EXPERIMENTAL INVESTIGATION ON METAL INERT GAS USING TAGUCHI METHOD FOR AUSTENITIC CHROMIUM-NICKEL STAINLESS STEEL 304 AND INDIAN STANDARD 2062

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ABSTRACT

Dissimilar metal welded joints are integral parts of modern-day power and process plant equipment. Among the various types of material combinations, welded joints of austenitic stainless steels and mild steel are very common in nuclear and chemical industries. The dissimilar metal joints have been emerged as a structural material for various industrial applications which provides good combination of mechanical properties like strength, corrosion resistance with lower cost. Selections of joining process for such materials are difficult because of their physical and chemical properties. Dissimilar material joints of stainless steel and mild steel are commonly uses as structural applications. Joining of stainless steel and mild steel is very critical because of carbon precipitation and loss of chromium leads to increase in porosity which affects the quality of joint leads deteriorates strength. Shielding gases are necessary in GMAW process to protect the welding area from atmospheric gases such as nitrogen and oxygen, which can cause fusion defects, porosity and weld metal embitterment. In the present study, stainless steel plate of AISI-304 has been welded with mild steel plate of IS: 2062 by Metal Inert Gas (MIG) welding processes. The tensile strength of dissimilar metal joints has investigated. For this study welding voltage, welding current and gas pressure taken as the input parameter and their effect on the tensile strength are investigated. The results were compared for different joints made by MIG welding processes and finally optimize the best combination of input parameters. The optimum joint also test in PTC Creo 4.0 a package which determines the von misses stress in combined joint

Keyword:- *MIG welding, Dissimilar material, AISI-304, Taguchi Method*

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1. INTRODUCTION

Welding has been used since ancient times, and over the centuries various welding techniques have been devised for making the utensils that are necessary for daily life as well as artistic handicrafts. For more than a thousand years swords have been made by forging, and sculptures, such as Buddha figures, by soldering and brazing. The invention of the electric arc early in the 19th century marked the beginning of rapid progress of welding technology in modern times. Now days, arc welding has become an indispensable method for joining metals in various fields of industry such as civil construction, shipbuilding, vehicle fabrication, and machinery fabrication. It has expanded its applications by utilizing its advantages and by coping with its drawbacks through unremitting researches and developments.

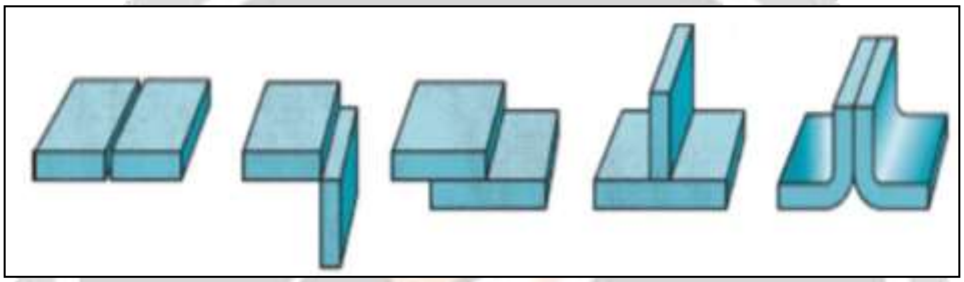
1.1 Introduction to Welding Technology

Welding is a permanent joining process used to join different materials like metals, alloys or plastics, together at their contacting surfaces by application of heat and/or pressure. During welding, the work-pieces to be joined are melted at the interface and after solidification a permanent joint can be achieved. Sometimes a filler material is added to form a weld pool of molten material which after solidification gives a strong bond. Weld ability of a material depends on different factors like the metallurgical changes that occur during welding, changes in hardness in weld zone due to rapid solidification, extent of oxidation due to reaction of materials with atmospheric oxygen and tendency of crack formation in the joint position.

1.2 Types of Welded Joints

The weld joint is where two or more metal parts are joined by welding. The five basic types of weld joints are the butt, corner, tee, lap, and edge.

- **Butt Joint:** It is used to join two members aligned in the same plane. In this joint type, the parts lie in the same plane and are joined at their edges. This joint is frequently used in plate, sheet metal, and pipe work. A joint of this type may be either square or grooved.
- **Corner Joint:** The parts in a corner joint form a right angle and are joined at the corner of the angle. . In cross section, the corner joint forms an L-shape
- **Lap Joint:** This joint consists of two overlapping parts. This is one of the strongest types of joints available; however, for maximum joint efficiency, the overlap should be at least three times the thickness of the thinnest member of the joint.



