Outstanding Features of Automatic FCAW Process

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Introduction

Inflation continues to exert pressures and the increasing cost of consumables coupled with wages result in steady increase of welding cost & consequently the price of the final product fabricated. To enter the competitive market, fabrication industries have to upgrade their technology by R & D and go in for new welding techniques to improve productivity, or to reduce unit cost of production by modernising the production centres. The modernising concept necessitated mechanising of various welding processes like Tig, Mig, Plasma etc. in both their semi and automatic varsions. While advanced countries are concentrating on robots for various operations like welding, painting, assembling and quality control, the welding equipment manufacturers in our country have lot of responsibility to design and develop equipments technically and economically suitable for the users to replace the human operations, bearing in mind that it is designed functionally simple to be operated and maintained by unskilled workmen.

Though the development of high deposition electrodes tried to compensate a portion of the rise in manual welding cost, it is not practically felt by the users due to various reasons beyond their control. All efforts to improve productivity by tuning up human elements by various methods and motivation techniques have achieved no significant results in many industries. Obviously, the latest trend is to concentrate more on mechanisation rather than wasting money on various studies on human motions despite plenty of available human resources. The welding operation being more labour intensive a significant change in the labour cost is possible only by replacing the manual process by an automatic fast deposition process even though it initially costs to provide suitable fixtures to take up various configuration of weld joints.

Automatic submerged arc welding process is already the only unchallenged welding process in the field for its high deposition rates and weld quality. The latest techniques like hot wire method has further increased the deposition rates in this process. Since this process is simple, adaptable and reliable the consumable manufacturers all over the world have been developing solid wires and fluxes to be used with this process for achieving various weld metal properties. The development of flux cored wire made their jobs simple for manufacturing and supplying the consumables for different alloys by altering the flux composition. Flux cored wires are used for submerged arc welding in many outside countries for most of the applications. The flux cored wire technology has made the users to switch over from solid CO_2 process to flux cored wire process for various advantages. This process is much faster, simpler and economical than submerged arc process in certain applications.

We have been successfully using this process for manufacturing structural and pressure parts for tyre curing equipments since last 3 years. Out of our annual deposits of 12 tonnes of pure weld metal, 10 tonnes of deposits is done through this process. This process is found more economical and technically suitable for our product line. We will discuss in this paper the features of this process for welding various components.

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Flux Cored Arc Welding

Flux Cored Arc Welding implies a continuously fed tubular wire consumable which strikes the arc with parent metal and forms the weld pool, with or without a shielding gas. These wires are classified by AWS classification as given in Table No. 1. The wires are now available for various materials including for hard facing equivalent to stellite grades. The flux cored wires with additional shielding are extensively used for better weld metal properties.

AWS CLASSIFICATION OF FLUX CORED WIRES

AWS	GAS SHIELDING	[illegible]	CHARACTERISTICS
E70T1	CO_2	DC +	SUITABLE FOR SINGLE AND MULTIPLE PASS WELDING CHARACTERIZED BY SPRAY TRANSFER, LOW SPATTER SLIGHTLY CONVEX TYPE DEPOSITE RUTILE SLAG COVERING
E70T2	CO_2	DC +	SIMILAR TO E70T1 HAS HIGHER MANGANESE AS PRINCIPAL DEOXIDIZING ELEMENT SUITABLE FOR SINGLE PASS WELDS ON SCALED RUSTED PLATES
E70T3	NIL	DC +	SPRAY TRANSFER TYPE SUITABLE FOR VERY HIGH WELDING SPEEDS USED TO MAKE SINGLE PASS WELDS ON THIN SHEETS
E70T4	NIL	DC +	GLOBULAR TYPE TRANSFER GIVES LOWER PENETRATION SUITABLE FOR POOR FIT UPS DESULFURIZED WELD OFFERS RESISTANCE TO CRACKING
E70T5	CO_2/NIL	DC +	SUITABLE FOR FILLET AND V' GROOVE WELDS GLOBULAR TRANSFER HAVE LIME FLUORIDE BASIC SLAG COVERING X' QUALITY WELDS WITH GOOD PROPERTIES
E70T6	NIL	DC +	SPRAY TRANSFER TYPE DEEP PENETRATION HAS LOW TEMPERATURE IMPACT PROPERTIES
E70T7	NIL	DC −	HIGHER DEPOSITION RATES ARE POSSIBLE DESULFURIZING OF WELD METAL MAKE THE WELD RESISTANT TO CRACKING
E70T8	NIL	DC −	SUITABLE FOR ALL POSITION WELDING HAS VERY LOW TEMPERATURE IMPACT PROPERTIES
E70TG	OPEN TO NEW ELECTRODES		

