposition Modelling (FDM), Stereolithography (SLA), and Selective Laser Sintering (SLS). The authors highlighted applications, material considerations, and challenges in the field. Overall, their review contributes to understanding the evolving landscape of additive manufacturing [16].

Baikerikar P, et al. (2021) The study investigated the accuracy of finite element analysis (FEA) in predicting the behavior of additively manufactured dogbone specimens using fused deposition modeling (FDM). Authors compared different FEA models for additively manufactured parts. They found that the orthotropic derived model provided more accurate predictions than isotropic models, emphasizing the importance of considering material anisotropy in FEA simulations for FDM parts. [11]

Samy, A. A., et al. (2021) investigates the impact of ambient temperature and nozzle speed on residual stresses and warpage in 3D printed semi-crystalline polymers using finite element analysis. A comprehensive model considers solid mechanics, heat transfer, and crystallization physics to simulate temperature evolution during FDM printing. Results show that increasing printing speed reduces residual stress and warpage, attributed to improved heat transfer. Experimental validation confirms the simulation findings, providing insights for optimizing FDM processes for semi-crystalline polymers. [21]

Zur P., et. al., (2020) investigated the method of 3D-printing ABS (Acrylonitrile butadiene styrene) using Fused Deposition Modelling (FDM) technology. They examined the influence of printing temperature and infill density on the quality of 3D-printed specimens. Their research contributed to optimizing the printing process for ABS vehicle parts, enhancing overall quality and efficiency [2]

Vyavahare S., et. al., (2020) explored various aspects of Fused Deposition Modelling (FDM). Their study covered process parameter optimization, environmental factors affecting part quality, post-production finishing techniques, numerical simulation, and recent advances in FDM. The authors identified research gaps and discussed future work to enhance the acceptability of FDM printed parts in industries [20].

Abbot, et al. (2019) conducted research involving the 3D printing of identical objects using various materials and infill patterns. Their study aimed to analyze the responses of these objects under compressive loads. By comparing the performance of the printed objects under different conditions, the research provided insights into the behavior of 3D printed components when subjected to compressive forces [23].

Dong G., et al. (2018) In their study, Dong, Wijaya, Tang, and Zhao investigated the influence of process parameters in Fused Deposition Modeling (FDM) on lattice structures. By employing the Taguchi method, they identified optimal parameters to enhance printing quality. Additionally, their research revealed that these optimized parameters not only improved print quality but also positively impacted the elastic modulus and ultimate strength of the lattice structures [7].

Zhao et al. (2018) introduced a novel printing technique called inclined layer printing, which addresses the short comings

of traditional support generation methods in 3D printing [18].

Dizon J., et. al., (2018) investigated the mechanical properties of 3D-printed polymers. They explored factors such as material selection, printing parameters, and post-processing techniques. The review highlights the importance of understanding material behavior and optimizing printing processes. Overall, this research contributes to advancing the reliability and performance of 3D-printed parts [22]

Cantrell, J. T., et al. (2017) The goal of the paper was to experimentally characterize the mechanical properties of 3D-printed ABS and polycarbonate parts using digital image correlation (DIC) to assess anisotropy in the materials. The outcome highlighted the impact of build orientation and raster orientation on the mechanical properties of the materials, emphasizing the need for shear testing to fully understand 3D-printed material behavior [19].

Christiyan, K. J., et al., (2016) conducted a study focusing on the influence of process parameters on the mechanical properties of 3D printed ABS composite materials. Their research aimed to investigate how variations in printing speed and layer thickness impact the mechanical characteristics of the printed components. The study found that lower printing speeds and thinner layer thickness resulted in higher tensile and flexural strength of the 3D printed ABS composite materials [5]

Divyathej M. V., et al. (2016) investigate and compare the mechanical properties of 3D printed ABS parts with those produced by conventional manufacturing methods, specifically Automated Injection Molding. The study aims to analyze the tensile, flexural, compression, and impact properties of the 3D printed samples and compare them with molded samples to understand the performance differences between the two manufacturing techniques. the study concluded that injection molded samples have higher tensile strength but lower elongation compared to FDM samples, highlighting manufacturing processes on the mechanical properties of ABS parts [14].

Conclusion :

In conclusion, this review has extensively discovered the effect of various factors on the mechanical performance of 3D printed ABS components fabricated using FDM. By analyzing recent research efforts, the study has identified key parameters that significantly impact the mechanical properties of ABS parts, including tensile strength, compressive strength, Young's modulus, impact resistance, and fatigue behavior. These parameters encompass infill patterns, layer thickness, printing speed, material composition, and build orientation. The review has also highlighted the growing importance of advanced modeling and simulation techniques, such as finite element analysis (FEA), in predicting and comprehending the mechanical responses of 3D printed ABS components under diverse loading conditions. By combining experimental insights with FEA, we can optimize designs, reduce costs, and accelerate product development. The future lies in seamlessly integrating physical testing and virtual simulations to create robust and innovative products.

By integrating the knowledge gained from this comprehensive review, researchers and engineers can strive to optimize the design, material selection, and process parameters for 3D printed ABS components. This optimization will lead to enhanced mechanical performance, improved reliability, and broader applicability of 3D printed ABS parts across a multitude of industrial applications. Future research directions could involve investigations into new infill patterns, exploration of functionally graded materials, and the implementation of advanced characterization techniques to gain deeper insights into the structure-property relationships of 3D printed ABS components.

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A Review paper on Types and Designs of Solar Cookers

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Abstract:
The study of different types and Designs of Solar Cookers are available . In the world there is number of cookers designed and produced by Researchers and Scientists. In this paper the detailed explanation with Advantages and disadvantages provides better understanding about Panel cookers, Box cookers and Parabolic Cookers. The solar cooker is type of outdoor cooking and it is also used in situation where minimum fuel consumption is necessary. The one of the challenging things of use of solar energy is solar cooking.

Introduction:

The Apparatus using the direct energy of sunlight cooking the food with the help of reflective glass/panels by concentrating on specific point is known as solar cooker. There are two types of energy resources i.e., Renewable and Non-Renewable energy resources. The solar is the one of the best renewable resources in before, today and also fortomorrow. As we know it is easily available source of energy, we can produce electricity, cooking, etc.The solar cooker is invented by the swiz physicist 'Horace de Saussure' in 1767.Now a days the solar cookers are very useful in order to increase national economy by reducing the use of LPG. Today there are uncountable styles of solar cookers and day by day it gets modified through Scientists and Researchers.

Types of solar cookers:1.Panel Cooker:
Fig.Panel Cooker.

The Panel Cooker is one of the simple types because of their construction and less cost material. The temperature range required for

the solar panels are up to 200-250 degree centigrade. The requirement for these panel cookers are poor as compare to others.

Advantages:

1. The performance of panel cooker is better than box cooker.

Disadvantages:

These types of cookers are not properly stable in high wind.

2.In monsoon season and cloudy days the performance is poor.

1. Box Cooker:

It is also known as solar ovens. In 1767 the first solar box cooker was invented by 'Horace de Saussure'. The cost required for this cooker is less. The design of this cooker is very simple. The inner part of the box cooker is painted with black colour for absorption of heat. The capacity of this cooker is maximum two-four vessels.

Advantages:

1. It does not do any type of pollution.
2. The maintains of solar cooker is free and long-lasting as solar energy does not lead any type of global warming and any harmful effect on environment.

Disadvantages:

1. As compare to other types of cookers it takes 2 to 3 hours to cook the food.2.It has high initial cost.
2. Cooking will be affected by unnecessary cloudy conditions
3. As the solar cookers is heavy in weight and bulky to carry.

2. Parabolic Cooker:

The name of this cooker describes the structure of cooker with parabolic disc. The design of this cooker is unique because of the parabolic shape the solar radiation is concentrated at the focal point. As

the sun rays get incident on the parabolic disc the rays are focused on one point of cooker. The temperature range required for the parabolic solar cooker is 200 degrees centigrade to 300 degrees centigrade. This type of cooker is not easy to operate as compared to other solar cookers. The capacity or the speed of parabolic cooker is depending upon the size of the collector.

Advantages:

1. As compared to other cooking speed is relatively high.
2. The temperature reaches up to 300 to 350 Degree centigrade.

Disadvantages:

1.The acceptance angle for parabolic cookers is low
2.There is less safety in this type
3.Difficult to cook in this type of cooker.4.Design is complex.

Different Designs of Solar cookers:

Conclusion:

No of studies are available at design and types of solar cooker for domestic use . There are number of advantages and disadvantages of working and construction of solar cooker in respect of commercial working system by using solar cooker one can reduce the use of LPG increasing national economy.

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Case Study of Solar Power Plant Generation and Their Factors Affecting

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Abstract :
Conventional Energy Coffers aren't climate sustainable. presently, masterminds and scientists are looking for sustainable energy results told by climate change. A wide variety of sustainable natural energy coffers are available, but they bear specialized results for their perpetration. The general trend in energy exploration is grounded on renewable coffers, amongst which solar energy stands out, being the most mature and extensively accepted. In this paper, the current state of the sustainable energy system has been analyzed., a detailed disquisition on air dust patches effect on photovoltaic (PV) model performance has to been carried out. Virtually drawing dust is also bringing veritably the dust impact on PV modules on base mount and rooftop systems and depend upon the terrain similar to soil type and environmental pollution may be means of artificial waste or by means of cost areas salty soil dust air or salty rain etc. It's set up that there's a significant drop in electrical power produced, Cost of perpetration and their ROI model.

Key Words: Renewable energy, Solar irradiation, Photovoltaic system…

Introduction

The advancement of mortal civilization depends on energy. Renewable powers are essential for unborn transportation, artificial work, and diurnal demands for people. currently, reactionary energy has a huge quantum of uses and has led to increased health problems like respiratory complaint, asthma, lung infection, and cancer . In addition, reactionary energy is limited on the earth and one day it'll be finished, leading to the need for indispensable energy for sustainable development. Solar energy is the most precious natural energy source, and can fulfil the energy demands on Earth. Solar power stations are essential because of unborn energy demand, and the present energy force comes from numerous sources Thirsty and semi-arid regions have a huge quantum of solar energy entered from the sun. However, the demand for fossil energies would be precipitously reduced, if we were to store that energy for uses of diurnal requirements. Environmental declination and global warming are caused by reactionary energy, and renewable energy sources represent an indispensable relief for the demand for energy in the future and volition for sustainable development Solar energy remains unique as a free, clean, and gushing energy source that provides electric energy to numerous corridor of the world . The energy of the solar system is constantly communicated in terms of the global vertical irradiance(GHI), which is the entire volume of the shortwave radiation entered from over by a face vertical to the earth's crust. The GHI comprises both the verbose vertical irradiance(DHF) and the direct normal irradiance(DNI) Solar energy is now distributed to energy systems worldwide, which is gradationally adding the demand . Solar power shops are necessary worldwide, and this new renewable technology is being erected in numerous corridor of the world.

Societies are growing, and the standard of living is rising, performing in a growing demand for energy. Solar energy is decreasingly used to produce electricity in India, but the environmental impact of constructing and running solar premises isn't yet well studied. Solar Park construction requires partial foliage junking and soil levelling. The use of fossil energies as a major energy source has led to environmental pollution and global warming. In addition, fossil energies aren't renewable. In recent decades, there has been a hunt for cheaper, affordable and more environment friendly and sustainable energy sources,

Amongst sustainable energy sources, solar energy is favoured, owing to its abundance and adding affordability. It's more abundantly distributed in nature than any other renewable energy source. Solar energy has extensively and exponentially grown in the last couple of decades, Solar photovoltaic(PV) technology converts the Sun's energy to terrain-friendly electricity, this has been one of the most booming forms of renewable energy in recent times, due to technological advancements

and favourable government programs that have made it decreasingly affordable and accessible,

Factors affecting on solar power plant generation:-

Dust

Dust may be defined as crushed form of nanosecond patches having size lower than 500 μm. Dust may come in the terrain from colourful sources similar as constructional spots, diligence and dust storm. Dust consists of visible and unnoticeable, floating and fallen patches of solid material.

Weather Change

As Heat exposure can be degraded solar cells as for daily production, high temperatures leads to a drop in voltage and also drop in overall power.

Location

Not all places have the same abundance of annual sunshine. Depending upon the season there will be a different climate in a different locations, hence your solar panel's production numbers will be different according to the season remember to consider annual production.

Solar shading

Solar pv panels are very sensitive to solar shadings Total or partial shading conditions have a significant impact rate on the capability of delivering energy and may result in lower output and power losses.

Roof orientation

The solar panel's inclination should be actively modified in response to seasonal.Is must face the sun in the proper direction if you want to get the most out of your solar panel's.

