Experimental Study on Weld Joint of SS-316 and MS-2062 their Behavior & Comparison on Different Process Parameters with MIG Welding

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Abstract
This paper presents the investigations carried out to study the microstructure and mechanical properties of SS-316 and MS-2062 alloys welded by MIG welding and to achieve the optimized process parameters for these weld joints. For each of the weld joint, detailed analysis was conducted on the microstructure characteristics and mechanical properties. In this investigation an effort has been made to study the influence of various process parameters of MIG welding on the mechanical properties and micro-structure of weld joints .These joints made by MIG Welding were at three different parameters by varying current, gas flow rate & wire speed and keeping other parameters constant. The results of the tensile strength analysis shows that the mean value of tensile strength of current variation specimens was recorded 529.6 MPa while the tensile strength of gas flow parameters and wire speed was 517.7 MPa & 529.6 MPa respectively. These tensile strength values are near to the tensile strength of stainless steel-316 and helped in achieving optimized results for MIG welding of these alloys. Microstructures of non-destructive specimens of different parameters were studied with (Scanning Electron Micrograph) SEM & EDX (Electron Dispersive X-rays Spectroscopy),which revealed that defects occurred because lack of penetration and composition changes.

Keywords
Wire Speed, Current Flow Rate, Gas Flow Rate, Inert Gas, MIG Welding, Tensile Strength, SS 316, MS2062, Weldments, Microstructure, SEM, EDX.

Technical Detail

I. Introduction

Welding is a process for joining two similar or dissimilar metals and alloys. Coalescence of different metals/alloys is carried by either with the help of processes in which heat is supplied either electrically or by means of a gas torch, or pressure may be executed for making the joint. In order to join two or more pieces of metal together by one of the welding processes, the most essential requirement is 'heat'. Pressure may be employed, but this is not, in many processes essential. As discussed in O.P. Khanna (2012)

Dissimilar metals are widely used in critical high service temperature applications. Combination of low alloy steel and austenitic stainless steel weldments are extensively used for boiler tubing, application at elevated temperature because of its relatively low cost, good weld ability and creep resistance. O.P. Khanna (2011)

The filler metal is most probably used in all welding techniques. The filler metal which is used during welding should be chemically same as should as possible for the sound, stable & high strength welding. In a joint between two dissimilar metals the metallurgy of the both base metals and weld metal must be taken into account because the weld metal is a composite of filler metal deposited and the fused base metals, three dissimilar metals may actually be involved in these joints. There are about 35 different welding and brazing processes and several soldering methods in use by industry today. All 35 types of welding come under these three categories. O.P. Khanna (2007)

- Gas welding
- Arc welding
- Resistance welding

When 11.5% or more chromium is added to iron, a fine film of chromium oxide forms spontaneously on the surfaces exposed to air. This film acts as a barrier to retard further oxidation, rust or corrosion. As this steel cannot be stained easily, it is called stainless steel. When compared with common steels, the austenitic stainless steels exhibit the following main differences:-

- Electrical resistance is about six times greater.
- Melting Point is about 930 centigrade lower.
- Thermal conductivity is about 50% lower.
- Thermal expansion is about 50% greater.

(As discussed in Hascalik A, Onal E, Ozdemir (2006))

II. Material Study

Austenitic stainless steel possesses austenitic structure at room temperature. They possess the highest corrosion resistance of all stainless steels. They have greatest strength and scale resistance at high temperatures so these steels are used at elevated temperatures and in corrosion zone. They retain ductility at temperatures approaching absolute zero and they have non-magnetic so that they can easily identified by a magnet. They have the following compositions C-0.03 to 0.25%, Mn-2 to10%, Si-1to2%, Cr-16to26%, NI-3.5to22%, P and S normal & Mo and Ti in some cases are also added. O.P. Khanna (2007)

