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An Investigation and FEA Analysis of Dissimilar Joints with Alloy Steel and SS409

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Abstract**—** *The dissimilar metal joints of 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. The quality of weld in MIG mainly influenced by independent variables such as welding current, speed of electrode and Torch angle. The planned experiments were conducted in the MIG welding machine. Image J software was used to find out the depth of penetration depending upon the temperature variation. Thermal flux and Thermal gradient values were obtained moderate value on that specimen analyzing through FEA. The good weldment obtained in the input parameter was AMPS 160 VOLT-18 Torch angle 45º for 6 mm thickness plate. It does not create any major changes and failures in the tensile and Hardness testing process and it was comparatively good and moderate depth of penetration value compared than others. According to the Taguchi design the optimized tensile strength parameter value for the 6 mm plate on EN 8 & SS409 steel was AMPS 140, VOLT-22, and Torch angle 45 º.*

Keywords**—** *MIG Welding, EN8, Austenitic Stainless Steel, AISI 409, Mechanical Property, FEA.*

I. INTRODUCTION

A. Introduction to Welding

Metal inert gas/ metal active gas (MIG/MAG) welding is an arc welding process, the melting takes place by Joule effect and a continuous electric arc, where the additional metal is supplied by a roll of wire. The weld is made by falling successive drops on the weld puddle. Argon gas (MIG welding) or active gas, CO2 (MAG welding) are used as plasma for providing protective atmosphere for the weld metal lied from the generator is controlled to reach a point chosen by the welder the short-circuit mode, where current flows at pre-defined law, in gas metal arc welding the molten metal drop detachment form an electrode have complex interactions between different physical phenomena. Some of the researchers have studied the electromagnetic effects and some studied the thermal effects and the fluid dynamics. It is an arc welding process where heat is generated for arc between the work piece and a consumable electrode. A bare solid wire called electrode is continuously fed to the weld zone, it becomes filler metal as it is consumed. Gas metal-arc welding overcomes the restrictions of using electrode of limited length and overcomes the inability to weld in various positions, which is a limitation of submerged-arc welding. In gas metal arc welding, the variations of power supplies, shielding gases and electrodes have significant effects, resulting in different process variations. All important metals used in different commercial applications such as aluminum, copper, stainless steel and carbon steel can be joined by this MIG welding process by choosing appropriate electrode, shielding gas and different welding conditions. MIG welding is such a welding process which is extensively used in the industries for its high precision and accuracy capability. But performance of the welding depends largely upon the parameters like voltage, current and also on type of work-piece materials, electrode material combinations. A large amount of research works have been noticed to find out the most suitable combination of input process parameters for a desired output. In our present study work piece of mild steel material of grade High Carbon High Chromium steel has been used tolerances.

B. Applications

The MIG/MAG process proved itself highly useful for rationalized welding of unalloyed and low-alloy structural steels, today it can be best put to use for aluminum alloys, high quality structural steels, and stainless steel. This is due to the pulsed and dips transfer arcs techniques. Despite of the type of arc, MIG/MAG displays significant advantages over other welding processes. These include good deposition rate, deeper fusion penetration, simple handling and total mechanization, in addition to high productivity. With the arrival of programmed welding, gas-metal arc welding has become the predominant process choice. The process of MIG/MAG is getting wider applications in the areas of high-production and automated applications i.e. ship building industry, pipelines, tack welding, pressure vessels, gas cylinders welding and maintenance repairs.

II. LITERATURE REVIEW

I. Aini Ibrahim, et al. were analyzed GMAW process is leading in the development in arc welding process which is higher productivity and good in quality. They were studied, the effects of different parameters on welding penetration, microstructural and hardness measurement in mild steel that having the 6mm thickness of base metal by using the robotic gas metal arc welding are investigated. The variables that choose in this study are arc voltage, welding current and welding speed. The arc voltage and welding current were chosen as 22, 26 and 30 V and 90, 150 and 210 A respectively. The welding speed was chosen as 20, 40 and 60 cm/min. The penetration, microstructure and hardness were measured for each specimen after the welding process and the effect of it was studied. As a result, it obvious that increasing the parameters value of welding current increased the value of depth of penetration. Other than that, arc voltage and welding speed is another factor that influenced the value of depth of penetration. The microstructure showed the different grain boundaries of each parameter that affected of the welding parameters.

D. S. Yawas, et al. were investigated fatigue behavior of welded austenitic stainless steel in 0.5 M hydrochloric acid and wet steam corrosive media has been investigated. The immersion time in the corrosive media was 30 days to simulate the effect on stainless steel structures/equipment in offshore and food processing applications and thereafter annealing heat treatment was carried out on the samples. The findings from the fatigue tests show that seawater specimens have a lower fatigue stress of 0.5 _ 10_5 N/mm2 for the heat treated sample and 0.1 _ 10_5 N/mm2 for the unheat-treated sample compared to the corresponding hydrochloric acid and steam samples. The post-welding heat treatment was found to increase the mechanical properties of the austenitic stainless steel especially tensile strength but it reduces the transformation and thermal stresses of the samples. These findings were further corroborated by the microstructural examination of the stainless steel specimen.