Research Background

Studies On Effect Of Dust

The accumulation of dust on the face of a photovoltaic module decreases the radiation reaching the solar cell and produces losses in the generated power . Dust reduces the radiation available for the photovoltaic conversion on the solar cell and increases the energy loss of the system. Accumulation of dirt or dust patches on the solar photovoltaic panel face, corresponding as dust, water, and beach, block or hamper light energy from entering the solar cells . It's a major problem since the accoutrements for light inhibition disguise as external resistances which reduce solar photovoltaic effectiveness. The dust will surely reduce the immersion capacity of the panel's photovoltaic cells. A single subcaste of dust is enough to obstruct the passage of light, and this will make the solar cells ineffective. Heavy dust covering the face of the solar panel will reduce the affair of the system .

The effect would be more egregious if the PV system consists of further cells or Stand-Alone Photovoltaic(SAPV) systems installed in areas where there will be heavy dust. Due to environmental conditions because of the exposure of shells, layers of dust are accumulated. numerous other factors, similar as the direction of the wind, moisture, etc also impact the deposit of dust . It's preferable to have high wind pets as they help in driving down from the accumulated dust. Pmax, Imax, Isc, and fill factor(FF) are the most affected performance characteristics by the dust deposits on the PV module face . Studies have shown that accumulated dust can reduce solar panel performance, but the results haven't been easily quantified .

2.2 Study Of Cleaning Agent And The Effects Of Coating Materials

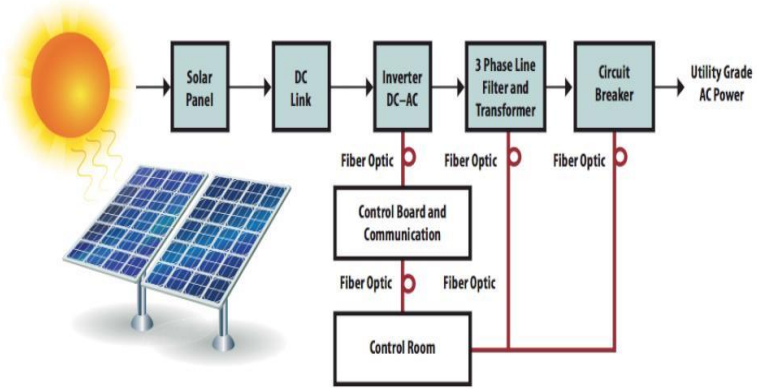
Dust cleaning on PV face is a veritably important exploration compass to explore more advanced cleaning systems with effective styles. Some of important cleaning styles are bandied as follows. PV module drawing technology handed bettered effectiveness and defended the solar cell. The authors epitomized all the dust junking styles similar as natural junking of dusts, mechanical junking dusts, tone- drawing nano- film and electrostatic junking of dusts (He etal. 2011).

For maximum power generation, a direct piezoelectric selector- grounded technology for solar panel cleaning is espoused in assiduity terrain. A wiper is fixed with the selector for direct stir to remove the dust subcaste down effectively from the solar module face. This cleaning technology is featherlight and compact in size (Lu etal. 2013).

Reducing the cost of the solar panel cleaning is a crucial exploration issue for feasibility of solar factory. The authors concentrated on optimizing the cleaning styles for solar factory at semidesert climate out-of-door conditions. Different cleaning styles are used, and according to attained results, the most effective cleaning system is grounded on water and an encounter cleaning. The attained results are validated the conception as average effectiveness of 98.8 in stormy ages and97.2 in dry seasons (Garcia etal. 2014).

The authors developed an innovative receiver tube study for covering the performance of solar panel cleaning styles. Five distinguish drawing styles have been applied and concluded that the receiver tube is the most effective system. This system is traditional in comparison with the rest of the tested styles. The authors (Kawamoto and Shibata 2015) have been developed an advanced cleaning system that uses electrostatic force to remove beach from solar panel face. The designed cleaning system is demonstrated and set up that further than 90 of the clinging beach is repelled from the PV module face. The performance of the system was bettered, indeed when the deposit of beach on the panel is extremely high. The proved technology is anticipated to enhance effectiveness of MW solar power shops located in desert areas.

Block Diagram:-



1implementation Of 1mw

Cost of implementation of 1MW ground mount is taken it to account, Where Land requirement is around 3 Acres and now a day's panel specification is increasing gradually till date it is about 600watts +, the cost of land is not taken into account. The cost of solar power systems has changed recently and the government is promoting green energy mission in many ways. A 1MW solar power plant con now be installed just by investing INR 4-5 crores. For instance, if INR 5 crores is spent, Thereafter, it can supply the electricity to the government for 25 years, it also awards warranty for panel for about 25 years and 5 to 10 years for inverters, and the operation & maintenance cost is around 3 Lakhs per MW.

Working for 1 MW

Solar photovoltaic panels do the same thing in all residential and commercial compositions regardless of the 1MW solar power plant cost or type. They absorb sunshine to generate clean solar electricity. The panel's surface contains multiple strings of solar cells (made up of silicon alloys) which lose their electrons. It happens in response to a change in their electrical field caused by photons present in sunlight. The drifting elections generate a flow of direct current. This is called the 'Photovoltaic Effect'.

Experimental Calculations

In Tamilnadu state as analysed practically by using PVsyst simulation in different part of the state it has come to know the generation per 1kW is in and around 4.3kW to 4.6 kW , we can take 4.5kW as an average generation part , Now a days bifacial solar panel are used, technically it increases 30% of generation, In other case some of them are increasing the DC side of the inverter connectivity according to their capacity of 1:3 ratio where we also able to increase the generation, In inverter selection area mostly preferred string inverter than going for centralized type even the cost of implementation is higher 10Lakhs to 15lakhs where the downtime of inverter service is reduced.

In an average 4.5kW of generation per one day, where cost of 1kW is 50000 INR (analysis from diving cost of 5 Crores per MW) for simplifying the calculation, 3.61 in INR (captive and Group captive model) given by TNERC, then if purchasing power from private producers at Rs 7.01 in INR (third party model), and wheeling chargers are also taken from 0.5% to 2.5% according to their traffic. In case of selling to government we get ROI of 8.5 years respectively.

Conclusion

Land selection or place where we are going to implement the solar plant so important which may affect the generation or even change the material property such as glass reflection even MMS used may cause damage due to external factor such as near to sea or implementation cost may increase or also affect ROI even make the project failure

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Customizable Autonomous Flight Controller For Agricultural and Surveillance Drone

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Abstract:

In the field of agriculture and surveillance activities, aided by a customizable autonomous flight controller makes a great difference in the overall performance, efficiency, and accuracy of the drone. This paper's impact on the development and advancement in drone technology for agriculture and surveillance activity is elaborated. Designing and developing a customizable autonomous flight controller for agriculture and surveillance is the main objective of this paper. UAV(Unmanned Aerial Vehicle) performs functions like navigating environments, executing predefined tasks and collecting data with reliability and precision. Integrating software and hardware to develop the flight controller aids the requirements in agriculture and surveillance activity. The Methods or techniques used in this paper illuminates the methodology necessary to apply and create a system comprising customizable hardware selection and integration based on application requirements. explaining software and hardware integration with customizable configurations, validation, and testing based on feedback from consumers, providing feedback-based corrections and optimization based on results. With an in-depth study of the gained outputs to provide a unique solution to agriculture and surveillance activities ultimately contributing to development in specifications like efficiency and precision. Through the cooperation of the methodology and current technology, the objectives of developing an autonomous flight controller can be achieved through the contents in this paper. The paper provides a detailed explanation of the required methodologies and terminologies used in the development of such autonomous flight controllers. This paper aims to illuminate the path to design and optimize autonomous UAV flight controllers that can adapt to conditions.

Keywords*:* UAV, RTH, Flight Plan, Autonomous

Introduction

In the recent past, drones have been integrated into various sectors bringing in a new age of changes and effectiveness. Agriculture and surveillance are a major area of focus in applying drone technology because of improve production and enhance security. The objective of this paper is to develop a custom flight controller system for drones in agriculture and surveillance applications[12].

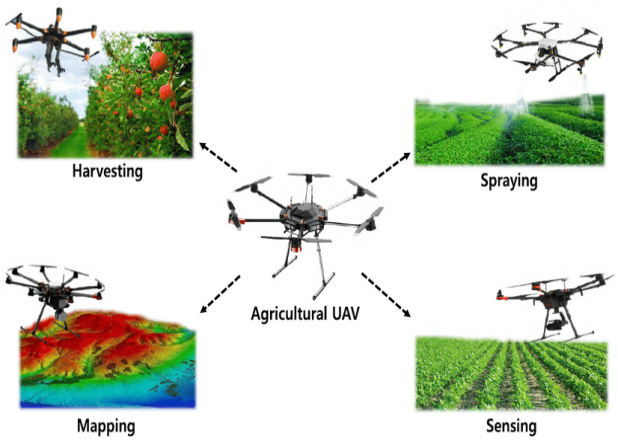

fig.no 1.1 Applications of Agricultural UAVs

Unmanned aerial vehicles (UAVs) equipped with advanced sensors and imaging technologies have revolutionized monitoring for comprehensive surveillance purposes. The performance efficiency

of such drones depends on flight control system capabilities.

Off-the-shelf flight controllers that suit general tasks lack the customization useful for tailoring toward precision farming or surveillance. Because of this gap researchers and engineers are developing bespoke flight controller solutions meant for agriculture and surveillance operations alone.

The development of these controllers uses advanced algorithms and sensor fusion techniques to help drones to navigate in complex environments with crop monitoring sensors or high-resolution Cameras[10].

In the agricultural sector, UAVs equipped with custom flight controllers provide beneficial knowledge on crop health, soil condition, and irrigation. These UAVs can detect stressed areas or peste infection via remote sensing images and multispectral sensors.

Similarly, custom flight controllers are also useful surveillance tools for law enforcement agencies, security firms, or emergency responders among others with autonomous patrols[17]. The paper will explore the design implementation and performance assessment of a bespoke flight control system for agriculture and surveillance drones[12]. We aim to show that using custom-made flight controllers in drones can enhance their multi-purpose functionality through theoretical analysis, practical analysisas well as case studies.

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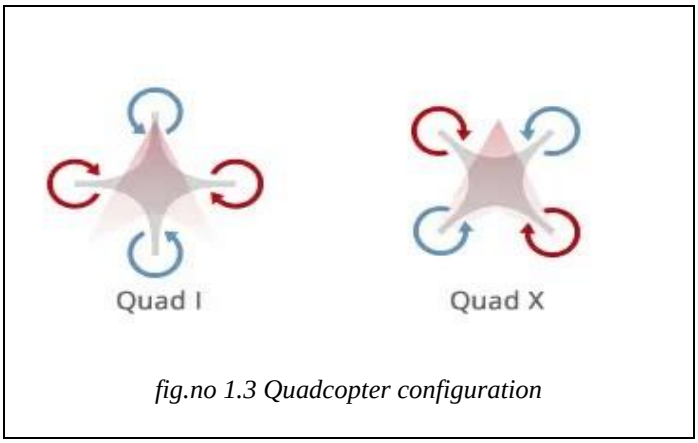

fig.no 1.3 Quadcopter configuration

The Quadcopter configuration which is highly efficient, stable, easy to implement, requires less hardware, and has adequate endurance to perform the majority of drone applications in the domain of agriculture and surveillance.

1.2 Drone Control Terminology

Some basic terminologies that are used to control and fly the drone, using these terminologies the drone can be controlled. These actions are performed based on the parameters such as roll, pitch, yaw, throttle, altitude.

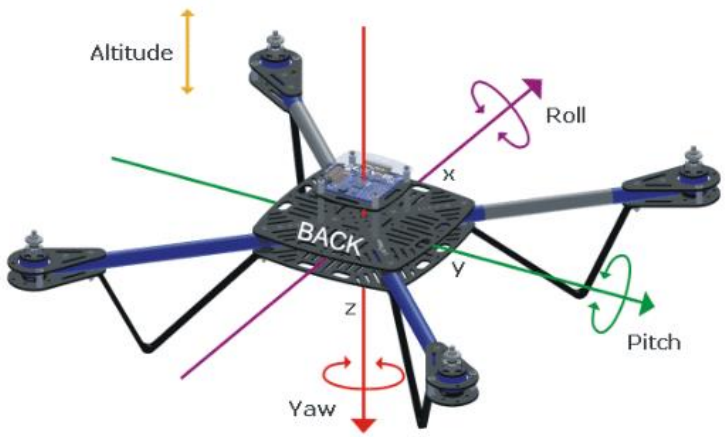

fig.no 1.4 Drone control terminologies and orientation entities

The ROLL parameter is responsible for the rotation of the drone around its longitudinal axis. Here the longitudinal axis is the X-axis of the drone. The PITCH parameter is responsible for the rotation of the drone around its lateral axis. The lateral axis is the imaginary axis is the Y axis..

The YAW parameter is responsible for the rotation of the drone along its vertical axis which is

an imaginary axis going through the center of aircraft from top to bottom ie the Z axis.

