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HARDSNESS TESTING OF MIG WELDING PROCESS FOR SIMILAR AND DISSIMILAR MATERIALS

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Abstract:

MIG Welding is massively used in industrial process. The major advantage of the MIG welding process is that not only its versatility but also it causes almost no loss of metals. MIG can be operated as a semiautomatic or fully automatic welding. During literature review we found that there is very less study and research work done on welding of two different metals joining together. Then we have been decided and selected material of Mild steel and Aluminium for the study and investigation of Mechanical properties. Initially, with the help of trial-and-error method, we successfully welded aluminium and mild still together using MIG Welding Process. MIG Welding setting Parameters we keep constant like voltage and current for different specimen for getting same result. We have also completed hardness testing for specimen. As a result, this study has been successfully completed with the help of MIG welding experimentation and welding joint hardness test for specimens.

Keywords: MIG, Hardness Testing.

Introduction:

Many common automatic, semi-automated, and manual processes fall under this group. Stick welding, gas welding, metal inert gas welding (MIG), tungsten inert gas welding (TIG) (also referred to as gas tungsten arc welding or GTAW), metal active gas (MAG) welding, flux cored arc welding (FCAW), gas metal arc welding (GMAW), submerged arc welding (SAW), shielded metal arc welding, and plasma arc welding are all various types of welding techniques used in the metalworking industry. A variety of metals, such as stainless steel, aluminium, nickel and copper alloys, cobalt, and titanium, can be welded using these techniques, which usually require the use of a filler material. Different sectors, including oil and gas, automotive, aerospace, power, and others, rely heavily on arc welding methods. Gas metal arc welding (GMAW) is an alternative name for Metal Inert Gas (MIG) welding, which employs a consumable wire electrode to act as the filler material, a semi-automatic or completely automatic arc to form the weld, and a shielding gas to protect the weld, encourage weld penetration, and lessen weld bead porosity.

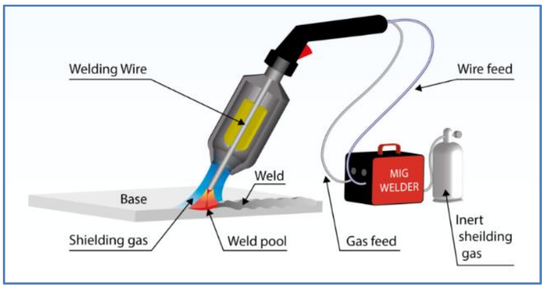


Fig.1. MIG Welding

The welding gun is fed with both the electrode and the shielding gas (or torch). Other mixtures may also be employed, depending on the materials being welded and other factors, but the standard shielding gas composition is 75% argon and 25% carbon dioxide. Additionally, a welding gun is fed a constant, consumable wire electrode and a shielding gas through a lead (sometimes called a torch). The types of metal being bonded, the thickness of the part, and the design of the connection all affect the composition and diameter of the wire electrode. The wire feed speed (WFS) settings, which required to supply adequate weld metal for the join, control how quickly the electrode is supplied into the weld.

Lap joint:

A lap joint is a type of joint in which two overlapping pieces are joined together at an angle ranging from 0° to 5° in the area surrounding the weld.

Features of Completed Weld:

