

EXPERIMENTAL ANALYSIS OF DISSIMILAR METAL WELDS OF MILD STEEL AND STAINLESS STEEL

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Abstract - Dissimilar metals joined or welded together have been widely used in all the fields such as automobile industries, nuclear reactors, boilers, petrochemical and chemical industries. The use of two dissimilar metals has increased widely due to light weight and increased mechanical and chemical properties as compared to using the materials separately.

During welding of dissimilar metals various types of defects can be produced like stress corrosion cracking, residual stresses, and unbalanced stress concentration on either side of the weld due to migration of the atoms, thermal stresses and thermal expansion of materials during welding.

In this work Stainless steel 304 is welded to Mild steel 1020 using Gas metal arc welding (MIG). The samples were welded using stainless steel welding electrode: (AWS: E308I-16) under different process parameters. The shielding gas used for this experiment is CO₂. Using the tensile test the mechanical properties of the welded joint were known. The yield strength and the tensile strength of the welded joint, done using stainless steel electrode at the best parameter were noted. Taguchi method is used for getting the optimized value. The results were compared for different joints made by MIG welding processes. During the tensile testing the failure of the weld at mild steel base metal gives the correct indication of stronger regions of stainless steel base metal zone.

Further the results shows that increasing the current and voltage increases the strength of welds.

Key Words: Tensile strength, dissimilar metal welding, Metal Inert Gas Welding, MS and SS

1. INTRODUCTION

The stainless steel is one of the most popular materials for structural applications, due to its excellent physical and mechanical properties but it increases the structural cost. The dissimilar metal welds of different steels have very vast requirement for industrial use for conventional structural engineering applications such as civil construction, nuclear reactors, thermal power plants, vessels and heat exchangers for several industrial applications [1-3]. Nowadays the requirement for production of many engineering and structural components is good joint efficiency, simple process, low fabrication cost, welding reliability and efficient metal joining processes [4]. The various metallurgical changes such as, precipitation of secondary phases, micro-

segregation, presence of porosities, solidification cracking, grain growth in the HAZ and materials loss due to vaporization are the major problems for poor mechanical properties in stainless steel welds [5]. Thus, for structural applications, stainless steels are efficiently utilized by dissimilar welds between carbon steels and stainless steels with economical use of the special properties of steels dependent on the same structure. The various metallurgical changes such as, porosities, solidification cracking, grain growth in HAZ and materials loss by vaporization are the major problems which produces poor mechanical properties in stainless steel welds. Therefore, for structural applications, the stainless steels are utilized efficiently by dissimilar steel welds between stainless and carbon steels with effective and economical utilization of the special properties of each steel dependent in the same structure [6].

2. MIG welding

Metal inert gas arc welding (MIG) also called as gas metal arc welding (GMAW) utilizes a consumable electrode thus the term metal appears in the title. There are other gas shielded arc welding processes utilizing the consumable electrodes, such as flux cored arc welding (FCAW) all these type of welding can be termed under MIG [6].

Though gas metal arc welding (GMAW) can be used to weld all types of metals, it is more suitable for thin sheets. But for welding thicker sheets of metal, the filler metal requirement makes GMAW difficult to use. Consumable electrode is in the form of a wire reel which is fed at a constant rate, through the feed rollers. The welding torch is connected to the gas supply cylinder which provides the necessary inert gas. The electrode and the work-pieces are connected to the welding power supply. The power supplies are of constant voltage type only. The current is changed by the rate of feeding of the electrode wire. Generally DC arc welding machines are used for GMAW with positive electrode (DCRP). The DCRP increases the metal deposition rate and also provides for a stable arc and smooth electrode metal transfer.

With Direct current reverse polarity, the arc becomes highly unstable and it also results in a large spatter which is a kind of defect which damages the physical property of the weld. But special electrodes having calcium and titanium oxide mixtures as coatings are found to be good for welding steel with DCSP. In the Gas Metal Arc Welding process, the filler material is transferred from the electrode to the joint.

Depending on the current and voltage used for a given electrode, the metal transfer is done in different ways [7-10].

3. Materials and Sample preparation

The materials used and the procedure of specimen preparation is given below.

