Evaluation Of Increased Deposition in Hotwire Submerged Arc Welding with chosen Parameters for Pipes upto 40mm Thickness

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I. INTRODUCTION

There have been various attempts to increase the deposition rate of submerged arc welding. The high productive multiwire submerged arc welding processes employ higher heat input which is not acceptable for certain applications. Also these processes need accurate joint preparations and proper backing. The use of neutral and basic fluxes in such processes poses problems in obtaining a good bead geometry and better weld quality as the welding speeds are higher for such set-ups. The hot wire submerged arc welding process is an attempt to increase productivity by about 50 to 70% through the addition of hot filler wire to the arc zone. Attempts have been made to adopt this process for the joining of Carbon-Manganese steel pipes having a diameter of 500 to 800 mm and a thickness 16 to 40 mm, without a change in the existing fit-up, filler metal, flux and the equipment.

A cost comparison was made between two wire tandem submerged arc welding process and hot wire submerged arc process.

II. SET-UP FOR LONG SEAM PIPE WELDING

The plates are hot pressed, tack welded by CO_2 and a backing run from inside is given. The outside is either machined or gouged and ground to prepare the edges. For hot wire trials, an auxiliary wire feeder is mounted integral with the standard submerged arc welding head. (Fig. 1).

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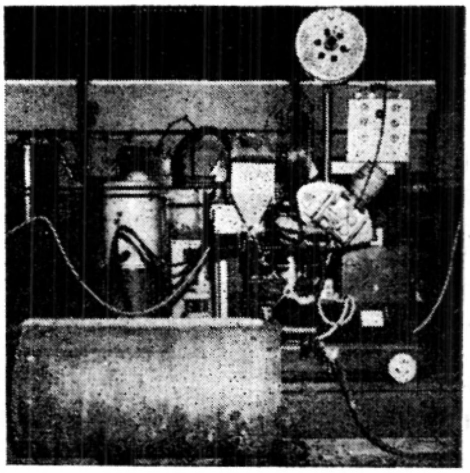


Fig. 1 : Hot Wire SAW Trial on Pipe

The hot wire nozzle is positioned at the leading edge[1]. The auxiliary wire deposits a bead of molten metal without an arc through I^2R heating. A separate hot wire AC power source having slightly drooping static characteristics with an OCV of 15V maximum is used. The use of AC for hot wire avoids arc blow. The feeding nozzle has facility for changing the stick out and angle of entry of the hot wire into the molten pool.

III. EXPERIMENTAL APPROACH

Trials were conducted for establishing the parameters for the long seam welding. The material chosen for our trials was SA515-Gr. 70. For the comparison of the productivity, bead geometry, weld quality and the economics between multiwire processes and hot wire process, parameters practised in the industry are taken as reference[3,5]. The joint volume per unit length is calculated. The joint design is selected so as to optimise number of layers. The thickness of backing maintained is 4 to 5 mm, and this is much less than that required for multiwire processes. The amount of hot wire to be added for a pipe joint depends upon the preheat temperature, type of flux and welding speed[2]. For our trials, three types of fused and one type of agglomerated fluxes are used. The wires containing high Manganese and high Manganese plus 0.5% Molybdenum are used in combination with above fluxes. The grain size as well as depth and width of flux layer control the bead appearance.

The extra deposition through hot wire decides the increase in productivity. It theoretically varies from 0 to 100%. The lack of fusion and slag inclusion is found beyond 70% additional deposition.

The voltage and current for hot wire are selected from the power requirement for a particular additional deposition rate. The constant power curve corresponding to the melting rate of the hot wire deposited and static characteristics of hot wire power source are superimposed. The meeting point of the two curves gives the operating point. The voltages are normally of the order of 9 to 10 volts. Below 10 volts self-extinction of the arc is seen. If the hot wire power source voltage is set at a higher level, erratic arcing results and the bead shape is impaired.