ALTITUDE a major of the height attained by the drone from the reference point on the ground based on the various sensors such as Lidar and barometer. Can be increased or decreased based on THROTTLE value[13].

Material And Methodology

2.1 Drone Flight Controller

The flight controller is the main driving component in a drone which measures all necessary sensor values and provides the necessary signals to the motors to stabilize the drone during flight and to control the drone's trajectory based on the received signal from the transmitter.

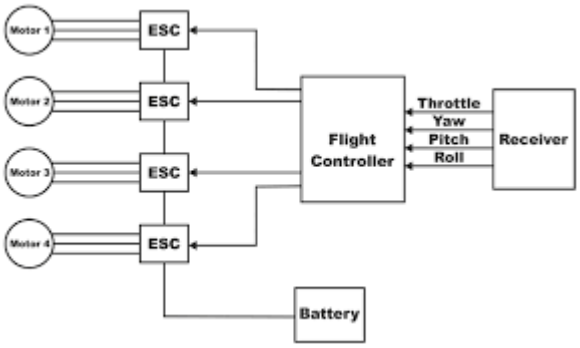

fig.no 2.1 basic drone block diagram and components

The flight controller is the component that is responsible for the PID management ie.PID calculation for the drone based on the sensor readings the most common sensor used in the drone for getting the three dimensional orientation of the drone is IMU (inertial measurement unit) sensor for example mpu 6050 sensor incorporates a accelerometer, gyroscope and temperature sensor[19]. Based on the readings of the accelerometer and gyroscope the orientation of the drone can be determined by the flight controller. Based on this data keeps the drone stable in X-Y plane.

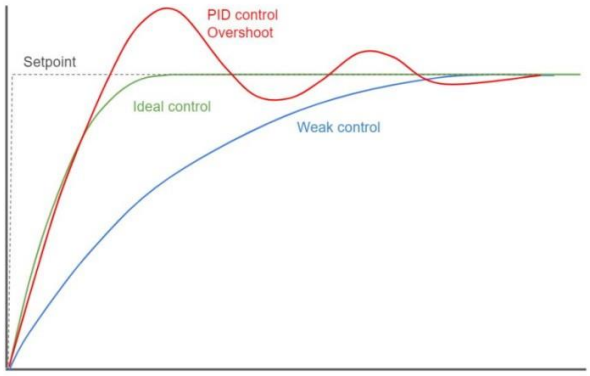

fig.no 2.2 PID tuning states

By changing this ROLL, PITCH, and YAW angle the drone can be moved in a particular orientation which results in the desired trajectory of the drone these changes can be made manually and autonomously based on the flight controller configuration in a custom flight controller[14]. Real-time controlling of the drone is possible with reduced delay and computing time using advanced telemetry systems. We can get real-time updates of the drone's coordinates, altitude[13], and provide way-points that are saved into the flight plane of agriculture and surveillance activities[2].

2.2 Sensors

Sensors are integral and the most important part of a drone to maintain a stable flight, drone needs information about the surrounding conditions and its orientations. There are various sensors involved to provide the flight controller with necessary data about the drone's orientation, speed, acceleration, trajectory, obstacles, ground level altitude, and Telemetry.

Some of the most important sensors are

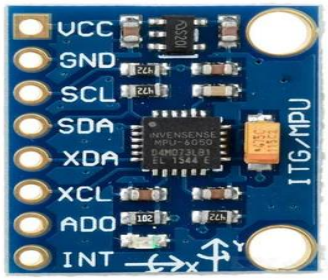

fig.no 2.3 MPU6050 IMU sensor

The initial measurement unit(IMU) is the most basic sensor that delivers the necessary orientation data to the drone flight controller. Based on this data the ROLL PITCH and YAW angle can be determined to stabilize the drone in a hovering condition and movement through the waypoint in a flight plan[15]

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fig.no 2.4 TOF(time of flight) sensor

A time of flight sensor (TOF) is responsible for calculating the height/ altitude attained by the drone. with reference point to the ground

.

fig.no 2.5 Neo7M GPS module

A global positioning system(GPS) is responsible for providing the coordinates, data based on latitude and longitude which helps the flight controller to understand the drone's location on the global map, this data is used by the flight controller to move the drone in a direction of the waypoint as set in the flight plan[22].

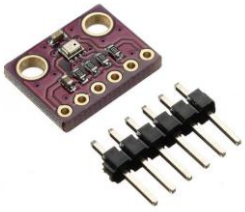


fig.no 2.6 *BMP280 Barometric Pressure and Altitude Sensor*

The Barometer sensor is responsible for providing the atmosphere pressure around the drone to the Flight controller which determines altitude attained by the drone based on change in atmospheric pressure which provides enhanced altitude stability and position hold functionality in a drone even though the ground reference may change based on the atmospheric pressure the drone can follow a stable altitude trajectory in a flight plan[13].

2.3.Hardware

The hardware required for Aiding the flight controller are essential for the complete functioning of the drones like the transmitter, receiver, telemetry transceiver, battery, physical frame of the drone, motors, ESCs and propellers etc.

The receiver is one of the crucial elements in any drone application where the flight controller receives the user control signals in order to control the drone in the user desired trajectory the parameters such as roll, pitch, yaw and throttle are received through this receiver and transmitter hardware.

The Telemetry system is responsible for providing real time coordinates and waypoint coordinates to the flight controller in order to control the flight trajectory of the drone to complete a flight plan in any applications.

The battery is the powerhouse of the drone as it provides the electrical energy to drive the entire circuitry in the drone, to power the motors, and ESCs for the functioning of the drone. This hardware should be selected very carefully as the capability and flight time of the drone depends on the capacity and power of the battery used in the drone application.

fig.no 2.7 Prototype drone with aluminum frame for testing Flight controller

The physical frame of the drone is a skeleton that holds the entire drone hardware together as one in order to provide the drone with physical strength for handling the payload. Also it provides necessary mounting for the motors and the flight controllers[16].

Commonly used BLDC motors in the drone applications are essential actuators necessary to make the drone move in three dimensional space, providing the drone with the rotational energy and thrust with the propellers to lift the drone along with payload.

In any drone application the ESC (electronics speed controller) is used to control the BLDC motors to control the rotation rate based on the signal provided by the flight controller

There are various other hardware in a drone such as LED's and indicator lights which indicate the drone's orientation to the user on the ground these LEDs provide the visual data of the drone status to the user.

2.3.1 Flight controller hardware

The basic flight controller hardware includes a microcontroller, inertial measurement unit a barometer and optionally GPS for autonomous flight in agriculture and surveillance activities[8]. These applications require GPS and realize greatly upon the real time coordinate of the drone and the target coordinates from the telemetry system[22]. The microcontroller used in our experiment is stm 32f103C8t6 this microcontroller provides high clock frequency and low power consumption highly efficient for flight controller application and unmanned aerial vehicle flight controller development, also provides sufficient GPIO pins and hardware communication capabilities required for unmanned aerial vehicle (UAV) development. Also highly robust and popular among the manufacturers for automation in complex and rapid application domains which includes the automobile and aviation sector.

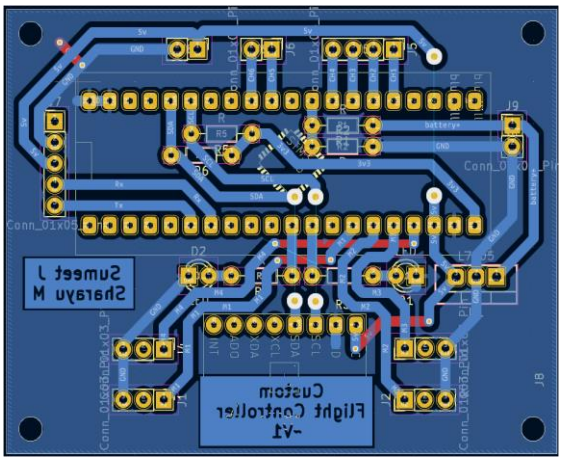


fig.no 2.8(a) fabricated PCB

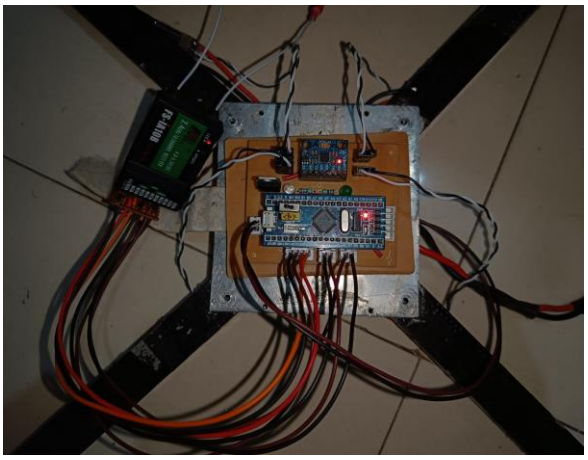


fig.no 2.8(b) PCB design

The IMU provides multiple degrees of freedom for the flight controller to analyze and know the uav's orientation one of the most popular IMU sensor is mpu 6050 and mpu 6000[15]. This sensor is highly responsive and provides high data rate with high accuracy and sensitivity for UAV application. Sensor has a inbuilt temperature sensor which can be used to calibrate the accelerometer and gyroscope values which is the sensitivity of change in accelerometer and gyroscope values based on the surrounding temperature before flight.

2.4.Concept of custom flight controller

Overall the custom flight controller design according to the task which is customized based on the surroundings can save a lot of unnecessary calculation and unnecessary hardwares which is not required in that area of application and reduce the computation time, increase the performance efficiency and overall performance of the drone with real-time response. for example in agriculture application the drone requires GPS, barometer and time of flight sensors, whereas in surveillance activities the drone requires manual sensors such as spy cameras and sensors such as scanners and three dimensional mapping sensors used to map targeted area[10]. Also some surveillance drone also requires autonomous activities or continuous surveillance activities where the flight path can be created using a GPS to move the drone in the specific location[22].

As discussed a custom flight controller reduces the computing time and overall memory of the flight controller by customizing the drone configuration that is quadcopter, tricopter, hexacopter compared to of the shelf flight controller which are genetically created to use for any of the above configuration which requires more memory space and more advanced hardware for computing. Custom controllers on the other hand require less memory and less complex hardware for computing the results which saves computing time and cost in long-term product development and also computes the necessary PID values faster compared to a generic flight controller based on different hardware compatibility and provides a real time application of the system.

***2.5.*Flight stabilization**

A flight controller is an essential part of any UAV application. The main purpose of any flight controller is to maintain the UAV's orientation about the ground plane this process is often referred to as flight stabilization or altitude stabilization[13]. The following calculation must be performed by the flight controller:

1. Calculate the aircraft.
2. Read the receiver's commands.
3. Randeep flight stabilization PID at high frequency.
4. Control the motor signal to stabilize the entire drone structure.

Reliable flight controller must perform these applications in minimum time. Any generic flight controller which is designed to operate with multiple different hardware of different making takes excess time to calculate these parameters on the other hand a customized flight controller reduces this reading time and in doing so optimizes the drone system for particular application.

***2.6.*Tuning and calibration**

Tuning and calibration is an essential stage in any flight controller development where the sensors with the center are calibrated based on the current surrounding conditions like atmospheric pressure temperature and altitude [1]. On the other hand tuning of the flight controller is based on the PID values which is the PID constants KP ki KD these constant must be tune perfectly in order for the PID to be effective in stabilizing the drone to the ground plane[20].

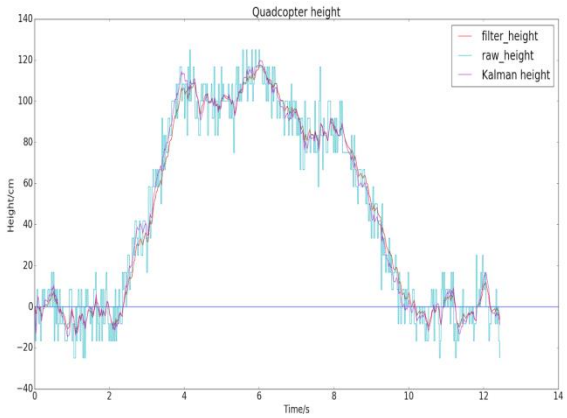


fig.no 2.9 graph showing the response of filter height and kalman height

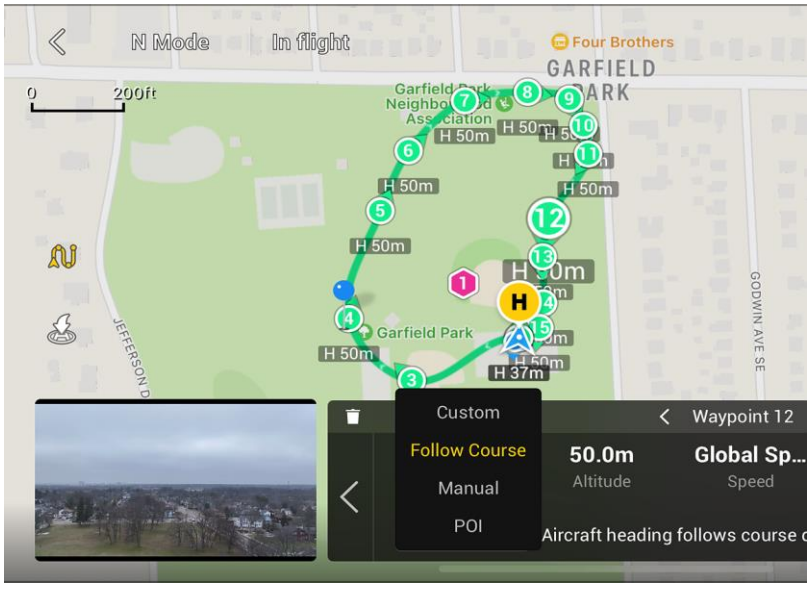
Various filters like the kalman filter are applied to the accelerometer and gyroscope velm values received from the IMU sensor in order to reduce the noise in the readings and prevent any mis-calculations in the PID calculation hence preprocessing the sensor data is highly essential [1]. Ziegler Nichols tuning method is one of the most popular tuning methods used for tuning the PID values for the flight controller[20].

