Comparison between Friction Stir Welding and Conventional Welding Process (MIG) – A Case Study

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Abstract

Aluminum 6066 is widely used for applications such as aircrafts and boat and ship building. Thus considering the applications, the joining of the metals must be such that minimum residual stresses and distortion must occur. Two different welding methods i.e. Stir friction welding and metal inert gas welding (MIG) have been compared by making a butt type of joint. Investigations have been carried out to compare the mechanical properties i.e. tensile strength, hardness and micro-structural properties. The results obtained showed that FSW welded joint possessed greater tensile strength and hardness whereas there was a general decay in the mechanical properties for MIG welded joints. The micro-structural images under SEM showed that the HAZ region for FSW welded joint is narrower than that for MIG. This is because of the high temperatures during MIG. Thus considering all these factors FSW is an optimum process for industrial applications as it saves energy and does not show any fusion related problems.

Keywords: Friction stir welding, MIG, Micro-structure, tensile strength

3) Introduction

Friction Welding is a solid state welding process in which actual melting of the base metal does not take place. In this type one part is stationary while the other rotates against it. This causes rubbing action generating friction and in turn leading to the generation of heat. Localized plastic deformation takes place and the two parts get welded.

The different types of friction welding are:

1) Conventional friction welding
2) Orbital friction welding
3) Linear variable friction welding
4) Frictions stir welding.

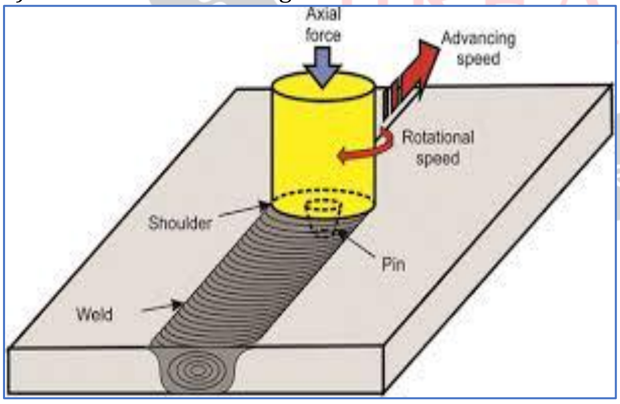


Fig.1.Friction stirs welding

3.1 Friction stir welding is a solid state welding process used for joining two components without melting of the parent metal. The tool is rotated against the work-piece to generate friction. The original metal characteristics remain un-changed.it is widely used for aluminium alloys and large work-pieces. In this, issue such as porosity, solute redistribution and cracking do not occur. The concentration of defects is low.

3.2 MIG Welding:

This is a welding process in which an electric arc is struck between the work-piece and the electrode. A shielding gas is used to protect the piece from contaminants. The electrode melts and acts as a filler material to weld the two components. MIG welding is considered one of the most versatile welding. It can be used to join many types of different metals and welding is also possible in various directions. Weld can be performed by creating a butt joint, lap joint, edge joint and T-joint. Different shielding gases are used depending on the metal to be welded. Aluminium, mild steel and alloy metals are welded by using an argon-CO2 blend. It is considered a semi-automatic process as the electrical characteristics of the arc are automatically controlled and the travel speed and gun position are manually controlled.

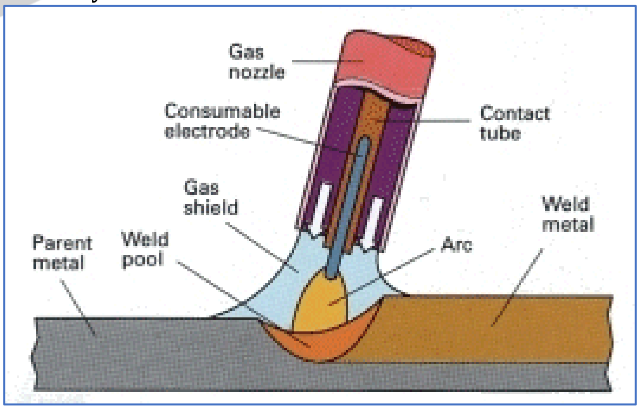


Fig .2 MIG welding.