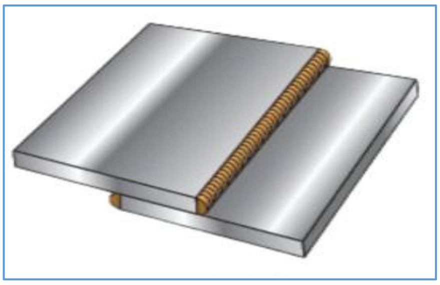


Fig.2.Lap joint

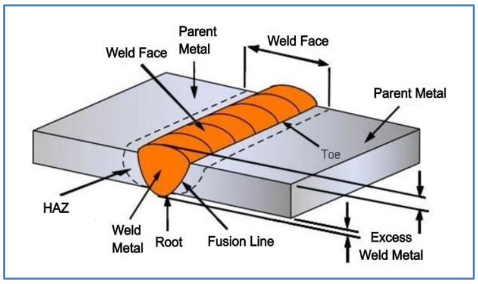


Fig. 3. Butt Weld

Parent Metal: The metal pieces that will be bonded, brazed, braze-welded, or surfaced together are typically referred to as the parent metals. **Filler Metal**: The metal that is added during brazing, braze-welding, welding, or surfacing to bond or fill the base metals is called the filler metal. **Weld Metal**: Any metal that is melted during welding and remains in the welded joint. **Heat Affected Zone**: The portion of the base metal surrounding the weld that has undergone metallurgical changes due to the heat of welding or thermal cutting, but has not melted. **Fusion Line**: The boundary between the heat affected zone and the weld metal in a fusion weld. This term is sometimes used to refer to the weld joint itself. **Weld Zone**: The area including the heat affected zone and the weld metal. **Weld Face**: The visible surface of the weld bead on the side where welding was performed. **Weld Root**: The point on the opposite side of the weld from where the first weld run began. **Weld Toe**: The point where the weld face or run intersects with the base metal. This is a critical area for stress concentration and crack initiation, so it is essential to ensure a smooth transition from the weld to the base metal. **Excess Weld Metal**: The weld metal that extends beyond the surface of the base metal, often used to fill gaps or reinforce joints. This is sometimes referred to as overfill or reinforcement. Run (pass): (Weld run pass) Metal that has been melted or deposited after passing via an electrode, torch, or blowpipe. **Layer:** In welding, a layer is a stratum of weld metal consisting of one or more weld runs. **Energy Sources**: The energy source used affects various processes, and there are numerous diverse approaches available. These procedures must be used with caution because they can result in burns, electric shock, visual damage, radiation exposure, or inhalation of toxic welding fumes and gases.

Problem Statement and Objective:

To investigate and analyze MIG Welding for Dissimilar Materials. Selected materials are Aluminum and Mild Steel and type of joint is Lap joint and Butt joint. Various types of tests can be performed on selected specimens in welding. Current and voltage to weld such material is determined. Analysis of different parameters of aluminium alloy and mild steel weld by MIG welding technique. To determine mechanical properties and behaviour of different material of welding specimen.

Literature Review:

To determine effects of gas metal arc welding (GMAW) parameters on mechanical properties of aluminum alloys. Lochan Sharma and Chandan Kaushal, 2015 On 6 mm thick aluminum alloy plates, explained free welds may be produced utilizing a gas metal arc welding method with a current of 150 to 170 A and gas flow rate being 14- 18 L/Min. Due to incorrect welding values, some welding samples, such as sample 4 and sample 6, failed the Tensile tests in the welding zone. The tiny grain structure of silicide led to an increase in Hardness. With welding parameters of 160 A and gas flow rates of 14 l/min and 18 l/min, respectively, Samples 2 and 5 were determined to be the best samples among the others, demonstrating how mechanical qualities depend on certain welding parameter values. **Study the effects of Welding Parameters on TIG welding of Aluminum plate.** It can be possible to weld aluminium plates uniformly using an automated welding system, according to Umesh Sharma and Viswas Yadav in 2020[7]. The tensile strength of a weld joint can be significantly affected by various welding parameters such as welding speed and welding current. The tensile strength of the weld joint increases with an increase in current. Due to changes in microstructure, the weld zone's hardness value varies with distance from the weld center. Strength is greater at lower welding rates because the current is more intense. Tensile strength on both sides of the welding is found to be about equal to the base material's strength. The tensile strength of the weld joint is unaffected by welding speed when both sides are welded at a high current (180 A). **Experimental Investigation of TIG Welding on Stainless steel and Mild Steel Plates.** Keyur Panchal [8] (2016) Investigations were conducted on the tensile strength, dilution of welded joints, hardness, and bend test. For the best S.S. and MS plate joint, use tungsten inert gas welding. Welding defects like as porosity, fractures, and other issues are not visible in the welding. The bend test also produced the greatest results for this work. The ultimate result was satisfactory and gave clear guidance on welding under bend force. Since relatively little Cr is lost from stainless steel during TIG welding, the material is resistant to field corrosion. Additionally, welding is carried out in an inert atmosphere to shield the joint from environmental hazards like hydrogen. According to reports, TIG welding produces excellently strong joints between different types of metal. Hardness rating at the filler metal's point. **The Effect of Gas Metal Arc Welding (GMAW) Processes on different Welding Parameters.** Izzatul Aini Ibrahim, Syarul Asraf Mohmat, Amalina Amir, Abdul Ghalib, 2012[9] conducted an experiment to investigate the effects of arc voltage, welding current, and welding speed on the depth of penetration and hardness of the weld bead. The results showed that increasing the welding current from 90 A to 210 A resulted in an increase in the depth of penetration. However, the penetration was also influenced by the welding speed and arc voltage. The highest value of penetration was achieved at 210 A and 22 V for all three welding speeds. At a welding speed of 60 cm/min, the best value for penetration was achieved at 210 A and 26 V. The hardness of the weld bead was found to be the highest at 90 A and gradually decreased with increasing welding current up to 150 A. At 210 A, the hardness slightly increased compared to 150 A. The highest hardness value was achieved at 90 A and 26 V at a welding speed of 60 cm/min. The microstructure's grain boundaries changed from a larger size to a smaller size as the welding parameters were changed.

