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Experimental Investigation and Effect of Flux Core Arc Welding (FCAW) Processes on Different Parameters on En36

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ABSTRACT: This project work is part of program for the development of EN36 Steel has to be increase mechanical properties and minimization of metallurgical defects to increasing weldment. The quality of weld in FCAW mainly influenced by independent variables such as welding current, speed of electrode and electrode stick out In our experiment we found out the input parameter value 160 AMPS VOLT-26 GAS PRESSURE-4Kg/cm² is the best value and it does not create any major changes and failures in the testing process. The planned experiments has to be conducted in the MIG welding machine the test piece examination will be carried out by impact test, Hardness, Depth of penetration .

I. INTRODUCTION

Flux Core Arc Welding (FCAW) uses a tubular wire that is filled with a flux. The arc is initiated between the continuous wire electrode and the work piece. The flux, which is contained within the core of the tubular electrode, melts during welding and shields the weld pool from the atmosphere. Direct current, electrode positive is commonly employed as in the FCAW process. There are two basic process variants; self shielded FCAW without shielding gas and gas shielded FCAW with shielding gas. The difference in the two is due to different fluxing agents in the consumables, which provide different benefits to the user. Usually, self-shielded FCAW is used in outdoor conditions where wind would blow away a shielding gas. The fluxing agents in self shielded FCAW are designed to not only deoxidize the weld pool but also to allow for shielding of the weld pool and metal droplets from the atmosphere. The flux in gas-shielded FCAW provides for deoxidation of the weld pool and, to a smaller degree than in self-shielded FCAW, provides secondary shielding from the atmosphere. The flux is designed to support the weld pool for out-of position welds. This variation of the process is used for increasing productivity of out-of-position welds and for deeper penetration.

II. LITREATURE REVIEW

Yang, Y.S et al studied about the effect of FCAW process on different parameters by using robotic welding with the variables in welding current, speed and arc voltage. The effects are on welding penetration, microstructural and hardness measurement. Mild steel with 6mm thickness is used in this study as a base metal. For all experiments, the welding currents were chosen are 90A, 150A and 210A and the arc voltage is 22V, 26V and 30V respectively. 20, 40 and 60 cm/min were chosen for the welding speed. The effect will studied and measured on the penetration, microstructure and hardness for all specimens after FCAW process. From the study, the result shown increasing welding current will influenced the value depth of penetration increased. Other than that, the factors that can influence the value of depth of penetration are arc voltage and welding speed. Li, Zhang et al found that Weld surfacing with super duplex grade stainless steel improves corrosion resistance and functional life of the mild steel components used in the process industries. The properties of the deposited layer were influenced by the process variables that affect the heat input to the process. The influence exerted by the process variables on the responses of super duplex stainless steel claddings were modeled using the response surface models. The response surface models developed by the regression

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techniques using the data collected from central composite rotatable design of experiments.. The developed models can be used to predict and simulate the influence of the process variables on the responses. The insignificant variables found in the full models were removed by the backward elimination technique. Sensitivity analysis performed on the reduced models helps to identify and rank the process variables based on their extent of influence on the responses. Then the ranked variables are closely regulated to tailor the properties of the surfaced layer.

Benyounis, K.Y et al presented Post weld heat treatment (PWHT) technique for relieving residual stresses after general repair welding. Besides, the primary purpose of reducing the effect of stresses induced by welding, PWHT is also intended to temper the metallurgical structure of the heat affected zone (HAZ). They also reported about the research work carried out to investigate, whether a fully automated flux cored arc welding process with bead tempering can be used in repair welding instead of manual metal arc welding in order to eliminate the use of post weld heat treatment. They also examined different percentages of bead overlaps and studies their effects on the mechanical properties as well as the microstructures. Sun, Z. described prediction of weld penetration as influenced by FCAW process parameters of welding current , arc voltage , nozzle-to-plate distance, electrode-to - work angle and welding speed .Optimization of these parameters to maximize weld penetration is also investigated. Yilbas, B.S, carried out the distribution of the residual stress in the weld joint of HQ130 grade high strength steel was investigated by means of finite element method (FEM) using ANSYS software. Welding was carried out using gas shielded arc welding with a heat input of 16 kJ/cm. The FEM analysis on the weld joint reveals that there is a stress gradient around the fusion zone of weld joint. J. Mousavi, S.A.A et al investigated reveals an elaborate analysis of variation of thermal properties of high carbon steel plate butt joints formed by DC Gas Tungsten Arc (GTA) welding. Experiment has conducted to predict the two dimensional temperature cycle developed. Anawa, E.M et al analyzed 3D thermo-mechanical simulation model was developed to predict distribution of temperature and residual stresses during Tungsten Inert Gas (TIG) double-side arc welding (DSAW) process on a low carbon steel plate. An uncoupled thermal–mechanical finite element analysis is performed using ANSYS. In his study the effects of welding process parameters (welding speed and welding current) in the symmetrical and asymmetrical double-side TIG welding process were investigated. The simulated results show that the residual stresses are tensile at the weld pool region and as the distance from the weld line increase it tends to compressive.

