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Effect of Flux Core Arc Welding Process Parameters on EN-24 Steel

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Abstract –The selection of improper FCAW process parameter may led to increases the power consumption, material consumption, man power, cost of the product and decrease the weld quality. This study was the part of program for the development of EN24 medium carbon steels to increase mechanical properties and minimization of metallurgical defects to increasing good weldment. The quality of weld in FCAW mainly influenced by independent variables such as welding current, speed of the electrode, torch angle and bevel angle. The planned experiment were conducted in MIG welding machine. For the entire experiments, the welding current were chosen are 160A,170A,180A and the arc voltage is 20V, 22V,24V and the bevel angle is 55°,65°,70°. From the study, the good weldment obtained in the input parameter value was 180AMPS,24VOLT and 70° BEVEL ANGLE was the best value as maximum hardness , good impact and high depth of penetration.

Key Words: Hardness , Depth of Penetration, Welding current, Bevel angle, MIG welding

1.INTRODUCTION

Flux Core Arc Welding (FCAW) which is either automatic or semi-automatic welding process has an electrode in a tubular wire form loaded with flux . Through the welding process the arc is generated in between the continuous wire electrode and the work piece. The flux, that has filled within the core of the wire electrode, starts to melt during welding and protect the weld pool without getting affected from the atmosphere. Direct current, electrode positive (DCEP) which is commonly used in the FCAW process. FCAW is divided into two basic process variants; self shielded FCAW (without shielding) and gas shielded FCAW (with shielding gas). The only difference in the middle of this two is due to different fluxing agents used in the electrodes , which provide different benefits to the user. Generally, self-shielded FCAW is used in open air condition. In self shielded flux core arc welding process the fluxing agents are used for not only to deoxidize the weld pool but also for the protection of the weld pool and metal droplets from the atmosphere. Whereas, in the gas-shielded flux core arc welding process the flux provides de-oxidation of weld pool to a smaller degree compared to the self shielded flux core arc welding, act as a secondary shielding from the atmosphere. Flux core arc welding has been evolved from MIG welding process in order to improve the metal transfer, weld metal properties arc action and weld appearance. The wired electrode which is used in welding is a hallow tube contains a mixture of fluxing agents, deoxidizers, metal powders and ferrous - alloy. The only difference between the flux-cored wire and solid core-drawn wire is the closure seam, which appears as a fine line. The process is usually applied semi automatically, even though it can be applied on both semi automatic and automatic welding. For getting a deep penetrating arc and better weldment without an external gas shielding, carbon dioxide gas can be added to the flux which provide an additional shielding.

2.Experimental

A rectangular block of grade EN-24 steel was chosen as a base metal specimen for welding with 10 mm thickness . In total 9 blocks were taken for the experiment .This base metal is a low carbon content steel plate and its surface is ground . The base metal was analyzed to obtain its chemical compositions are given in the table 1.

Table 1 : Chemical Composition (in weight %)

Element	Carbon C	Manganese Mn	Silicon Si	Molybdenum Mo	Chromium Cr	Sulphur & Phosphorous
Wt (%)	0.45	0.70	0.35	0.35	1.40	0.05

The entire operation were performed in MIG welding machine which uses a flux cored tubular wire (K-71 AWA 5.20) having a diameter of 1.2 mm along with 100% of co_2 used as shielding gas in this flux cored arc welding process. The normal discharge rate of the CO_2 from the cylinder . Changes in different properties were tested while varying different parameters of welding like arc voltage , welding current , bevel angle and gas pressure. The approximate values chosen for arc voltage , welding current and gas pressure are 20V, 22V and 24V and 160A , 170A and 180A and 5 bar, 6 bar and 7 bar respectively. Movable carriage on a table was used as experimental setup for the process for holding the specimen. The welding torch attached to the work table remains in fixed position . According to the parameters, the deposition of the electrode wire on the base metal plate takes place randomly. After the completion of the process, the specimen were taken off from the plate and its depth of penetration were measured using image J software . Finally , hardness test using rockwell hardness test method , ultrasonic test , tensile test were conducted.

