KAWASAKI STEEL TECHNICAL REPORT
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MAGLAY Process >+ Electro-Magnetic Controlled Overlay Welding Process with ESW

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Synopsis :
Surfacing with electro-slag welding process is found superior to that with submerged arc welding process in view of the smaller dilution of base metal and stable welding phenomena even with such a wide electrode as 150 mm. The formation of under-cutting is found to be in close relations to the flow of molten slag and metal which is driven by the electro-magnetic force induced by the welding current. To counteract this force, two solenoids are equipped adjacent to the edges of the electrode. The Lorentz force based on the interaction between welding current and the electromagnetic field forces molten slag and metal to flow toward the sidelelmKe]TJ20.9327 0 TD0012Tc.0417Tw[sl9( )f)5.7(meld)3( )p3(oo

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MAGLAY Process—Electro-Magnetic Controlled Overlay Welding Process with ESW*

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2 ESW Overlay Process

Fig. 2. When the quantity of flourides is less than 40% it is arc conduction; if it is over 50% it is slag

use of Joule's heating of a fused slag bath formed just after the electrode. It is necessary to make a stable

range subject to welding condition. Consequently, additions of fluorides in excess of 50% will be sufficient

$$F = iB = i\mu_0 H \quad \cdots\cdots\cdots\cdots\cdots\cdots (1)$$

field intensity generated 15 mm below a 400-turn coil and the calculated values of Lorentz force generated

current of 2 A, and it is shown that this force can fully meet the fluid force of the fused slag and fused

jaw and can be controlled left or right independently.

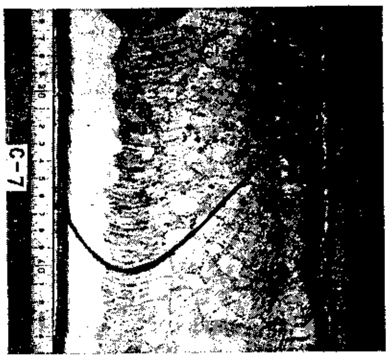
The cross section of a bead obtained is shown in

4 Control of Crater Shape by Means of the External Magnetic Field

Crater shape should be used as a criterion for

the edge on the side of molten pool was generated, and undercutting can be prevented. Furthermore, as current is increased to 3 A to 5 A, a space between the bulge in the back edge of the crater and concavity

Left



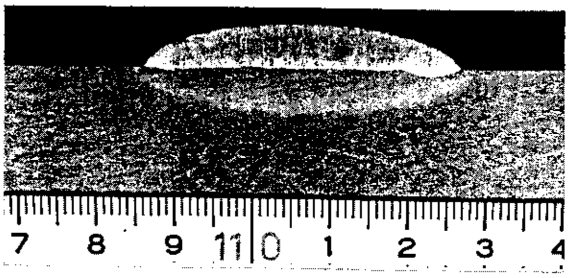
Right

Coil current
Left: 3 A
Right: 0 A

5 Changes in Dilution Ratio and Bead Shape Due to Electrode Width

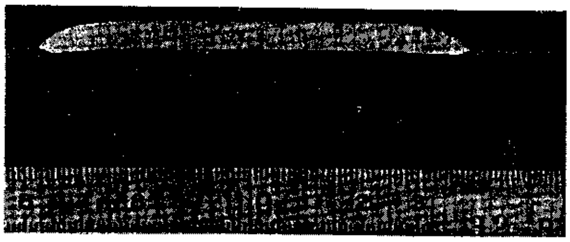
The dilution ratio with constant current density, voltage, and welding speed is presented in **Fig. 9**. Since penetration of bead toe is large in this welding process, the narrower the electrode width the larger the dilution ratio. However, because the dilution ratio varies greatly with welding condition as explained later, it is possible to get a fixed dilution ratio regardless of electrode width so long as proper welding condition is chosen. As shown in **Photo. 6**, cross

Electrode width 37.5 mm



Without magnetic control

75 mm



With magnetic control

Table 3 Comparison of cleanliness between ESW and SAW overlay deposit metal

$$\delta_1 = 3.2\mathrm{Cr_{eq}} - 2.5\mathrm{Ni_{eq}} - 24.7$$
$$= 3.2(\mathrm{Cr_{depo}} + \mathrm{Mo_{depo}} + 1.5\mathrm{Si_{depo}} + 0.5\mathrm{Nb_{depo}}) - 2.5(\mathrm{Ni} \ldots$$

An example of experiments using SA 533 steel is shown in **Fig. 12**. At the normal dilution ratio of 8 to 12%, the calculated values are in agreement with measured values by a ferrite scope.

Fig. 13 presents the result of investigating the relationship between ferrite quantities in electrodes and ferrite quantities in deposited metals. Except for the case of an extremely large ferrite quantity in the electrode, calculated values are in agreement with

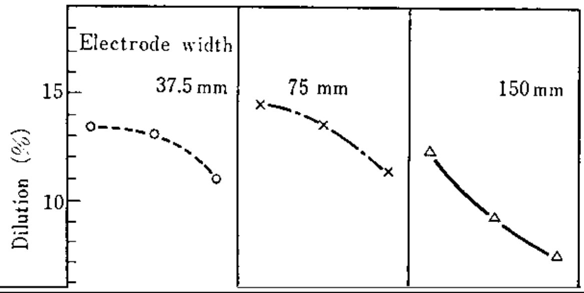


Table 4 Base metal used in chemical and mechanical test of MAGLAY deposit metal

SA 533 B Cl.1	163	0.18	0.21	1.41	0.006	0.002	0.68	0.09	0.49	0.009

Table 5 Electrode used in chemical and mechanical test

Specification	Size (mm)	Chemical analysis (%)								
		C	Si	Mn	P	S	Ni	Cr	N	δ

Table 6 Welding condition

Current	DCRP 2 500 A	Extension	35 mm
Voltage	28 V	Height of flux	15 mm
Speed	15 cm/min	Post heat	100℃, 10h
Pre-heat	95～200℃		

Table 7 Test results

Item	Result	Specification
Chemical composition of deposit metal (%)	C 0.032, Si 0.33, Mn 1.39, P 0.022, S 0.002, Ni 10.07, Cr 18.73	JIS Z 3221 C ≦0.04, Si ≦0.9, Mn ≦2.5, P ≦0.04, S ≦0.03, Ni 9～12, Cr 18～21
Ferrite content	As weld : 9.0～10.2 [illegible]	≥ 5 after SR [illegible]

Bend angle El.

10 Conclusion