Characteristics of WC-Co Layers Produced by the Electron Beam Cladding Method†

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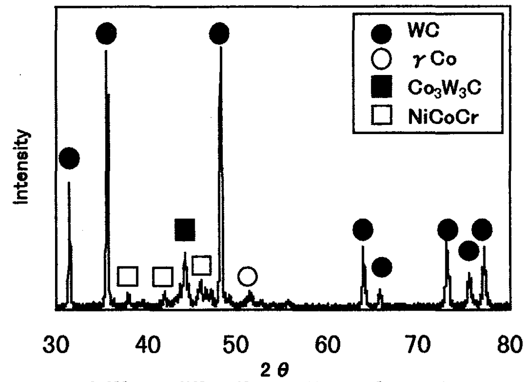
KEY WORDS: (Electron Beam Cladding)(WC-Co Layer)(Hardness)(Abrasive Wear)(Corrosion Resistance)

In the previous report[1)], electron beam cladding of WC-12%Co alloy powder by an electron beam welder was reported. WC-Co layers of over 800μm in thickness were formed on mild steel plates of 3mm in thickness. In this report, the characteristics of electron beam cladded layers were examined for abrasive wear and corrosion resistance.

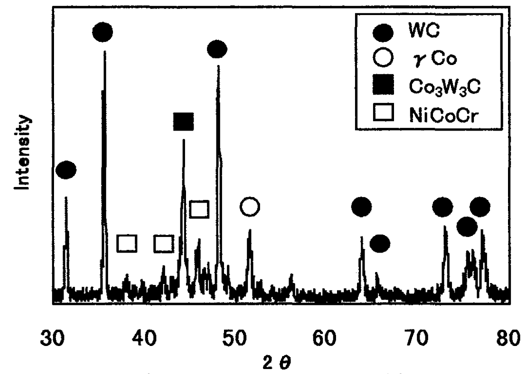
Test pieces after electron beam cladding were cut and molded in the resin of 25mm in diameter and 15mm in height. After polishing with an abrasive paper (#1500) and diamond paste of 0.3μm, they were examined by an optical microscope. They were also examined by X-ray diffraction and EPMA while Vickers hardness tests, abrasive wear tests and corrosion tests were carried out. Examination conditions were Cu-40kV-40mA for the X-ray diffraction, 20kV-0.05μm for EPMA and 300g load-15s for the Vickers hardness test. Abrasive wear tests were carried out for an abrasive surface area of $1.00cm^2$ at 660g load in 30min-100 rpm . The replacement interval of abrasive paper #120 was 10min. For the corrosion test, test pieces were soaked in $50\%H_2SO_4aq$ which was kept at 313K in a water bath after the cladded area of $1.00cm^2$ was masked with epoxy resin,. The weight loss was measured and corrosion rate was calculated.

Figure 1 shows the X-ray diffraction patterns of raw materials of the WC-Co/Ni-Cr SFA mixed powder and the WC-12%Co layer cladded by the electron beam cladding method. The decomposition of WC to WC_{1-x}, W_2C or W was suppressed and the composition of elements in the cladded layer did not changed from raw materials.

The result of corrosion test is shown in **Fig.2**. It was found that electron beam cladded layers showed little penetration porosities, because it had a very low corrosion rate of $5g/m^2/hr$ compared with that of $25g/m^2/hr$ for SUS304. The cladded layers of smaller particle size of raw materials showed higher corrosion resistance.



(a)X-ray diffraction pattern of powder.



(b)X-ray diffraction pattern of cladded layer.

Fig.1 Comparison of X-ray diffraction pattern.
(a) X-ray diffraction pattern of powder
(b) X-ray diffraction pattern of cladded layer
(Accelerating voltage=40kV, beam current=70mA, a_b =1.0, particle size=40μm, mixing rate of SFA=50% and thickness of powder layer=3mm)

Figure 3 shows the result of EPMA. It can be seen that WC-Co particles are homogeneously dispersed in SFA alloy in the cladded layer. The Fe-Ni-Cr diffusion zone can be seen between the mild steel and the cladded layer. It was thought that this interlayer played an important factor in the interface between base metal and cladded layer.

† Received on June 1,1998
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Transactions of JWRI is published by Joining and Welding Research Institute of Osaka University, Ibaraki, Osaka 567-0047, Japan.

Figure 4(a) shows the comparison of Vickers hardness between 50%WC-Co – 50%SFA mixture of 40μm particle size and mild steel. The Vickers hardness of 50%WC-Co – 50%SFA mixture was more than 1200Hv, while that of the mild steel was 150Hv. Furthermore, the Vickers hardness of 80%WC-Co – 20%SFA mixture became more than 1400Hv. High abrasive wear resistance of the cladded layer was shown by the abrasive wear test results in Fig.4(b).

