An Investigation and Welding Characterization of Dissimilar Joints of Alloy Steel with SS410 through GMAW

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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. Selections of joining process for such a material are difficult because of their physical and chemical properties. The stainless steel and mild steel dissimilar material joints are very common 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 affects the quality of joint leads deteriorate strength.. In the present investigation, stainless steel of grades 410 and EN 24 were welded GMAW processes. Quality of the weld bead is always governed by its geometry and configuration which, in turn are controlled by various welding process input parameters such as welding speeds, current, and voltage as well as the type of the welding process. The planned experiments were conducted in the semi auto MIG welding machine.. Image J software were used to find out the depth of penetration depending upon the temperature variation. Experimentally found the input parameter value Ampere rating 140 ,Volatge -18 and Gas pressure 4 Kg/cm2was the best value and it did not create any major changes and failures in the testing process and it was comparatively higher tensile value than other values. Finally optimized through Taguchi design optimum parameter value for 6 mm dissimilar stainless steel was Ampere rating 180 ,Volatge -18 and Gas pressure5 Kg/cm2.

Index Terms – GMAW,Depth of penetration, Hardness, optimization, orthogonal array, S/N ratio.

1. INTRODUCTION

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, CO_2 (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. It has been very important to know the performance of a welding process over a wide range of input process parameters.

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.

2. WELDING PROBLEM ON DISSIMILAR STEEL

2.1 Problem Identification

In many cases the welder needs only to know the techniques of actual welding and does not need to be concerned about the type or grade of steel being welded. This is because a large amount of steel used in fabricating a metal structure is low Carbon or plain carbon steel (also called mild steel). When welding these steels with any of the common arc welding processes like Stick Mig or Tig there are generally few precautions necessary to prevent changing the properties of the steel. Steels that have higher amounts of Carbon or other alloys added may require special procedures such as preheating and slow cooling, to prevent cracking or changing the strength characteristics of the steel. The welder may be involved in following a specific welding procedure to ensure weld metal and base metal has the desired strength characteristics.

3. MATERIAL DETAILS

3.1 Work Material Details

Work material – EN24 steel

Work material size–100*100mm 6 mm thickness

EN24 is usually supplied in the finally heat treated condition (quenched and tempered to “T” properties) up to a limiting ruling section of 250mm, which is superior to grades 605M36, 708M40 or 709M40 – see properties below. Please refer to our selection guide for comparisons.EN24 is a very popular grade of through-hardening alloy steel, which is readily machinable in the “T” condition. (Refer to our machinability guide). EN24T is most suitable for the manufacture of parts such as heavy-duty axles and shafts, gears, bolts and studs.EN24T can be further surface-hardened typically to 58-60 HRC by induction or nitride processes, producing components with enhanced wear resistance.In addition to the above, EN24T is capable of retaining good impact values at low temperatures, hence it is frequently specified for harsh offshore applications such as hydraulic bolt tensioners and shipborne mechanical handling equipment.

3.1.1 Chemical Properties

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

Table 3.1 Chemical properties

3.1.2 Application

EN 24 steel is a high tensile alloy steel and wear resistance properties and also where high strength properties are required. EN24 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.

SS 410

Grade 410 is 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 410 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. Martensitic stainless steels are optimized for high hardness, and other properties are to some degree compromised. Fabrication must be by methods that allow for poor weld ability and usually the need for a final heat treatment. Corrosion resistance of the martensitic grades is lower than that of the common austenitic grades, and their useful operating temperature range is limited by their loss of ductility at sub-zero temperatures and loss of strength by over-tempering at elevated temperatures.

3.1.3 Composition

Grade	410 Min
c	-0.15
Mn	-1.00
Si	-1.00
p	-0.040
s	-0.030
Cr	11.5 13.5
Mo	-
Ni	0.75
N	-

Table 3.2 Composition ranges for 410 grade stainless steel

3.1.4 Applications

Typical applications include:

- Bolts

- Nuts
- Screws
- Bushings
- Pump and valve parts and shafts
- Steam and gas turbine parts
- Petroleum fractionating towers
- Work material size–100 X 100 X6mm

4. EXPERIMRNTAL DESIGN

4.1 Taguchi Introduction

Basically, experimental design methods were developed original fisher. However experimental design methods are too complex and not easy to use. Furthermore, a large number of experiments have to be carried out when the number of the process parameters increases, to solve this problem, the Taguchi method uses a special design of orthogonal arrays to study the entire parameter space with a small number of experiments only. The experimental results are then transformed into a signal– to – noise (S/N) ratio to measure the quality characteristics deviating from the desired values Usually, there are three categories of quality characteristics in the analysis of the S/N ratio, i.e., the–lower–better, the–higher–better, and the–nominal–better.