4)LITERATURE REVIEW

This study aims to compare the mechanical properties of FSW and MIG welded joints for aluminium alloy - AA 6066.

Anjeneya Prasad B. and Prasanna P. experimented al6066 alloy welded by MIG and FSW. Semiautomatic welding machine MIG350 was used. FSW was carried out on CIMTRIX milling machine. The FSW showed 10-110 times smaller grains than in MIG welded joints. MIG showed less tensile strength.

Biswajit Parida et al. [2011]. This study was on the development of friction stir welding of Al alloys and the research included analysis of the

Joints for tensile strength, hardness and micro-structural properties. The study was in two different sections. First section contained mechanical properties while the second section contained the micro-structural properties and changes.

Harmeet Singh, Harish Kumar carried out research for aluminium alloy 6066 and tested tensile strength, microstructure and hardness for FSW and MIG welded joints. The results showed that there is decay in mechanical properties for MIG welded joints while the uniform distribution of grains in FSW gave more tensile strength.

Wichai Pumchan [2011]. Influence of friction stir welded joint on the hardness and microstructure of aluminum alloy. The hardness test showed that the maximum harness was 152HV at the weld centreat a speed of 50mm/min.

L. Karthikeyan et al. [2012] studied the commonly used alloys AA2011 and AA6063 in various aerospace applications. Friction stir welding gained popularity in joining of dissimilar metals.On evaluating it was found that sound weld was produced and the strength increased with increasing speed. Optimum rotational speed for defect free nugget zone was 1400rpm.

D. Muruganandham et al. [2011]. Friction stir welding was performed at different speeds. Defects were analyzedfor different speeds and maximum defects were found at 600rpm. Tensile tests and Bend test values were also reported.

5)PARAMETERS GOVERNING MIG AND FSW.

Table no. 1

FSW	MIG
1.Tool Rotational Speed	1. Melting Point of Material
2. Axial Force	2. Surface conditions
3. Welding Speed	3. Electrical properties such as voltage and current.
4. Work-piece material	4. Work-piece material

6)CASE STUDY

6.1 EXPERIMENTAL SETUP

The setup is broadly classified in two mains parts:

Preparation of the specimen: The alloy6066 containing 0.9-1.8%Si, 0.5%Fe, 0.7-1.2%Cu and 0.6-1.1% Mn is prepared of the dimension size (150x70x6). 4 nos. of such specimen were prepared. The specimen was prepared by FSW as well as MIG welding to carry out the comparison.

The types of tests carried out are as follows:

1. Tensile test on universal testing machine.
2. Hardness test on Vickers Hardness Machine 3.Microstructural analysis on Scanning Electron Microscope (SEM).

6.2 TENSILE TEST

Various parameters were measured on the universal testing machine such as Tensile Strength Proof Stress and Percentage Elongation. Fig no. 3 shows the specimen for tensile testing.

Proof Stress: The maximum stress that causes permanent extension of fraction of gauge length is known as proof stress. The proof stress in MIG is less than that in FSW. The joint efficiency that is the ratio of the tensile strength in the weld to that of the base metal is greater in FSW than in MIG. It is 70% in FSW while 6% in MIG.