Methodology:

Aluminum is a particularly intriguing metal in the world of engineering because of its special qualities of light weight and corrosion resistance. Because of their light weight and great strength to weight ratio, aluminium alloys are widely used in the aerospace, automotive, rail, bridge, and offshore, and high-speed ship industries. Mild steels have great weldability and don't require any additional alloying elements. Because it is affordable, weldable, and readily available, mild steel is the optimum material for welding. Mild steel is available in any shape or thickness throughout the world and is of exceptional quality. Mild steel and Aluminum were selected for the experimental study because of their many benefits and straight forward accessibility to the market.

Fig.5.MS Specimen Sample

Fig.6. Al Specimen Sample

Process Selection:

The development of the high-productivity, high-quality arc welding technique is being led by the GMAW method. A Metal Inert Gas (MIG), is also called as Gas Metal Arc Welding (GMAW), is a technique which heated, melted and solidified the filler materials and base metals in a constrained fusion zone. Due to this a joint is created between parent metals. The internal resistive power and heat from the welding arc melt the continuous wire electrode that is fed through the contact tip of the welding torch from an automatic wire feeder. Heat generated by the molten metal that transferred to the weld pools and from the melting electrode's end to the weld pools. The quality, productivity, and cost of the welding joint are influenced by the GMAW welding parameters. If all welding variables are in compliance, the ideal arc will be produced. Arc Voltage, arc welding current, welding speed, free wire length, nozzle distance, welding location and direction, torch length and gas flow rate are among the various parameters that affect the quality, productivity, and cost of a welding joint in the GMAW process. In 1987, researchers utilized regression analysis to establish a correlation between the process factors and the bead geometry in welding. By considering factors such as the type of base metal, the shape of welded components, and the welding process, it is possible to create optimal welding conditions. A previous study that employed the MIG or GMAW welding process found that by increasing the welding current, the depth of penetration increased, while decreasing the voltage resulted in a reduction in penetration depth. Furthermore, by reducing the arc travel rate, the penetration depth increased again, with a minimum value being dependent on the arc power. The analysis of the GMAW process and its relationship with bead geometry indicates that the arc current has the most significant impact among all process factors. The findings of an investigation into the weld deposit area were provided, and they showed how the weld deposit area was affected by the electrode polarity, extension, and diameter, arc voltage, welding current, power source settings, flux and travel speed .These are some of the key factors that need to be considered for optimal results. The MIG welding process offers several benefits such as high deposition rates, fast welding speeds, deep penetration, consistent wire diameter, and the ability to fully automate the process. It is commonly used for unalloyed and low-alloy steels (MAG), but is also increasingly used with CrNi steels (MAG) and aluminum materials (MIG). Some common applications of MIG welding include steel construction, shipbuilding, rail vehicle construction, and container construction.

Chemical Composition of Specimen:

The ratios of atoms in a chemical substance's molecule are referred to as chemical makeup.

In a nutshell, it is the proportion of a specific ingredient in a compound as a percentage.

The substance's physical and chemical qualities are determined by its chemical composition.

We require the chemical makeup of aluminium and mild steel materials for our study.

Specifications for this samples are as given below:

Mild Steel - 50mm x 50mm x 6mm,

Aluminum - 50mm x 50mmm x 6mm.

