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The influence of particle diameter on the powder melting process in diode laser cladding

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1. Introduction

The surfaces of many engineering components requires the quality of wear and corrosion resistance in order to extend the service life. Laser cladding is one of the surface modification methods to produce high quality, metallurgically bonded coatings on substrates with a minimal heat input into the substrate**.** Recently, weight reduction and energy consumption of engineering components is required because of resource depletion. One approach for meeting this demand is formation of thin cladding layer on thin substrate. Powder material with small particles are needed in order to form thin cladding layer. The effect of particle diameter on powder melting process is important in laser cladding. In this study, Ni-Cr-Si-B alloy coating was produced in order to investigate the effect of the particle diameter on powder melting process.

2. Experimental

Fig. 1 shows the schematic diagram of experimental system used in this experiment. This system consists of a 600 W direct diode laser, XY stage and high speed video camera. The beam spot size was 2600×300 μm^2 as shown in Fig.2. The laser beam was focused onto the powder material and scanned along the major axis of the laser spot. Ni-Cr-Si-B powder material was deposited on type 304 stainless steel plate with dimensions of 50×50×3 mm^3.

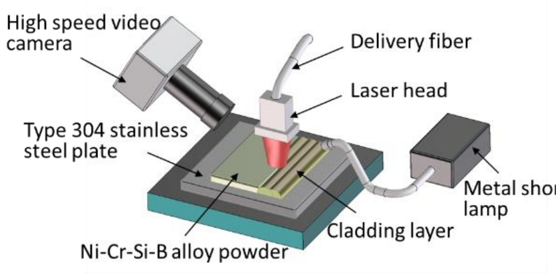

Fig. 1 Schematic diagram of experimental system.

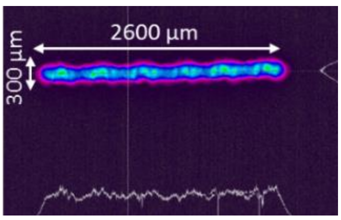

Fig. 2 Beam profile of the laser beam at the focal point.

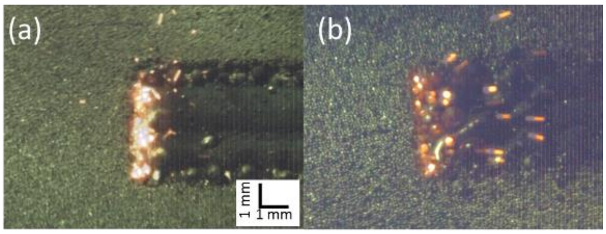

Fig. 3 High speed images of laser cladding process at the scanning velocity and power density of 33 mm/s and 6.4×10^4 W/cm^2. The average particle diameter of 30 μm (a) and 55 μm (b).

The experiments were performed at the scanning velocity and the power density of 33 mm/s and 6.4×10^4 W/cm^2. Powder material was placed on the substrate as the powder bed of 200 μm. The powder material with the different average particle diameter of 30 μm and 55 μm was used in this experiment. The laser cladding process was observed with high speed video camera at the frame rate of 1000 fps.

3. Results and discussion

Fig. 3(a) and (b) is the high speed images with average particle diameter of 30 and 55 μm at the scanning velocity and power density of 33 mm/s and 6.4×10^4 W/cm^2. Molten pool and smooth cladding layer was formed when the average particle diameter was 30 μm. However, the molten pool was not formed and the droplet was generated at the laser irradiated area when the average particle diameter was 55 μm. The laser beam has scanned before heating the interface between the molten metal and the substrate when the average particle diameter was 55 μm because the melting time of powder material is long compared with small particles. As a result, the droplet was formed because of poor wettability.

3. Conclusions

The influence of particle diameter on powder melting process was observed with high speed video camera. Molten pool and smooth cladding layer was formed with the small particles. However, the droplet was formed with large particles. This is thought that the temperature of the interface between the molten metal and the substrate was not enough high.