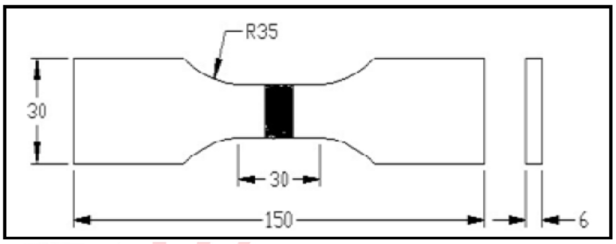


Fig no. 3 –Tensile Test Specimen

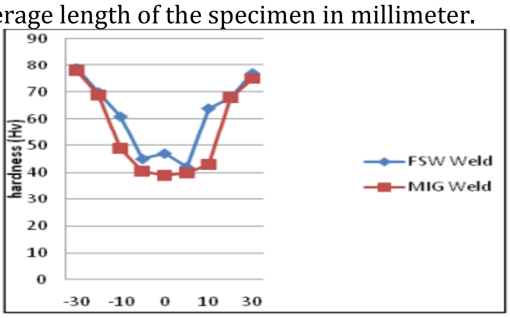
Fig no. 4 Universal Testing Machine

TABLE NO.2- Tensile Test Result

6.3 HARDNESS TEST

Hardness test was carried out on Vickers Hardness testing machine. The different locations were selected at -5,-10,-15,-30, 0, 10 and 30. A load of 500gf was applied on the specimen for 15 seconds and the hardness was calculated using the formula: $HV = 0.189F/d^2$

Where F is the force applied in Newton and d is the average length of the specimen in millimeter.



Graph: 01 – Hardness Profile

6.4 MICROSTRUCTURAL ANALYSIS

Fig. no 5 shows the microscopic image of the base metal. This image shows uniform structure and finely distributed precipitates.

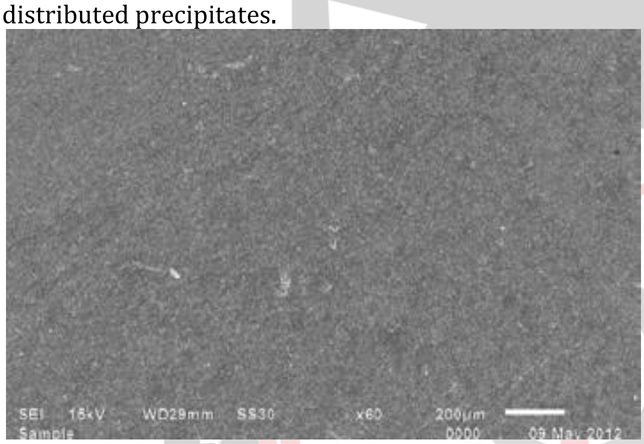


Fig No. 5Base Metal (SEM Image)

Fig. No. 7 shows the images of FSW and MIG welded specimen for the Heat Affected Zone (HAZ) and Fig. 6shows weld nugget region. The weld nugget region in FSW contains equi-axed grains and those in MIG contain grains with dendrite structure. Fig no.7 shows equi-axed grains in FSW due to re-crystallization whereas those in MIG are due to fast heating of the base metal. Strength is imparted to the metal due to the magnesium and silicon present in the alloy. These elements precipitate that help in strengthening. These are termed as Beta. In MIG the precipitates are lower in number than the base metal. In FSW due to high temperatures the beta easily dissolves. The precipitate strengthening is weak in MIG as even the filler of AlSi cannot improve the amount of precipitates.

SPECIMEN/ TESTING	PROOF STRENGTH	TENSILE STRENGTH	%ELONGATION
BASE METAL	160	195	14
FSW	107	139	7.19
MIG	103	131	6.12

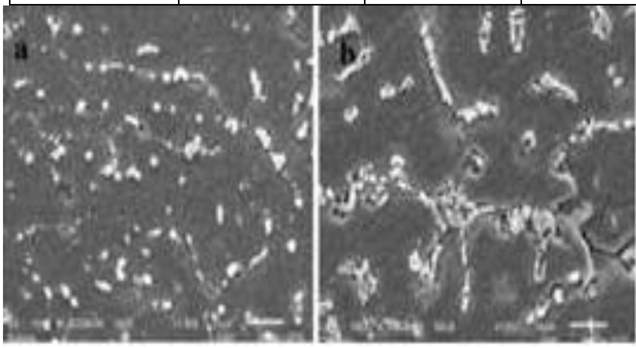


Fig. No.6: Weld nugget a) FSW b) MIG (SEM Image)

