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Experimental Investigation and Comparative Study of MIG and TIG Welding on SS309 Materials

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Abstract : Recent trend in the fabrication process in the Industry is very commonly consider as Welding. The most commonly fabrication has been preferred as MIG and TIG and MIG welding methods. To protect the welding pool from oxidation the active as well as inert gases are preferred in today's modern industry. In these welding methods electric spark has been used to create fusion between the parent materials. Helium and argon is the preferable gases used in TIG welding to protect the pool material. CO_2 gas is the preferable gas used in MIG welding to protect the pool material. Tungsten electrode which is basically non-consumable electrode has been used in TIG Welding. The permanent joint is mainly implemented by using MIG and TIG Welding Processes in most of the fabrication Industry. The present research work mainly deals with the TIG and MIG Welding Processes. The material considered during the experiment is Stainless Steel of grades of SS309. The dimension of the sample is (10×76×5) mm. The welding processes implemented are Tungsten Inert Gas (TIG) and Metal Inert Gas (MIG) welding processes. The output responses are Hardness measurement, tensile strength, and impact test. Mechanical properties along with physical properties have been investigated too.

Keywords **– MIG, TIG, Impact Strength, Tensile Strength, and Hardness**

I. INTRODUCTION

Alloys, Plastics as well as Metals are joined permanently by using welding processes. But the surfaces are brought together and by using heat or pressure the materials are joined together. In various areas welding processes are implemented as a fabrication processes. Permanent joint has been obtained at the interface of the metal due to the melting of the workpiece as well as due to solidification too. Implementation of filler materials depends on the processes that have been applied. Where pressure is implemented there filler materials is not used. Hardness in the Weld beads, metallurgical characteristics, oxidation formation, crack in the weld beads, etc are the various factors that affect the weldability [3,4,8]. From Rural farm to constructions as well as in the industries, each and every places Welding fabrication plays an important role. The process is as simple as it is. The technique and the working principle are very simple. At molecular level the joining of similar or dissimilar metals occurs. V.Anand Rao et al. [4] stated the welding process as a homogeneous bond and also state that the strength of the joint is more than the parent materials. The components that have been used during welding processes includes heat, parent materials, filler materials, and a protective shield Gases. The base metal is heated to create a pool of molten metal and filler material has been added and together it's solidified to create the weld beads to create a permanent joint in the presence of shield gas just to protect the molten pool from the impurities from the atmosphere. Welding is carried out by implementation of heat or without heat as well as pressure or without pressure. Seeram Rupa et al. [7] has mentioned MIG (Metal Inert Gas Welding), TIG (Tungsten Inert Gas Welding), Flux Core Arc Welding are the commonly used Welding process in the Industry. It is suitable for repair and fabrication purpose for ship building, large structures, etc. For broad range thickness materials MIG is the preferable one. The latest pulse technology has enable MIG to provide greatest finish compared to TIG Welding. Welding is a permanent joint process where similar or dissimilar materials can be joined by the application of heat or pressure. Large variety of materials can be joined by welding process. A permanent joint occurs at the interface of the work-pieces after getting solidified. In some of the cases filler materials forms a weld pool and later gets solidified to become permanent joint. Weldability depends upon various factors such as metallurgical changes during welding, hardness of the weld zone because of rapid solidification, oxidation formation because of the reaction between metals and oxygen presents in atmosphere, crack formation tendency in the weld beads etc. An application of welding includes outdoor setup in the rural farm, construction sites, job shops, as well as in factories. Welding is a quick learning process as well as simple process to understand. At molecular level joining occurs in welding. The weld beads strength is more with respect to base materials as because homogeneous bond exist between similar or dissimilar metals. The parameters that affect the joining process includes filler materials, heat, pressure, and shield gases. Base metals are heated in the presence of shield gas and a filler metal gets added in the molten pool to get solidified and the welding is completed. Akah Srivastava et al. [6] stated that welding can be performed with or without filler materials as well as with or without pressure. Several welding processes includes GTAW, MIG, Stick Welding, Flux Core Arc Welding has been used to carry out welding process in various industries.

II. EXPERIMENTAL PROCEDURE

The TIG welding and MIG welding has been carried out on metal SS309. The dimensions of the specimens are 10 x 76 x 5 mm. Table 1 mention the parameters included to carry out welding for MIG.

Table 1 MIG Welding Process Parameters

Sl No	Base Metal	Filler Metal Diameter(mm)	Gas Pressure(bar)	Ampere (amp)	Volts(V)
1	SS309 2pcs	1.2	15	175	24

Remarks: (i)Square butt joint (ii)full penetration (iii)More Spatters (iv)Room temperature (v)root gap 2mm (vi) Welding Temperature above 800 °C

Table 2 mention the parameters included to carry out welding for TIG.

Table 2 TIG Welding Process Parameters

Sl No	Base Metal	Electrode Diameter	Root gap(mm)	Gas Pressure	Ampere(amp)
1	SS309 2pcs	2.4mm Tungsten	1.2	15litre/Min	165

Remarks: (i) Full penetration (ii) Room temperature (iii) No Spatters (iv) Welding Temperature above 900 °C

Chemical Compositions has been represented in Table 3 for the material stainless steel 309.