(a) (b) (c) (d) (e)

Fig.1 Types of Welded Joints: (A) Butt (B) Corner (C) Lap (D) Tee (E) Edge

1.2 Welding Process Parameters

The parameters which affect the selection of welding process, strength of the welded joints, microstructure of the heat affected zone (HAZ) etc. are considered as the welding process parameters. The parameters that affect the quality and outcome of the MIG welding process are given below. All welding processes are characterized by specific process parameters. Some of the process parameters are discussed below.

1.3 Problem Statement:

The aim of this research project has been to study dissimilar metal joint using a filler metal. Dissimilar welding is used to fabricate the pressure vessels and piping in Nuclear reactors, thermal power plants, vessels and heat exchangers but failures occurs frequently due to low tensile strength. This tensile strength of weld specimen is most commonly affected due to welding process parameters. This work presents the results of an investigation into MIG welding of dissimilar metals materials using. The mixing behavior of the materials in the fusion zone, the presence of defects, hardness and residual stress of the joints were all investigated.

2. LITERATURE REVIEW

V. Subravel et al. [1] studied the effect of welding speed on tensile and microstructural characteristics of pulsed current gas tungsten arc welded AZ31B magnesium alloy joints. They have considered five joints fabricated using different levels of welding speeds (105,115,125,135 and 145 mm/min). The material used was rolled AZ31B magnesium alloy. A plate with a thickness of 3 mm which was cut into the required size of 150×150 mm was used as a test specimen. Welded joints were prepared in single pass with argon gas as a shielding gas medium at a flow rate of 20lpm. Microstructural analysis was done using optical light microscope with an image analyzing software. It was observed from the micrographs that the joints fabricated with a welding speed of 135 mm/min contained finer grains as compared to other. Joints fabricated using welding speed of 105 mm/min shows the coarser grains. Tensile test was carried out on 100 kN, electro mechanically controlled universal testing machine. From the results of tensile testing it was observed that the joint fabricated with a welding speed of 135 mm/min exhibited high yield strength (165 MPa), tensile strength (214 MPa) and elongation (7.2%). At higher welding speed partial penetration was observed due to low heat input. At lower welding speed; burn through of the weld was observed due to higher heat input. They observed that tensile properties of the welded joints gets affected by welding speed. At optimum welding speed of 135mm/min full penetration was observed. Due to full penetration joint got the maximum tensile strength. Hardness of the joints fabricated with a welding speed of 135 mm/min was higher in the fusion zone. From this study they concluded that optimum welding speed of 135 mm/min should be used during welding process for achieving good penetration and tensile strength.

Vineeta Kanwal and R.S.Jadoun et al have studied Optimization of MIG Welding Parameters for Hardness of Aluminium Alloys Using Taguchi Method; parametric optimization of MIG welding for Hardness has been performed by using Taguchi method. Welding Speed, Welding Current and Welding Voltage were chosen as welding parameters. The materials used for this purpose were aluminium alloys of grades 6061 and 5083 having dimensions (75x60x6) mm. Argon was used as a shielding gas. Filler wire 4043 of diameter 1.2 mm was used. An orthogonal array, L9 was used to conduct the experiments. Signal to noise (S/N) ratio and analysis of variance (ANOVA) were employed to study the welding characteristics of material. Optimization of parameters was done by Taguchi method using statistical software MINITAB-17. Confirmation tests were carried out with optimal levels of welding parameters to validate the Taguchi's optimization method. Measurement tests were conducted on Rockwell hardness testing machineIn this research study the optimization of the process parameters for MIG welding of aluminium alloys 5083 and 6061 with greater hardness has been reported. A Taguchi orthogonal array, the signal-to-noise (S/N) ratio and analysis of variance (ANOVA) were used for the optimization of welding parameters. It was found that welding current has major influence on hardness of welded joints.
Subodh Kumar et al. have studied the influence of heat input on the microstructure and mechanical properties of gas tungsten arc welded 304 stainless steel (SS) plates. The size of plates used was 200x100x6mm. The welded joint was created using two numbers of passes with 308 SS solid electrode of 3.15mm diameter. Argon gas was used as a shielding gas with constant flow rate of 15 lpm. Three different heat input combinations corresponding to three different welding currents i.e. 120 A (low heat input 2.563 kJ/ mm), 150 A (medium heat input 2.784 kJ/mm) and 180 A (high heat input 3.017 kJ/mm) were selected. Specimens were tested on a servo hydraulically controlled digital tensile testing machine of 400 kN capacity to investigate the effect of heat input on tensile strength of welded joints. Also the size of the HAZ and the extent of grain coarsening obtained in these weld joints was less.

