

Development of Submerged Arc Welding Equipment in India

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Considerable progress has been made in the manufacture of equipment and consumables for manual welding in this country. In addition to manufacture of practically all types of electrodes, power sources of different kinds namely motor generators, transformers and transformer-rectifiers have been in production for quite some time. However, manufacture of semi-automatic and automatic welding equipment and the consumables needed for these processes has not made much progress till very recently. While there are several semi-automatic and automatic installations in the country these have been imported. Even for consumables, dependence on imports has continued. The need for making a beginning towards change-over to semi-automatic and automatic processes from manual welding where the applications call for such a change-over, does not need much stressing. The trend in more advanced countries has been to switch over to these processes wherever possible. In these countries the production of continuous electrodes, fluxes and shielding gases has increased while that of manual electrodes has shown a decreasing trend.

The last few years have seen the tremendous gains made by semi-automatic welding particularly of the metal inert gas type (or what is popularly known as CO₂ welding) in these countries. This type of welding has to a considerable extent replaced manual welding in several applications.

CO₂ welding however, has not found wide application in this country, the reason mainly being non-

availability of the continuous electrodes used in this process. One does see a few installations using the CO₂ process here and there but the dependence on imports for the consumables has made it difficult for this process to gain much popularity. On the other hand, some progress has been made in the manufacture of consumables for automatic and semi-automatic submerged arc welding during the last few years and both fluxes and continuous electrodes are being manufactured in the country for these processes. Several firms having imported submerged arc installations are already using these indigenous consumables. In these circumstances it is profitable to investigate the use of submerged arc welding.

It will not be out of place here to review briefly the advantages of the submerged arc process. The submerged arc process is a high current density process using 6 to 10 times the current density employed in manual welding. Consequently weld penetration obtained is very much more than in manual welding and it is possible in most cases to do away with or reduce the edge preparation normally required for hand welding. Because of the use of continuous electrodes the operating factor is very much improved and consequently, savings in labour and overheads result. The working conditions are also improved due to absence of visible arc which is an advantage. Elimination of spatter improves weld appearance and self-detaching slag reduces cleaning time. The heat-insulating properties of the flux concentrate the heat of the arc within a relatively small zone reducing distortion.

One disadvantage, particularly with semi-automatic submerged arc welding is that since the arc is not visible, greater skill is required on the part of the operator.

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However, an operator can acquire this skill within a fairly short time.

For this process the three requisites are the consumables namely flux and continuous electrode, the power source and welding accessories such as the welding gun with the wire feed mechanism. As already stated, a beginning has already been made in the manufacture of the consumables. As for power sources, direct current power sources appear to be more popular for the submerged arc process than alternating current power sources. Some of the reasons for this preference are given later in this paper. Direct current power sources for manual welding especially motor generators of practically all capacities are already being manufactured in this country. It is possible to use these power sources by operating them either singly or in parallel for both semi-automatic and automatic submerged arc welding. Thus by developing the accessories required for the process it is possible for us to take advantage of this process.

Regarding the choice of power sources it has been stated earlier that while both A.C. and D.C. power sources are used the latter are preferred for certain reasons. With an A.C. power source i.e. a welding transformer the initial cost is low and the phenomenon of arc blow is absent, which is an advantage. But arc stability with A.C. is poor, arc striking is more difficult and it is also not possible to weld with A.C. in the case of certain parent and filler metals. More porosity is also observed with submerged arc welds done with A.C. resulting in lower welding speeds than D.C.

Direct current power source for submerged arc welding consists of a motor generator or a transformer rectifier. The first cost of these power sources is high compared to A.C. power sources. But direct current has certain definite advantages in submerged arc welding. The arc starting is easier and the arc is more stable. Consequently higher welding speeds can be attained with D.C. power sources. Another advantage of D.C. welding is that the build up and the penetration can be influenced by changing the polarity of the current. With positive polarity deep penetration, low porosity and lowest build up are obtained, while with the negative polarity a high melt off and low burn-through are obtained. This is due to the change in distribution of energy between cathode and anode when the polarity is changed.