3 . Result and discussion

Three tests were performed after all the 18 test pieces had been welded to 9 joint pieces. As a result , the different parameters shows the effect on the penetration , hardness and also the tensile strength .

3.1 Rockwell Hardness Test

The specimen which was mounted on the movable carriage is taken off and it is grinded and polished by using the grits with different grades. The specimen is etched with natal solution clearly in the welding zone of the metal. The Rockwell Hardness values for HAZ uses the 1/ 16 intender having a load capacity of 10 kg applied on the specimen .The hardness value are determined and performed in table 2. During solidification , the original strength of the material decreases due the strain hardening effect in the zone of fusion. The formation of the bainite phase ,the hardness of the material gets increased in low carbon steel material .The effect of different process parameters to the hardness are shown in the table 2. The entire table shows the hardness versus constant welding current with three various arc voltage and three various gas pressure . The hardness tends to decrease due to when the arc voltage and gas pressure are increase .

Table 2 Hardness Test Result

No	Current (A)	Voltage (V)	Gas pressure (Bar)	Hardness HRB
1	160	20	5	103
2	160	22	6	102
3	160	24	7	101
4	170	20	5	100
5	170	22	6	102
6	170	24	7	97
7	180	20	5	96
8	180	22	6	101
9	180	24	7	109

3.2 Ultrasonic test

If there is any flaws and discontinuity in the welded specimen it can be detected by the ultrasonic test. In this test ,to detect the flaws location the sound waves passed through the specimen. It shows that some energy with and some beam gets reflected is displayed and then examined. UT Instrument – pulse echo size – 7*8 material: 409 ,PX transducer angle – 75 , 6 MHz Technique , Thickness-10mm .The ultrasonic test report are shown in table 3 .

Table 3: Ultrasonic test result

No.	Current (I)	Voltage (V)	Gas Pressure(Bar)	Indication
1	160	20	5	NI
2	160	22	6	ICP
3	160	24	7	Cr
4	170	20	5	ICP & Por
5	170	22	6	ICP & Por
6	170	24	7	EP
7	180	20	5	SI
8	180	22	6	NI
9	180	24	7	Cr

3.3 Tensile Test

To determine the breaking point the specimen or component, tensile test is applied using different load conditions. Transverse tensile test – Model: UTE 60 M/c, SL No: 7/2006 -2673 .The test result are shown in table 4.

Table 4: Tensile Test Report

No.	Thick (mm)	Width(mm)	CSA(mm^2)	TL(KN)	TS(N/mm^2)	Fracture & Location
1	5.48	20	110.2	20.24	183.26	Brittle fracture /Weld metal
2	5.56	20	111.1	19.46	180.65	Brittle fracture /Weld metal
3	5.5	20	110	20.68	183.98	Brittle fracture /Weld metal
4	5.52	20	109.7	19.73	195.48	Brittle fracture /Weld metal
5	5.24	20	108.3	21.39	181.9	Brittle fracture /Weld metal
6	5.38	20	111.6	20.54	184.10	Brittle fracture /Weld metal
7	5.57	20	104.9	19.98	187.7	Brittle fracture /Weld metal
8	5	20	100	21.56	214.5	Brittle fracture /Weld metal

9	5.48	20	110.5	20.84	185.34	Brittle fracture /Weld metal

4.Conclusion

The three welding parameters in Flux core arc welding such as welding current , voltage and gas pressure was carried out on EN-24 steel . According to the results from the Rockwell hardness test ,it shows an increase in hardness of the specimen along with increasing welding current and voltage with medium gas pressure. The maximum hardness of 109 HRB shown in the specimen 9 having the parameters of 180 amps, 24 volts with 7 bar gas pressure. In the ultrasonic test , only two specimen having parameters of 160 amps, 20 volts, 5 bar and 180 amps ,22 volts and 6 bar pressure shows no flaws . Finally in the tensile test, the specimen 8 which is 214.5 N/mm^2 shows the maximum tensile strength. From the above results by the detailed observation and analyzing we can conclude that the parameters of the specimen 8 shown the most suitable in welding the EN-24 grade steel.

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