2.7.

Software and flight plan

software is required for programming the flight controller in order to read the data received from the telemetry system to move the drone in a trajectory as planned by the user this coordinates are transmitted by the user to the drone and the flight controller moves the drone in the required coordinate trajectory to complete the flight plan one after another. A software is required to transmit and receive the data to the drone from the user and this software is used to command the telemetry system and transmit the data to the drone similarly in the hardware programming of the flight controller[2].

fig.no 2.10 Sample of waypoint co-ordinates for autonomous flight



2.8.Simulation

These parameter for PID logic development and stabilization logic development can be implemented on simulation softwares where a real life scenario can be simulated in a development environment like ROS that is Robot operating system can be used to simulate and formulate the necessary PID logic and to calculate the necessary PID raw values which can be for the tune in physical tuning this simulation provides the user with an estimated value for the flight stabilization and prevent any mishappening during physical testing[5][1].

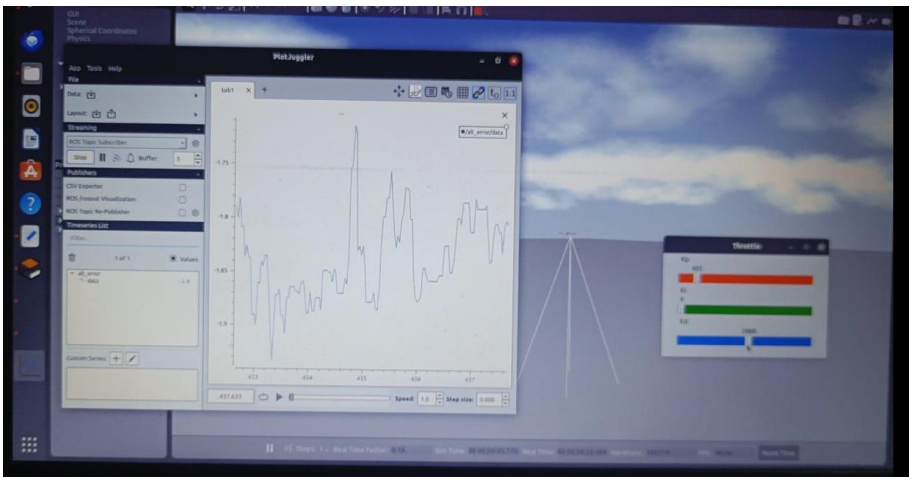


fig.no 2.11 Simulation Output on ROS and Gazebo

In our research we have implemented this logic on a stm 32f103c8t6 microcontroller. As it provides a high operating clock frequency of 70 Mhz and high reliability in terms of operation.

2.9.

Working

In a custom flight controller, a hardware test function incorporated with start-up calibration of gyroscope and accelerometer values as the inertial measurement units(IMU) is sensitive sensors and the readings change based on the change in the temperature, with constant calibration values the flight controller may lose control and cause severe damages[20]. flight controller initiates rule check where it checks the connection with the transmitter module and then checks the sensor availability and sensor response after successful detection of all the sensors it initiates sensor calibration for IMU, gyroscope and acceleration also for the barometer it takes the reference reading of current altitude by reading the atmospheric pressure before takeoff and stores this as a reference point after this the flight controller waits for reliable reading from the GPS module which take some time to provide accurate coordinates location[22].

The onboard LED is used to indicate all these stages of rule checks, in the case of any sensor failure the onboard LED can indicate to the user that the sensor is faulty or there is an error during the rule check and hardware check. The rule check does not allow the user to arm the drone until all the rule checks are satisfied. Rule checks act as the first layer of security to prevent any mishappening during the drone operation. In case after arming there is connection loss or sensor failure the drone shall return to the home position at which it started on takeoff[7]. This system is called failsafe and incorporates the return to home feature. The telemetry system can also trigger the return to home system by the handheld transmitter in case of urgency or emergency[18].

In an ideal working scenario when the design rule is checked and the censors are working properly, the drone will start an indicated ready-to-fly indicator through the onboard LED once the drone is earned the telemetry system then wait for the coordinates to be transmitted according to the flight plans. Users can monitor the drone's real-time coordinates by the telemetry system. Once the flight plan is successfully executed the drone will automatically return to the home position which is the takeoff position[18].

A custom flight controller can be programmed to fly autonomously for other agriculture and surveillance activities like livestock management/monitoring and resource surveillance[21][6]. Application of custom flight controllers in the domains of surveillance can save lots of human life and improve time to tackle these surveillance activities[12]. In the agricultural domain it prevents the involvement and infection from harmful pesticides to humans by reducing human involvement in agriculture spraying activities.

Results And Discussion

3.1.Results

The key findings in this research was a custom flight controller compared to a traditional of the self controller requires less hardware and requires less operation time also is highly efficient and robust while completing the specific activity as it is customized according to the application area that is agriculture and surveillance activities in this case on the other hand and of the shell flight controllers requires another mediating controller which operates and reads the receiver data and then sends appropriate control signals to the flight controller which is a cost clear approach to solve the problem hence developing custom flight controller results in faster and cost efficient application of drone application in the fields of agriculture and

surveillance. According to the requirement of the activity the flight controller can be customized and programmed according to the required sensors and prevent any unnecessary calculation and computations during the completion of the activity. This custom flight controller provides the user with the ability to customize the flight trajectory and flight algorithm according to the application needs

As well as the implementation of various failsafe functions like return to home and sensor calibration on startup helps improve the overall system accuracy and reliability.

3.2.Discussion

This custom flight controller enables the manufacturer in areas where there are certain ban on import of drone components / hardwares. to promote in-house custom flight controller hardware to facilitate and improve the production of UAV in countries where these bans are imposed. In India a ban was imposed on import of drones in India with immediate effect on 10th February 2022

Our research tackles the current demand of customized drone components required for the development of UAV in the field of agriculture and surveillance[12]. Also supports the requirement of customized flight controllers for industrial applications.

Conclusion:

Our main objective in this research was to find evidence of the benefit of a custom flight controller over off the shelf flight controller in an unmanned aerial vehicle application for agriculture and surveillance[11]. In this paper we conclude that application of customize flight controller can boost the efficiency and improves the production cost for manufacturing these components for specific drone applications in the field of agriculture and surveillance. The key finding of this paper is off the shelf flight controller use excessive hardware requirement and less programmability to specific application causes extra hardware application and less control over the overall application of drone technology in specific activities in the domain of agriculture and surveillance.

We found that custom flight controller provide improved precision and efficiency in agriculture operations enhanced data collection and analysis for surveillance activities.

Further advancement in custom flight controllers can be aided by the emerging technology in the domains of AI and machine learning to further support the autonomous custom flight controller.

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Experimental Investigation of corrosion and wear behaviour of AL 7075 alloy reinforced with Silicon Carbide (Sic) and Aluminium Oxide (Al2O3)

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Abstract:
This review paper provides a comprehensive analysis of the manufacturing processes, properties, and applications of aluminium metal matrix composites (AMMCs), with a specific focus on AL 7075 alloy reinforced with Silicon Carbide (Sic) and Aluminium Oxide (Al2O3). The paper discusses various processing techniques for AMMCs, highlighting their advantages and limitations. It also explores the recent developments and applications of AMMCs, emphasizing the need for innovative manufacturing techniques to meet the evolving demands of industries such as automotive and aerospace.

Additionally, the review addresses challenges in material cost, processing techniques, reinforcement costs, machining, and recycling. By examining the mechanical and wear properties of AL 7075-based composite. This investigation contributes to the understanding of how reinforcement with ceramic particles can enhance the properties of aluminium alloys for applications requiring resistance to corrosion and wear. this paper aims to contribute to the ongoing research in the field and provide insights for future studies.

Keywords:*Aluminium metal matrix composites, AL 7075 alloy, Silicon Carbide, Aluminium Oxide, mechanical properties, stir casting, industrial applications.*

Introduction:

Metal matrix composites (MMCs), as their name suggests, feature a metal material as the primary matrix. These composites utilize various matrices such as aluminum, magnesium, titanium, etc. The reinforcements incorporated may consist of silicon carbide, aluminum oxide, boron carbide, carbon fiber, glass fiber, among others. The primary purpose of these composites is to offer advantages over their monolithic counterparts. Key benefits include enhanced mechanical strength and reduced material density. The development of top-quality and high-strength aluminum is of paramount importance in the aviation and automotive industries. Aluminum finds extensive applications in electronic packaging, aircraft structures, components of internal combustion engines, and power transmission towers.

Hybrid Aluminium metal matrix composite (HAMMC) materials present a compelling alternative to conventional materials due to their improved hardness, specific strength, and resistance to creep. According to the findings from the literature review, one may consider employing the Al7075 matrix reinforced with silicon carbide (SiC) and alumina (Al2O3) particles for various automotive and aerospace applications. These include pistons, camshafts, brake components, bearing surfaces, and cylinder liners in automobiles, as well as wing and fuselage sections of aircraft structures, internal components of aerospace engines, and exhaust systems. Silicon carbide (SiC) is a robust ceramic material known for its exceptional hardness, high thermal conductivity, and excellent abrasion resistance. It serves as a vital reinforcement in metal matrix composites, enhancing their mechanical properties and wear resistance. In applications ranging from automotive components to aerospace structures, SiC contributes significantly to the performance and longevity of composite materials.

Aluminium oxide (Al2O3), also known as alumina, is a durable ceramic material prized for its high hardness, corrosion resistance, and thermal stability. Widely used as a reinforcement in metal matrix composites, Aluminium oxide enhances mechanical properties such as strength and wear resistance. Its versatility and reliability make it indispensable in applications spanning automotive engineering to aerospace technology, ensuring enhanced performance and durability in composite materials.

Aluminium alloy 7075 is renowned for its exceptional strength-to-weight ratio, making it ideal for aerospace and high-stress applications. With a tensile strength of around 570 MPa and yield strength of approximately 505 MPa, it offers

impressive toughness and fatigue resistance. Additionally, it boasts good machinability and corrosion resistance, further enhancing its suitability for demanding environments.

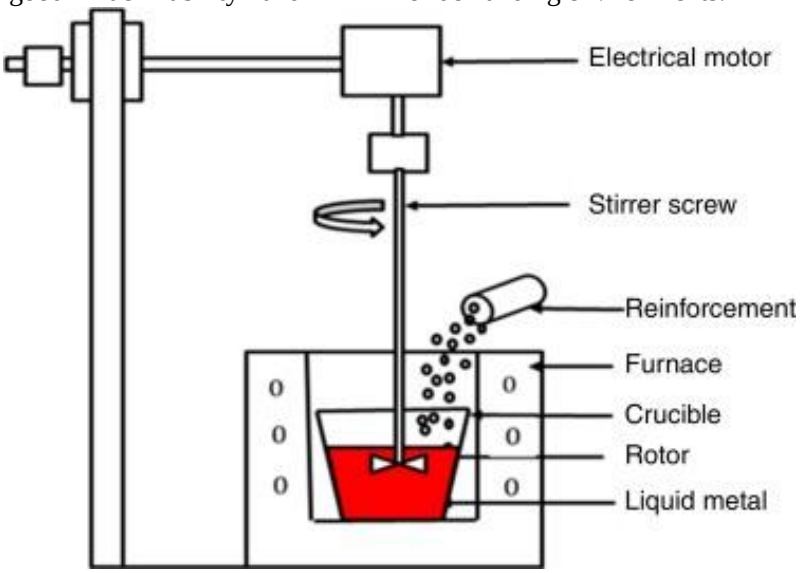

Fig 1. Schematic of Stir casting

Stir casting is a metal casting process that involves stirring molten metal with dispersed particles to create composite materials. Typically conducted at temperatures below the melting point of the reinforcement material, it ensures uniform distribution of particles. This method is versatile, allowing for the incorporation of various reinforcements like ceramics or fibers into the metal matrix. Stir casting facilitates the production of metal matrix composites with enhanced mechanical properties such as strength, stiffness, and wear resistance. It is widely used in industries such as automotive, aerospace, and electronics for manufacturing components with tailored properties.