In the following paragraphs, a brief description of arc control in semi-automatic and automatic submerged arc equipment using motor generator power sources is given.

Rating of Power Sources for Semi-Automatic and Automatic Welding

When used for manual welding, these power sources are rated at 60% duty cycle. For semi-automatic welding also the same duty cycle holds good since the gun is directed by hand even though the wire feed is automatic. For fully automatic welding, however, the duty cycle is higher and may approach 100%. Therefore, the rated maximum continuous hand welding current can be used for semi-automatic welding while for fully automatic welding, about 70—75% of this value can be safely used.

Semi-Automatic Submerged Arc Welding Equipment

The power source consists of a separately excited drooping characteristic, compound wound D.C. generator. The wire feed motor is connected across the electrode and the ground through a control rheostat as shown in fig. 1. The field of the main generator and the wire feed motor are supplied by the same separate exciter. Since the gun is operated by the welder there is no need for electrode retraction during start of welding. The arc is started by scratching the electrode on the work.

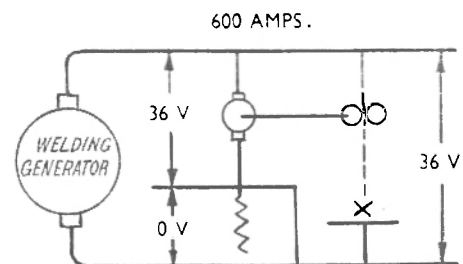


FIG. 1.

Let us suppose that with the full arc voltage applied to the wire feed motor, wire can be fed to deliver a maximum welding current of 600 amps at 36 volts. This operating point is shown on the static characteristic 'A' of the power source in Fig. 2. If now it is

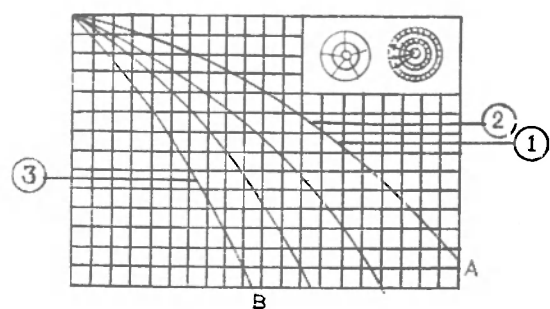


FIG. 2.

desired to increase the arc voltage to 40, the corresponding welding current on the static characteristic would be 550 amps. Assuming the wire feed speed to be proportional to current, the wire feed motor speed should be brought down by applying the lower voltage of 33 volts on the wire feed motor. This is done by cutting in some resistance into the motor armature circuit. As shown in fig. 3 out of the total arc volts of 40, 33 volts are applied to the wire feed motor with 7 volts drop in the resistance.

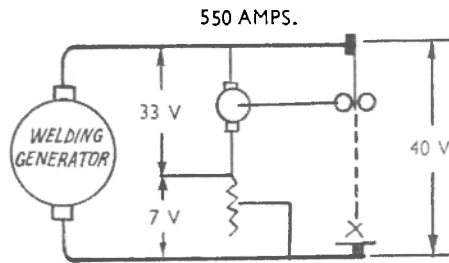


FIG. 3.

If it is now desired to weld at 300 amps and 30 volts the machine is set on a different static characteristic shown in curve 'B' of Fig. 2. Assuming again that the wire feed speed is proportional to current the supply voltage on the motor should be half that required for 600 amps i.e. 18 volts. By cutting in some more resistance the wire feed speed motor has 18 volts across it with the resistance drop increasing to 12 volts as shown in Fig. 4.

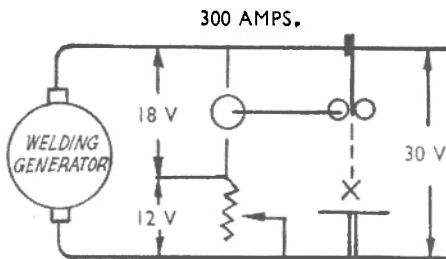


FIG. 4.

