Abstract:

J-STAR® W[illegible] In the welding current under 200A, with that of conventional CO

$_2$ gas shielded arc welding method.

1. Introduction

Broadly speaking, there are three types of gas-shielded arc welding processes in application: MIG welding (Ar gas), MAG welding (a mixed gas of Ar and CO

$_2$), and CO_2 gas-shielded arc welding (CO_2 gas). The type depends upon the shielding gas used during the welding. CO

$_2$ gas-shielded arc welding, a process devel- [illegible]

$_2$ gas, the improvement of the welding work by arc stabilization is now regarded as an important task.

"J-STAR Welding," a method developed to meet the above-described requirement, has successfully realized the [illegible]

Table 1 Evaluation of effect of polarity/wire combinations on arc stability

Polarity	Welding wire	
	Si-Mn/Si-Mn-Ti	Si-Mn-Ti-REM
Electrode positive (EP)	Normal	Poor
Electrode negative (EN)	Poor	Excellent

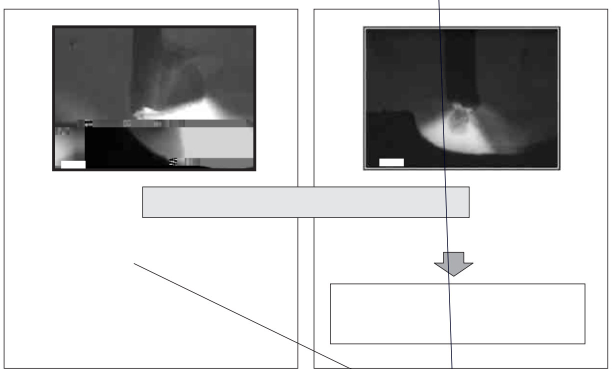


Fig. 1 Arc phenomena in CO_2 gas shielded arc welding

the droplet, which in turn causes spattering. Concretely, the spatter can be attributed to the scattering of the molten metal during the re-arcing after the droplet and molten pool are short-circuited, or after the droplet itself is scattered under the arc force. The coarsening of the droplets compounds the spattering effect. Table 1 shows an evaluation of the stability of CO_2 gas-shielded arc welding when applying different combinations of polarity and wire. Figure 1 shows arc phenomena during two processes: rst, in the conventional welding process in EP mode; second, in the JFE-developed welding process in EN mode. In each case, the welding is performed at a welding current of 300 A with or without a REM-added wire. In the conventional EP welding, CO_2 gas-shielded arc welding with an Si-Mn/Si-Mn-Ti-based wire is less stable when no REM is added to the wire, compared to the case when REM is added. In the EN welding plus the use of REM-added wire, the arc generation point is substantially displaced and a coarser droplet is formed, resulting in an unstable arc and increased spatter. In EN welding, an ideal conical arc terminating in the wire tip is formed with the use of an Si-Mn/Si-Mn-Ti-based wire treated with an appropriate amount of REM, and the micro-droplets in the spray are smoothly transferred onto the base-metal sheet side without shaking from the tip.

2.2 J-STAR Welding Wire "KC-500"

Table 2 shows the chemical composition of the KC-500 wire for J-STAR Welding. KC-500, the same material as YGW11 in JIS Z 3312, contains a trace amount of added REM.

Table 3 shows the results of a total deposited metal test of CO_2 gas-shielded arc welding with KC-500. The deposited metal obtained from KC-500 as a welding wire for 490 N/mm^2 class steels has sufficient strength and toughness. Tests have confirmed that the addition of a trace amount of REM into the welding wire leads to good welding characteristics with J-STAR Welding Wire regardless of the strength level, and the ready development of welding wires for application to 540 N/mm^2 class and 590 N/mm^2 steels.

Table 2 Chemical composition of steel welding wire

Table 3 Chemical composition and mechanical properties of deposited metal

2.3 Welding Characteristics of J-STAR Welding

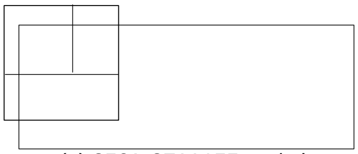
Tests have confirmed for the very rst time that J-STAR Welding, a technique characterized by the formation of a stable conical arc terminating with the wire tip at its apex, realized a fine spray transfer optimal for droplet transfer in CO_2 gas-shielded arc welding. The advantages of this technique over conventional CO_2 gas-shielded arc welding are enumerated below.

(1) The generated spatter is reduced to 1/10 that generated by the conventional technique.
(2) No spatter adheres near the weld bead.
(3) The generated fumes are reduced to 1/2 the level generated by the conventional technique.
(4) The sound of the Arc is soft, with sound pressure reduced to 1/2 that of the conventional technique.

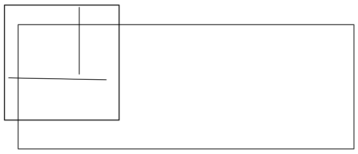
These advantages of J-STAR Welding are expected to improve working environments for welding lines and beautify the appearance of welded structures.

3. Welding of Steel Sheets

J-STAR Welding is capable of ultra-low-spatter welding through a process of fine spray transfer. A relatively

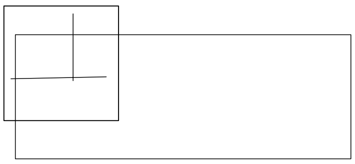


(a) 250A-27 V-155 cm/min



(b) 125A-17 V-60 cm/min

(1) J-STAR (EN, Si-Mn-Ti-REM wire)



(c) 160A-18 V-60 cm/min

(2) Conventional (EN, Si-Mn wire)

Fig. 2 Welding bead appearance and cross-sectional macroscopic organization

high current (250 A or more) is required to obtain this effect. Figure 2 (a) shows the weld appearance and cross-sectional macrostructure of a T fillet welded joint with a plate thickness of 20 mm. In spite of favorable performance features (a smooth weld bead shape with no spatter adherence) during high-speed welding at 155 cm/min, the penetration exceeds 80% of the thickness and there appears to be a risk of burning with thicknesses of 1.6 mm or less. Arc stabilization in a lower current region is required for the stable welding of steel sheets of lower thicknesses.

3.1 Spatter Reduction by Waveform Control of the Welding Current

Figure 3 shows the waveform control of current in

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Figure 4 shows variations in the waveform of current and voltage and the short-circuit transfer cycle. In conventional EP welding, no great difference is observed in the variations in the short-circuit transfer cycle ascribable to the difference in welding wire composition. In EN welding, however, the use of a wire with a trace amount of added REM reduced the variations in the short-circuit transfer cycle twofold and the application of optimum waveform control reduced the variations six-fold.

Figure

5 shows the relationship between welding current and the amount of generated spatter. The

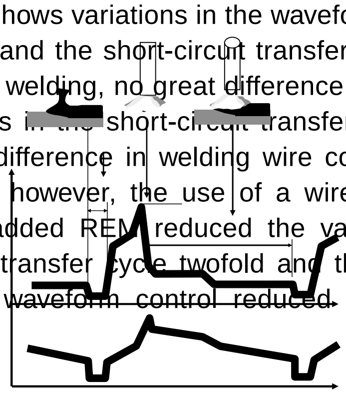

Fig. 3 Waveform control of welding current