TECHNICAL NOTE

Electron Beam Cladding of WC-12%Co Alloy Powder

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KEY WORDS: (Electron beam cladding)(Electron beam welder)(WC-12%Co alloy powder)(Ni-Cr SFA powder)

Tungsten carbide, WC, is well known as a wear resistant material. But it is difficult to form a cladded layer of WC by conventional techniques, because WC is oxidized easily in atmospheric environments and at high temperatures and easily decomposed W_2C or W. In this report, the formation of a WC coated layer of a few hundred μm on a surface of mild steel plate of 3mm thickness was carried out with WC-12%Co alloy powder and an electron beam.

An electron beam welder of maximum power of 30kW and accelerating voltage of 40kV was used as the heat source. The powders used for the cladding were WC-12%Co alloy powder with Nickel-Chromium Self-Fluxing Alloy (Ni-Cr SFA) powder, whose particle sizes were the same following the irradiation of both powders by the electron beam. They were mixed with various ratios of WC-12%Co from 80% to 50% and particle sizes from 25μm to 38μm.

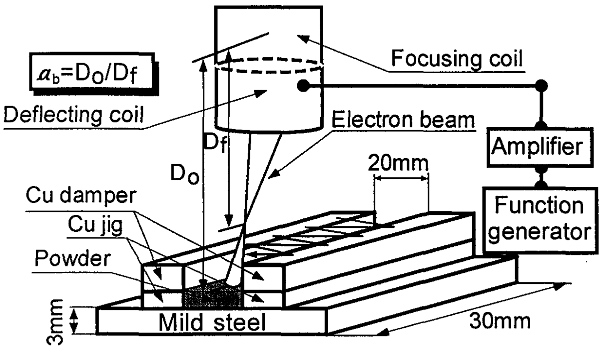

Fig.1 Schematic illustration of experimental setup and definition of a_b value.

The experimental apparatus is shown in Fig. 1. After a copper jig was set on the surface of mild steel of 3mm thickness, the powder was placed inside the jig in order to standardize the thickness of powder. A copper damper was set on the jig to prevent melting from excess heat input at the turning points of the scanning electron beam, and to prevent variations of cladding due to the change of overlapping ratio of electron beam. The electron beam was scanned on the specimen at a constant velocity of 50m/s by a deflecting coil and a function generator with a triangular wave and a sawtoothed wave. The experiments were carried out with various a_b values and various beam currents. The a_b value is a parameter to determine the focusing of electron beam defined as $a_b=D_o/D_f$. D_o is the distance from the center of the focusing coil to the irradiation spot and D_f is the distance from the center of the focusing coil to the focus of electron beam.

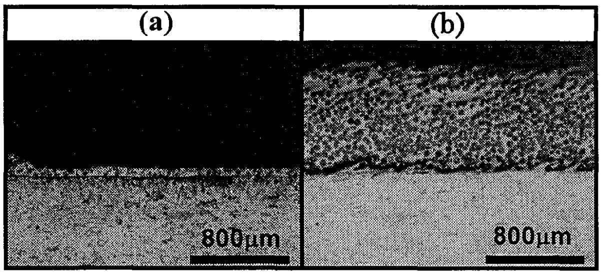

Fig.2 Cross sections of WC-12%Co/SFA cladded layers when the thickness of powder layer is (a) 1mm and (b) 3mm.
Accelerating voltage=40kV, particle size=40μm and ratio of WC-12%Co=50%.
(a) Beam current=30mA, a_b=1.25
(b) Beam current=80mA, a_b=0.95

† Received on December 8, 1997

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Transactions of JWRI is published by Joining and Welding Reseach Institute of Osaka University, Ibaraki, Osaka 567, Japan.

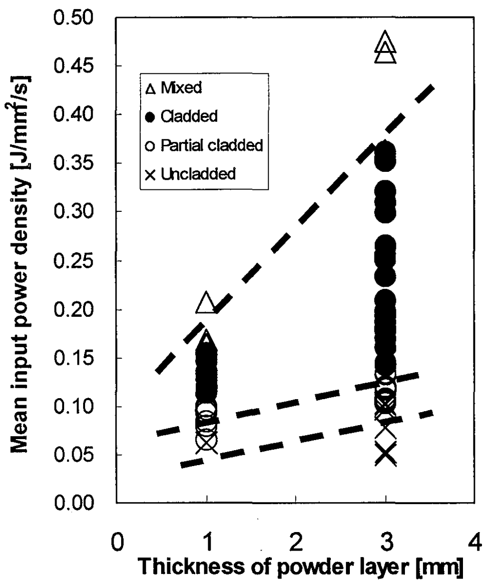

Fig.3 Effect of the thickness of powder layer on mean input power density.
Accelerating voltage=40kV, beam current=20~130mA, a_b=0.55~1.75, particle size=40μm and Ratio of WC-12%Co=50%.