Fully Automatic Submerged Arc Welding Equipment

With the fully automatic head the following additional requirements arise :

- (1) Need for wire retraction at start.
- (2) Controls for inching up and inching down the electrodes.

The current requirements may also be larger than in semi-automatic welding. For this reason, two motor generator sets are operated in parallel. As before, the welding generators are separately excited drooping characteristic compound wound D.C. Machines.

The principle of the control circuit employed is shown in fig. 5. The wire feed motor is connected across the welding generator through a control exciter, the voltage of the control exciter opposing that of the main generator. The wire feed motor thus gets impressed on it the voltage difference between the arc voltage and the control exciter voltage.

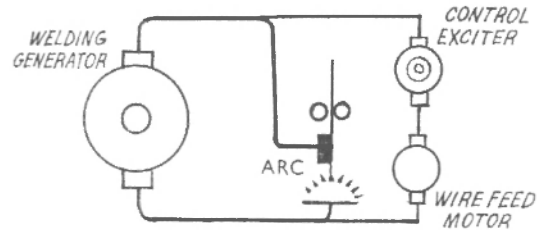


FIG. 5.

Arc Starting

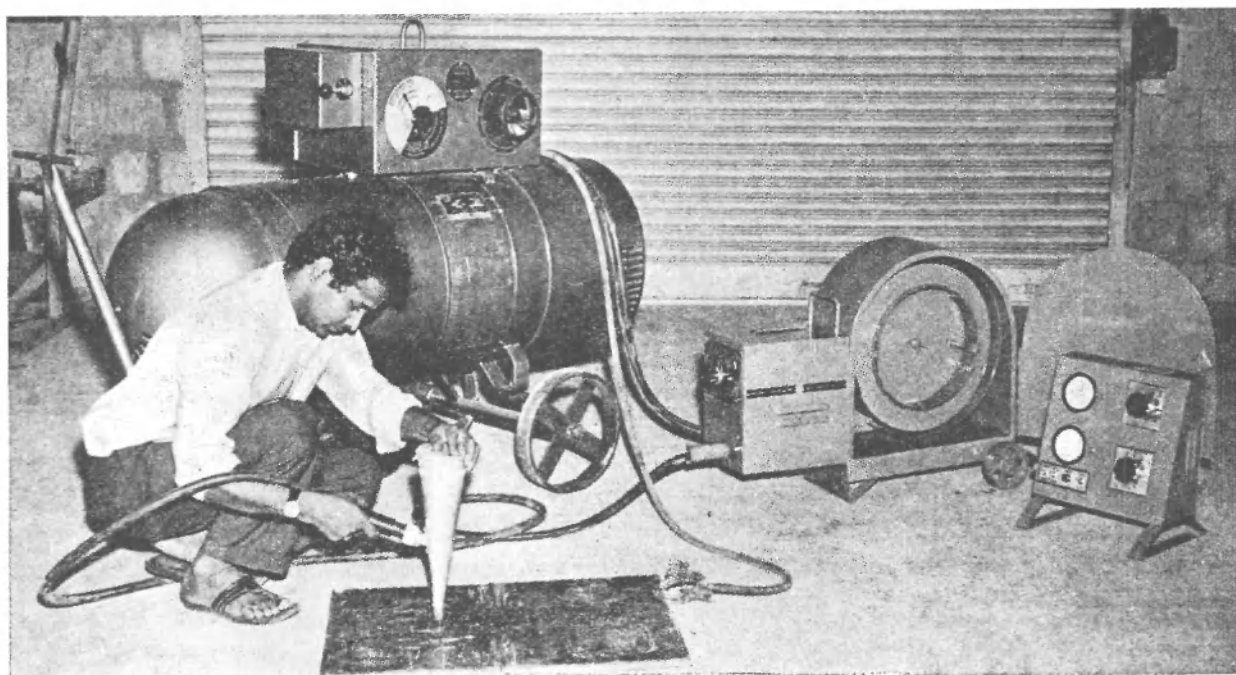
To start with, the wire is inched down to make contact with the ground. When the welding 'start' push button is switched on, the welding generator voltage being zero, the control exciter drives the wire feed motor in the opposite direction and the wire retracts momentarily establishing the arc. The wire will inch up to a point when the control exciter voltage equals the arc voltage and at this point stops moving. As the wire melts off further and the arc voltage exceeds the control exciter voltage, the wire starts feeding down.