3. METHODOLOGY

3.1. Base Metal

For the current study, weld plates of AISI304 and IS2062 as shown in fig. 3.1 are used as it has a very large scale application in the process industry. The specimen size selected is 150 x 50 mm and of uniform thickness of 12 mm with a single groove of 30° as per ASTM standards. All the test specimens were cleaned thoroughly before welding them.

Fig. 2 Workpiece Specimen

3.2 Filler Metal

There are many types of materials used when making welds, which are generally categorized under the term filler metals. Filler metals are defined as, the metal to be added in making a welded joint. The filler metals used are consumed and become a part of the finished weld. Filler metals are classified into four categories:
a) Covered electrodes b) Solid electrode wire or rod c) Fabricated electrode wire d) Fluxes for welding
For the present study, 1.2 mm diameter electrode having specifications as IS: 6419 AWS SFA: 5.18 ER70s-6 electrode using 100% Carbon dioxide gas is used as a filler material. ER 70s-6 represents the following:

- ER– An electrode or filler rod that is used in either a MIG wire feed or TIG welding.
- 70– A minimum of 70,000 pounds of tensile strength per square inch of weld.
- s -Solid wire.
- 6– The amount of deoxidizing agent and cleansing agent on the electrode.

Carbon	Silicon	Manganese	Sulphur	Phosphorus	Cu
0.07	0.85	1.45	0.025	0.025	0.5

Table 1 Chemical Composition of Filler Material

3.3 MIG Welding Machine

In the present study, MIG welding machine as shown in fig.3.2 that we were going to use for joining the mild steel work pieces. The technical details of the welding machine are given below:

Make :	SAI ARC CV 300
Input supply voltage 3PH :	450
Output :	DC
Welding current range :	0 – 500A
Voltage :	0 – 60 V
Type of cooling :	Forced air cooled
Approximate dimensions (L x M x H) mm .	750 x 515 x 585
Approximate weight (Kg) :	220

Welding machine was provided with gas regulating attachment which is used for controlling the shielding gas flow manually during the experimentation. Welding current and voltage were manually regulated with the help of current indicator and voltage indicator respectively

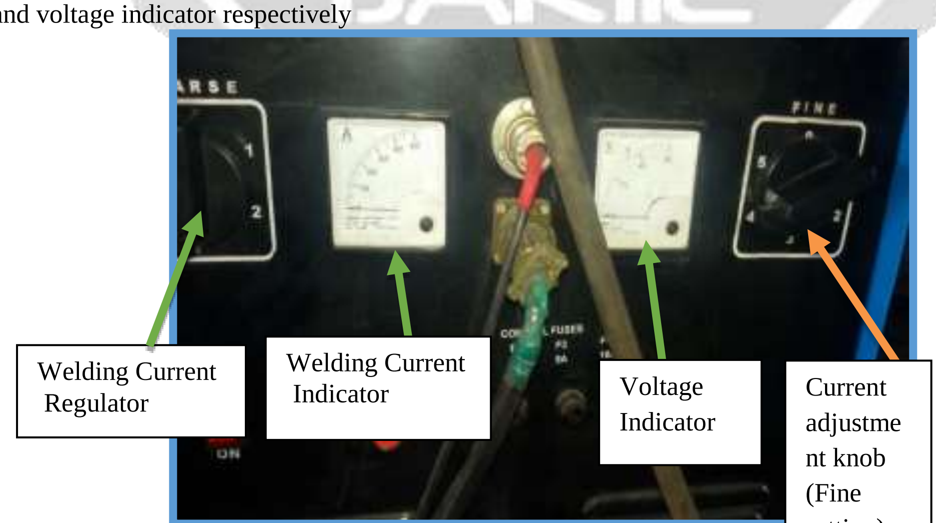


Fig.3 MIG Welding Machine

3.4 Shielding Gas

Welding process is protected from coming in contact with nitrogen and oxygen in the air by a shielding gas. If the welding process is not protected by a shielding gas then oxygen can oxidize the alloying elements and cause slag inclusions and nitrogen dissolves in the molten metal and after solidification, due to lower solubility of nitrogen, pores are formed. The shielding gas can be inert or active

In MIG welding process, different shielding gases used are:

a) Argon b) Co_2 c) Argon / Co_2 mixture

The important properties considered while selecting the shielding gases are their heat transfer properties, density relative to air and the ease with which they undergo ionization. Shielding gases can be used pure, or as a blend of two or three gases. The gas selection is based on the metal to be welded. Pure argon is used only for some nonferrous metals. Pure Co_2 gas is used for the weld, but it creates more spatters during welding. Argon & $Co_2$are more commonly used as it is available readily. Using 80% Argon & 20% C_{O2} shielding gas the arc was very stable and controllable and the weld turned out quite neat.