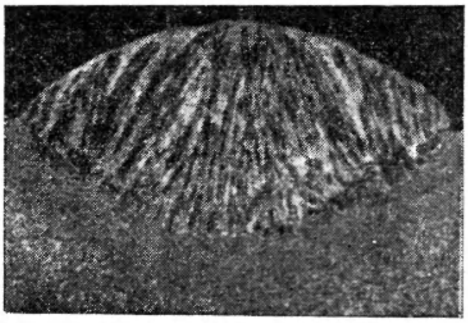
The hot wire current decides the penetration and reinforcement of the bead and should be closely controlled. A higher current employed causes wandering of the tip due to overheating. The heating current drawn depends upon hot wire diameter, feed rate and stick out. By previous investigators 1.6mm diameter wires were used[3,4]. However, there are cases where 2.0mm and 1.2mm wires have been successfully used by us.

At lower welding speed, there is a build-up through the hot wire addition which results in reduced stick out. When high welding speeds are employed, the contact between the hot wire tip and the weld pool is imperfect. So the normal speed used in the industry is chosen for a satisfactory bead formation.

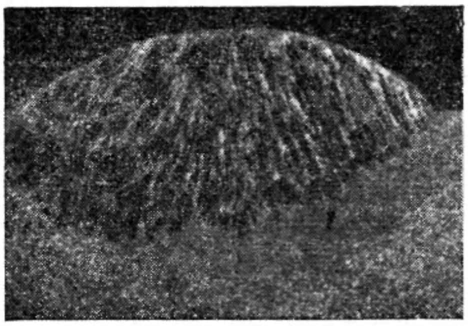
The angle of entry of the hot wire into the molten pool varies from 40 to 60°. The point at which the hot wire touches the plate, is at a distance of 10 to 20mm from the main wire, so that the hot wire can touch the leading edge of the molten pool.

IV. DISCUSSION

The pipe welding was carried out at various percentages of hot wire addition. The slag inclusion and lack of fusion become more prominent when the extra deposition is increased beyond a definite value, for a given main arc parameter. This is because of the formation of more convex beads at higher extra deposition and lower total heat input. (Main arc+hot wire) (Fig. 2).



Bead Shape at 60%



75% Hot Wire Addition

Fig. 2.

The percentage of maximum deposition through hot wire is decided by total heat input per unit volume Table 1

The extra hot wire helps absorbing the additional heat from the main arc, thereby avoiding burn through. A backing of 4 to 5mm is sufficient as the penetration is controlled with hot wire addition. Travel speeds are maintained at 30-36 M/Hr for the initial layer.

The heat input varies upto 4.5 KJ/mm for such applications. The relationship between penetration and total heat input is plotted for different hot wire deposition. At 50-70% extra deposition through hot wire for different main arc parameters used in the industry,

Table 1. Effect of % Deposition through Hot Wire

Pipe dimension Main wire Parameter	% Hot Wire	Bead Quality
508ϕ×16mm	55	6 layers, side wall wetting good.
500—600A	65	4 layers, bead satisfactory.
30—34V,36M/Hr	75	lack of fusion, slag inclusion.
600 dia×32mm	55	6 layers, good penetration
550—600A, 32-	65	lack of fusion, convex beads.
34V, 33M/Hr	75	slag inclusion 400mm.
780ϕ×40mm	60	burn through, under cut.
550—600A, 32V	70	10 layers, satisfactory joints.
27M/Hr	80	lack of fusion
	100	slag inclusion, lack of fusion.

