strength steels, and nextly some mechanical and metallurgical characteristics of the deep-penetrated weld metal were made clear in this investigation. Moreover some problems of the EB-welding procedure in practical use were investigated by using 25 mm thick plate of SM50A. The remarkable conclusions are as follows;

(1) The weld defects occurred in the thicker materials were divided into two main classes, that is, the vertical crack-like center and bottom defects in the stand point of the occurred location in the deep-penetrated weld metals. The former often occurred nearly in a_b; 1.0, and the latter occurred in $a_b > 1.3$ or < 0.5. Besides the crack-like center defect sometimes switched over to the cavern-like defect in case of the weld bead in a large weld heat input.

(2) It was found that the sound weld metal without defect, the penetration depth of which is 75～77 mm, was obtained nearly for a_b; 0.7 in case of 27KW beam power. The regions for the sound weld metal obtained tended to be expanded with a decrease of the beam power.

(3) There is no obvious variation in the oxygen and nitrogen contents between the base and weld metals, or between the face and bottom parts of deep-penetrated weld metal. Furthermore the Mn content in weld metal is decreased 10 % less than that in base metal according to the EPMA-analysis. The degree of the decrease tends to be decreased with an increase of the penetration depth for the analized location.

(4) The impact strength of the deep-penetrated weld metal tends to be lowered in general with an increase of weld heat input, and the strength of the bottom part in the penetration showed higher value than that of the face part. Moreover the impact strength of EB-weld metal had a tendency to be increased with an increase of the hardness of it in general.

(5) It was comfirmed to be possible to enlarge the allowable limit for groove opening and to improve the impact characteristics for EB-weld metal by using the cut wire as an insert material. Furthermore the allowable limits for groove condition in L joint were respectively clarified against the three levels of welding condition, the bead shape of which makes the wedge, well and wine-cup types.

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Effect of Duplex Addition of Ti and N on Grain Refinement in Weld Heat Affected Zone of Steels

by Shizuo Mukae, Mitsuaki Katoh anh Kazumasa Nishio

Suppressive effects of Ti and N to the austenite grain growth in weld heat affected zone of steels were investigated from a standpoint of the time exponent, n and the activation energy for boundary migration, Q in isothermal grain growth test. The results obtained are as follows. 1) Austenite grain growth of steels added together both Ti and N can be expressed by Beck's equation. 2) Value of n is remarkably influenced by the quantity of a insoluble Ti (or N) and independent of a soluble Ti (or N). 3) Value of Q is increased considerably in duplex addition compared with separate addition of Ti and N. In this case an extent of the effect of a soluble Ti (or N) to Q is a greater than a insoluble Ti (or N). 4) Grain size of austenite isothermaly heated can be estimated using coefficient of austenite grain growth which is decided by quantity of Ti and N added in steels.

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A Study on Occurrence and Prevention of Defects of Electron Beam Welding (Report 5)

—A Study on Horizontal Position Electron Beam Welding of Heavy Section Steel Plates—

by Tomohiko Shida, Hisanori Okamura, Hisanao Kita anh Yoji Akutsu

Horizontal position electron beam welding of heavy section 0.17C-steel, $2\frac{1}{4}$Cr-1 Mo low alloy steel and 18 Cr-8 Ni steel plates up to 100 mm in thickness was investigated using a 42 kW (60 kV) high vacuum type welding machine.

Penetration characteristics and occurrence and prevention of welding defects were discussed comparing horizontal position welding with flat position welding.

It was concluded that,

I. Partial penetration

(1) Penetration depths in horizontal position were 15 to 20 % deeper than in flat position.

(2) Voids occurred, when the penetration depth in horizontal position exceeded 50 mm and no oscillation was applied to the beam.

(3) Effects of focus position on tendency of occurrence of welding defects and bead shapes in horizontal position were smaller than in flat position.

(4) Lack of molten metal seemed to cause voids in horizontal position welding.

II. Full penetration

(1) Occurrence of voids in horizontal position was influenced by value and fluctuation of penetration current, and oscillation conditions of the beam.

(2) Beam oscillation (X direction, 100 Hz) was effective to prevent void formation in full and partial penetration welding.

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