3.1 Chemical Composition

The chemical compositions of the 1020 mild steel and 304 stainless steels are shown in Tables.

Table-1: Chemical Composition of SS 304 [11]

Fe	C	Si	Mn	S	P	Cr	Ni
71. 43	0.05 8	0.35	1.32	0.0 7	0.03 2	18. 52	8.28

Table-2: Chemical Composition of Mild Steel 1020 [11]

Fe	C	Si	Mn	S	P	Cr	Ni
99.3 1	0.2	0.35	0.4	0.0 5	0.0 4	18. 21	8.06

3.2 Sample Preparation

Specimen of AISI 304 stainless steel and 1020 Mild Steel cylindrical rod with the dimensions given below is prepared [5-6].

Table-3: Specimen dimension

Overall length	150 mm
Distance between shoulders	44 mm
Diameter or width	12 mm
Grip section diameter	15 mm
Grip section length	53 mm
Fillet radius-	5 mm

The specimens were turned to above dimensions in a lathe machine and faced to prepare the weld surfaces. The surfaces to be welded were cleaned thoroughly prior to welding. MIG welding process was used for welding steel with mild steel. The AWS: E308l-16 rod of 2 mm diameter filler material was used for all welding process. The specimen prepared is shown in the figure 1 [5] and the specimen geometry is shown in figure 2 [6].

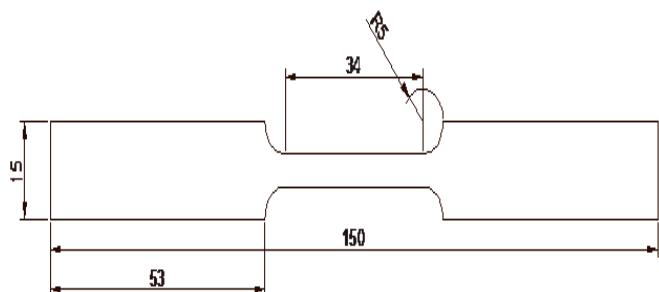


Fig-1: Specimen prepared [5]

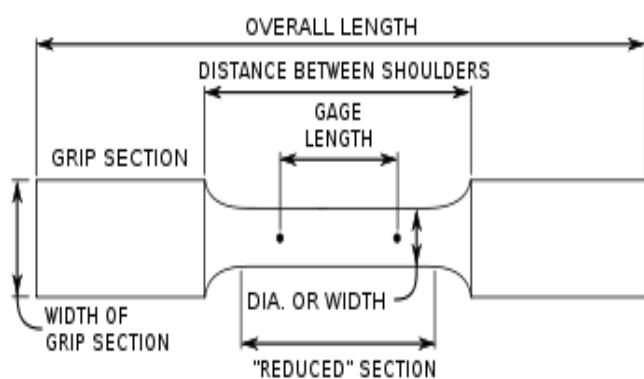


Fig-2: Specimen geometry [6]

4. Experimental work

An experiment work is carried out for MIG welding process on dissimilar materials 304Stainless steel and 1020 Mild steel. Good strength can be achieved at high welding rate by proper control on the welding parameter. The experimental work shows the study conducted on tensile strength as output parameter with reference to variable input parameters such as gas pressure, current and voltage [9-10].MIG 300 GN welding Machine is used. The Gas flow rate is 10 L/min.

Table-4: Parameters considered for experiment

S.no	INPUT PARAMETERS
1	Gas pressure (Psi)
2	Current (Amp)
3	Voltage (V)
S.no	CONSTANT PARAMETER
1	Electrode size
2	Shielding Gas
S.no	OUTPUT PARAMETER
1	Tensile Strength (KN)

These are the required process parameters which are used with their different values for the welding of mild steel and stainless steel test samples.

Table-5: Parametric values

Parameter level	Gas pressure (Psi)	Current (Amp)	Voltage (volt)
1	12	150	15
2	15	170	20
3	18	190	25

The above table shows the values of the different parameters taken for carrying out the experiment.

The Rilon welding machine of MIG Welding is used for this experiment.

