CASE STUDY .... (GMAW)

HIGHER DROPLET RATE AND IMPROVED METALLURGICAL PROPERTIES IN GMA WELDING THROUGH EXTERNAL MAGNETIC FIELD

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Key Word : *MAG Welding, External Magnetic field, Droplet Transfer, Voltage Transients, Dendrite Arm Spacing, Carbon diffusion*

Applications of external magnetic fields to welding processes are used to induce disturbances in the arc and weld pool. As a result arc deflection and changes in metal transfer characteristics are observed. Metallurgical properties of the weld metal are also affected. An investigation was undertaken to study the effect of external magnetic field on the metal transfer characteristics in CO_2 welding. The metallurgical characteristics of the weld metal were also studied. It has been observed that magnetic field imposition affected the droplet transfer rates and droplet transfer times. Dendrite arm spacing of the weld metal was found to decrease with magnetic field. Magnetic field also increased the carbon diffusion rate from the high carbon base metal to the low carbon metal.

1. INTRODUCTION

External magnetic fields applied to the weld pool region have been used for many years to introduce disturbances into the arc and the weld pool to get some beneficial effects. Besides affecting the metal transfer and droplet rates, it also affects the microstructure of the weld metal.

Basler, et al [1] have reported that the superimposition of a longitudinal magnetic field on conventional MIG welding of steel results in the melting of the electrode wire in field on conventional MIG welding of steel results in the melting of the electrode wire in the form of a spiral due to the rotational forces.

Many researchers have reported that grain refinement can be achieved by the application of magnetic field.

Abralov, et al [2] reported grain refinement of titanium alloys under the effect of external magnetic field.

Blinkov [3] has presented the results of the influence of an external magnetic field in argon arc welding on the structure and properties of welded of welded joints in high tensile steel. He concluded that the application of variable magnetic field makes it possible to alter the solidification process and to produce a fine grained structure.

Baradokin, et al [4] have found that in welding of aluminium with longitudinal external electromagnetic field of low frequency, it was possible to obtain weld metal in which the axes of the columnar grains had loop shaped paths, which inhibits the propagation of a hot crack along the central boundary between the grains.

Tseng and Savage [5] used a commercial solenoid fed with a square-signal input to impose a.c. transverse or parallel fields during GTA welding of steels. They reported that arc oscillation reduced the sub grain (dendrite) spacing, and caused variations in local growth velocities that tended to reduce the crack sensitivity.

2. OBJECTIVE

An investigation was undertaken to study the effect of external magnetic field on metal transfer characteristics in CO_2 welding. The changes in the metallurgical properties of the weld metal were also studied.

3. EXPERIMENTAL PROCEDURE

The parallel d.c. magnetic field applied to the arc zone was produced by a d.c. electromagnet. Bead-on-plate welds were deposited with 1.2 mm dia. low carbon CO_2 welding filler wire on two types of base metals — low carbon and high carbon steel plates of 10 mm thickness. The welding was done with an Automatic Welding Head. The process was automatic with preselecting the welding parameters. The power source had constant voltage (CV) V-I characteristics.

For recording the voltage transients, a voltage recorder was used with 100 mm/sec paper speed. The voltage records were later analyzed to find the droplet formation time, droplet transfer rate etc.

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For metallurgical studies, small samples were cut from each bead and were polished and etched. The samples were studied with the help of an optical microscope at different magnifications. Necessary microphotographs were also taken.

4. RESULTS AND DISCUSSIONS

4.1 Droplet Rate:

The mean droplet transfer time was calculated by dividing the total droplet transfer time by the number of droplets transferred during the period. The droplet rate per second is the inverse of the mean droplet transfer time.

Figures 1 and 2 show the droplet rates at various welding currents and magnetic field levels. It can be observed that the droplet rate increases with the magnetic field to a optimum value, then it again decreases with further increase in the field strength. With the increase in welding current the rate also increases in general.