A. *Scope of the Project*

The main objective of the project is during welding process we have to get the minimum changes in the physical properties and no metallurgical defect is present. Defect free welding process should be made. To achieve a good weldment has to be analysis with many samples and quality checks with destructive testing in this experimental work

III. Experimental Analysis

A. *Experimental Setup*

A AC constant current Sun power source (DC Inverter machine MIG/MMA 500) was used in our experiment. The process required clamping joint in fixtures, setting welding parameters (voltage, welding current, arc travel speed, wire feed rate, electrode position and orientation of gun). The setting of welding parameters is very important so that the correct relationship must be obtained between current, voltages, stick-out, gas flow, welding speed and gun angles. There should be proper selection of filler wires, and shielding gases. The process does not require very skilled welders; the welders can be semiskilled welders. During the welding special attention should be given to the arc glare, smokes, fumes, electrode changing, and nozzle clean. After the welding has been done, the quality of weld bead appearance has to be examined.

B. *Welding Equipments*

Power source used for this research work is an important factor worth mentioning in the subject of welding of sheet metal using modified arc. Latest developments in electronic technology have a considerable impart on the arc welding method to make it adjustable. These developments have made modified arc welding process faster and more productive. FastMigTMsynergic welding machine can be used in FastROOT welding program together with MIG/MAG processes.

IV. EN8 Steel & SS409

EN 8 steel is a high tensile alloy steel and wear resistance properties and also where high strength properties are required. EN8 is used in components subject to high stress and with a large cross section. This can include aircraft, automotive and general engineering applications for example propeller or gear shafts, connecting rods, aircraft landing gear components.

Grade 409is the basic martensitic stainless steel; like most non-stainless steels it can be hardened by a "quench-and-temper" heat treatment. It contains a minimum of 11.5 per cent chromium, just sufficient to give corrosion resistance properties. It achieves maximum corrosion resistance when it has been hardened and tempered and then polished. Grade 409 is a general purpose grade often supplied in the hardened, but still machinable condition, for applications where high strength and moderate heat and corrosion resistance are required.

A. *Chemical Properties of EN8*

TABLE 1.1

SL.NO	ELEMENT	COMPOSITION IN WEIGHT % MIN	MAX
1	Carbon, C	0.35	0.45
2	Manganese, Mn	0.45	0.70
3	Silicon, Si	0.1	0.35
4	Molybdenum, Mo	0.20	0.35
5	Chromium,Cr	.90	1.40
6	Sulphur&phosphorous	--	0.05

B. *Comparison of Thermal flux and Thermal gradient*

TABLE 1.2

SL.NO	AMPS	VOLT	TORCH ANGLE°	TF W/m^2	TG K/m
1	140	18	30	5544.4	154.01
2	140	20	40	6930.9	192.51
3	140	22	50	8316.59	231.01
4	160	18	40	11088.8	308.02
5	160	20	50	12474.9	346.52
6	160	22	30	13861	385.02
7	180	18	50	15247.1	423.53
8	180	20	30	13861	385.02
9	180	22	40	12474.9	346.52

V. Taguchi

A. *Design of Experiment*

TABLE 1.3

Levels	Process parameters		
	CURRENT AMPS	VOLTAGE VOLT	TORCH ANGLE°
1	140	18	30
2	160	20	45
3	180	22	60

B. *HARDNESS TEST-Rockwell-B-SCALE-HRB*

TABLE 1.4

Materials	AMPS	VOLT	TA	HARDNESS SS409	EN8
SS 409 & EN8	140	18	30	82	90
	140	20	45	90	95
	140	22	60	86	87
	160	18	45	82	90
	160	20	60	87	94

	160	22	30	90	92
	180	18	60	84	95
	180	20	30	89	87
	180	22	45	87	89

C. Tensile Load Result

TABLE 1.5

SL.NO	AMPS	VOLT	TORCH ANGLE°	TL KN
1	140	18	30	15
2	140	20	45	22
3	140	22	60	20
4	160	18	**45**	30
5	160	20	60	20
6	160	22	30	18
7	180	18	60	15
8	180	20	30	15
9	180	22	45	13

D. ANOVA table for Tensile Strength

TABLE 1.6

Source	DF	Seq SS	Adj MS	F	P	% OF CONTRI BUTION
AMPS	2	96.22	48.111	2.00	0.334	46
VOLT	2	16.89	8.444	0.35	0.741	8
TORCH ANGLE	2	48.22	24.111	1.00	0.500	23
Error	2	48.22	24.111			23
Total	8	209.56				100

VI. Result and Conclusion

A. Result

GMAW process can be used successfully to join SS409&EN8. The processed joints exhibited better mechanical and metallurgical characteristics. The specimen failures were associated depending upon the improper changes of heat value. Finally I found the tensile strength value of the GMAW welded Bimetallic joints was comparatively higher value (AMPS160, VOLT-18 &TORCH ANGLE 45º) than other value .Thermal flux and Thermal gradient values were obtained moderate value on that specimen analyzing through FEA.

B. Optimal Control Factor

According to the Taguchi design and optimized parameter is value for the 10 mm plate of dissimilar structure steel were AMPS 140 VOLT-22 TORCH ANGLE 45º

C. Percentage of Contribution

Tensile strength was most influenced with current rating of 46% of these bimetallic joints during GMAW process.

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