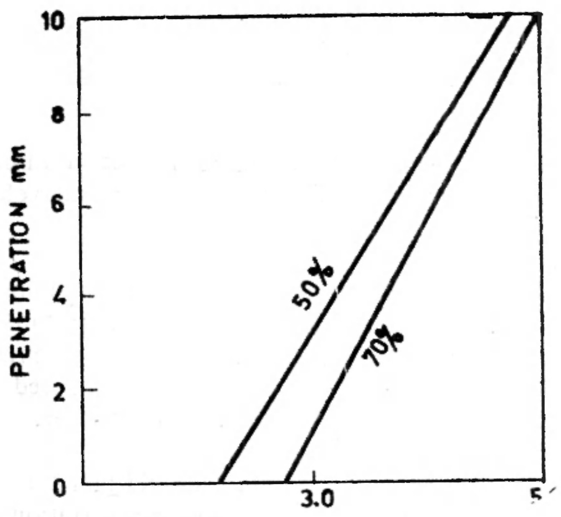


FIG. 3 PENETRATION VS TOTAL HEAT INPUT

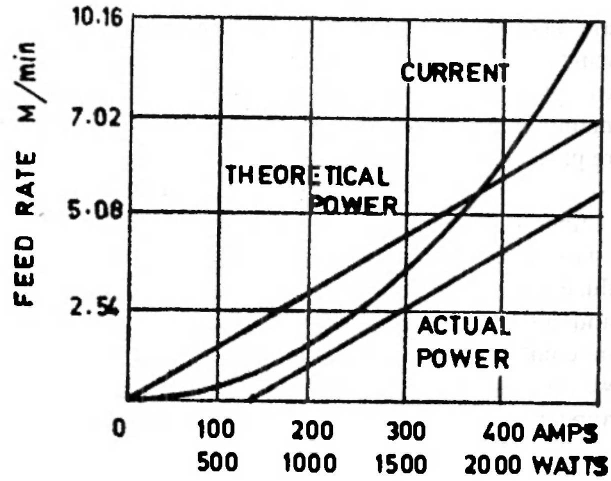


FIG:4 FEED RATES VS CURRENT VS POWER

the relationship between penetration and total heat input is found to be linear. The linearity of the above relation is because the ratio of total heat input to the total metal deposited (Main arc wire+hot wire) is optimum at 50-70% extra deposition. (Fig. 3).

Theoretical power needed for melting steel $\} = 1.27 \times 10^6 J/kg$

The current is known from the operating point depending upon the deposition rate (i.e , wire feed rate) for hot wire. It was matched with experimentally determined I^2R curve given by Manz[1]. It did not agree for all applications due to process variation. The current change is associated with change in voltage. Therefore, the theoretical power curve was used by us to decide the wire feed rate when voltage and current both vary. The actual power requirement is more than the calculated one due to various power losses. (Fig. 4).

The grain size from 14×D to 20×D shapes the bead. It is observed that an agglomerated flux gives the best results due to its good fluidity and slag detachability at different welding speeds from 18M/Hr to 36M/Hr. This flux can be used for various wires to give a strength upto 57/kg/mm².

Economic Aspects :

The flux consumption increases with hot wire feed rate. The ratio of slag produced to weight of metal deposited (K-factor) is less than that in conventional process. The hot wire submerged arc welding compared to two wire tandem method is economical in terms of both initial investments and energy consumption.

Table 2. A Comparison for 40mm Pipe Welding

Process	Capital Cost	Heat Input	Deposition Kg/Hr.	Control (W.F)	K-Factor	Penetration	Back-up
2-wire Tandem	100%	4.2 KJ/mm	10.8	Preset	1-1.2	High	10mm
Hot Wire SAW	30-40 %	3.3 KJ/mm	10.2	In-process	0.8	Low	4-5mm

*Cost calculations are as per Indian market in 1980.

The weld can be in process controlled for penetration, the tracking is easy and joint preparation is simple. The auxiliary wire feeder can be fitted easily to the conventional submerged arc welding head.

A comparison was made between two wire tandem and hot wire processes. (Table 2).

Our study shows less cost for hot wire submerged arc welding compared to the conventional and two-wire tandem processes (Table-3). The cost is for filling 1 Metre length.

The equipment is simple to attach with conventional submerged arc welding heads, gives extra deposition upto 70% with 20% extra heat input, easy to adopt in the industry and saves time upto 30-40%.

V. FUTURE STUDIES

The hot wire submerged arc welding process offers wide scope for improvement and some of the areas for further study are as listed below :

(1) The main arc parameters—especially voltage may be modified suitably so as to avoid the convex beads which may result when the hot wire addition exceeds a maximum limit of about 70%.

(2) The hot wire process which is a relatively low heat input process compared to conventional process can be advantageously used for the welding of GT steels and high strength steels.

Table 3. Cost Comparison

Process	No. of Layers	Total Time in Sec.	Total Cost in Rs.
Single-wire SAW (20mm)	8	1130	51.50
HW-SAW (20mm)	5	900	47.80
Single-wire SAW (40mm)	17	2400	193.90
HW-SAW (40mm)	10	1830	181.80
2 Wire Tandem (40mm)	4+7	1750	199.00

(3) Because of excellent control over penetration in this process, this can be effectively used for surfacing applications.

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