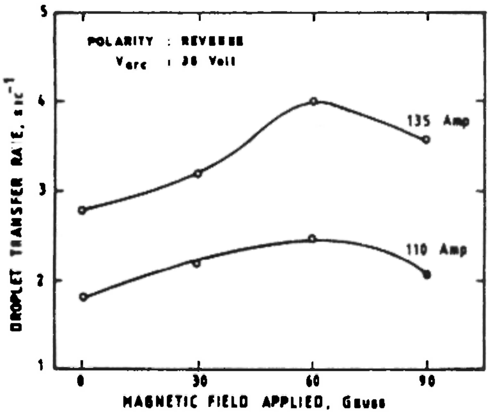

Fig.1.: Effect of magnetic field on droplet transfer rate at 30 volt (Reverse polarity)

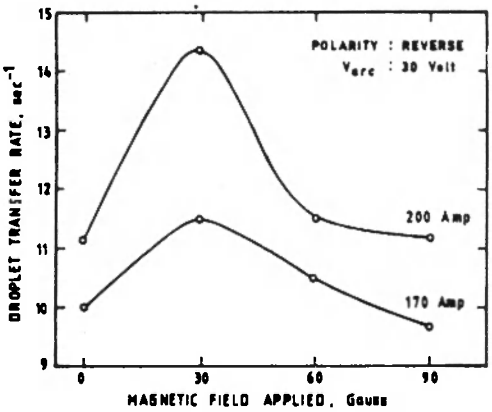

Fig.2.: Effect of magnetic field on droplet transfer rate at 30 volt (Reverse Polarity)

It has been reported [6,7] that in CO_2 shielding a restraining force appears to exist, operating on the underside of the pendant globule and prevents the detachment. The force is more at lower currents and decreases as the welding current is increased. The magnetic field imposition produces a balancing effect on this restraining force, the droplet transfer becomes easier and the droplet rate is thus increased. At lower currents the restraining force being more, higher magnetic field strength is, therefore needed to attain the maximum droplet rate than the field strength required at higher currents. Again at higher magnetic field there will be a substantial arc deflection. Arc blow results in, the arc becomes erratic and unstable. The balancing effect is reduced and hence the droplet rate again decreases at higher field strength. Increase in current is associated with increased wire feed rate, more metal melts at the same time and it leads to increased droplet rates.

4.2 Metallurgical Characteristics:

The dendrite arm spacing of the weld metal has been taken as a measure of grain refinement. Figure 3 shows the change in the dendrite arm spacing due to the application of magnetic field. It can be seen that in all the cases the spacing decreases as the field strength is increased and that the decrease is almost linear. Increase in welding current also increases the arm spacing.

The magnetic field applied imposes some additional force on the liquid weld metal which causes dendrite arm

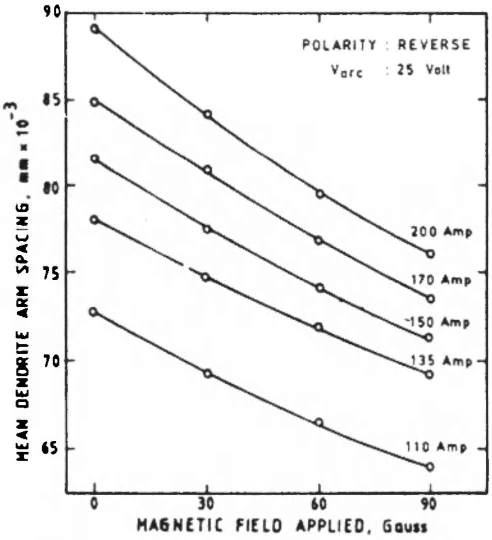

Fig.3.: Effect of magnetic field on mean dendrite arm spacing of the weld metal at 25 volt (Reverse polarity) [Base metal : Low carbon steel]

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fragmentation and prevents the growth of a large dendrite. Rather this fragmentation leads to formation of large numbers of small dendrites with less spacings. Increased welding current means higher heat addition with leads to slower solidification and due to this the dendrite arm growth time is more and the spacing increases.