TABLE 1

Flux Cored Wire

The seamless flux cored wires are found more satisfactory compared to rolled wires, in feeding aspects. The wires do not get opened due to squeezing under pressure rolls and thus flux loss and jamming of flux inside the conduit which offers lot of friction to wire feeding are averted. Defective welds are produced some time due to total absence of flux for certain length. This phenomenon is very rare in case of rolled wires. Flux Cored wires to AWS specification E70T, E70T4 E70T5 are available indigenously.

Safety Requirements

Self shielding flux cored wire while welding produces thick fumes which demands necessarily a vaccuum extractor at the point of welding; other wise, it is dangerous to the welder engaged. Work place with high roof level provided with roof extractors are found serving the purpose of extracting fumes in case of Flux Cored wire welding with CO_2 shielding. The radiation of heat comparably is less than in bare wire CO_2 welding. Special welding glass filters to specification 13EW & 14EW are recommended for this process. Easily washable creams are available to protect the skin from the heat radiation.

The MIG fume removal system is designed to efficiently remove and filter fumes generated during CO_2 welding from immediate vicinity of the operator. The efficiency of extraction varies (50 to 90%) depending upon the factors affecting the system, like air drafts torch angle, nozzle to work distance and position of aspirator attached to welding outfit. The system in its simplest form has a set of filter bags, air blower & long hoses with aspirator which can be fixed at required position to the welding torch.

Cooling fans in the power sources may be utilised for extracting fumes from workspot by proper positioning of jobs near power source.

Shielding Gas

CO_2 is the cheapest and the best shielding gas used in this process. Gas mixtures like Argon + CO_2, CO_2 + oxygen are used extensively in other countries where they are readily available in cylinders as gas mixtures.

CO_2 MANIFOLD SYSTEM

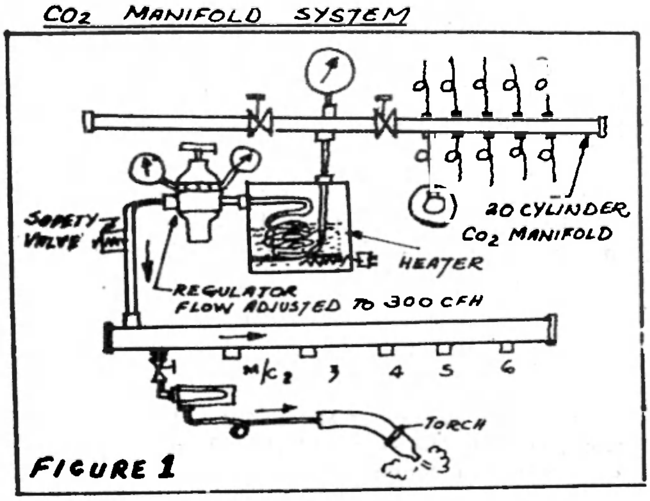


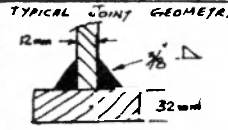
FIGURE 1

WELDING PROCEEDURE

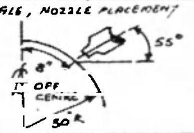
BASE METAL	A 285 GR C	PROCESS	FCAW (AUTO)
FILLER METAL	E 70 T5	POSITION	FLAT. (REFER SKETCH)
GAS SHIELDING	CO_2 (WELDING QUALITY)	HEAT TREATMENT	NIL
CURRENT & POLARITY	DC +	POST WELD HEAT TREATMENT	NIL
PREPARATIONS	NIL	CLEANING	WIRE BRUSH BEFORE WELDING.
APPEARANCE	NO UNDERCUTTING	REPAIR OF WELDS	BY MMA
PEENING	NIL	REMARKS	NIL