Aluminium alloy 7075 finds extensive industrial applications in aerospace components, such as aircraft structures and fuselages, due to its high strength-to-weight ratio. It is also utilized in automotive components like chassis and engine parts for its excellent fatigue resistance and durability. Additionally, Al7075 is employed in bicycle frames and sporting equipment where lightweight, yet robust materials are required for optimal performance.

Literature Review

1) The study by **Rajesh A. M. and Mohammed Kaleemulla** investigates the mechanical behavior of aluminum metal matrix composites. These composites aim to combine the desirable attributes of metals and ceramic within the base metal. Specifically, the researchers developed an aluminum metal matrix hybrid composite by reinforcing Aluminium 7075 alloy with silicon carbide (SiC) and aluminum oxide (alumina) using the stir casting method.

2) The study by **Roy, Singh, and Pal** investigates the mechanical and tribological properties of SiC- and CB-reinforced Aluminium 7075 hybrid composites. Through friction stir processing, they achieved a remarkable 2.5 times increase in ultimate tensile strength and improved wear resistance. These findings have significant implications for engineering applications.

3) The research by **Suryakumari and Ranganathan** explores the wear behavior of aluminum hybrid composites. Their study, published in Materials Today Proceedings, investigates the mechanical properties and tribological performance of these composites. The findings contribute valuable insights for engineering applications and material design.

4) The study conducted by **Rajesh A. M.** and **Mohammed Kaleemulla** focuses on the mechanical behavior of aluminum metal matrix composites. They investigated the properties of these composites, specifically using Aluminium 7075 alloy reinforced with silicon carbide (SiC) and aluminum oxide (alumina). The research provides valuable insights into the potential applications of these composites in engineering and manufacturing .

5) The study by **Moona, Walia, Rastogi, and Sharma** investigates the fatigue behavior of hybrid aluminum metal matrix composites. Through parametric optimization, they explored the influence of different process parameters on fatigue life. The hybrid composites exhibited significant enhancement in fatigue resistance, with the highest number of load cycles achieved by a specific composition of Al 7075-T6 base metal reinforced with eggshell particles, SiC particles, and Al2O3 particles. These findings contribute valuable insights for engineering applications

6) The research conducted by **Dong, Chen, Liu, and colleagues** investigates the microstructure and microhardness of hot extruded 7075 aluminum alloy micro-gears. Their study explores the effects of extrusion temperature, extrusion velocity, and lubrication conditions on the formability and material properties of these micro-gears. The findings contribute valuable insights for engineering applications and the development of novel production methods for micro-scale components

7) The study by **Raturi, Mer, and Pant** investigates the mechanical, tribological, and microstructural behavior of Al 7075 metal matrix composites reinforced with nano aluminum oxide (Al2O3) particles. Using the double stir casting process, they explored different weight percentages (0%, 3%, 5%, and 7%) of nano Al2O3. The results indicate that increasing the nano particle content enhances mechanical properties but may lead to increased porosity. Additionally, sliding wear resistance improves with higher nano particle content, while SEM and optical microscopy reveal microstructural details.

8) The research by **Surappa, Uyyuru, and Brusethaug** investigates the tribological behavior of Al-composite/brake pad tribocouples. Their study explores the impact of reinforcement volume fraction and size distribution on wear characteristics. The findings contribute valuable insights for understanding the performance of these composite materials in braking systems.

9) The review by **Deuis, Subramanina, and Yellup** examines the dry sliding wear behavior of aluminum composites. Their study, published in Composites Science and Technology, delves into the effects of reinforcement volume fraction and size distribution on wear characteristics. These findings contribute valuable insights for understanding the performance of these composites in various applications.

10) The research by **Radhika, Subramanian, and Venkat Prasat** investigates the tribological behavior of aluminum/alumina/graphite hybrid metal matrix composites using Taguchi's techniques. Their study explores the influence of design parameters on dry sliding wear. The results provide valuable insights for optimizing the wear resistance of these composites in engineering applications.

11) The study by **Radhika, Subramanian, and Venkat Prasat** investigates the dry sliding wear behavior of aluminum/alumina/graphite hybrid metal matrix composites. Using Taguchi's techniques, they explore the influence of design parameters on wear properties. The findings contribute valuable insights for optimizing wear resistance in engineering applications.

12) The study by **Doddamani, Kaleemulla, Begum, et al.** investigates the wear behavior of graphite-reinforced aluminum metal matrix composites. They prepared specimens using the stir casting method with varying graphite content (ranging from 3% to 9% by weight). Under dry sliding conditions, they evaluated the tribological behavior in terms of coefficient of friction and wear rate. The results suggest that these composites have the potential to act as self-lubricating materials

13) The research conducted by **Rajesh A. M.** and **Mohammed Kaleemulla** focuses on the mechanical behavior of aluminum metal matrix composites. Specifically, they investigated the properties of Aluminium 7075 alloy reinforced with silicon carbide (SiC) and aluminum oxide (alumina) using the stir casting method. Their findings contribute valuable insights for engineering applications and material design .

14) The research by **Li and Bhushan** investigates the micromechanical and tribological characterization of hard amorphous carbon coatings as thin as 5 nm for magnetic recording heads. Their study, published in the journal Wear, delves into the mechanical properties, friction behavior, and wear resistance of these ultrathin coatings. The findings contribute valuable insights for understanding the performance of these coatings in magnetic storage systems

15) The research by **Rajesh A. M.**, **Mohammed Kaleemulla**, and **Saleemsab D.** investigates the wear behavior of hybrid aluminum metal matrix composites. They studied the influence of adding silicon carbide (SiC) and aluminum oxide (Al2O3) as reinforcements. The results indicate that these hybrid composites exhibit improved wear resistance compared to unreinforced aluminum alloy. These findings contribute valuable insights for engineering applications and material design.

Conclusion:

The research on aluminum metal matrix composites (AMMCs) by various scholars has provided valuable insights into their mechanical behavior, wear resistance, and tribological characteristics. These studies highlight the advantages of incorporating materials like silicon carbide (SiC) and aluminum oxide (Al2O3) in enhancing the properties of AMMCs. The findings underscore the potential of AMMCs in diverse engineering applications, offering improved corrosion resistance, wear behavior, and mechanical strength.

Further research in this area is essential for advancing the development and utilization of these hybrid composites. The future scope of aluminum metal matrix composites (AMMCs) lies in continued research and development to optimize their properties and applications. Innovations in manufacturing techniques, such as stir casting and friction stir processing, will further enhance the

performance of AMMCs in terms of corrosion resistance, wear behavior, and mechanical strength. The integration of advanced reinforcements like silicon carbide (SiC) and aluminum oxide (Al2O3) will play a crucial role in expanding the capabilities of AMMCs for diverse engineering sectors. Collaborative efforts between researchers, industries, and academia will drive the evolution of AMMCs towards more efficient and sustainable solutions for future applications .

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Ramification of the steam treatment on density and hardness of sintered parts

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Abstract:

The hardness and density of sintered parts are critical properties that can significantly impact the performance and functionality of the final product. Sintering is a manufacturing process where powdered materials are compacted and heated to bond the particles together.

Keywords:*Hardness, density, sintered parts, sintering, manufacturing process*

Introduction

Normally parts having required dimensions are manufactured by machining. Also, hot or cold casting, molding, turning etc. process are followed for component manufacturing. Some parts having critical shape are not possible for machining and they cannot easily melt or cast. To overcome these mentioned disadvantages new process introduced is called as powder metallurgy. Powder metallurgy is special process of component manufacturing.

Ease Of Use

A. Definition of Powder Metallurgy

Powder metallurgy is process of forming components by combining metal as well as non-metal powders.

Science of producing components by mixing metallic and non-metallic constituents with or without addition of lubricants.

B. Mechanical Properties of Powder Metallurgy Parts

There are 4 main mechanical properties which are considered during formation of parts by powder metallurgy

1. Hardness: - Because of porosity in parts hardness of powder metallurgy components is less. It will not be uniform if density of varies at different locations.
2. Strength: - Because of only grains bonded together so strength of powder metallurgy parts is low.
3. Ductility: - Because of porous structure of components it has low ductility it is increased by sintering process.
4. Dampness: - Powder Metal parts have good dampness property so they absorb vibrations.

Types Of Sintering Techniques

Sintering is a thermal process of converting loose fine particles into a solid coherent mass by heat and/or pressure without fully melting the particles to the point of melting. Most of the four types of sintering techniques currently being investigated.

a. Conventional pressure less sintering:
It is the simplest form of sintering. It is also known as pressure less sintering. In this process heat treatment of compact is done after prepared specimen at ambient temperature without any external pressure applied on it during sintering.

b. Spark Plasma Sintering (SPS) or Pulsed Electric Current Sintering (PECS):
It is also called as pressure assisted pulse energizing process. It is a synthesis as well as it is a processing technique which makes possible sintering and bonds developed by it at low temperature

c. Hot pressing:
It involves a high pressure as well as low strain rate powder. It involves the application of the uniaxial pressure.

d. Microwave sintering:
It involves shorter processing time and also grasping sintering temperature more quickly. This method is mostly used to produce ceramic components.

e. Laser Sintering:
In laser sintering we use laser source to provide thermal energy to selectively fuse particles together to make powder matrix with shape of complex structure.

A. *Abbreviations and Acronyms*

H2O – Hydrogen Oxide (Water), Fe – Iron, H2 -

Hydrogen Fe3O4 – Magnetite or Iron Oxide

B. *Units*

°C – Degree Celsius

°F – Degree Faren height Ppm -Parts per meter

μm – Micrometres

C. *Methodology*

Steam treating is performed on ferrous parts through a deliberate addition of steam (H2O) into a tightly sealed heat-treating furnace in the temperature range of 315-540°C (600-1000°F) so as to ensure that only Fe3O4 (magnetite) is formed on the surface. The following oxidizing reaction takes place at the surface of the parts:

3Fe + 4H2O (g) <> Fe3O4 + 4H2 (g)

Many P/M parts are processed in furnaces exposed to superheated (e.g., 160°C/320°F steam) at a temperature around 550°C (1020°F). The oxide layer formed is typically 5-7μm (0.00020-0.00028 inch) thick on the surface with interconnected subsurface porosity. Fe3O4 is stable and tenacious, forming a bluish or bluish-black surface layer that does not easily break down. Ferrous parts are typically heated in the 315-375°C (600-700°F) range before steam introduction, while for nonferrous parts this value is around 150°C (300°F). Purging of the furnace with steam then takes place to an oxygen level less than 1% (10,000 ppm), typically around 0.1% (1,000 ppm).

This step must be complete before the temperature exceeds 425°C (800°F) for ferrous parts. A dew point in the furnace of +15°C (+60°F) or higher is typical. After soaking, parts are cooled in steam to an intermediate temperature before removal or rapid quenching finishes the cycle. Steam treatment is reportedly most effective on parts with a maximum carbon content of 0.5-0.8%. Dew point +15 and oxygen below 1% before 425 degrees is key. We have to take care that if we make Fe3O2 it is rust.

Ferrous parts are typically heated in the 315-375°C (600-700°F) range before steam introduction, while for nonferrous parts this value is around 150°C (300°F). Purging of the furnace with steam then takes place to an oxygen level less than 1% (10,000 ppm), typically around 0.1% (1,000 ppm). This step must be complete before the temperature exceeds 425°C (800°F) for ferrous parts. Before 425-degree part temperature we need no oxygen.

For this steam treatment trial or study purpose we two types of powder which are produced by atomization method and also, they have 100 grain size which is suitable for getting or produce high density parts which are used in automotive industries. We take three trials. In this trial we used different temperature cycles for different time span. And we use nitrogen as a external agent which helps to develop Fe3O4 layer on sintered components. After these three trials we observed that hardness and density of sintered parts is more after steam treatment than parts before steam treatment. i.e., hardness as well as density of sintered parts also increases after steam treatment.