The S/N ratio for each level of process parameter is compared based on the S/N analysis. Regardless of the category of the quality characteristic, a greater S/N ratio corresponds to better quality characteristics. Therefore, the optimal level of the process parameters is the level with the greatest S/N ratio Furthermore, a statistically significant with the S/N and ANOVA analyses, the optimal combination of the process parameters can be predicted. Finally, a confirmation experiment is conducted to verify the optimal process parameters obtained from the parameter design. There are 3Signal-to-Noise ratios of common interest for optimization of Static Problems. The formulae for signal to noise ratio are designed so that an experimenter can always select the largest factor level setting to optimize the quality characteristic of an experiment. Therefore a method of calculating the Signal-To-Noise ratio we had gone for quality characteristic. They are

1.Smaller-The-Better,
2. Larger-The-Better,
3. Nominal is Best.

4.2 Design Of Experiment

Process parameters and their levels

Levels	Process Parameters		
	Welding Current AMPS I	Arc Voltage V	Gas pressure Bar
1	140	18	4
2	160	20	5
3	180	22	6

Table 4.1 Process parameters and their levels

4.3 An Orthogonal Array L9 Formation (Interaction)

AMPS(I)	VOLT(V)	Gas Pressure(BAR)
140	18	4
140	20	5
140	22	6
160	18	5
160	20	6
160	22	4
180	18	6
180	20	4
180	22	5

Table 4.2 L9 Array formation

5. ROCKWELL HARDNESS TEST

1. Rockwell Hardness systems use a direct readout machine determining the hardness number based upon the depth of penetration of either a diamond point or a steel ball. Deep penetration indicated a material having a low Rockwell Hardness number.

2. However, a low penetration indicates a material having a high Rockwell Hardness number. The Rockwell Hardness number is based upon the difference in the depth to which a penetrator is driven by a definite light or "minor" load and a definite heavy or "Major" load.

3. The ball penetrators are chucks that are made to hold 1/16" or 1/8" diameter hardened steel balls. Also available are ¼" and ½" ball penetrators for the testing of softer materials.

4. There are two types of anvils that are used on the Rockwell hardness testers. The flat faceplate models are used for flat specimens. The "V" type anvils hold round specimens firmly.

5. Test blocks or calibration blocks are flat steel or brass blocks, which have been tested and marked with the scale and Rockwell number. They should be used to check the accuracy and calibration of the tester frequently.

Using the "B" Scale;

a. Use a 1/16 indenter

b. Major load: 100 Kg, Minor load: 10 Kg

c. Use for Case hardened steel titanium, tool steel.

d. Do not use on hardened steel

Materials	AMPS	Volt	Gas Pressure	Hardness	
				SS410	EN24
SS410 & EN24	140	18	4	82	90
	140	20	5	90	95
	140	22	6	86	87
	160	18	5	82	90
	160	20	6	87	94
	160	22	4	90	92
	180	18	6	84	95
	180	20	4	89	87
	180	22	5	87	89

TABLE 5.1: (After Welding)-Mig

5.1 TENSILE TEST&ELONGATION

Friction processed joints are evaluated for their mechanical characteristics through tensile testing. A tensile test helps determining tensile properties such as tensile strength, yield strength, percentage of elongation, and percentage of reduction in area and modulus of elasticity. The welding parameters were randomly chosen within the range available in the machine. The joints were made with random parameters and evaluate tensile strength and burn off. Then the joints were made and evaluate the mechanical and metallurgical characteristics.The friction welded specimens were prepared as per the ASTM standards. The test was carried out in a universal testing machine (UTM) 40 tones FIE make.

5.2 Tensile Strength Result

Sl.no	Tensile load kn
T1	46.82
T2	42.34
T3	41.56
T4	42.58
T5	40.36
T6	45.26
T7	45.71
T8	43.69
T9	44.26

TABLE 5.2: Result of Tensile load

5.3 Taghuchi Analysis For Tensile Strength-Sn Ratio

AMPS	Volt	Gas Pressure	Tensile Strength	SNRA1
140	18	4	46.82	33.4086
140	20	5	42.34	32.5350
140	22	6	41.56	32.3735
160	18	5	42.58	32.5841
160	20	6	40.36	32.1190
160	22	4	45.26	33.1143
180	18	6	45.71	33.2002
180	20	4	43.69	32.8076
180	22	5	44.26	32.9202

Table:5.3 SN ratio value for tensile strength

Taguchi Analysis: TENSILE versus VOLT, AMPS, GAS PRESSURE

Level	AMPS	VOLT	GAS PRESSURE
1	32.77	33.06	33.11
2	32.61	32.49	32.68
3	32.98	32.80	32.56
Delta	0.37	0.58	0.55
Rank	3	1	2