The magnetic field also affects the range of dendrite arm spacings (Fig.4). The range decreases as the field strength is increased, which means that the arms are more uniformly and evenly spaced.

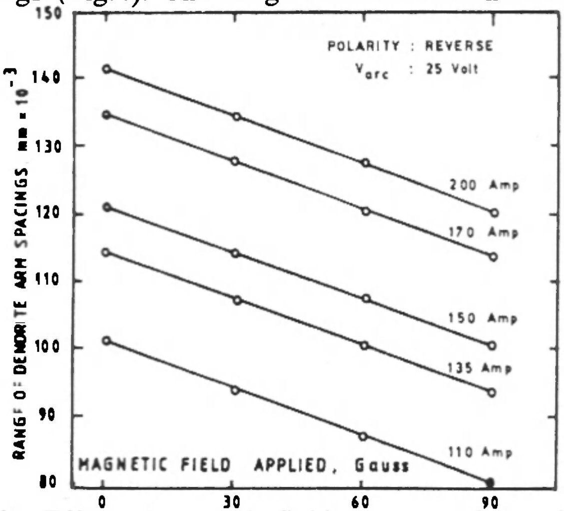

Fig.4. : Effect of magnetic field on range of dendrite arm spacings of the weld metal at 25 volt (Reverse polarity) [Base metal : Low carbon steel]

Figures 5 and 6 show the change in carbon diffusion from the high carbon base metal to the low carbon weld metal under the effect of magnetic field. It is evident from the figures that magnetic field increases the diffusion rate.

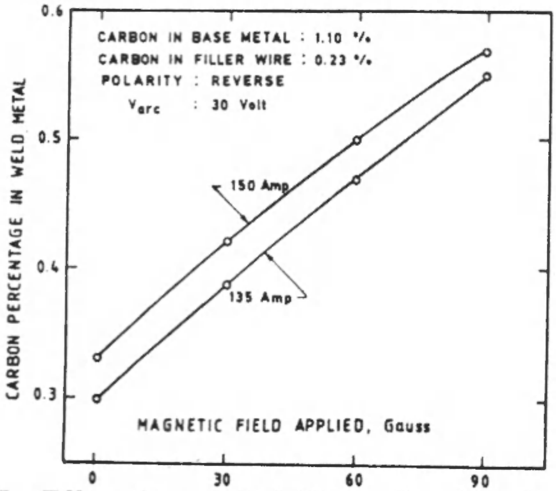

Fig.5. : Effect of magnetic field on carbon diffusion in weld metal at 30 volt (Reverse polarity)

The magnetic field imposition causes a stirring effect and disperses the hot liquid metal evenly in the weld pool, which leads to the increase in the degree of diffusion of carbon.

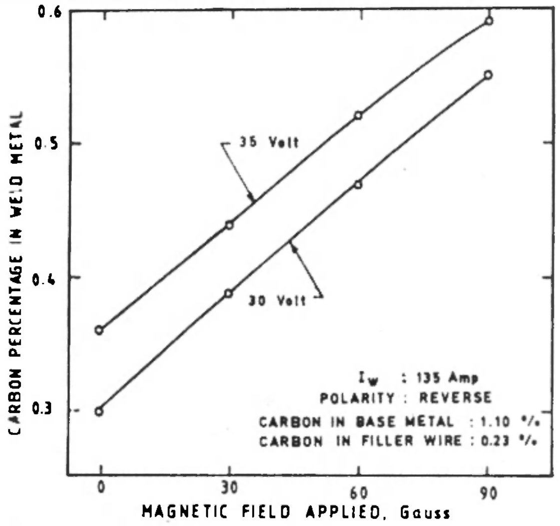

Fig.6. : Effect of magnetic field on carbon diffusion in weld metal at 135 amp (Reverse polarity)

5. CONCLUSIONS

(1) Magnetic field affects the droplet rate. The rate first increases to a optimum value as the field strength is increased. Further increase in magnetic field again reduces the rate.