III. PROBLEM IDENTIFICATION

3.1 WELDING PROBLEM ON STEEL

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.

IV. EXPERIMENTAL DESIGN

4.1 TAGUCHI METHOD

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

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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 3 Signal-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

Table 1.1 Process parameters and their levels

Levels	Process parameters		
	AMPS	VOLT	GAS PRESSURE
1	140	22	4
2	160	24	5
3	180	26	6

Table 1.2 L9 Array Formation

T.NO.	Designation	AMPS	VOLT	Gas Pr Lit/min
1	A ₁ B ₁ C ₁	140	22	4
2	A ₁ B ₂ C ₂	140	24	5
3	A ₁ B ₃ C ₃	140	26	6
4	A ₂ B ₁ C ₂	160	22	5
5	A ₂ B ₂ C ₃	160	24	6
6	A ₂ B ₃ C ₁	160	26	4
7	A ₃ B ₁ C ₃	180	22	6
8	A ₃ B ₂ C ₁	180	24	5
9	A ₃ B ₃ C ₂	180	26	4

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4.3 SELECTION OF MATERIAL

EN 36 is a medium carbon and medium tensile steel used mainly for axles, spindles, studs, automotive and general engineering components. Suitable for heat treatment where extra strength is required. It is medium high carbon steel that can be strengthened by heat treating after forming. Machinability and weldability are fair. Typical uses include machine, plow and carriage bolts, cylinder head studs, machine parts etc. It is also used for U bolts, concrete reinforcing rods, forgings and non critical springs.

Table 1.3 Composition of EN 36

Material	C %	Mn %	Si %	Cr %	S %	P %	Ni %	Mo
EN 36	0.2	0.5-1	0.3 5	0.75 - 1.25	0.0 5	0.0 5	1- 1.5	0.08- 0.15

V. RESULT AND DISCUSSIONS

There are three types of tests used with accuracy by the metals industry; they are the Brinell hardness test, the Rockwell hardness test, and the Vickers hardness test. Since the definitions of metallurgic ultimate strength and hardness are rather similar, it can generally be assumed that a strong metal is also a hard metal. The way the three of these hardness tests measure a metal's hardness is to determine the metal's resistance to the penetration of a non-deformable ball or cone. The tests determine the depth which such a ball or cone will sink into the metal, under a given load, within a specific period of time.

Table 1.4 Hardness Value of Before Welding

MATERIAL	HARDNESS VALUE
EN36	85

Table 1.5 Hardness Value of After Welding

Materials	TEST PLATE	AVG HRB
EN36	S1	90
	S2	104
	S3	95
	S4	94
	S5	96
	S6	96
	S7	107
	S8	76
	S9	108

Table 1.6 Impact strength

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Materials	TEST PLATE	Average in Joules
SS409	S1	28
	S2	20
	S3	30
	S4	24
	S5	22
	S6	26
	S7	18
	S8	24
	S9	20

5.1 Taguchi Optimization Through Minitab -16 Impact Strength

Table 1.7 S/N ratios values for the Impact strength

T.NO.	Designation	AMPS	VOLT	Gas Pr Lit/min	IMPACT STRENGTH	S/NRATIO
1	A1B1C1	140	22	4	28	28.9432
2	A1B2C2	140	24	5	20	26.0206
3	A1B3C3	140	26	6	30	29.5424
4	A2B1C2	160	22	5	24	27.6042
5	A2B2C3	160	24	6	22	26.8485
6	A2B3C1	160	26	4	18	25.1055
7	A3B1C3	180	22	6	26	28.2995
8	A3B2C1	180	24	5	24	27.6042
9	A3B3C2	180	26	4	20	26.0206

Table 1.8 Response Table for Signal to Noise Ratios

LEVELS	AMPS	VOLT	GAS PR
1	28.17	28.26	26.69
2	26.82	26.52	27.08
3	27.31	26.89	28.23
Delta $\Delta_{\max-\min}$	1.65	1.46	1.54
Rank	1	3	2

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Table 1.9 Analysis of Variance (ANOVA) results for the Roughness

Source	DF	Seq SS	Adj SS	Adj MS	F	P	% of contribution
AMPS	2	32.89	32.89	15.11	0.93	0.519	26
VOLT	2	27.56	30.22	15.11	0.85	0.541	22
GASPR	2	30.22	30.22	17.18	0.85	0.541	24
Error	2	35.56	35.56				28
Total	8	126.22	16.14				100