To study ramification of furnace temperature while loading on density and hardness of iron sintered parts

Studying the ramifications of furnace temperature during loading on the density and hardness of iron sintered parts involves investigating the impact of various sintering conditions on the final properties of the components. Here are key considerations for such a study:

1.	**Sintering Temperature:**	
	• **Density:**	The sintering temperature significantly affects the density of iron sintered parts. Higher
		temperatures generally lead to better particle bonding and increased density. However, excessively high temperatures may also result in grain growth and other undesired effects.
	• **Hardness:**	Sintering temperature influences the microstructure of the iron matrix. An optimum temperature can enhance the hardness by promoting the formation of a dense and well-bonded structure.
2.	**Heating Rate:**	
	• **Density:**	The rate at which the furnace temperature increases (heating rate) can impact the density. A
		controlled heating rate allows for proper diffusion and particle rearrangement, contributing to higher density.
	• **Hardness:**	The heating rate can influence the kinetics of phase transformations and diffusion, affecting the final microstructure and, consequently, the hardness of the sintered parts.
3.	**Holding Time**	:
	• **Density:**	The holding time at the peak sintering temperature allows for sufficient particle bonding and

		densification. Too short a holding time may result in incomplete sintering, leading to lower density. • **Hardness:** Adequate holding time is crucial for achieving the desired microstructure and hardness. Insufficient holding time may result in incomplete diffusion and insufficient bonding between particles.
4.	**Cooling Rate:**	
	• **Density:**	Controlled cooling rates are important for minimizing thermal stresses and ensuring the integrity of the sintered parts. Rapid cooling may introduce defects and reduce density.

A systematic experimental approach, including factorial design or response surface methodology, can be employed to analyze the combined effects of these parameters on the density and hardness of iron sintered parts. Additionally, microstructural analysis techniques such as metallography and hardness testing can provide insights into the material properties at different sintering conditions.

While steam pressure is not a conventional parameter in the sintering process, it seems you may be referring to a unique or specific sintering method involving steam. If you are indeed exploring a novel or specialized technique, it's essential to consider the potential ramifications of steam pressure on the density and hardness of iron sintered parts. Below are hypothetical considerations:

To study ramification of steam pressure on density and hardness of iron sintered parts

1. **Steam Sintering Process:**
   - **Density:** Steam pressure may influence the compaction and densification of iron powder during sintering. Higher steam pressure might enhance particle bonding, leading to increased density in the final sintered parts.
   - **Hardness:** The steam environment could affect the microstructure of the iron matrix. Controlled steam pressure may contribute to a more uniform and refined structure, potentially impacting the hardness of the sintered parts.
2. **Effect on Porosity:**
   - **Density:** Steam, being a vapor, can penetrate the powder bed and assist in reducing porosity. Higher steam pressure may lead to a more effective elimination of voids between particles, contributing to higher density.
   - **Hardness:** Reduced porosity often correlates with increased hardness. If steam pressure contributes to a denser structure with fewer pores, it may positively affect the hardness of the sintered iron parts.
3. **Sintering Atmosphere and Oxidation:**
   - **Density:** Steam may act as a reducing agent, mitigating oxidation during the sintering process. Minimizing oxidation can promote better particle bonding and higher density.
   - **Hardness:** Oxidation can affect the hardness of iron-based materials. A controlled steam atmosphere may help maintain the desired chemical composition and structure, influencing hardness.
4. **Temperature and Steam Pressure Relationship:**
   - **Density:** The interplay between sintering temperature and steam pressure is crucial. Higher temperatures may necessitate higher steam pressures for optimal results, and finding the right balance is essential for achieving the desired density.
   - **Hardness:** The combination of temperature and steam pressure can affect the kinetics of phase transformations and diffusion, influencing the microstructure and, consequently, the hardness of the sintered iron parts.
5. **Cooling and Quenching Effects:**
   - **Density:** Rapid cooling after steam sintering might impact the density of the final parts. Controlled cooling

rates are essential to avoid introducing defects or reducing density.

- **Hardness:** The cooling rate can influence the formation of specific phases and the resulting hardness. Proper control of cooling conditions is necessary to achieve the desired material properties.

It's crucial to note that the specifics of the steam sintering process, including the equipment, duration, and other parameters, will play a significant role in determining the outcomes. Experimental studies, controlled conditions, combined with microstructural and hardness analyses, can provide valuable insights into the effects on density and hardness of iron sintered parts in this unique processing environment.

Studying the ramifications of steam cycle time on the density and hardness of iron sintered parts involves exploring the effects of the duration for which steam is applied during the sintering process. The steam cycle time can influence various aspects of the sintering process, and understanding its impact is crucial for optimizing the properties of the final sintered parts. Here are considerations for such a study:

To study ramification of steam cycle time on density and hardness of iron sintered parts

1. **Densification and Particle Bonding:**
   - **Density:** The duration of the steam cycle may affect the extent of densification during sintering. Longer steam cycle times might allow for more effective particle bonding, contributing to higher density in the sintered parts.
   - **Hardness:** Improved densification resulting from longer steam cycle times could influence the microstructure of the iron matrix, potentially affecting hardness.
2. **Porosity Reduction:**
   - **Density:** Extended steam cycle times may contribute to a more thorough elimination of porosity within the powder bed. Reduced porosity is generally associated with higher density in sintered parts.
   - **Hardness:** Lower porosity often correlates with increased hardness. Longer steam cycles may promote a denser structure with fewer voids, positively impacting hardness.
3. **Temperature and Time Relationship:**
   - **Density:** The interplay between sintering temperature and steam cycle time is critical. Longer steam cycles may allow for better utilization of temperature, leading to enhanced densification and higher density.
   - **Hardness:** The duration of exposure to steam, coupled with temperature, can influence the kinetics of phase transformations and diffusion, affecting the microstructure and hardness of the sintered iron parts.
4. **Effect on Microstructure:**
   - **Density:** Prolonged steam exposure may contribute to a more refined and uniform microstructure by allowing for sufficient particle rearrangement and bonding.
   - **Hardness:** Microstructural changes resulting from longer steam cycle times could impact the hardness of the sintered parts. A more uniform and well-bonded structure may lead to improved hardness.
5. **Optimal Cycle Time:**
   - **Density:** There might be an optimal steam cycle time that maximizes densification without leading to undesirable effects such as excessive grain growth.

   Hardness: Balancing the steam cycle time with other parameters is crucial to achieving the desired hardness. Too short or too long a cycle time may result in suboptimal hardness.
6. **Cooling Phase:**

   DensityThe cooling phase following the steam cycle is essential. Controlled cooling rates are

: necessary to avoid introducing defects and to maintain the achieved density.

Hardness: Proper control of the cooling phase is crucial for achieving the desired microstructure and hardness in the sintered iron parts.

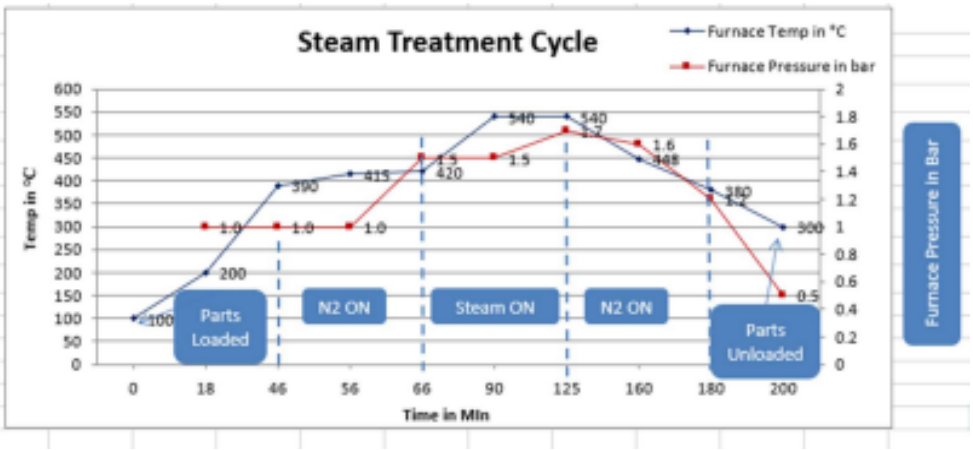
Experimental studies involving varying steam cycle times, along with thorough microstructural and hardness analyses, are essential for gaining insights into the effects on density and hardness of iron sintered parts. Additionally, statistical techniques such as design of experiments (DOE) can help optimize the sintering process by identifying the most influential parameters and their optimal ranges.

D. Figures and Tables

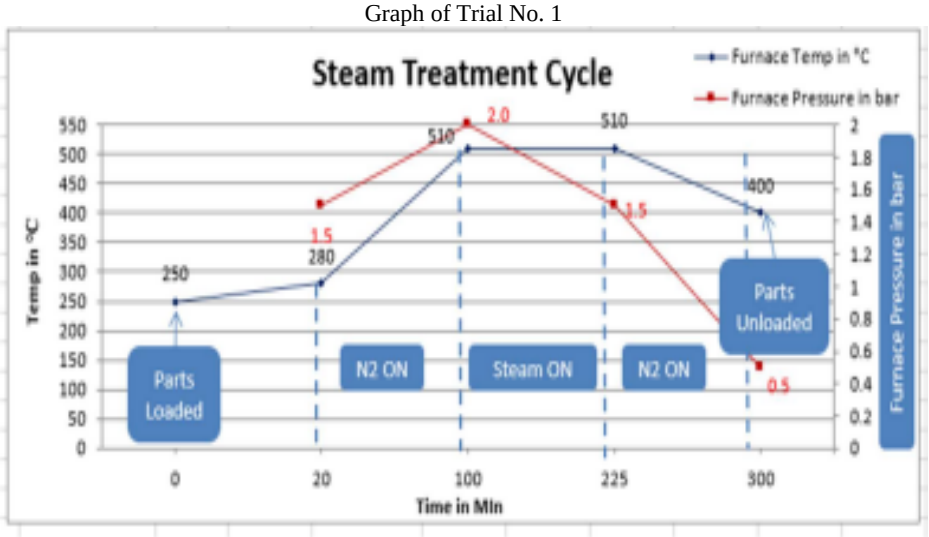
Below attached graphs and table gives us the information of steam treatment cycle trials taken by us.

Table I. Table Of Parameters And Trial

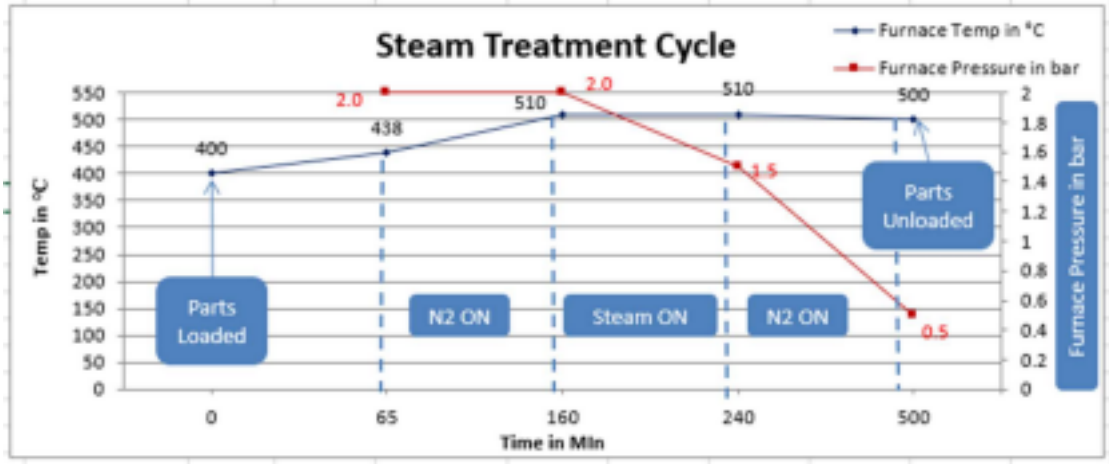
Sr. No.	Parameters	Standard	Trial 1	Trial 2	Trial 3
1	Furnace Temperature while loading (in degree)	100 - 430	100	250	400
2	Steam Pressure (in bar)	1.0 – 2.0	1.0	1.5	2.0
3	Steam Cycle Time (in min)	400	200	300	400
4	Soaking Time (in min)	30 - 120	40	80	120
5	Pressure of Nitrogen (in bar)	-	1.5	2.0	2.5
6	Furnace Temperature while unloading (in degree)	-	300	400	500



Graph of Trial No. 1



Graph of Trial No.2



Graph of Trial No.3

Acknowledgment

After these trials taken it is observed that, the following oxidizing reaction takes place at the surface of the parts:

$3Fe + 4H_2O (g) <> Fe_3O_4 + 4H_2 (g)$

This oxidation reaction is more important in steam treatment layer creation on component to protect it from corrosion if this reaction is not performed properly than Fe_3O_2 is developed and component gets rusty.