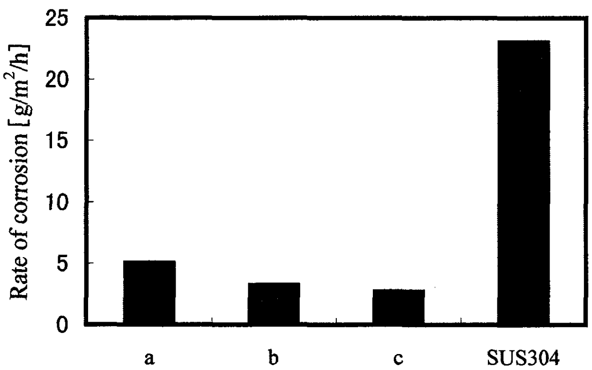


Fig.2 Result of corrosion test for electron beam cladded layers and SUS304.
Accelerating voltage=40kV
a: Beam current=110mA, a_b=0.7, particle size =40μm rate of WC-12%Co=50%
b: Beam current=70mA, a_b=1.00, particle size =40μm, rate of WC-12%Co=20%
c: Beam current=110mA, a_b=0.7, particle size =30μm, rate of WC-12%Co=50%

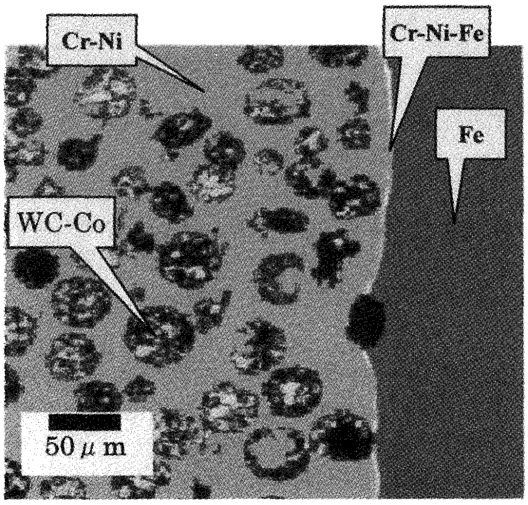
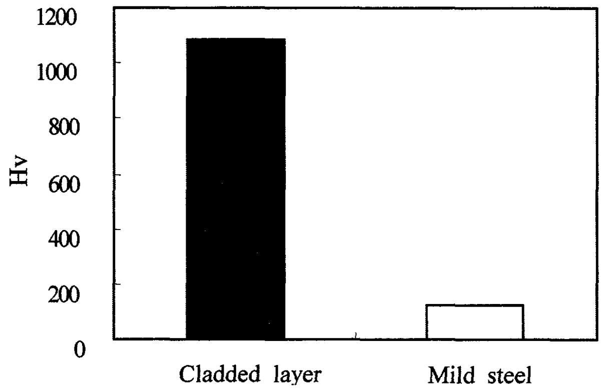


Fig.3 EPMA images of combination of Fe-Kα1, Ni-Kα1
(Accelerating voltage=40kV, particle size=40μm, ratio of SFA=50%, beam current=80mA, a_b= 0.95 and thickness of powder layer=3mm)

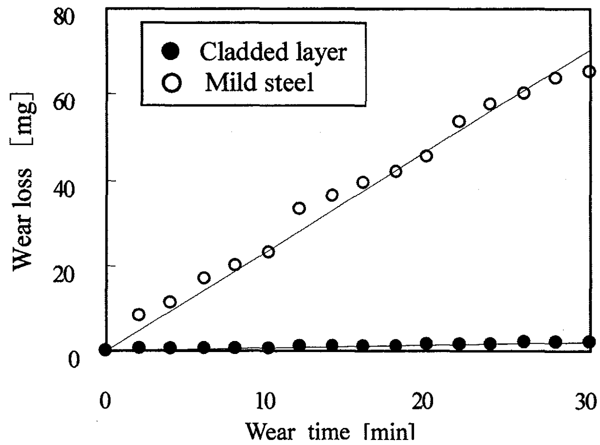
In conclusion, it was found that the electron beam cladding method can form WC-12%Co cladded layers without decomposition and possessing having sufficient corrosion resistance, abrasive wear resistance and Vickers hardness.

Reference

1)N.Abe, S.Baba, J.Morimoto and M.Tomie: Trans. JWRI, Vol.26(1997)No.2,pp.95-96



(a) Vickers hardness at 300g load.



(b) Abrasive wear test at polishing down to #240 smoothness, 670g load and 100r.p.m.

Fig.4 Results of Vickers hardness test(a) and abrasive wear test (b).
(Accelerating voltage=40kV, particle size=40 μ m, mixing rate of SFA=50%, beam current=70mA, thickness of powder layer=3mm, and ab=1.0).