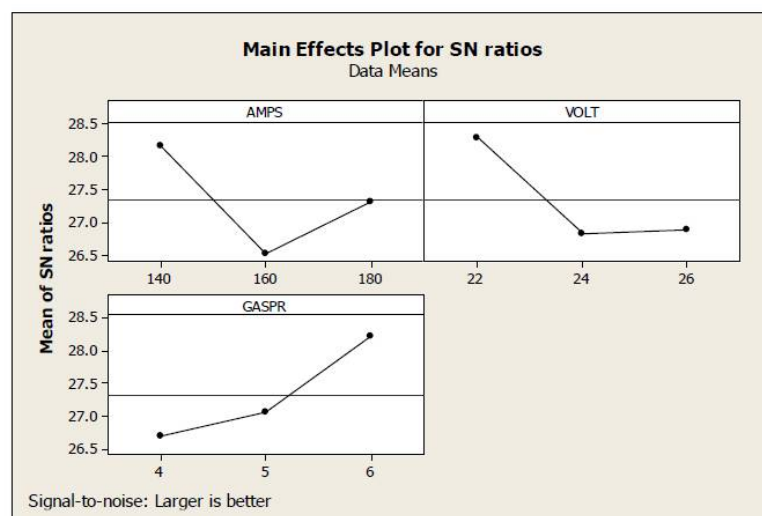


Fig. 1.1 Main effectsplot for SN Ratio

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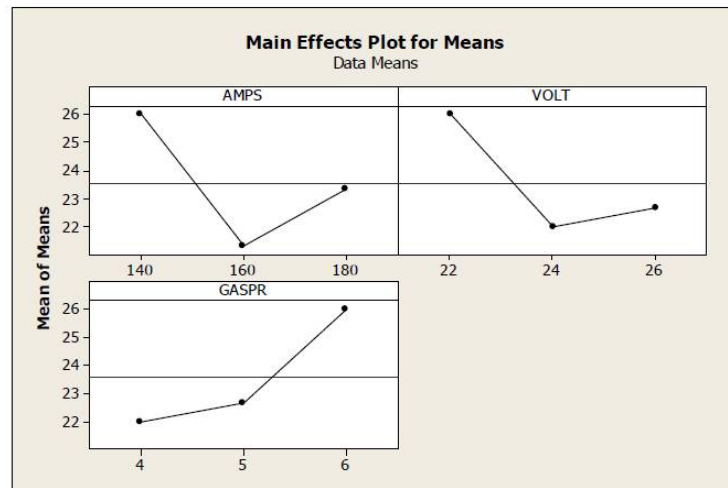


Fig. 1.2 Main effectsplot for Means Ratio

Table 2.0 Various Sizes Of Bead Width(BW), Depth Of Penetration(DOP) And Heat Affected Zone-En36 Fcaw

Test Sample	Location	Area	Mean	Min	Max	Angle	Length
Sample-1	BW	0.6	116.413	37.496	180.345	-2.793	14.034
	DOP	0.313	151.336	42.05	247.467	86.947	6.419
Sample-2	BW	0.51	136.293	113.49	207.421	-3.691	13.275
	DOP	0.249	170.289	111.407	220.232	88.512	6.583
Sample-3	BW	0.531	97.065	46.887	138.422	-0.905	16.241
	DOP	0.292	105.5	55.549	120	89.215	6.24
Sample-4	BW	0.698	110.581	19.707	164.766	-0.682	14.36
	DOP	0.337	123.722	60.618	148.667	88.652	7.267
Sample-5	BW	0.506	114.088	35.333	181	0.418	11.71
	DOP	0.377	86.576	24.489	155.4	93.489	7.022
Sample-6	BW	0.53	108.535	77.28	162.69	-0.694	14.104
	DOP	0.263	105.531	33.396	155.396	91.809	8.124
Sample-7	BW	0.569	153.884	112.953	188.667	-1.697	11.544
	DOP	0.398	216.282	158	234.256	89.182	5.984
Sample-8	BW	0.499	99.125	43.826	123.873	-2.862	13.692
	DOP	0.364	104.479	50.333	132.333	88.363	5.985
Sample-9	BW	0.671	184.613	119.244	211.759	0.455	10.77
	DOP	0.304	214.453	176	233.667	90	5.726

IX. CONCLUSION

FCAW welding can be used successfully to join EN36 . The processed joints exhibited better mechanical and metallurgical characteristics. The joints exhibited 90-95% of parent material's Hardness value. The specimen failures were associated depending upon the improper changes of heat . In our experiment we found out the input parameter value 160 AMPS VOLT-26 GAS PRESSURE-4Kg/cm2 is the best value and it does not create any major changes and

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failures in the testing process. . According to the Taguchis design and optimized parameter is value for Impact strength the 10 mm plate of EN36 steel is 140 AMPS VOLT-26 GAS PRESSURE-5.

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