**Fig-3:** MIG Welding Machine

Figure shows the Rilon MIG welding machine having power voltage of 3phase 380V (15%). It has efficiency of 85% and the type of wire feed is internal feeding. The power factor is 0.85 and the output voltage for MIG is 16.5-29 and for MMA 22.4-32. The rated input current in Ampere is 18.5 for MIG and 20.5 for MMA and the output current adjustment is 50-300 for MIG Welding and 70-300 for Manual Metal Arc welding. The overall weight of the entire unit is 60 kg. The welding thickness is generally more than 0.8 mm.

The UTM testing machine used for tensile testing of specimens

**Fig-4:** Universal testing machine**Fig-5:** SS and MS weld



Fig-6: Tested Welds in UTM

5. Results and Discussions

Table 5 shows the parameters used during welding and results obtained from the tensile test. From the Table 5, it is shown that the maximum value of tensile strength 125 KN is obtained at experiment no 4. While the minimum value of tensile strength 100 KN is obtained at experiment no 1. Figure 7 and figure 8 shows the main effect plots of mean of means and signal to noise ratio graphs of the tensile strength test which are obtained by using Taguchi's analysis with proper design of experiment.

The result shows that on increasing the current and voltage the tensile strength increasing and more force is required to break the weld. But simultaneously on increasing the gas pressure, current and the voltage the tensile strength decreases as can be seen from the main effect graphs and the result values. The mean of means curve shows the average value of the tensile strength for all the three parameters taken and also the maximum and the minimum values are obtained.

S.NO	GAS PRESSURE (Psi)	CURRENT (Amp)	VOLTAGE (Volt)	TENSILE STRENGTH (KN)
1	12	150	15	100
2	15	170	20	110
3	18	190	25	105
4	12	170	20	125
5	15	190	25	100
6	18	150	15	120
7	12	190	25	105
8	15	150	15	115
9	18	170	20	105

Table-5: Results of tensile strength obtained from experiment

Greater the signal to noise ratio more optimized will be the value of the experiment. From the main effect plot for the signal to noise ratio it can be seen that the maximum value of the SN ratio is obtained at maximum current and voltage and the at the average gas pressure. Thus for better value of the response, the optimal values of the parameters should be taken.