Table: 5.4 Response Table for Signal to Noise Ratios Larger is better

Source	DF	Seq SS	Adj MS	F	P	% Of Contri Bution
AMPS	2	4.978	2.489	0.96	0.510	14
VOLT	2	12.697	6.349	2.45	0.289	37
Gas Pr	2	12.454	6.227	2.41	0.293	35
Error	2	5.173	2.587			14
Total	8	35.303				100

Table: 5.5 Aanalysis of Variance for TENSILE, using Adjusted SS for Tests

TS = 43.620 - 0.047 AMPS_140 - 0.887 AMPS_160 + 0.933 AMPS_180 + 1.417 VOLT_18- 1.490 VOLT_20 + 0.073 VOLT_22 + 1.637 GP_4 - 0.560 GP_5 - 1.077 GP_6

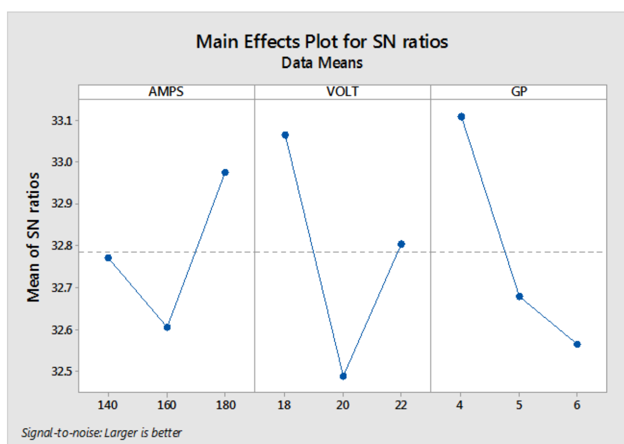
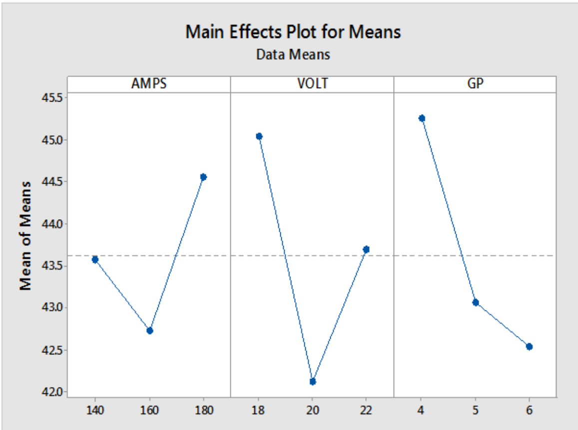


Figure 5.1 :Main Effects Plot for SN Ratios



Figures 5.2 :main effects plot for means

6. DEPTH OF PNETRATION

Inadequate weld bead dimensions such as shallow depth of penetration may contribute to failure of a welded structure since penetration determines the stress carrying capacity of a welded joint .To avoid such occurrences the input or welding process variables which influence the weld bead penetration must therefore be properly selected and optimized to obtain an acceptable weld bead penetration and hence a high quality joint . To predict the effect of welding process variables on weld bead geometry and hence quality researchers have employed different techniques .

6.1 Various Sizes Of Bead Width, Depth Of Penetration -Ss410 And En24-Gmaw

Samples	Area	Mean	Min	Max	Angle	Length
S1	0.514	126.424	97.958	166.467	-179.523	13.585
	0.128	112.152	76.667	147.333	90	4.796
S2	0.604	124.14	66.667	185.638	1.219	15.966
	0.172	111.501	63.617	140.867	91.432	4.53
S3	0.501	111.475	80.615	157.333	1.469	13.25
	0.175	94.547	62.667	145	90	4.642
S4	0.523	118.153	78.085	152.888	-179.53	13.812
	0.138	116.258	79	156.542	86.424	3.63
S5	0.488	122.947	90.333	157.067	179.497	12.906
	0.158	132.61	91.667	208.667	90	4.189
S6	0.51	127.672	87.493	215.72	0.481	13.472
	0.158	132.135	67	180	90	4.189
S7	0.608	117.222	70.667	185.333	0.403	16.076
	0.111	98.91	64.333	126.667	90	2.943
S8	0.561	134.543	76.763	208.972	-2.622	14.846
	0.141	107.569	63.667	141.333	90	3.736
S9	0.54	122.51	93.603	176.31	178.636	14.268
	0.155	98.504	69.324	139.944	88.409	4.077

Table:6.1 Depth Of Penetration

7. RESULT AND CONCLUSION

MIG welding can be used successfully to join SS410 &EN24. The processed joints exhibited better mechanical and metallurgical characteristics. The specimen failures were associated depending upon the improper changes of heat value . According to Taguchi optimum value of in our experiment we found out the input parameter value AMPS140, VOLT-18 &Gas pressure 4 Kg/cm2 was the best value and it does not create any major changes and failures in the testing process. The tensile strength value of the MIG welded Bimetallic joints was comparatively higher value (AMPS140, VOLT-18 &Gas pressure 4 Kg/cm2) than other value.

