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Author(s)	Tomie, Michio; Abe, Nobuyuki
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Electron Beam Cladding of Cu Foil on Carbon Steel Plates†

Michio TOMIE* and Nobuyuki ABE*

Abstract

Cu thin foil of 0.2mm in thickness was successfully welded on carbon steel plates of 3mm in thickness. Cu surface layers of about 0.2mm in thickness were obtained under the conditions of I_b= 18-26mA and a_b value of 0.9-1.05.

KEY WORDS: (Electron Beam Cladding)(Cu)(Carbon Steel)

The authors have already reported electron beam cladding method using thin foil and high speed beam scanning system, and electron beam cladding of Ti foil on stainless steel plates was also reported[1]. In this note, electron beam cladding of Cu foil on carbon steel plates is reported with the dependences on electron beam irradiation parameters.

Cu thin foil of 0.2mm in thickness was selected for cladding materials. Base material was carbon steel of 3mm in thickness. Cu thin foil was fixed by a pressure jig of Cu square blocks on carbon steel plate and irradiated by electron beam of 800-1200 W over the area of 20 mm × 40 mm.

Figure 1 shows a typical example of Cu cladding surface and beam scanning pattern. Cladding conditions are as follows:

beam accelerating voltage: 40kV
beam current: 22mA
a_b value: 0.95
beam velocity of X direction: 160mm/sec
beam velocity of Y direction: 2mm/sec
beam overlap: 50%

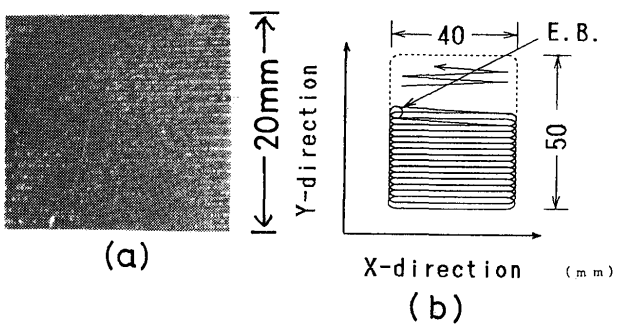

Fig. 1 Typical example of Cu cladding layer surface(a) and beam scanning pattern(b).

As shown in this photograph, good surface layer was obtained with surface roughness of around 50μm.

Macro photograph of crosssection and SEM photograph of boundary between Cu and carbon steel with EPMA results are shown in **Fig. 2**. The boundary between Cu layer and base material is rather flat and there is no apparent boundary layer. The boundary layer is also apparent in EPMA results shown in Fig. 2(b). This is thought that the electron beam penetrate just the thickness of Cu foil and melt only a little amount of base material. In fact, a large amount of Cu mixing into carbon steel was observed under the conditions of excess input power.

Figure 3(a) shows the beam current dependence on Cu layer thickness under the same a_b value and scanning conditions. Below 16mA of beam current, electron beam could not penetrate Cu foil of 0.2mm in thickness and no cladding layer was formed. On the other hand, over the electron beam current of 24mA, mixing of base material

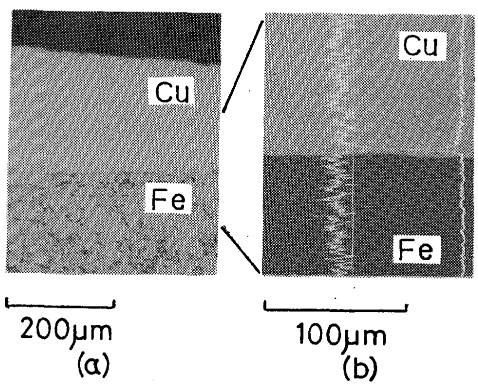

Fig. 2 Macro photographs(a), SEM photographs around boundary of Cu and carbon steel and EPMA results(b).