Table.1 Chemical Composition

Sr. No.	Sample Identification	Chemical Composition, %				
		C	Mn	Si	S	P
1	Mild Steel Sample	0.286	0.438	0.137	0.034	0.026

Sr. No.	Sample Identification	Chemical Composition, %						
		Si	Cu	Fe	Mn	Mg	Ti	Al
1	Aluminium Sample	0.266	0.091	0.391	0.191	1.913	0.014	96.966

Mechanical Properties of Specimen:

The most used mechanical characteristics to evaluate a material's properties are yield stress, elongation, hardness, and toughness. Yield stress and elongation are measured in a tensile test, where a sample is subjected to a load until it begins to experience plastic strain, and the amount of strain that is not recovered when the load is removed is measured. Hardness, on the other hand, is a quasi-mechanical property that is influenced by several other mechanical characteristics, including elastic modulus, yield strength, and tensile strength. The ability of a material to resist indentation under a given load and its ability to recover after the load is removed are both affected by these characteristics.

Specifications for this samples are as given below:

1. Mild Steel: 15mm x150mm x 5mm
2. Aluminium: 15mm x150mm x 5mm

Table.2. Mechanical Properties

1.0 Tensile Strength

Sr. No.	Sample Identification	Tensile Strength (MPa)	Elongation (%)
1	Mild Steel Sample	526.94	17.80
2	Aluminium Sample	172.83	12.20

2.0 Hardness

Sr. No.	Sample Identification	Hardness in HRB (HV)
1	Mild Steel Sample	77 to 78 (141 to 144)

Sr. No.	Sample Identification	Hardness in BHN (250 Kg load, 5mm Dia. ball)
1	Aluminium Sample	85 to 90

Specifications and Preprocessing of Aluminum Sample:

Samples were collected and expected dimensions of the samples were achieved by performing various manual processes like cutting by hacksaw, filing etc.

Given samples (Al): 120 mm x 50 mm x 6 mm

Final samples (Al Lap joint): 120 mm x 20 mm x 5 mm

Final samples (Al Butt joint): 120 mm x 20 mm x 5 mm

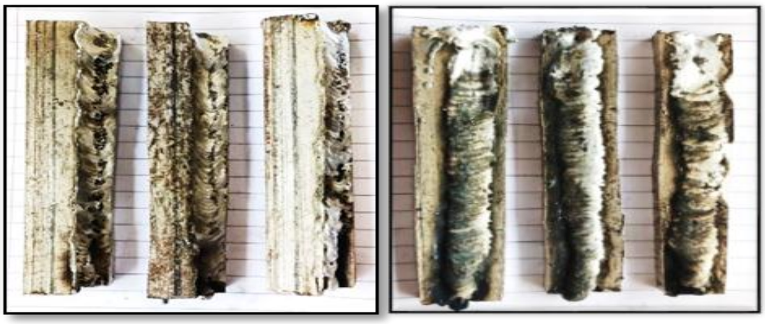


Fig. 7. Al Lap and Butt Welding Specimen.

Specifications and Preprocessing of Mild Steel Sample:

Samples were collected and expected dimensions of the samples were achieved by performing various processes like metal cutting by machine, filing etc.

Given samples (MS): 120 mm x 20 mm x 6 mm

Final samples (MS Lap joint):120 mm x 20 mm x 5 mm

Final samples (MS Butt joint): 120 mm x 10 mm x 5 mm

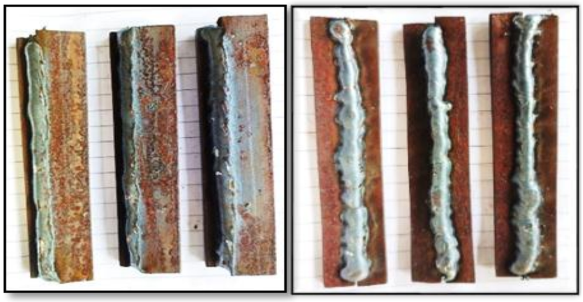
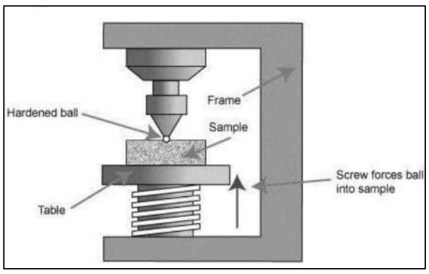
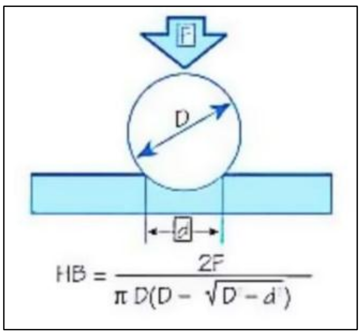