Table 3 Chemical Compositions of material SS309

Elements	Fe	Ni	Cr	Si	Mn	C	S	P
SS-309	60	14	23	1	2	0.20	0.030	0.045

III. PHYSICAL, THERMAL, MECHANICAL PROPERTIES OF SS309

Stainless steel of grade 309 is very popular for its high resistance against corrosion and for its high strength compared to SS304. The following description below gives the details properties for SS309.

III.I Physical Properties: Table 4 shows the physical properties of grade 309 Stainless Steel.

Table 4 Physical Properties of SS309

Properties	Imperial	Metric
Melting point	2650°F	1455°C
Density	0.289 lb/in³	8 g/cm3

III.II Mechanical Properties: Table 5 shows the mechanical properties of annealed grade 309 Stainless Steel.

Table 5 Mechanical Properties of SS309

Properties	Imperial	Metric
Tensile strength	89900 Psi	620 MPa
Yield Strength(For steel)	45000 Psi	310 Mpa
Impact Strength (Izod)	88.5 -122 ft-lb	120-165J
Shear Modulus (For steel)	11200 Psi	77 Gpa
Modulus of Elasticity	29008 Psi	200Gpa
Hardness Value (BHN)	147	147
Rockwell Hardness No. B	85	85
Hardness Value (VHN)	169	169
Elongation at break	45%	45%

III.III Thermal Properties: Table 6 shows the mechanical properties of annealed grade 309 Stainless Steel.

Table 6 Thermal Properties of SS309

Properties	Metric	Imperial
Thermal conductivity (0-100°C / 32-212°F)	15.6 W/mK	108 BTU in/hr.ft².°F
Co-efficient of Thermal expansion (0-100°C / 32-212°F)	14.9 µm/m°C	8.28 µin/in°F

Iv. EXPERIMENTAL SETUP

Figure: 1 Experiment Setup

Figure: 2 Butt joint by MIG welding

Figure: 3 Butt joint by TIG welding

Figure: 4 Rockwell Hardness Test Machine

Figure: 5 Universal Testing Machine

Figure: 6 Impact Test Machine

Figure 1 shows the setup for the experimentation purpose. Figure 2 and Figure 3 shows the experiment carried out by MIG Welding and TIG Welding. Figure 4 represents Rockwell Hardness Test Machine to carry out hardness test. Figure 5 represents Universal Testing Machine to carry out tensile test. Figure 6 represents Impact Test Machine to carry out impact test.

v. RESULTS AND DISCUSSIONS

V.I HARDNESS TEST

Hardness test (Rockwell) has been carried out on the weld beads area of the specimen SS309. The average hardness values were found for TIG and MIG is to be 47.83 HRB & 44.5 HRB. The hardness value of the welded joint in case of TIG is higher in comparison with MIG joint.

Table 7 Rockwell Hardness Testing Values for MIG and TIG

Sl. No	Metal	Specimen	MIG	TIG
1	Similar	SS309	44.5HRB	47.83HRB

V.II TENSILE TEST

Tensile test has been carried out for both MIG and TIG welded specimen of SS309 plates for similar joints and results are mentioned in the below table. Tensile strength values for TIG welding is more compared to MIG because of the presence of activated flux.

Table 8 Tensile Testing Values for MIG and TIG

Sl.No	Metal	Specimen	Tensile Strength(MPa) MIG	Tensile Strength(MPa) TIG
1	Similar	SS3309	0.019	0.022

V.III IMPACT TEST

The impact strength is the strength of material due to which suddenly apply load is absorb by material. Impact load is maximum load which is absorbed by material before fracture. Workpiece specimen dimension was 10mm x 76mm x 5 mm for MIG and TIG

Welding. In TIG joint the Impact strength was 68J and the specimen not break fully. In MIG joint the Impact strength was 60J and the specimen break partially. In this test TIG and MIG joint break under ductile fracture.

Table 9 Tensile Testing Values for MIG and TIG

Sl. No	Metal	Specimen	Impact Strength(Joule) MIG	Impact Strength(Joule) TIG
1	Similar	SS3309	60	68

Figure: 7 Tensile Strength Test

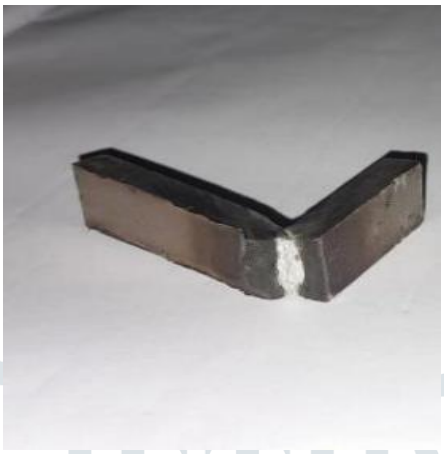

Figure: 8 Impact failure of TIG joint

Figure: 9 Impact failure of MIG joint

VI. CONCLUSIONS

Form the above experiment the following conclusions has been obtained that Tensile strength values for TIG welding is more compared to MIG because of the presence of activated flux. The average hardness values were found for TIG and MIG is to be 47.83 HRB & 44.5 HRB. The hardness value of the welded joint in case of TIG is higher in comparison with MIG joint. In TIG joint the Impact strength was 68J and the specimen not break fully. In MIG joint the Impact strength was 60J and the specimen break partially. In this test TIG and MIG joint break under ductile fracture.

So finally it has been validated that the tensile strength, hardness number, and impact strength of TIG welding is higher in compared to MIG weld joint.

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