After our steam treatment trials, we observe the following points

1. It is mandatory to use nitrogen gas as agent for developing layer of Fe_3O_4 on component.
2. Properties of component like hardness as well as density increases after steam treatment.
3. Soaking period for component is more important for creating layer of Fe_3O_4.
4. Strength of components depending on the density as well as hardness of components
5. Change in density and hardness of sintered parts

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Role of the Corporate Sectors in an Environmental Protection & Sustainable Development of the Nation

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Abstract:

The present research paper is an attempt to study the role of corporate sectors in an environmental protection and various aspects regarding sustainable development, especially in India. This article seeks to explain various initiatives taken in the field of CSR by the different companies of India. "CSR refers to the obligations of businessmen to pursue those policies to make those decisions or to follow those lines of relations which are desirable in terms of the objectives and values of our society." During the last two decades, industries have been more or less taking efforts so as to protect the environment. Accordingly, reporting of the environmental issues have been finding place in the annual reports of the companies. But such environmental reporting is not found regularly in the annual reports of the Indian Companies. There is no purposeful accounting standard and standard definition while dealing with the environmental issues.

This study also shows that the companies which apply systems and practices to maintain and improve the quality of the natural environment in the long run can beneficial competitive advantage. This is not only because they can reduce costs by recycling and reusing but also because their reputation improves among their customers, which are the company's most important stakeholders. This research paper is also conclude that one of the most important ways that sustainable development reduces its environmental impact is by reducing our carbon footprint. All the objectives of this study have been successfully obtained.

Keywords*:* Sustainable Development, Environmental Issues, Harmful Effects, Four Pillars, SDGs, Business.

Introduction:

Environmental issues are the harmful effects of human activities on the environment. These include pollution, overpopulation, waste disposal, climate change, global warming, the greenhouse effect, etc.

Various environment protection programs are being practised at the individual, organizational and government levels with the aim of establishing a balance between man and the environment.

Product manufacture is an important stage in contributing to environmental performance. The design and development of high environmental performance products must be based on a certain number of action foundations, from materials management to eco-design. These environment-friendly products thus constitute energy-saving solutions and therefore contribute to sustainable development.

Environment and economy are interdependent and need each other. Hence, development that ignores its repercussions on the environment will destroy the environment that sustains life forms.

Need & Importance of the Study:

Sustainable development aims at promoting the kind of development that minimises environmental problems and meets the needs of the present generation without compromising the ability of the future generation to meet their own needs. And it is important that state entitlements for such issues should be improved.

The concept of sustainable development is based on a set of requirements. It must allow the basic needs of present and future generations to be fulfilled with regard to demographic constraints, such as: access to water, education, health, employment, and the fight against hunger or malnutrition. Another aim of this type of development is to improve quality of life, which involves easier access to medical care, social services, culture, and therefore also social well-being. In addition, respect for rights and freedoms and the promotion of new forms of renewable energy such as wind, solar, and geothermal power, are important aspects of sustainable development. Sustainable development must allow the planet's resources and condition to be protected for future generations and natural assets to be shared. The concept of sustainable development also involves narrowing the gaps

between rich and poor countries, insofar as these gaps, if maintained or accentuated, could be the cause of violent conflict, which by its very nature leads to regression rather than development.

Objectives:

1. To understand the concept of sustainable development.
2. To study the Various Environmental Issues which are the effected on human life.
3. To study the various types of sustainable development.
4. To inculcate the knowledge about the goals of sustainable development.
5. To understand the various challenges regarding environmental protection.

Hypothesis:

1. Environmental issues are the harmful effects of human activities on the environment.
2. Environmental issues are a warning of the upcoming disaster. If these issues are not controlled, there will soon be no life on earth.
3. Human sustainability aims to maintain and improve the human capital in society.
4. There is no purposeful accounting standard and standard definition while dealing with the environmental issues.

Research Methodology:

The Researcher has used the Primary and Secondary method of data collection. The primary sourced of data is collected by social and personal observations and also she has referred the reference books, articles and internet websites to collect the secondary data to analyse and conclude the research study.

Concept of Sustainable Development:

The concept of sustainable development can be interpreted in many different ways, but at its core is an approach to development that looks to balance different, and often competing, needs against an awareness of the environmental, social and economic limitations we face as a society. "Sustainable development is development that meets the needs of the present, without compromising the ability of future generations to meet their own needs." Sustainability is the foundation for today's leading global framework for international cooperation—the 2030 Agenda for Sustainable Development and its Sustainable Development Goals.

The Four Pillars of Sustainability:

The term sustainability is broadly used to indicate programs, initiatives and actions aimed at the preservation of a particular resource. However, it actually refers to four distinct areas: human, social, economic and environmental – known as the four pillars of sustainability. Introducing the four pillars of sustainability; Human, Social, Economic and Environmental; as follows:

1. Human Sustainability:

Human sustainability aims to maintain and improve the human capital in society. Investments in the health and education systems, access to services, nutrition, knowledge and skills are all programs under the umbrella of human sustainability. Natural resources and spaces available are limited and there is a need to balance continual growth with improvements to health and achieving economic wellbeing for everyone.

2. Social Sustainability:

Social sustainability aims to preserve social capital by investing and creating services that constitute the framework of our society. The concept accommodates a larger view of the world in relation to communities, cultures and globalisation. It means to preserve future generations and to acknowledge that what we do can have an impact on others and on the world. Social sustainability focuses on maintaining and improving social quality with concepts such as cohesion, reciprocity and honesty and the importance of relationships amongst people.

3. Economic Sustainability:

Economic sustainability aims to maintain the capital intact. If social sustainability focuses on improving social equality, economic sustainability aims to improve the standard of living. In the context of business, it refers to the efficient use of assets to maintain company profitability over time.

4. Environmental Sustainability:

Environmental sustainability aims to improve human welfare through the protection of natural capital (e.g. land, air, water, minerals etc.). Initiatives and programs are defined environmentally sustainable when they ensure that the needs of the population are met without the risk of compromising the needs of future generations.

The principle of the four pillars of sustainability states that for complete sustainability problems to be solved in relation to all four pillars of sustainability and then need be maintained. Although in some cases these may overlap, it is important to identify the specific type of green business to focus on, as the four types present unique characteristics. Businesses need to make a strategic decision about it so as to effectively incorporate the chosen approach into their policies and procedures.

Sustainable Development Goals:

The **Sustainable Development Goals (SDGs)** are a collection of 17 interlinked global goals to transform our world. They were designed to be a "blueprint to achieve a better and more sustainable future for all" and part of the United Nations 2030 Agenda for Sustainable Development.

They were agreed by 193 countries in September 2015. They are as follows:

1. To end poverty in all its forms everywhere.
2. To end hunger, achieve food security and improved nutrition and promote sustainable agriculture.
3. To ensure healthy lives and promote well-being for all at all age.
4. To ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
5. To achieve gender equality and empower all women and girls
6. To ensure availability and sustainable management of water and sanitation for all
7. To ensure access to affordable, reliable, sustainable and modern energy for all
8. To promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
9. To build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation
10. To reduce inequality within and among countries
11. To make cities and human settlements inclusive, safe, resilient and sustainable
12. To ensure sustainable consumption and production patterns
13. To take urgent action to combat climate change and its impacts
14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development
15. To protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
16. To promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development. Etc.

Challenges:

In the field of sustainable development, there are many major challenges to be addressed. They require us to re-think our economy and our growth in favour of a society that is more economical in its use of raw materials and energy. Some of these challenges include: climate change, energy consumption, waste production, threats to public health, poverty, social exclusion, management of natural resources, loss of biodiversity, and land use. In this context, sustainable development approaches are now essential obligations.

Energy and the preservation of resources are currently at the heart of the international debate on sustainable development. Energy occupies a major role in the alleviation of poverty and the construction of sustainable development. This is a basic aspect of the physical and natural world and humanity's socio-economic systems.

Solutions to Environmental Issues:

Following are some of the most common solutions to the environmental issue:

1. Replace disposal items with reusable items.
2. The use of paper should be avoided.
3. Conserve water and electricity.
4. Support environmental friendly practices.
5. Recycle waste to conserve natural resources.

Environmental issues are a warning of the upcoming disaster. If these issues are not controlled, there will soon be no life on earth.

Conclusion:

Sustainable development aims at promoting the kind of development that minimises environmental problems and meets the needs of the present generation without compromising the ability of the future generation to meet their own needs. Energy and the preservation of resources are currently at the heart of the international debate on sustainable development. Promotion of natural resources, conservation, preserving regenerative capacity of ecological system and avoiding the imposition of environmental risks on future generations would lead to sustainable development. One of the most important ways that sustainable development reduces its environmental impact is by reducing our carbon footprint. It is also found that there is no purposeful accounting standard and standard definition while dealing with the environmental issues.

Suggestions:

1. We have to first understand the significance and contribution of environment to economic development.
2. Businesses need to make a strategic decision about it so as to effectively incorporate the chosen approach into their policies and procedures.
3. Natural resources and spaces available are limited and there is a need to balance continual growth with improvements to health and achieving economic wellbeing for everyone.
4. There is no purposeful accounting standard and standard definition while dealing with the environmental issues

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Solar Photovoltaics Roof Top Installation -A Case Study

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Abstract:

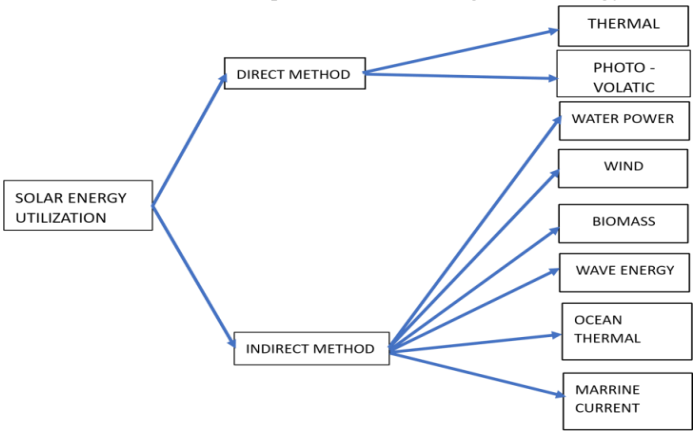
When it comes to supplying the electrical needs of residential or commercial structures, solar energy is more alluring than other renewable energy sources because of its simplicity of installation, affordability, and decreased dependency on the field. Sunlight can be harvested using photovoltaic (PV) systems, which can be installed on rooftops, in the ground, or integrated into structures. Because rooftop PV systems are easy to install and don't require any exterior space, their use has grown in popularity in recent years. On the other hand, there are concerning consequences of growing penetration of PV in the distribution network. The power network is experiencing issues with voltage quality due to power loss, reverse power flow (RPF), voltage oscillations, and voltage imbalance. However, changes in power quality are being caused by harmonics, power factor, and system frequency. Excessive PV penetration negatively impacts the protection system and is the primary source of voltage stability. This article's goal is to thoroughly investigate how rooftop solar energy affects distribution networks and assess potential mitigation strategies regarding quality of power and voltage, system stability, and protection with the consideration of a case study. A comparison of the benefits and drawbacks of the various solution approaches will also be presented, along with an analysis of the approaches that address optimization and strategies based on artificial intelligence, deep learning, and machine learning in contrast to typical approaches.

Keywords ***:Non-conventional energy sources, solar energy, rooftop photovoltaic, renewable energy*.**

Introduction:

The amount of solar energy that the world receives from the sun is around 1.8×1011 MW, which is far more than what is currently consumed [1]. Thus, solar energy is one of the most dependable energy sources as it can continuously supply all of the energy needs for the now and the future. It is a clean energy source as well. India has a lot of potential for solar energy. The nation experiences 300 sunny days annually on average, and its average radiation per hour is 200 MW/KM^2 [2]. By establishing a feedin-tariff framework and creating precise regulations, the Jawaharlal Nehru National Solar Mission (JNNSM) has greatly benefited the sector [3]. The Mission has set a goal to construct 20GW of CSP and solar PV generating capacity during the next ten years. A number of state governments, including those in Gujarat and Rajasthan, also have plans in place to increase the generation of solar energy in the upcoming ten years.

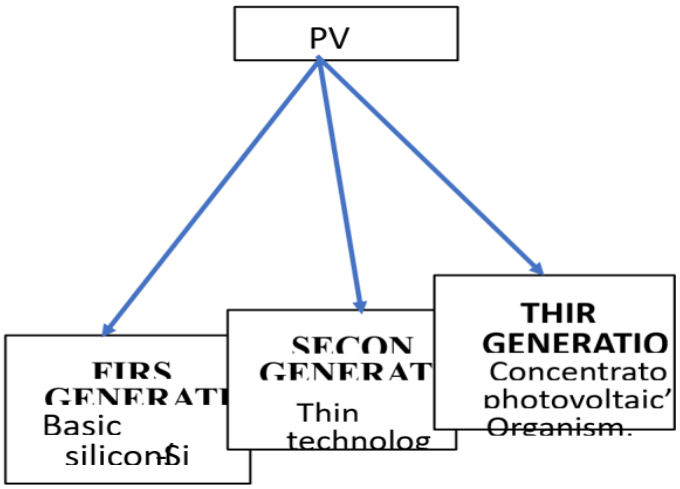
A comprehensive categorization of diverse techniques for harnessing solar energy.



