Formation of Ni Based Self-Fluxing Alloy Layers by Electron Beam with a Powder Feeder †

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In the previous reports[1,2], the formation of hard surfacing layers and the evaluation of their properties were reported using electron beam cladding method with a pre-placed mixed powder of WC-Co and Ni based self-fluxing alloy. WC-Co layers formed by the electron beam cladding method had a high hardness and wear resistance. However, the bonding strength between substrate and cladding layer was not uniform and the cladding area was limited. In this report, a powder feeder was developed for continuous feeding of powder and the formation characteristics and the broadening of formation area were investigated using self-fluxing alloy powder only.

Figure 1 shows an experimental setup using a powder feeder which can work in vacuum conditions and an electron beam for welding. The material used was Ni based self-fluxing alloy powder of -54+63μm in diameter. The substrate material was SS400 mild steel. The powder fed constantly by the powder feeder on the substrate, moving with constant speed of 5mm/s, was irradiated by an electron beam oscillating with constant amplitude at a focusing condition of a_b=1.0.

Figure 2 shows the photographs of layer cross sections by microscope at electron beam currents of 20, 25 and 30mA, and SEM photographs and EPMA results near the interface of the cladding layer and substrate. An uniform Ni based self-fluxing alloy layer was obtained at beam current of 25mA.. Porosity occurred at a beam current of 20mA, and the substrate material was mixed into the layer at beam current of 30mA. An Fe-Ni-Cr interlayer was observed between the cladding layer and substrate by SEM observation and EPMA. With increasing electron beam current, the

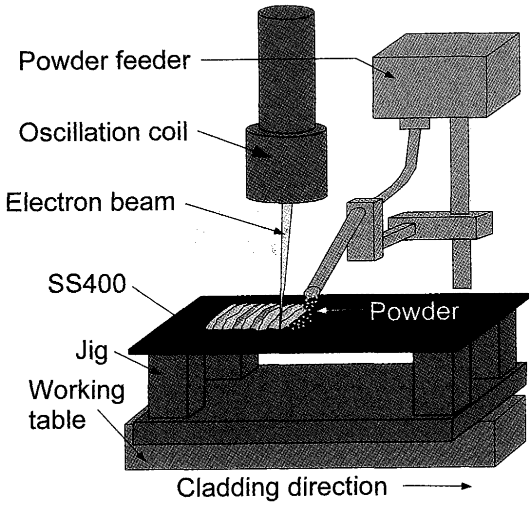

Fig. 1 Schematic drawing of experimental apparatus.

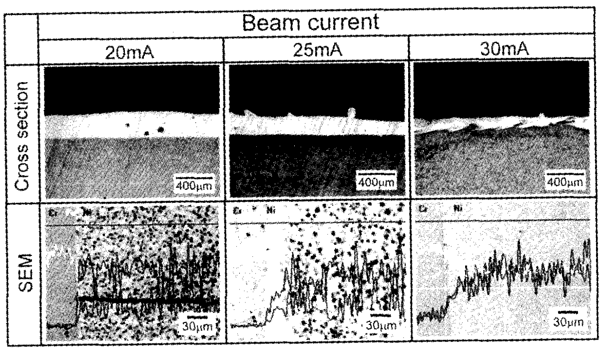

Fig. 2 Cross sections and SEM photographs of cladding layers. (Accelerating voltage: 40kV, Amplitude of beam oscillation: 15mm, Powder feed rate: 0.4g/s)

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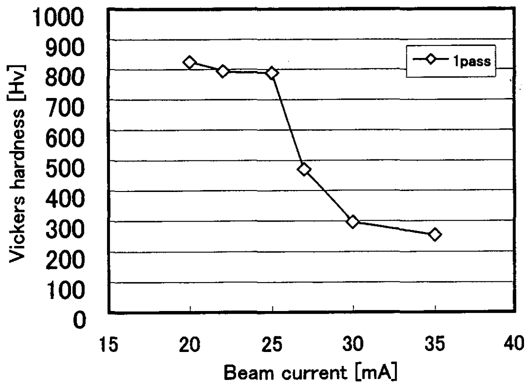

Fig. 3 Vickers hardness dependency on beam current. (Accelerating voltage: 40kV, Beam current: 25mA, Amplitude of beam oscillation: 15mm, Powder feed rate: 0.4g/s)

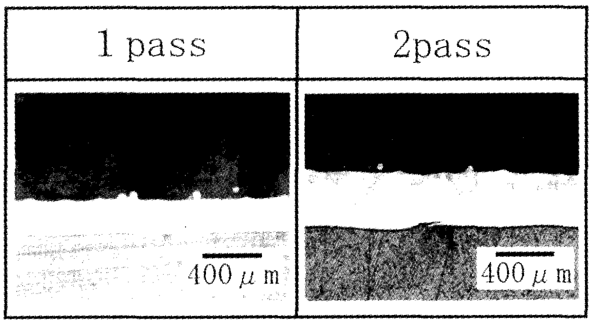

Fig. 4 Cross sections of multi-pass cladding layers. (Accelerating voltage: 40kV, Beam current: 25mA, Amplitude of beam oscillation: 15mm, Powder feed rate: 0.4g/s)

interlayer became thicker, and Fe was observed inside the layer at beam current of 30mA.

Figure 3 shows results of the Vickers hardness test. The layers formed at beam currents of 20-25mA showed a hardness of Hv800. The hardness suddenly decreased above beam currents of 25mA. This is thought to be because of the mixing of Fe to the cladding layer, which was also recognized by SEM observation and EPMA results. It is found that a proper electron beam current can form uniform cladding layers.

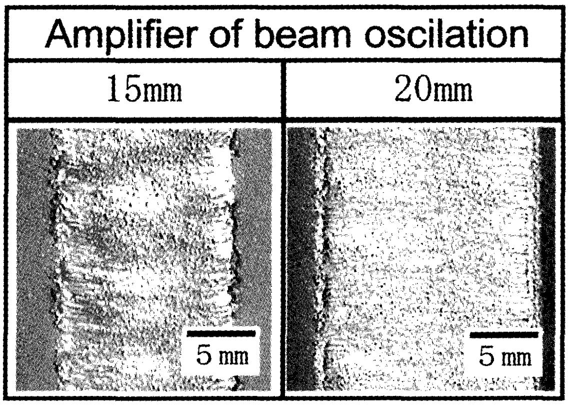

Fig. 5 Surface appearance of cladding layer. (a) Beam current: 25mA, (b) Beam current: 30mA (Accelerating voltage: 40kV, Amplitude of beam oscillation: 15mm, Powder feed rate: 0.4g/s)

Figure 4 shows a multiple layer formation under the optimum condition of an electron beam current of 25mA. The layer after double cladding achieved 1.5 times greater thickness and the border of these layers cannot recognized by visible observation.

In order to form wider cladding areas, beam currents of 30mA and amplitudes of 20mm were examined. The surface appearances are shown in **Fig.5**. It was also found that the increase of both beam current and amplitude resulted in a uniform and good cladding layer on wide cladding area, even though the thickness was somewhat reduced.

References

1) N. Abe, S. Baba, J. Morimoto and M. Tomie; Trans. of JWRI, Vol.26, No.2, 1997, p.95.
2) N. Abe, C. Doi, J. Morimoto and M. Tomie; Trans. of JWRI, Vol.27, No.1, 1998, p.111.