The use of welding in today technology is extensive. It had a phenomenal rise since about 1930; this growth has been faster than the general industrial growth. Many common everyday use items, e.g., automobile cars, air craft's, ships, electronic equipment, machinery, household appliances, etc, depend upon welding for their economical construction. MIG welding and TIG welding process is used for various dissimilar welding processes like welding of aluminum and its alloys, welding of magnesium and its alloys, welding of copper and its alloys, hard facing of the materials, joining two dissimilar metals like Austenitic stainless steel and mild steel etc. TIG welding is an arc welding process wherein coalescence is produced by heating the job with an electric arc struck between a tungsten electrode and a job. A shielding gas like argon, helium, nitrogen etc. is used to avoid atmospheric contamination of the molten weld pool. A filler metal may be added if required. In MIG welding process wherein coalescence is produced by heating the job with an electric arc established

between a continuously fed metal electrode and the job. No flux is used but the arc and molten metal are shielded by an inert gas, which may be argon, helium, carbon dioxide or a gas mixture. As on www.gowelding.com accessed on 27/12/2011.

A. Stainless steel 316 (Properties & applications):-

In metallurgy, stainless steel, also known as inox steel or inox from French "inoxyable", Is defined as a steel alloy with a minimum of 10.5 or 11% chromium content by mass. Stainless steels does not corrode, rust or stain with water as ordinary steel does , but despite the name it is not fully stain proof. It is also called corrosion-resistant steel or CRES. When steel grades and the alloy types are not detailed, particularly in the aviation industry. There are different grades and surface finishes of stainless steel to suit the environment the alloy must endure. Stainless steel differs from carbon steel by the amount of chromium present. Unprotected carbon steel rusts readily when exposed to air and moisture. This iron oxide film is active and accelerates corrosion by forming more iron oxide. Stainless steel contains sufficient chromium to form a passive film of chromium oxide, which prevents further surface corrosion and blocks corrosion from spreading into the metals internal structure. The common applications are of stainless steels are given below:

1. Oil & petroleum refining equipment
2. Food processing equipment
3. Pulp and paper processing equipment
4. Soap & photographic handling equipment
5. Textile industry equipment
6. Architectural equipment
7. Pharmaceutical processing

Table 1: The Table Shows Mechanical Properties of Stainless Steel 316:

Hardness, Rockwell B	79
Tensile strength, Ultimate	558 MPa
Tensile strength, Yield	290MPa
Elongation at Break	50%
Modulus of Elasticity (Tensile)	193 GPa
Modulus of Elasticity (Torsion)	77 GPa

Table 2: The Table Shows Chemical Composition of SS-316.

C	Si	Mn	P	S	Cr	Ni	Mo	N
0.020	0.47	1.77	0.031	0.002	17.10	10.11	2.05	0.048

1. MS-2062 (Properties & Application):

This standard was formerly known as IS-226. Now IS-2062 has replaced this specification. Mild steel is the most common form of steel because its price is relatively low whole it provide material properties that are acceptable for many applications. Low carbon steels contain approximately 0.05-0.015% carbon and mild steel contains 0.16 to 0.29% carbons; therefore, it is neither brittle nor ductile. It has relatively low tensile strength, but it is cheap and malleable; surface hardness can be increased through carburizing. The density of mild steel is approximately 7.85g/m3 and modulus of elasticity is 210 GPa.

Table 3: Chemical Composition (in % Max Values) of MS-2062:

Carbon	0.23%
Manganese	1.50%
Sulphur	0.045%
Phosphorus	0.045%
Silicon	0.40 %
Carbon equivalent	0.42%

MS-2062 is carbon steel typically with a maximum of 0.25% carbon and 0.4%-0.7% Manganese, 0.1%-0.5% silicon and some = traces of other elements such as Phosphorous, it may also contain lead or sulphur.

2. Applications:-

- Bullets
- Nuts & bolts
- Chains
- Hinges
- Knives
- Armor
- Pipes
- Magnets etc