[Fig. 1. Classification of methods of solar energy Utilization]

1.1 Photo Voltaic Technology

Solar cells, also known as photovoltaic (PV) cells, are composed of semiconductors, which are unique materials such as silicon, which is now the most often utilized. In essence, a portion of the solar energy that strikes the solar cell is absorbed by the semiconductor material. Now that the semiconductor is filled with energy, the electrons are knocked loose and are free to move about. An electrical current is this flow of electrons. The power (or wattage) that the solar cell may generate is determined by this current in conjunction with the voltage of the cell, that is a function of this internal electric fields [4]. This PV technology categorization is displayed in Figure 2.



[Fig. 2. Classification of PV technologies]

1.2 Crystalline silicon

Owing to their high efficiencies, first generation solar cells are the most established and widely utilized technological kind. On wafers, the first generation of solar cells are made. Every wafer has a 2w-3w power capacity. Solar modules, which are made up of several cells, are used to boost power. First-generation solar cells often come in two varieties, as the list illustrates. Their degrees of crystallization distinguish them. It is referred to as a single crystal solar cell if the entire wafer is made of only one crystal. A wafer is referred to as a multiscriptal solar cell if it contains crystal grains. The borders between the grains on the solar cell are visible to everyone. While monocrystalline solar cells have a better efficiency than multiscriptal solar cells, the manufacturing of Cheaper and simpler is the multiscriptal wafer. They therefore face competition from monocrystals [5].

1.3 Thin film

Thin-film solar cells are a type of second-generation solar cell. Their costs are lower than those of the first generation, even if their efficiency is lower. They also have an edge in terms of aesthetics. Thin-film solar cells are considerably more suitable for integration into windows, automobiles, buildings, and other structures since there are no fingers in front of them for metallization. Moreover, these thin films can be developed on pliable surfaces. Therefore, foldable gadgets and textile items may use second-generation solar cells. Thin-film solar cells have the benefit of being able to develop across vast regions up to 6 m2. Wafer-based solar cells, however, can only be generated according to wafer dimensions. Amorphous Si (a-Si)-based thin films solar cells, Cadmium Telluride/Cadmium Sulphide (CdTe/Cds) solar cells, and Copper Indium Gallium Selenide (CIGS) solar cells are examples of second-generation solar cells [5]

1.4. Concentrator PV

Third Generation Solar Cells are new and promising technologies that have not yet been demonstrated to be profitable. Desensitized and concentrated solar cells are the most advanced forms of third-generation solar cells [6]. The basis of dye molecules between electrodes is used in dye-sensitized solar cells. Electron holes can be seen in dye molecules delivered via nanoparticles of TiO2. Their cost is likewise quite inexpensive, despite their extremely low efficiency. It is easier to produce them than using other

technologies. The colours of desensitized solar cells [7]. Moreover, concentrated photovoltaic cells are a promising technology. Concentrated cells' primary idea is to direct a lot of solar light into a tiny area Where is costly—is used. An ideal optical system ought to be incorporated into this system. Ten suns to thousands of suns are the starting point for concentration levels. Thus, overall costs may be less than those of traditional systems. CPVs are a technology that has promise for the near future [8].

2. Salient Features Spv:

The following noteworthy characteristics of solar photovoltaic cells are present:

1. Power is produced without the need of fuel.
2. Solar radiation is freely and abundantly available.
3. It's friendly to the environment.
4. Dry locations can have it put.
5. Solar modules or panels have no moving parts and are quiet.
6. A solar module should have a minimum 20–30 year lifespan.
7. Solar modules can be incorporated into the building as pergolas, windows, roof tiles or walls.
8. Solar power may be integrated into the grid.
9. As demand or funds increase, more solar modules may be installed in the future.

2.1 Roof Top Spv System

These days, rooftop solar photovoltaic (SPV) systems are frequently utilized in distributed generation (DG) to generate renewable energy [9]. This SPV system, installed on the rooftops of residential or commercial buildings, employs one or more PV panels to convert sunlight into electricity. Photovoltaic modules, mounting systems, cables, solar inverters, and other electrical accessories are some of the parts of a rooftop solar power plant [10]. Urban areas naturally avoid possible land use and environmental issues and offer a considerable quantity of vacant rooftop space. The process of estimating rooftop solar insolation is complex. procedure, as the following factors affect rooftop insolation values: [11]:

1. Season of the year
2. The state of the weather
3. Shadowing caused by nearby structures
4. Shade provided by overhanging foliage
5. Aspect and slope of the roof
6. Shadowing from nearby structures and trees

The roof space of a typical house is more than sufficient to accommodate the required number of solar panels in order to generate enough solar electricity to meet the demands of the entire house. Solar panel arrays may be scaled to provide enough electricity for a household by use the appropriate inverters to convert the DC current produced by solar panels into AC currents [12]. On a panel (module) size of many square feet, several panels can be stacked in series and parallel circuits to produce high power. A solar array is made up of many modules that are linked electrically in series and parallel configurations to provide the necessary voltage and current. Along with Due to the declining cost of solar energy and growing awareness of the need to generate solar power, several solar power projects have lately been put into operation [13]. A substantial portion of the nation's enormous solar energy potential may be realized by encouraging grid connected solar photovoltaic power systems in different sizes depending on demand and affordability, all the while guaranteeing a sufficient return on investment [14]. The organization or system using the SPV uses less energy from the grid or diesel generators due to its lower power demand [15]. SPV systems are split into two types: OFF grid and ON grid systems, depending on the availability of the grid. The primary OFF grid system source, where the Electricity Board (EB) is located, is SPV. There is a lack of supplies [16]. When there is no solar power available, load demand exceeds solar power output, and SPVs linked in parallel to the EB supply are able to import electricity from the grid, exporting energy to the grid when solar energy availability exceeds load demand [17]. Rooftop solar power systems come in two varieties: freestanding and grid-connected [18].

2.2. Independent solar photovoltaic systems installed on roofs:

There is no link between standalone rooftop solar photovoltaic systems and the electrical grid. Their capacities vary from milliwatts to several kilowatts. This system's primary parts are the inverter, battery, charge controller, and solar panels. The DC electricity generated by the solar modules is directed through a charge carrier and put on a mount structure. controller to replenish the battery at the storage location.

A charge controller's two primary duties are to stop the battery from overcharging and to stop any reverse current flow from the batteries back to the solar panels. in the evening. The energy generated by the solar array during the day is stored in the battery bank for usage

whenever needed, day or night. To power your AC appliances, the inverter converts the DC energy kept in the battery bank into 120 or 240 VACS [18].

2.3 Grid-connected solar photo voltaic systems:

Because a PV module only produces dc power, grid-connected solar photo voltaic systems are connected to the public electrical grid using an appropriate converter. PV systems typically have very little impact on the grid. impacting transformers, load-on lines, and power quality, among other things. However, these factors must be considered for a higher percentage of PV in low-voltage networks, such as solar colonies. From a technological perspective, integrating as much PV into low voltage networks as the peak demand of the corresponding segment's central grid connected PV systems and decentralized grid-connected PV systems shouldn't be too problematic. Decentralized grid-linked PV systems are often mounted on flat roofs of buildings or incorporated into building facades, and their power range is limited. PV linked to the central grid Systems can have installed power up to a million megawatts. Direct input into the medium or high voltage grid is feasible with such central solar power plants [19].

2.3 Comparison of benefits:

Pros and cons of a stand-alone roof-top solar photovoltaic system [20] :

Pros:

1. Perfect for isolated locations when bringing in power is expensive.
2. No electricity costs.
3. There are no blackouts.
4. Self-sufficiency using only sustainable, renewable energy.

Cons:

1. Generators and batteries are costly and need upkeep.
2. The solar array has a longer lifespan (35+ years) than the batteries and generator (10–15 years).
3. The greatest capacity of batteries is limited to a few days' worth of power storage.
4. Unless you can put the remaining power to immediate use, they are squandered when they are full.
5. Power usage needs to be well thought out.

Grid-connected solar photo voltaic systems' benefits and drawbacks [21]:

Pros:

1. Simple grid power backup.
2. Removes the need for pricey batteries and fuel-consuming generators.
3. Offers seasonal storage in the event that a feed-in tariff or net metering scheme is accessible.
4. A solar power system requires no maintenance.
5. Inverters made specifically for use with individual solar panels can be utilized with internet monitoring.
6. You are giving the grid clean energy.

Cons:

1. Power outages: Unless you purchase a battery bank, your system will also shut down when the utility power goes off. The electric provider requires that you do this, and is for the people fixing the system's safety.
2. You are exempt from paying for whatever electricity you have generated, but you still have to pay the basic utility payment.
3. In the absence of solar energy, you are still utilizing non-renewable resources.

3. A Comparison Between Ground Mounted Solar Plants And Rooftop Solar Plants:

Advantages:

1. Unlike roof-top systems, large solar farms are subject to a multitude of rules and approvals [22].
2. Solar farms incur extra expenditures for Grid Connection, whereas rooftop solar may utilize the current transmission system [23].
3. While farms provide 100% of the grid with electricity, a large portion of rooftop solar power is used locally. This makes it challenging to manage the grid as solar penetration rises [23].

Disadvantages:

1. Compared to smaller installations, these plants' larger size enables less installation costs. Permitting and upkeep expenses are decreased as well [23].
2. Waste land can be used for the construction of solar farms; in Germany, this has happened with old air bases [23].
3. While rooftop solar is managed by individuals or private companies, large solar farms are
4. usually in the control of business or household proprietors. These reduces resistance from utilities that typically regulate transmission and make it simpler for people to adopt solar energy [24].

3.1 Technical Issues:

1. The efficiency limit in the current market is between 4% and 12% for thin film and less than 22% for crystalline [25].
2. Performance limitations of the BOS components, such as those pertaining to batteries, inverters, and other power conditioning equipment [26].
3. The demand for photovoltaic systems (PV) has surpassed supply, which has somewhat halted the expansion of the solar industry [27].
4. The supply of tellurium and cadmium for certain thin-film cells: these two components are byproducts of the mining and processing of copper, respectively, and

their availability is dependent on the development of these industries [28].

3.2. Case Study Analysis:

The entire load of room number 103 in the Department of Electrical Engineering, Government College of engineering, Kalahandi, Odisha is 1.5KW approximate so as to fulfil this load there was an enormous expenditure required but now after installing the solar panel's this has eventually dropped down is presented in Appendix A1 & A2.

1740 Wh = 1.74 Kwh

Energy to be stored in battery assuming 20% loss through in inverter to battery.

Future Scope:

Solar panels are an inexpensive, clean, and sustainable energy source that may be employed in both residential and business settings. Utilizing solar energy, one can Provide the department with all appliances. Although solar panels have a 25+ year lifespan, cleaning is still necessary, and this happens every 15 days.in order for us to also include automatic wiper to consistently clean the panels for improved functionality. We can leverage natural life to create a more efficient power source for light also. Automation via the use of effective using AI in wiring.

1.74 Kwh ÷ 0.8 = 2.175 Kwh

While loss through Pannel 20% .

2.175 Kwh ÷ 0.8 = 2.71 Kwh (Total energy need)

Battery Design:

Total energy required 2.71 Kwh.

Battery depth of discharge 60% (DOD=0.6)

2710 ÷ 0.6 = 4517 Kwh

Battery Capacity (Ah) =150Ah

Calculate Wattage of the Solar Panels:

4517 Kwh /day ÷ 5 sun hours/day = 903.4 W (2 Solar panels each 450watts)

For this project it is required to use 2 panels (mono crystal) of 450 Watts (24V DC) each.

Appendix A1: Load Data

Appliance	Quantity	Watts (W)	Operation (Hours)	Total (W/H)
LED Tube Lights	2	15	6	120
Fan	2	60	6	720
PCs Computer	4	70	3	840
Total Watt Hours per day				1740

Appendix A2:

Cost of Off Grid completely runs on solar:

Equipment	Quantity in No.	Unit	Costin in (Rupees ₹)
Solar Pannel	2	350 watt	19,600
Battery	2	150Ah	28,000
Inverter	1	635watt	8,000
Miscellaneous	_____	_____	5,000
Total Cost			60,600

Conclusion:

Government support for solar rooftop use in homes must include financial assistance for customers. The Indian government has two options for promoting solar rooftops [29]:

1. Capital cost subsidy.
2. Incentive depending on generation.

The government should offer incentives to encourage the use of solar electricity in urban areas as it improves the nation's renewable energy sources [30]. This campaign will contribute to the decrease of greenhouse gas emissions release. Nowadays, the capital cost of a solar rooftop is too high for the average home to choose [31]. A home will only choose a solar rooftop if specific benefits are offered [20]. It may be marketed as follows: the Indian government would grant a fixed subsidy for a certain capacity, say 5KW, and any excess power produced can be sent to the grid in exchange for a set payment [31] .

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