(2) The dendrite arm spacing is reduced by the application of magnetic field.

(3) The range of dendrite arm spacings is also reduced by magnetic field imposition.

(4) The rate of carbon diffusion from the high carbon base metal to the low carbon weld metal is increased with magnetic field application.

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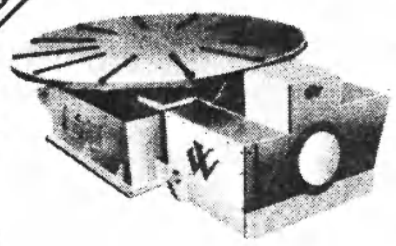

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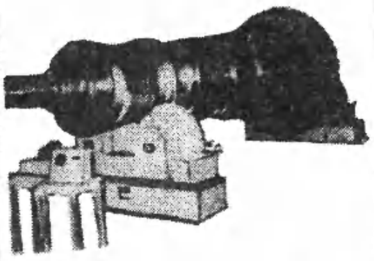

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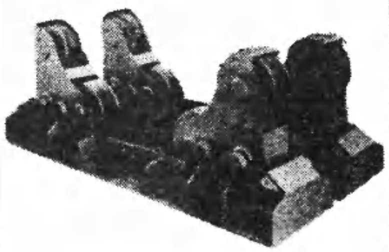

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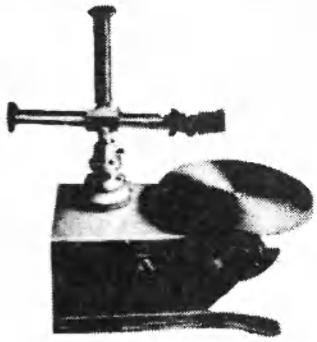

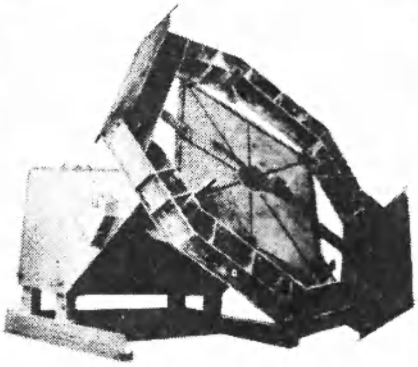

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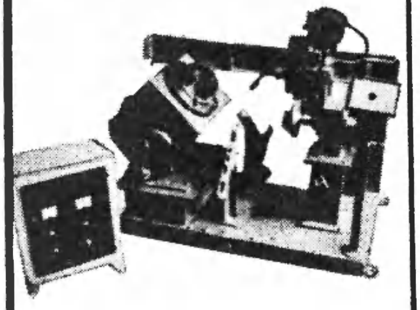

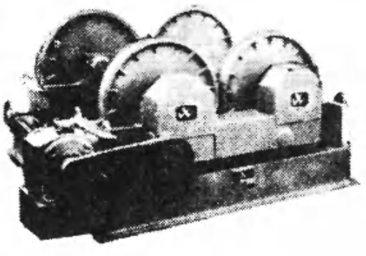

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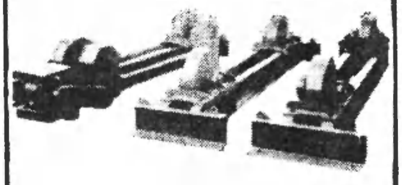

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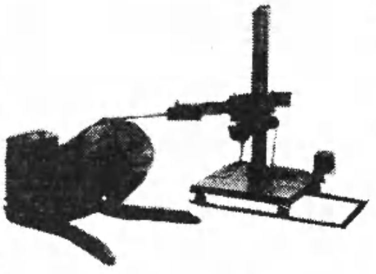

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