Optimal Control Factor

According to the Taguchi design and optimized parameter is value for Tensile strength was 6 mm plate of dissimilar structure steel were AMPS 180 VOLT-18 GAS PRESSURE-5 Kg/cm2

Percentage Of Contribution

Tensile strength was most influenced with Voltage- 37%

REFERENCES

[1] Syarul Asraf Mohamata*, Izatul Aini Ibrahima, Amalina Amira, Abdul GhalibaThe Effect of Flux Core Arc Welding (FCAW) processes on differentParameters aUniversiti Teknologi Mara (UiTM), Faculty of Mechanical Engineering, 40450 Selangor

[2] B. Senthilkumara and T.Kannanb Sensitivity analysis of flux cored arc welding process variables in super duplex stainless steel claddings. Assistant Professor, Department of Mechanical Engineeirng, Kumaraguru College of Technology, Coimbatore – 641 049, Tamilnadu, India.bPrincipal, SVS College of Engineering, J P Nagar,Arasampalayam, Coimbatore – 641 109

[3] A. Aloraier a,*, R. Ibrahim a, P. Thomson FCAW process to avoid the use of post weld heat treatmenta Department of Mechanical Engineering, Monash University, P.O. Box 197, Caulfield East, Vic. 3145, Australia b School of Physics and Materials Engineering, Monash University, Box 69M, Clayton, Vic. 3800, Australia

[4] N.B. Mostafa , M.N. Khajavi Optimisation of welding parameters forweld penetration in FCAWMechanical Engineering Department, Shahid Rajaee University, Tehran, Iran

[5] J.S. Seo, H.J. Kim*, H.S. Ryoo Microstructural parameter controlling weld metal cold cracking, Korea Institute of Industrial Technology, 35-3 HongChonRi, IbJangMyun, ChanAnSi, 330-825, Korea

[6] J. Dutta* and Narendranath S. Experimental and analytical investigation of thermal parameters developed in high carbon steel joints formed by gta welding department of mechanical engineering, national institute of technology karnataka, surathkal, india *corresponding e-mail:

[7] Vishnu V.S, Nadeera M, Joy Varghese V.M Numerical Analysis of Effect of Process Parameters on Residual Stress in a Double Side TIG Welded Low Carbon Steel Plate Dept. Of CIM, T.K.M College of engg./ Kerala University, India 3Dept. of ME, SCT College of engg. / Kerala University, India

[8] M. Pal Pandi, Dr. R. Kannan Thermal Analysis on Butt Welded Aluminium Alloy AA7075 Plate Using FEM Department of Mechanical Engineering, PSNA College of Engineering and Technology, Dindigul, India.

[9] M Sundar1, G Nandi, A Bandyopadhyay and S C RoyASSESSMENT OF RESIDUAL STRESS AND DISTORTION IN WELDING BY

[10] FINITE ELEMENT METHODSchool of Laser Science & Engineering, Jadavpur University, Kolkata-7000322

[11] N. Akkuş1,a, E. Toptas2,b, O. Topal3 Thermomechanical Analysis of Arc Welded Joint by Finite Element Method 1Gedik University, Cumhuriyet Mahallesi, E-5 Yanyol No:29 Kartal, Istanbul 2Marmara University, High Collage for Technical Sciences, Goztepe, Istanbul 3Marmara University, Institute of Pure Sciences, Goztepe Campus, Istanbul

[12] 11. BY L. A. JAMES Fatigue-Crack Propagation Behavior of Several Pressure Vessel Steelsand Weldments

[13] A. Anca¤, A. Cardona, and J.M. Risso 3d-thermo-mechanical simulation of welding processes Centro Internacional de M´etodos Computacionales en Ingenier´ıa (CIMEC) Universidad Nacional del Litoral–CONICET

[14] Appala Naidu A., Kumaresh Babu S.P., Manikandan M.,Arivarasu M., Devendranath Ramkumar K., Arivazhagan N. Hot Corrosion Studies on Welded dissimilar Boiler steel inPower plant environment under cyclic conditionAppala Naidu 1Department of Metallurgical and Materials Engineering, National Institute of Technology, Triuchirapalli -620115