M/C UNIT	JOINT THK.	FILLER DIA	PASS No	WELD SIZE	GAS FLOW	VOLTAGE	CURRENT	INDEX	SLOPE	WIRE FEED	ARC SPEED
LINDE 600 AMPS MIG	12 mm To 32 mm	1.6 mm	1 SINGLE PASS	3/8"	20 To 30 CFH	29 V	365 AMP	–	FLAT	365 IPM	12" IPM

TYPICAL JOINT GEOMETRY



WORK ANGLE, NOZZLE PLACEMENT



PROCESS AUTOMATIC FLUX CORED ARC WELDING	IVPS No 1004

The purity and quality of the CO_2 is the prime requirement for better weld quality. The moisture content in the gas has to be kept minimum within 66 PPM at—40°F. To compensate the freezing effect of CO_2 gas through regulators, heaters are to be provided before the regulators. The sketch of our manifold system supplying CO_2 gas to six machine in line is illustrated in Fig. 1. The dissociation of CO_2 in the arc stream results in carbon pick up depending upon the carbon content of the parent metal and the dilution level during welding. High flow rates cause turbulence in the weld and produce porosity and spatter. The best flow rate in normal welding condition is 20 to 30 CFH. The gas consumption shall be reduced by accurate control of gas by flow meters to each machine and the average ratio of gas c onsumption to weld metal deposited is found 1:3 by weight.

Equipment

The power source used is the transformer rectifier constant potential type with reactance and voltage control. The wire feed rate and current level are electrically interlocked. The auto weld station has controlled motions in three directions with a 10 ton

FCAW PROCESS - OPTIMUM PARAMETERS

AWS	SIZE OF WIRE	CURRENT	VOLT	WIRE FEED	ELECTRICAL STICKOUT	ARC SPEED	WELDING POSITION	DEPOSITION RATE
E70T1	1.6	360 AMPS	29 V	370 IPM	1 1/8"	10" IPM	FLAT	150 gms/MIN
	2.0	420 AMPS	30 V	280 IPM	1 1/2"	12"	FLAT	175 gms/MIN
E70T4	1.6	360 AMPS	29 V	365 IPM	2 1/2"	10 IPM	FLAT	150 gms/MIN
	2.0	–	–	–	–	–	–	
E70T5	1.6	380 AMPS	29 V	375 IPM	1 1/2"	10" IPM	FLAT	150 gms/MIN
	2.0	400 AMPS	30 V	200 IPM	1 1/2"	12 IPM	FLAT	175 gms/MIN
E70T5	2.4	500 AMPS	32 V	300 IPM	1 3/4"	13" IPM	FLAT	250 gms/MIN

