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Effect of Beam Oscillation on Electron Beam Melting†

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KEY WORDS : (Beam Oscillation) (Electron Beam) (Melting)

As superior properties of the electron beam heat source, it is well known that the scanning path of beam can be controlled at high speed and in high accuracy by use of electromagnetic deflection coil, and this has become an effective means of material surface treatment.

In this report, the authors tried to check the effect of beam oscillation on the depth of melting and melted surface conditions by using a prototype of beam oscillation pattern input system.

For irradiation of beam, an electron beam welding apparatus with 30 kW power was used. **Figure 1** shows a schematic diagram of the test system in which a beam oscillation pattern is to be put in the computer at discretion and location of beam irradiated on the surface of specimen is moved at vairous set speeds by magnetic field of deflecting coil. As specimen, aluminium alloy having low melting point was used, which size was ϕ 30 mm x 30 mm, and oscillation pattern is as shown in **Fig. 2.** Beam oscillation parameters are radial wave pattern, radial scanning frequency f_R and rotational frequency f_D. Radial beam moving speed is controlled by changing radial wave pattern and frequency f_R. In this report, rotational frequency f_D was fixed at 0.1 Hz.

Radial beam moving speed was changed continuously in radial movement of beam with such three type wave patterns as shown in **Fig. 3** to thereby change density distribution of energy applied on the specimen to check melting profiles. Beam irradiation conditions were as follows: acceleration voltage $V_b = 70kV$, beam current $I_b = 20mA$, $a_b = 1.0$, radial frequency $f_R = 10Hz$, rotational frequency $f_D = 0.1Hz$, beam rotation was one cycle. The specimen was cut off at 180° from the point where beam was started to view the melting profiles on that section. As shown in Fig. 3, Wave Pattern 1 in which radial beam moving speed was constant has uniform melting profile, but Wave Pattern 2 in which beam resided for a time when it moved to two-thirds from the center of specimen shows deeper melting at such location. While, Wave Pattern 3 in which beam moving speed was decreased as beam moved to the periphery shows that melting becomes deeper at such outer areas. Thus, beam moving speed corresponds well to the profile of melting, and so it may be possible to control the melting depth freely by

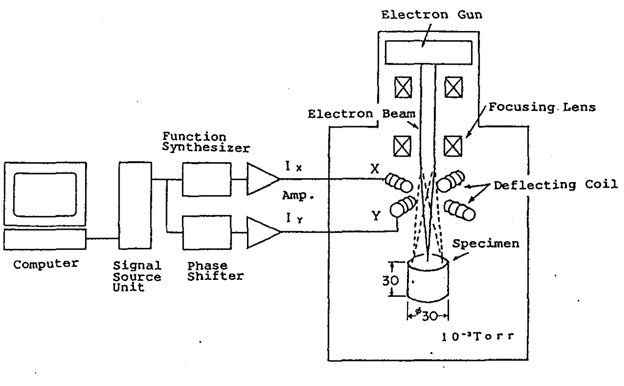

Fig. 1 Schematic Diagram of Test System.

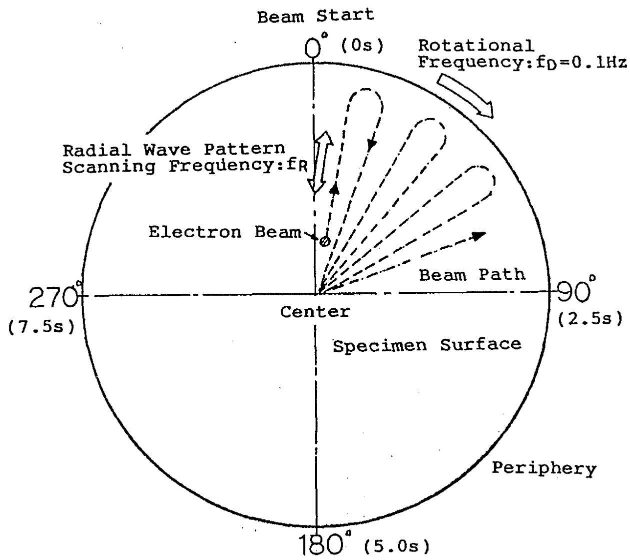

Fig. 2 Beam Oscillation Pattern on the Surface of Specimen.