B. Literature Review of MIG Welding

MIG is an arc welding process wherein coalescence is produced by heating the job with an electric arc established between a continuously fed metal electrode and the job. No flux is used but the arc and the molten metal are shielded by an inert gas, which may be argon, helium, carbon-dioxide or a gas mixture. Before igniting the arc, gas and water flow is checked. Proper current and wire feed speed is set and electrical connections are insured. The arc is struck by any one of two methods. IN first method current and shielding gas flow is switched on and electrode is scratched against the job as usual practice for striking the arc. In second method, electrode is made to touch the job, is retrenched and then moved forward to carry out welding; but before striking the arc, shielding gas, water and current is switched on. About 15mm length of electrode is projected from the torch before striking the arc. During welding, torch remains about 10-12 mm away from the job and arc length is kept between 1.5 to 4mm. Arc length is maintained constant by using the principles of self adjusted arc, and self controlled arc in semi-automatic and automatic welding set respectively. Power sources possessing flat or drooping characteristics and rated at 400 Amps can be employed for MIG welding. Flat characteristics welding sources ensure a more constant arc length. The major types of power sources are DC generator or AC transformer with rectifier. The welding torch energizes the electrode, feeds the electrode and the shielding gas. The torch may be water cooled or air cooled. Torches working above 200Amps are generally water-cooled. The torch may have straight or bent nozzle fitted at end. A bent nozzle can be used for welding complicated shapes and intricate joints. The different diameters of electrode wire are .8, 1.2, and 1.6mm etc. A standard wire pool may have from 1 to 15Kgs of wire. Steel electrodes are generally copper coated. AS far as possible the chemical composition of the work piece and that of the electrode should be similar. Electrodes are available for welding aluminum, magnesium, nickel, their alloys, carbon, low alloy & stainless steels etc. As discussed in Anderson, P.C, et al. (2004).

These are the base metals commonly welded by MIG are give below:-

1. Carbon and low alloy steels
2. Stainless steels
3. Heat-Resisting alloys
4. Aluminum and its alloys
5. Copper and its alloys
6. Magnesium and its alloys

III. Definition of the Problem

A. Work Plan

1. Methodology

The present work has been completed in five stages which have to be preceded in parallel fashion, as described below:

- Literature review
- Documentation
- Material Requirement (Stainless Steel -316 & Mild steel-2062)
- Machining / welding
- Experimental Testing

2. Facility used for Proposed Work:

Various facilities required for proposed work are as follows:

- Referred journals and publications
- Internet facility
- Various books from library
- Machining / welding facility

B. Mechanical Analyses

In this experimental study firstly, work piece of stainless steel-316 of following cylindrical dimensions were prepared before MIG welding for testing.

C. Specimen For Testing

The dimensions for SS-316 are:
Number of work pieces: 02
Length of work piece: 60mm
Diameter of work piece: 20mm

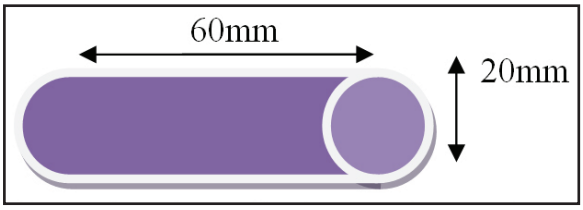

Fig. 1: Shows Specimen for Destructive Testing

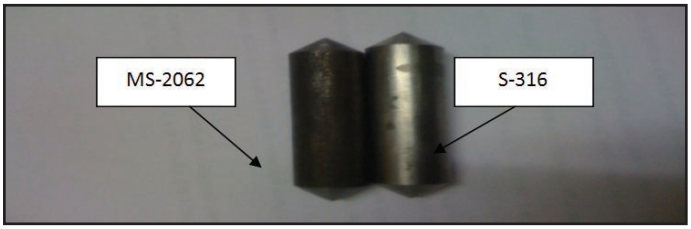

Fig. 2: Shows Prepared Specimens of SS-316 & MS-2062

D. Preparation of Weldments

Specimen of SS-316 & MS-2062 rods of diameter 20 mm was cut in the shape of smaller section, having 60 mm length of each piece. Each specimen was machined to obtain v groove, having angle of 45º.