Arc Control

The inclusion of the control exciter helps keep a constant arc length. If for any reason, say a depression in the work, the arc voltage increases this will speed up the wire feed bringing the arc length to the original value.

In order to increase the current at a given arc voltage the control exciter voltage is lowered so that the wire feed motor which is driven by the difference in the arc and control exciter voltages feeds the wire faster. Photographs 1 and 2 show semi-automatic and fully automatic submerged arc welding equipment manufactured in India on the principles described above.

Photograph 1 shows welding being done with a semi-automatic unit. The power source shown is a separately excited drooping characteristic motor generator rated at 600 amperes on 60% duty cycle. The exciter is designed to meet the extra requirements of the controls on the semi-automatic unit in addition to providing excitation for the main generator. Bare electrodes of diameter 3/32" and 5/64" are used. The power source provides welding currents from 250—600



Photograph 1.

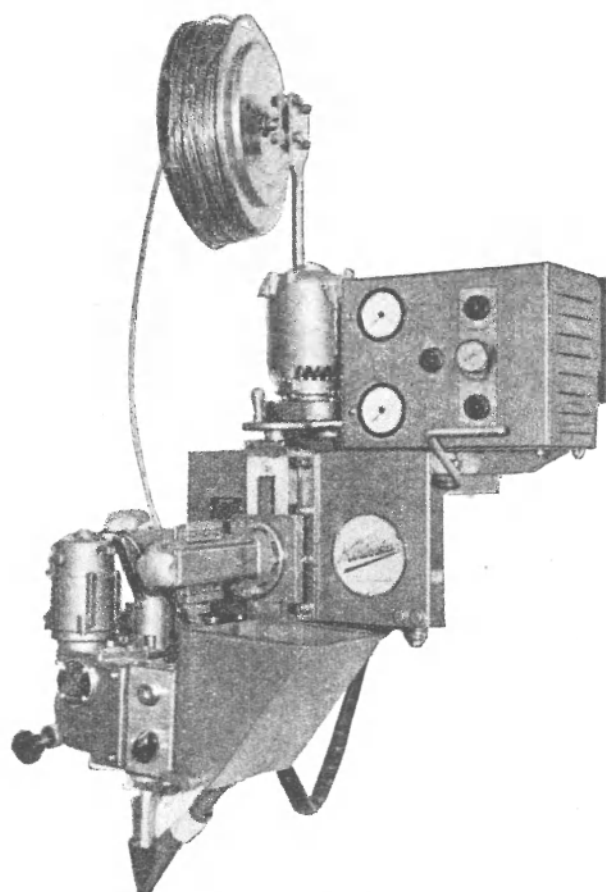
amperes. This unit can weld plates upto $5/8$ " without edge preparation.

Photograph 2 shows a fully automatic welding head which can be mounted on a beam for longitudinal welding or used with a positioner for circumferential welds. Bare electrodes of diameter $1/8$ ", $3/32$ ", $5/32$ " and $7/32$ " are used. Welding currents up to 800 amperes can be used and, where required, provision upto 1200 amperes can be made.

Two 600 ampere power sources, similar to that used with the semi-automatic unit, are operated in parallel to provide a continuous welding current of 800 amperes at 100% duty cycle.

Conclusion

Automatic welding processes have not gained much popularity in India since consumables for the various processes are not indigenously available. For the same reason equipment manufacturers also have not shown much interest in entering this field. Now that a start has been made in the manufacture of consumables for submerged arc welding, the position has changed. Manufacture of semi-automatic and fully automatic submerged arc welding equipment has just begun. Power sources on lines similar to those used for manual welding have also been developed. This development is sure to give a fillip to the manufacture of equipment and consumables for other automatic processes also.



Photograph 2.