Fig. 8. M.S. Lap and Butt Welding Specimen

Hardness Testing:





The hardness of a material is not a fundamental physical property but rather a characteristic that describes its resistance to indentation. In non-destructive hardness testing, a controlled force is applied to a metal surface using a pointed or rounded object, and the permanent depth of the resulting indentation is measured. This depth measurement is then used to determine the material's hardness. Indentation tests are a common method for measuring hardness, and there are various techniques available to perform such tests on a given material. The Rockwell hardness test is a widely used method for measuring a material's resistance to indentation. It involves applying a major load and a minor load to the material surface using different indenters and measuring the depth of penetration of the major load in relation to the minor load. The Rockwell scale employs different indenters and loads to provide various scales, which are identified by a single letter. The hardness value obtained from this test is represented by a dimensionless number with a letter indicating the corresponding Rockwell scale, such as HRA, HRB, HRC, and so on.

Table .3. Hardness Testing Results.

MS-MS lap joint (HRB)

MS-MS LAP JOINT (100 kgf load)					
MS-MS LAP POINT	1	2	3	4	5
HRB	92	94	95	90	93

MS-MS BUTT JOINT (100 kgf load)					
MS-MS LAP POINT	1	2	3	4	5
HRB	84	75	79	82	84

MS-MS butt joint (HRB)

Al-Al lap joint (BHN)

Al-Al LAP JOINT (187.5 kgf load (P), 2.5 mm steel ball (D)			
Al-Al LAP POINT	1	2	3
Depression Dia. (d) (mm)	1.55	1.35	1.4
BHN	88.66	120.62	111.35

Al-Al BUTT JOINT (187.5 kgf load (P), 2.5 mm steel ball (D)			
Al-Al LAP POINT	1	2	3
Depression Dia. (d) (mm)	1.58	1.6	1.55
BHN	84.87	82.45	88.66

Al-Al Butt Joint

MS-MS lap joint (HRB)

MS-MS LAP JOINT (100 kgf load)					
MS-MS LAP POINT	1	2	3	4	5
HRB	84	75	79	82	84

MS-MS BUTT JOINT (100 kgf load)					
MS-MS LAP POINT	1	2	3	4	5
HRB	43	42	45	45.5	43

MS-MS butt joint (HRB)

AL-MS BUTT JOINT (187.5 kgf (P), 2.5 steel ball diameter (D))			
Al-MS Butt point	1	2	3
Depression Dia. (d) (mm)	1	1.05	1.02
BHN	228.60	206	219.47

Al-MS butt joint (BHN)

Al-Al LAP joint (BHN)

Al-Al LAP JOINT (187.5 kgf load (P), 2.5 mm steel ball (D)		
Al-MS Lap point	1	2
Depression Dia.(d) (mm)	1	0.95
BHN	228.60	254.60

Results:

Hardness test was performed on all the samples. A weight of 187.5 kg was applied for 15 seconds before being released to test the hardness (HRB) of several materials using an indentation/scratch cone, or “Indenter.” The ratio of the tester’s indenter’s depth during heavy loading to the preload’s penetration. The hardness measured is a number with one unit subtracted, abbreviated HRB, where B is the variable scale

Scope for Future Work:

Research can be conducted using different type of metals or even alloys. By selecting a different type of welding process such as tungsten inert gas or plasma arc welding, advancements can be achieved. In this project we have taken lap and butt joint there are many more different types of joints we can explore and study. Hardness testing has been conducted on the given specimens. One can perform more such tests like tensile test and microstructure to determine more about obtained specimen. Industrial uses of these types of welding can be huge if applied correctly and implemented without errors.

Conclusion:

Al-MS was welded successfully with filler material Mild steel. When aluminium was used as filler metal joint was not welded as it cracked. This study aims to examine the variation in hardness that occurs when welding two dissimilar metals together. From the results shown above we can conclude that the hardness of weld increases when we weld two dissimilar metals. This increase in hardness can be very beneficial for industrial applications. We have performed welding of two mild steel plates and two aluminium plates. Welding was performed for butt as well as lap joint. In all four of these cases, we have observed that the hardness of the weld of aluminium and mild steel was greater than each sample

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