Table 4: Shows Parameters During Mig Welding

MIG WELDING	PARAMETERS
Wire speed	5.5 m/min
Gas	co_2
Wire	stainless steel copper coated
Diameter of wire	0.8 mm
CO_2 gauge pressure	4 kg/cm^2

Fig. 3: Shows MIG Welding Setup Used (MIG-202, Manufacturer: Sohal Industries)

Fig. 4: Shows Preparations of Weldments by MIG Welding

Fig. 5: Shows Preparations of Specimens on Lathe Machine

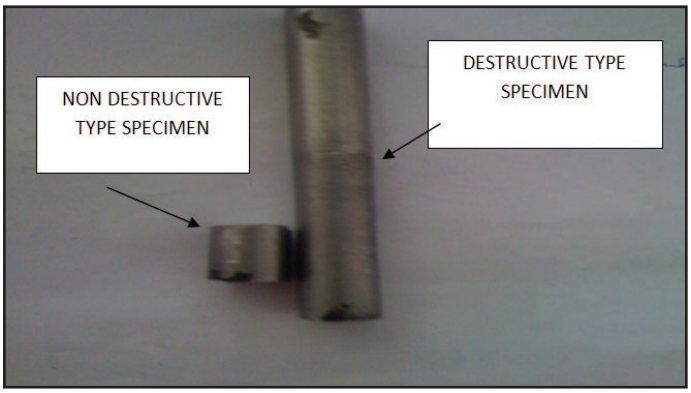

Fig. 6: Shows Specimens with Required Dimensional Specifications

E. Experimental Setup and Design

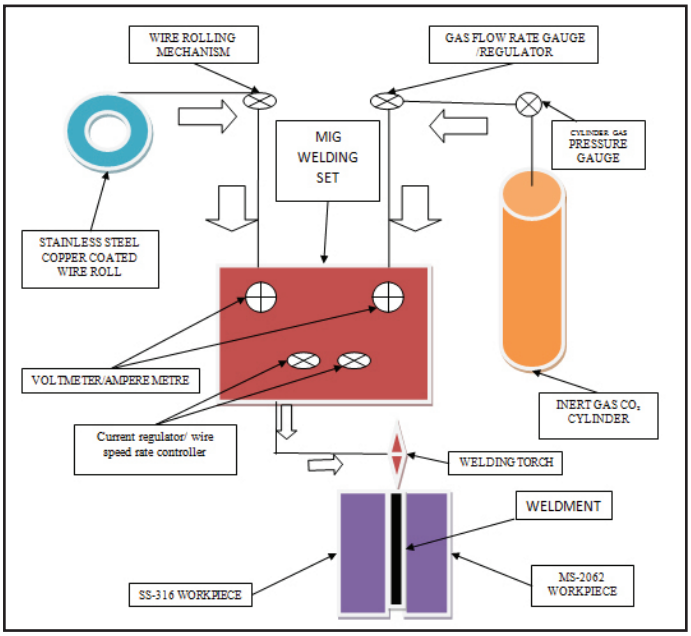

Fig: 7: Experimental Setup and Design

IV. Results & Discussion

A. Based on Mechanical Analysis

This work has been carried out in order to achieve optimized process parameters in duplex/dissimilar weldments in MIG welding process with improved mechanical properties and micro structural properties for the weld joint of SS 316 and MS 2062.

B. Conclusion

On the basis of this investigation, the following conclusions can be drawn.

1. Sound welds could be obtained between SS-316austenitic stainless steel and MS-2062 low alloy steel by all the three achieved optimized welding parameters.
2. In MIG welded SS-316 and MS-2062 dissimilar metals, the mean value of tensile strength was optimized for all three parameter, influence of current parameter on weld joint was maximum and optimized value of tensile strength was achieved.
3. Welding parameter variation investigation leads to observations of various welding defects like dimples, blow holes etc. and other irregularities because of lack of penetration and composition changes, revealed in this investigation provided ways to rectify these defects by achieving optimized process parameters.
4. The influence investigation of gas flow rate and wire speed on the weld joint of SS-316 and MS-2062 represents that as these parameters are increased, tensile strength decreases.
5. In the other process parameter investigation, it has been concluded that when current flow rate increases, the tensile strength of weld joint of SS-316 and MS-2062 decreases.
6. It was evident through SEM analyses that the ultimate weld microstructure in joints is determined by the solidification mode and the subsequent solid-state transformation.

C. Future Scope

This study provides further scope in investigating galvanic corrosion, which results because of high thermal stresses, current variations and temperature shoot-up during MIG welding. This further investigation was not carried because of some financial and time limitations, but this provides future scope for further research on this topic.

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