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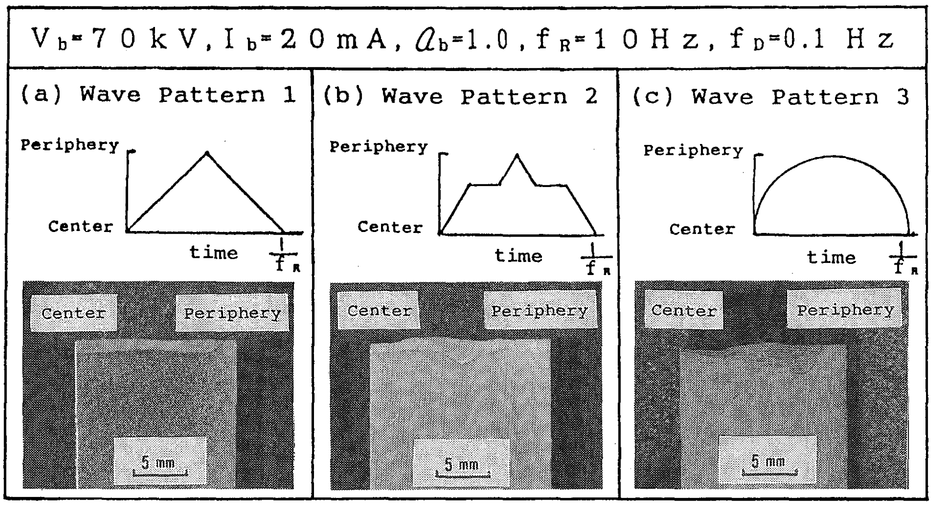

(a) Wave Pattern 1 (b) Wave Pattern 2 (c) Wave Pattern 3

Fig. 3 Relation between Radial Wave Pattern and Melting Profile.

inputting proper wave pattern.

On Wave Pattern 1, which had uniform melting profile, radial frequency f_R changed to 5 Hz, 10 Hz, and 20 Hz, when melting surfaces were observed. When frequency f_R was 5 Hz and 10 Hz, the melting surface was substantially flat and smooth, but when it was 20 Hz, the melting surface became disturbed significantly.

On Wave Pattern 1, the beam current was changed at frequency $f_R=10$ Hz to determine the melting depth. As shown in **Fig. 4**, the melting depth was almost unchanged with angles at beam current $I_b=30$ mA and less, while the depth became greater as the angle was increased at 40 mA and over. This is considered because the preheat effect by heat transfer becomes noticeable as the beam current is increased and, as a result, the meltig depth brocomes greater.

The oscillation pattern input system constructed as prototype for testing was found to be able to control the melting depth and melting surface conditions with adequate input oscillation pattern.

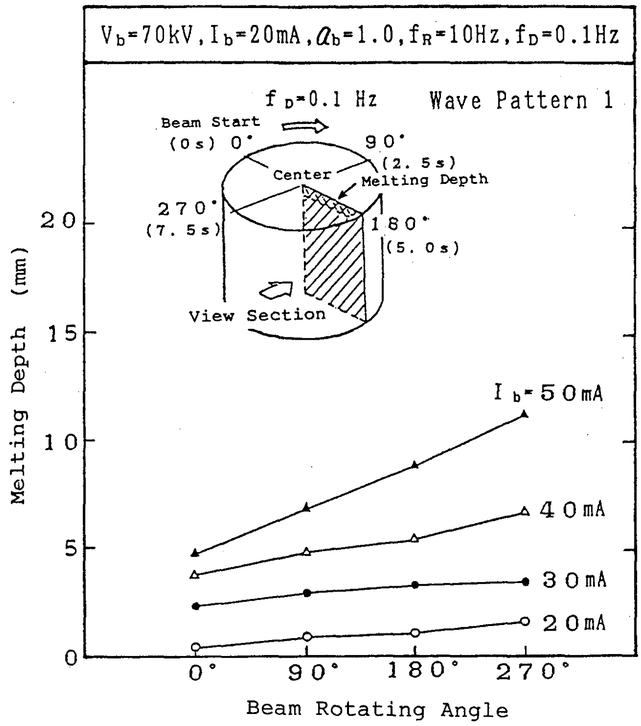

Fig. 4 Relation between Beam Rotating Angle and Melting Depth.