TABLE : 2

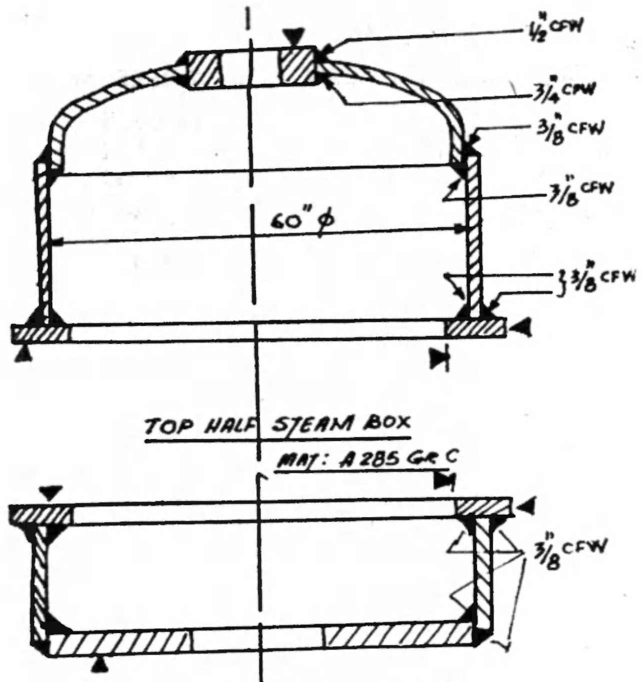


FIGURE: 2

CASE STUDY

TIME ANALYSIS - FCAW AUTOMATIC VERSES MMA

1	PROCESS USED	FCAW (AUTO)	MMA
2	MATERIAL WELDED	A 285 Gr C	A 285 Gr C
3	POSITION OF WELDING	REFER WELD PROCEDURE	2 F
4	POWER SOURCE	AUTO MIG 600 10 TON POSITIONER	600 AMPS D C. GENERATOR
5	ELECTRODE	E 70 T5	E 7016
6	SIZE OF CONSUMABLE	1.6 ϕ	4 MM. ϕ
7	SIZE OF WELD	3/8 CFW	1/2 CFW
8	TOTAL LENGTH OF WELD	756"	756"
9	NUMBER OF PASSES	SINGLE	3 PASSES
10	WT OF WELD DEPOSITE	9.5 KGS.	13.5 KGS.
11	DEPOSITION RATE/ARC HR	9 KGS	2.5 KGS.
12	OPERATING FACTOR	0.5	0.3
13	ARC TIME	64 MTS	324 MTS.
14	TOTAL TIME OF OPERATION	2 HRS.	16 HRS.
15	RATIO	1 :	8
16	FOR 2MM ϕ FLUX CORED WIRE	1.6 HRS.	–
17	FOR 2.4MM ϕ FLUX CORED WIRE	1.4 HRS.	–

CASE STUDY

COST ANALYSIS FCAW (AUTO) VERSES MMA

1	PROCESS USED	FCAW AUTO	MMA
2	WT. OF WELD METAL DEPOSITED	9.5 Kgs	13.5 Kgs.
3	DEPOSITION EFFICIENCY OF ELECTRODE	85 %	70 %
4	WT. OF CONSUMABLE REQD.	11.2 Kgs	19 Kgs.
5	COST OF CONSUMABLE / KG	Rs. 27	Rs. 18
6	TOTAL COST OF CONSUMABLE	Rs. 302	Rs 347
7	COST* OF SHIELDING GAS / KG.	Rs. 4.50	NIL
8	REQD. SHILDING GAS BY WT	5.6 Kgs	NIL
9	COST OF SHIELDING GAS	25.20	NIL
10	MAN HOURS BOOKED	2 HRS	16 HRS.
11	COST OF LABOUR / HR INCLUDING ALL OVERHEADS	Rs. 50/HR	Rs. 35/HR.
12	COST OF LABOUR	Rs. 100/-	Rs. 560/-
13	TOTAL COST OF WELDING	Rs. 427/-	Rs. 907/-
14	RATIO	1 :	2

* EVERY KG. OF WELD DEPOSITE REQUIRES ½ KG OF CO_2 GAS

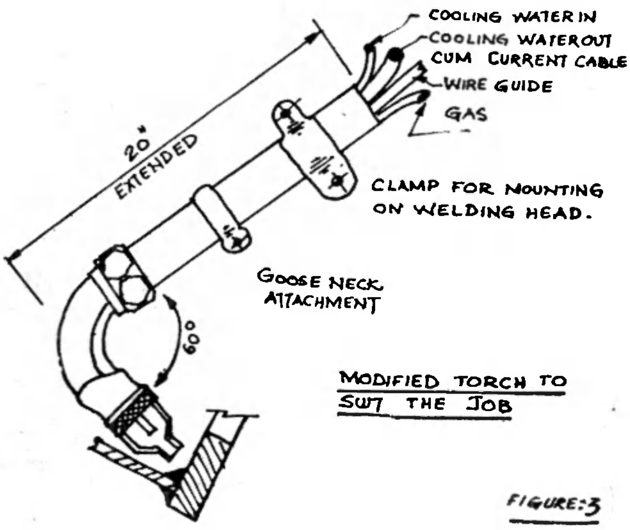


FIGURE: 3

tilting type rotary positioner adjustable in height. The outfits of the equipment are adjustable to locate the welding torch in various positions.

Optimum parameter used

The maximum current level with maximum voltage without causing porosity is found to be giving the highest deposition rates possible in the process. The table 2 gives parameters used in both semi and fully auto work centres.