3.5 Experimental Set Up

Figure 4 shows MIG welding setup with its main components like SMAW welding machine, welding torch, Co_2 gas cylinder, work piece, fiberglass helmet, C-clamps & operator. The welding on E250 grade work piece is performed in two steps. Initially the work pieces are tagged for alignment and then the final welding run is performed. For holding the work piece in both of these operations two C-clamps were used as shown in Fig. 3.4. Out of two C-clamps one is 4 inches Taparia 1261 C-clamp and other 6 inches Taparia 1263 C-clamp.

Fig. 4 Welding Machine Setup

4. RESULT AND DISCUSSION

In this work effect of main input welding parameters on the tensile strength of the welded joints in the gas metal arc welding process was investigated.

Worksheet 2 ***

↓	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
	GP	I	V	UTS	SNRA1	MEAN1				
1	12	150	15	231.4	47.2873	231.4				
2	12	170	20	245.9	47.8152	245.9				
3	12	190	25	256.8	48.1919	256.8				
4	15	150	20	260.2	48.3061	260.2				
5	15	170	25	276.4	48.8308	276.4				
6	15	190	15	287.9	49.1848	287.9				
7	18	150	25	294.8	49.3905	294.8				
8	18	170	15	286.2	49.1334	286.2				
9	18	190	20	291.5	49.2928	291.5				
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Table 2 Experimental Result for Uts and S/N Ratio

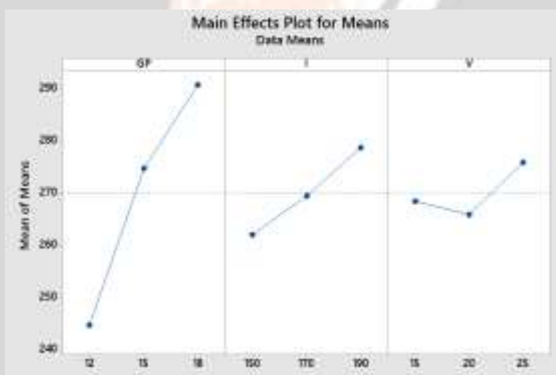

Figure 5 Main effect Plot for SN Ratios

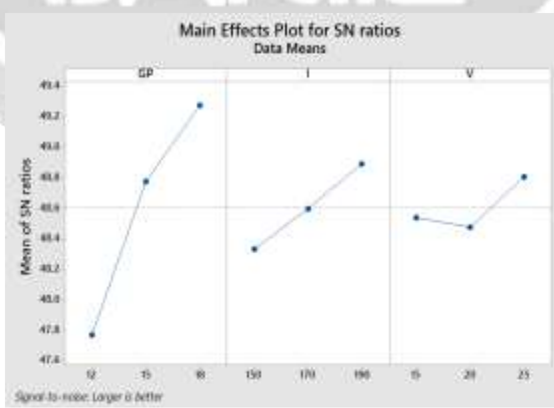

Figure 6 Main effect plot for Means.

Level	GP	I	V
1	47.76	48.33	48.54
2	48.77	48.59	48.47
3	49.27	48.89	48.80
Delta	1.51	0.56	0.33
Rank	1	2	3

Table 3. Response Table Fr Signal to Noise Ratio (Larger Is Better)

The study found that the control factors had varying effects on the Tensile strength, welding voltage having the highest effects. They affect the weld quality in terms of mechanical properties and weld bead geometry. The methods that can be applied for welding process parameter optimization work are Grey Relation Analysis and Taguchi. Welding current, arc voltage, type of shielding gas, gas flow rate, wire feed rate, the diameter of the electrode, etc. are the important control parameters of the Metal Inert Gas Welding process. The optimum welding condition obtained for the highest tensile strength by Taguchi Method is at gas flow rate 18Psi, Welding current 150 Amp, welding voltage 25 volt

5. References

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