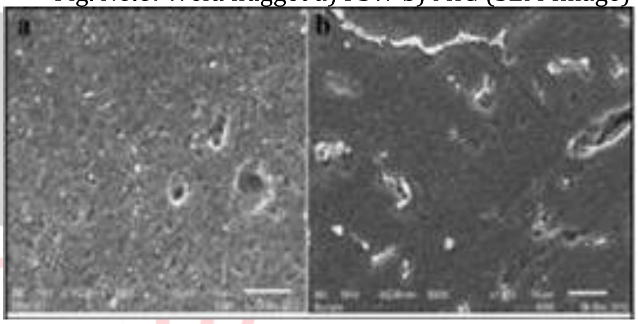


Fig. No.7 HAZ a) FSW b) MIG (SEM Image)

7) ADVANTAGES OF FSW

1. Friction stir welding is an environmental friendly process As it does not generate fumes gases or smoke.
2. Friction welding is suitable for quantities ranging from Prototype to high production.
3. It allows choosing of either manual or automated loading.
4. In case of friction welding joint strength is much greater as compared to the conventional methods.
5. Friction welded joints can withstand high temperatures.
6. It reduces machining labor which in turn increases Capacity and reduces perishable totaling cost.
7. It reduces maintenance cost.
8. FSW shows a narrower HAZ as compared to MIG.
9. FSW welds have greater ductility as compared to MIG welds and also have lower distortions as compared to MIG welds.
10. The shielding gas in MIG has to be replaced from time to time hence it increases the time required.

8) DISADVANTAGES OF FSW

1. Heavy duty clamping setup is required in FSW to hold the work piece during the process.
2. Weld joints that require deposition of metal cannot be made using FSW.

3. It is less flexible than conventional welding methods like MIG.
4. Large downward forces are required for the tool to insert inside the metal.
5. Exit hole is left when the tool is withdrawn.
6. Traverse speed is slower than some fusion welding processes.
7. Due to low temperatures and low rotational speeds the weld material may not accommodate the deformation during welding. This results in long-tunnel like defects along the weld on the surface.
8. Low temperatures reduce the continuity of the bond formed.

9) APPLICATIONS OF FSW

1. Freezer Panels: Hollow aluminium panels are made by using FSW to store fish on the fishing boats. FSW welds show minimum distortion and good reproducibility and hence is a preferred method to produce these stiff panels.
2. Corrosion Resistant Panels: These panels are formed by FSW and are used as ship cabin walls. FSW is used for this application due the property of good flatness of the root and weld underside.
3. Panels for deck and Wall construction: Aluminium panels made using FSW are used in high speed ferry boats. Compared to other welding processes heat input is lower thus reducing thermal stresses.

10)APPLICATIONS OF MIG

1. Automotive Repair: repairing of various vehicle parts is carried out by MIG welding. MIG welds are strong even up to 0.5mm of depth.
2. Railroad track: MIG welding is used to reinforce the surface of worn out tracks
3. Rebuilding: It is used as rebuilding equipment. Worn out parts are repaired by MIG thus reducing the cost.

11)CONCLUSIONS

1. The tensile strength in FSW is much greater than that in MIG welded joints as shown in table no 2. The ductility for FSW welded joints is also greater.
2. The hardness profile graph shows that there is a general decay of mechanical properties in the welded joint. In case of FSW there is a decay of properties in HAZ and the hardness value differs in different zones.
3. From fig no.6, 7 we can conclude that the microstructure of FSW welded specimen has equi-axed grains those results in better tensile strength as compared to those in MIG welded joints showing dendrite structure.

Thus we can conclude that FSW is a preferred process over MIG welding as it saves energy, does not show any fusion related problems and is cost effective.

12)FURTHER SCOPE:

1. The next stage of FSW will be use the other desirable of properties of this method. We can assess the use of FSW in joining of different weld design and increasing the flexibility of the weld.
2. Marine industry uses the the FSW and thus research can be carried out on the types of joints formed and strength of the material in order to reduce the thickness of the metal used.
3. Modifications in the tool design and the type of tool used so as to weld other metals such as steel efficiently.
4. FSW is also used for titanium and its alloys although research can be carried out to weld these alloys considering their applications in oil pipeline industry and aerospace industry. They require highly corrosion resistant materials and thus the weld formed must satisfy the requirements.

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