The layer of WC-Co was homogeneously formed without the heat damage to the base metal of mild steel when the a_b values were properly controlled. The cladded area was 20mm × 30mm. The forming time was about 6 seconds. The cross sections of cladded layers of 1mm and 3mm thickness are shown in Fig.2 and reveal low dilution and freedom from cracking and porosity. The effect of the mean input power density versus thickness of powder layer on the appearance of cladded layer is shown in Fig.3. It was found that the range of mean input power density for cladding was wide and the range of mean input power density for a powder thickness of 3mm was wider than that for a 1mm thickness. Vickers hardness of the cladded layer was more than 1000Hv, while that of the mild steel was 150Hv. The wear loss of the cladded layer was smaller than that of mild steel.

The mixing ratio of WC-12%Co and Ni-Cr SFA was varied from 50% to 20% in order to increase the wear resistance. The effect of the mean input power density versus the ratio of WC-12%Co powder is shown in Fig.4. Vickers hardness of the ratio of WC-12%Co 20% was higher than 50% and was more than 1400Hv. It was found that a ratio of WC-12%Co of 80% required a higher power density and could be achieved higher hardness compared with that of the 50% mixture. The effect of the mean input power density versus the particle size of both powders, in order to increase the wear resistance, is shown in Fig.5. Vickers hardness of the particle size of powder 30μm was higher than 40μm and was more than 1200Hv. It was found that the particle size of powder of 30 μm required a lower power density and could be achieved higher hardness compared with that of 40μm. The conclusion was that the layer of WC-Co, which is difficult to coat by usual thermal spraying methods, could be clad with the electron beam at high speed and without any oxidation.

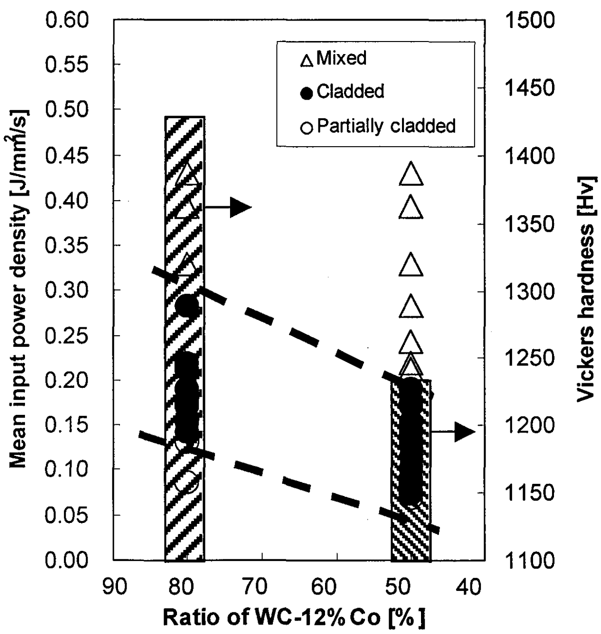

Fig.4 Effect of WC-12%Co ratios on mean input power density and result of Vickers hardness test.
Accelerating voltage=40kV,
beam current=110mA, a_b=0.55~1.75 and thickness of powder layer=3mm.

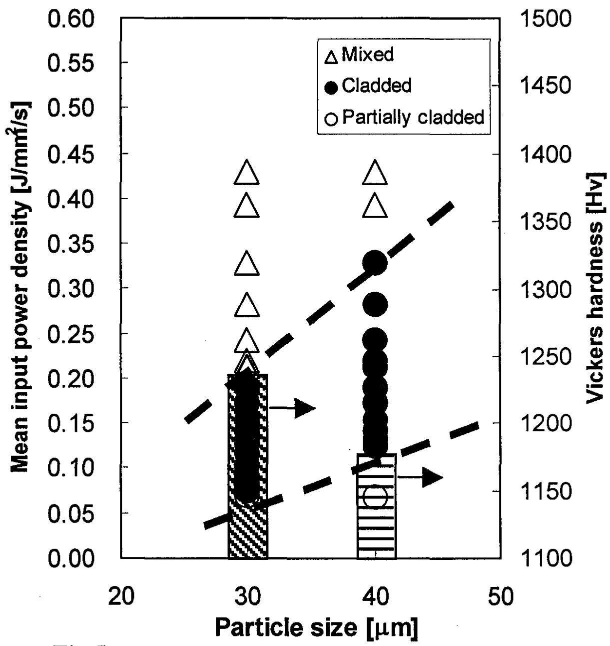

Fig.5 Effect of particle size on mean input power density and result of Vickers hardness test.
Accelerating voltage=40kV,
beam current=110mA, a_b=0.55~1.75 and thickness of powder layer=3mm.