Case Study

Figure 2 shows the details of steam boxes used in our equipment. The boxes are to be tested hydraulically to 250 psig and the working steam pressure is about 150 psig. The welds were made manually by qualified welders as per ASME Section IX, previously. The welds are to be checked by dye penetrant check before machining and no stress relieving is called for. The metal arc process was producing lot of distortion on the flanges eating away the machining allowance. Distortion after machining was also noticed in certain cases. At present, we have resorted to flux cored arc welding process to manufacture these boxes. The submerged arc welding process was also found not economical and suitable for producing fillet welds as required. Horizontal and down hand position welding was possible with a goose neck torch attached to the welding head with modification as shown in fig. 3.

EFFECT OF OFF-CENTRE DISTANCE ON BEAD SHAPE.

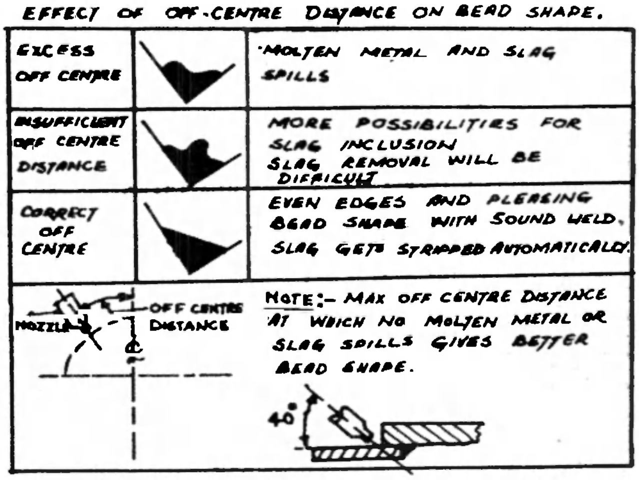


FIGURE: 4

OFF CENTRE CIRCUMFERENTIAL DISTANCES AND ANGLES

DIA. OF JOB WELDED	FROM	TO	TORCH ANGLE
6" - 12"	1 ¾	2 ⅝"	18°
15" - 21"	3 ¼"	4 ¼"	20°
24" - 30"	4 ¾"	5 ¾	25°
33" - 40"	5 ¼"	7 ¼"	30°
43" - 49"	7 ¾	8 ¾"	35°
52" - 58"	9 ¼	10 ¼	45°
61" - 67"	10 ¾"	11 ¾"	45° TO 55°

TABLE: 3

Lot of trials were carried out to arrive at correct parameters presented in the weld procedure sheet reproduced here. The offset circumferential distance of the torch from the centre line has lot of influence on the weld bead appearance, and it is found more than that required in the submerged arc welding. The distances required for various diameters are given in fig. 4 and table 3.

The torch angle to the flange and shell joint had lot of effect on soundness of weld. Any changes in this angle caused root porosity in the weld wherever the gap was present. Single and multiple passes were tried to produce the required fillet sizes. Single pass welds were found more economical and the appearance of weld was more acceptable. The cost and time analysis of producing this component by MMA and flux cored arc welding is tabulated here. The practical advantages of automatic flux cored wire process over submerged arc welding are enumerated below :

1. Easy slag removal ; mostly the slag strips off automatically even in 'V' groove joints.

2. No need for drying flux in special ovens which required additional investment.

3. All manual operations like collecting, screening, redrying and filling of flux are eliminated.

4. Arc is visible and easy for manipulation on uneven configuration of joints, and poor fit up conditions.

5. Out of position welds are easier and no special arrangements are required to be made for flux retention.

6. Fusing of flux into the weld metal or entrapment of flux into the gap of the joint are rare.

7. Finish of weld is superior.

8. Higher welding speeds possible than submerged arc welding.

9. With longer stick out and higher size of flux cored wire, we can achieve better deposition rate than possible in submerged arc welding.

10. Certain uncleanliness like rust and scale on weld joints are acceptable for welding.

Conclusion

There is lot of scope for this process to be extended for all type of fabrication jobs where submerged arc welding is employed. The relative merits and demerits are to be worked in case to case basis before the selection of the process is done.

The success of this process lies in the areas given below where lot of improvement is possible :

1. Availability of flux cored wire suitable to various material and quality approved by various agencies.

2. Users to take initiative in establishing weld procedures suitable for pressure vessel fabrication.

3. Design and development of cheaper and trouble free equipment indigenously.

I thank the Management of L & T-McNeil and The Indian Institute of Welding for having given me an opportunity to present this paper.