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* Associate Professor

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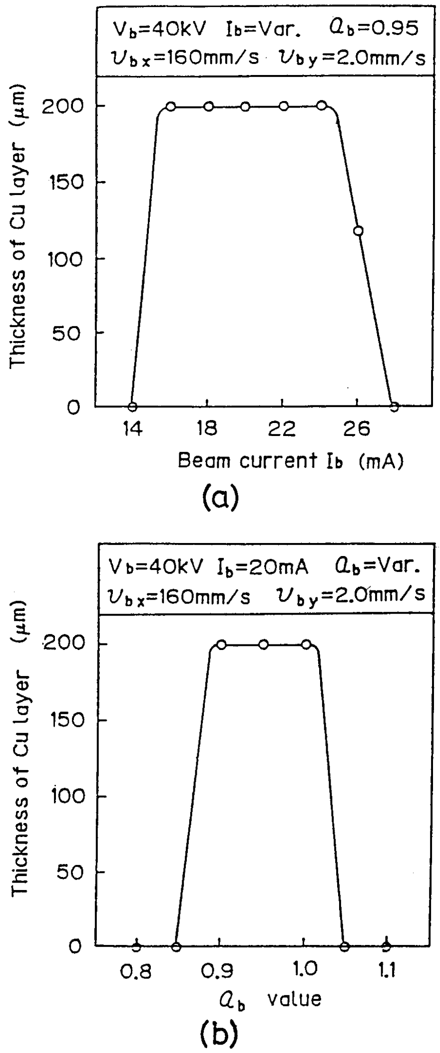

Fig. 3 Dependence of beam current and a_b value on the thickness of Cu layer. (a)beam current (b)a_b value

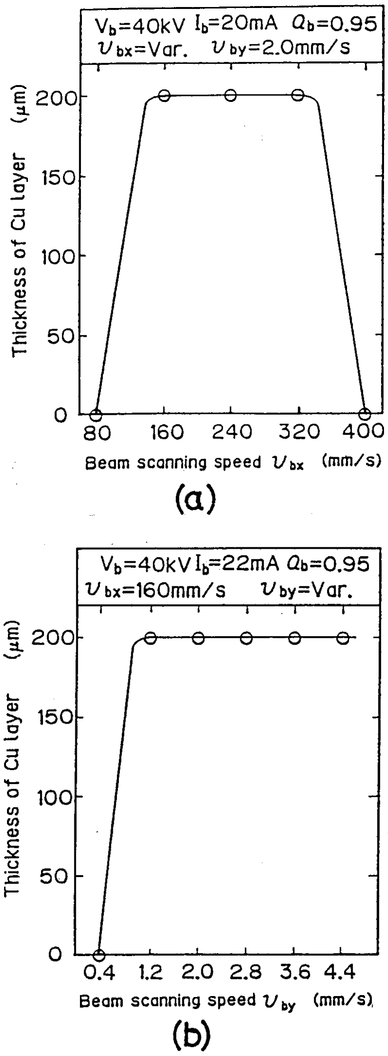

Fig. 4 Dependence of beam scanning speed on the thickness of Cu layer. (a)beam speed in X-direction (b)beam speed in Y-direction

occurred and the thickness of Cu layer steeply decreased. This is caused with the excess input power which melts not only Cu foil but also a large amount of base metal. a_b value dependence is shown in Fig. 3(b) under the constant beam current which brings good result in Fig 3(a). Cladding layers were obtained under the a_b value range of only 0.9-1.0. This means that energy density of the electron beam is one of the important factor for cladding.

Beam scanning conditions are also important factor obtaining good cladding layers. **Figure 4** shows beam scanning speed dependence on the thickness of Cu layer under the beam conditions of beam currents of 20-22mA and an a_b value of 0.95. It is found that the beam scanning speed in X direction is very important parameter on cladding. Below the beam speed of 160mm/sec Cu was mixed into carbon steel, and the beam did not penetrate over a beam speed of 320mm/sec. On the other hand, there is little importance on beam scanning speed in Y direction. It determines overlap ratio of beam irradiation zone and roughness of the surface. Cladding was possible in any speed over 1.2mm/sec so long as the overlap is not zero.

In conclusion, Cu foils were successfully cladded on carbon steel under the conditions of beam currents of 18-24mA, a_b values of 0.9-1.0 and scanning speeds of 160-320mm/sec. Welding mechanism in boundary layer between Cu and base material, cladding phenomena during beam irradiation and principal factor on electron beam cladding are now under investigation.

Reference

1) M. Tomie and N. Abe: Trans. of JWRI, 19(1990)1, 51-55.