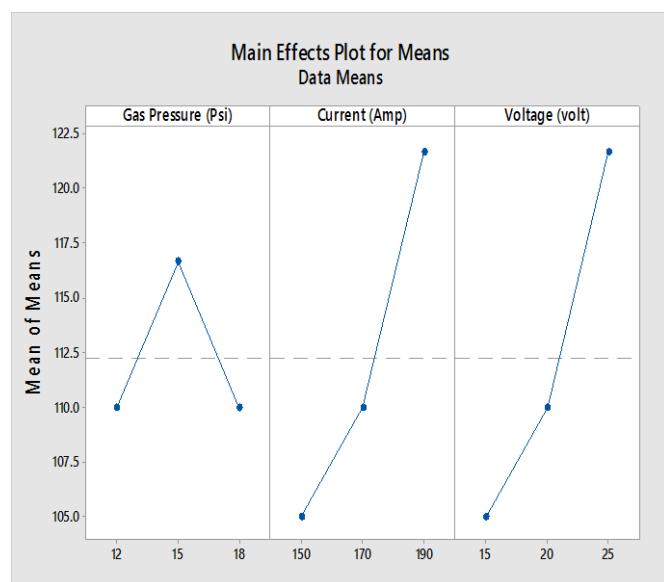


Fig-7: Main effect plot for means

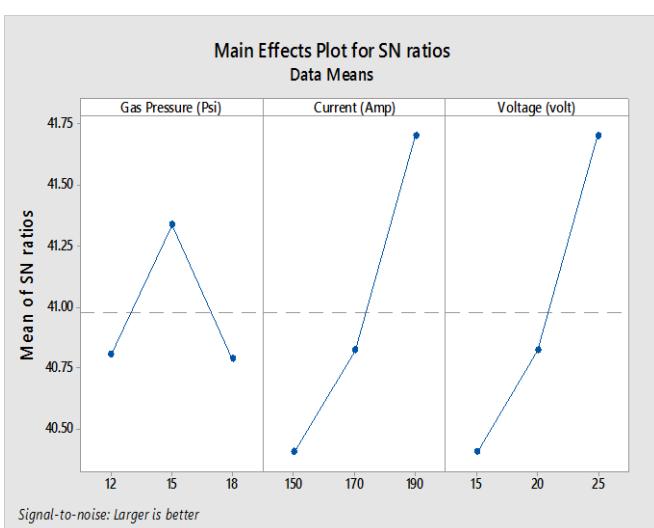


Fig-8: Main effect plot for SN Ratio

7. Conclusions

The experimental result shows that the ultimate tensile strength is same for 12 and 18 psi gas pressure and maximum for 15 psi gas pressure. This suggests that on increasing the gas pressure than the required value the strength of weld decreases and is best for average gas pressure. It is shown that the ultimate tensile strength increases with increase of current value from 150 Amp to 190 Amp. From the results we can see the following conclusions:

Firstly as we can see that on keeping gas pressure constant to 12 psi, current to 150 ampere and increasing the voltage to 20 volts the ultimate tensile strength increases. Then on keeping the gas pressure constant and increasing the current and voltage to 170 ampere and 15 -20 volts the ultimate tensile strength increases slightly. But when we increase the gas pressure to 15 psi and kept the current and voltage constant to 150 ampere and 20 volts respectively the ultimate tensile strength decreases.

REFERENCES

- [1] Abdul wahab H. Khuder and Esam J. Ebraheam, Study the factors effecting on welding joint of dissimilar metals||, Al-Khwarizmi engineering journal, April (2011), Vol 7, No. 1, pp.-76-81.
- [2] Wen-chun Jiang and Xue-wei Guan —A study of the residual stress and deformation in the welding between half-pipe jacket and shell *Materials and Design*, Vol. 43, 2013, PP 213-219.
- [3] Man Gyun Na, Jin Weon Kim and Dong Hyuk Lim —Prediction of Residual Stress for dissimilar metals welding at nuclear plants using Fuzzy Neural Network Models *Nuclear Engineering and Technology*, Vol. 39, 2007, PP 337-348.
- [4] M.M.A. Khan, L. Romoli, M. Fiaschi, G. Dini and F. Sarri —Laser beam welding of dissimilar stainless steels in a fillet joint configuration *Journal of Materials Processing Technology*, Vol. 212, 2012, PP 856-867.
- [5] Yoshiyasu Itoh and Kabushiki Kaisha Toshiba —Joined structure of dissimilar metallic materials *Patent Publication Number*, EP0923145A2, 1999.
- [6] P. Delphin, I. Sattari-Far and B. Brickstad —Effect of thermal and weld induced residual stresses on the j-integral and ctd in elastic-plastic fracture analyses *Final Report Vol. SINTAP/SAQ/03*, 1998, PP 1-47.
- [7] Ajit Hooda, Ashwani Dhingra and Satpal Sharma, —Optimization of MIG welding process parameter to predict maximum yield strength in AISI 1040, *International journal of Mechanical engineering and Robotics research*, October (2012), Vol 1, No. 3, pp.-203-213.
- [8] T.A. Mai and A.C. Spowage —Characterization of dissimilar joints in laser welding of steel-kovar, copper-steel and copper-aluminium *Materials Science and Engineering*, Vol. 374, 2004, PP 224-233.
- [9] Paul Colegrave, Chukwugozie Ikeagu, Adam Thistlethwaite, Stewart Williams, Tamas Nagy, Wojciech Suder, Axel Steuwer and Thilo Pirling — The welding process impact on residual stress and distortion *Science and Technology of Welding and Joining*, Vol. 14, 2009, PP 717-725.
- [10] N.Arunkumar, P. Duraisamy and S. Veeramanikandan —Evaluation Of Mechanical Properties Of Dissimilar Metal Tube Welded Joints Using Inert Gas Welding *International Journal of Engineering Research and Applications*, Vol. 2, Issue 5, 2012, PP 1709-1717.
- [11] Wei-Chih Chung, Jiunn-Yuan Huang, Leu-Wen Tsay and Chun Chen —Microstructure and Stress Corrosion Cracking Behavior of the Weld Metal in Alloy 52-A508 Dissimilar Welds *Materials Transactions*, Vol. 52, 2011, PP 12-19. 50.

BIOGRAPHIES



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