High speed welding of thin steel plates with high power and high power density diode laser system †

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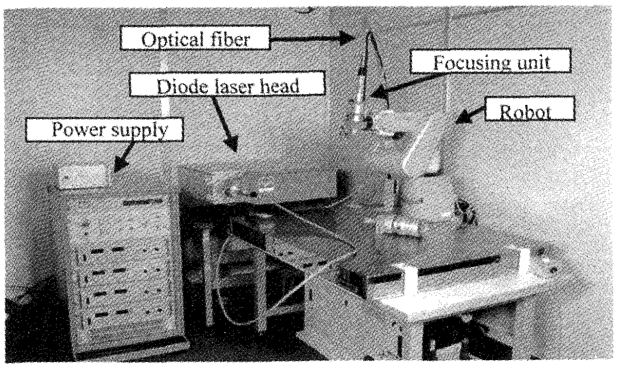
In the previous report, a 2kW class high power density direct diode laser materials processing system was developed and its processing characteristics were examined. Full penetration single pass welding was successfully achieved for a 5mm thick SUS304 stainless steel plate at a welding speed of 0.24m/min, with a parallel bead shape and no welding defects by the system[1]. In this report, high speed welding of thin steel plates from 1mm thickness to 5mm thickness is reported

Figure 1 shows a photograph of the 2kW diode laser materials processing system. Four 1kW diode stack modules (one pair with an 807nm wavelength and another pair with a 940nm wavelength) were combined using a wavelength and polarization coupling method. The beam delivered through the optical fiber was focused with a focusing unit installed on 5-axis robot. The size of the laser head is 520L×700W×220Hmm, and the weight is 90kg. The size of the power source equipment is 553L×600W×970Hmm. Compared with 2kW class CO_2 or Nd:YAG laser, this direct diode laser materials processing system is very compact.

Figure 2 shows the beam profiles at different energy and working distances. The minimum beam



Diode laser head
Wave length: 807 and 940nm
Size: 520 × 700 × 220mm
Weight: 90kg

Power supply unit
Output: 50V, 70A × 4
Size: 553 × 600 × 970mm
Weight: 160kg

Water cooling unit
Size: 560 × 730 × 1650mm
Weight: 100kg

Focusing unit
Focusing distance: 50, 60mm
Weight: 0.98, 2kg

Fig.1 2kW class diode laser system

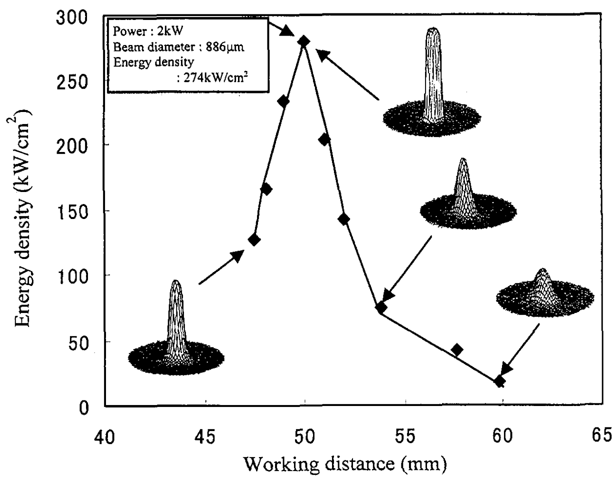


Fig.2 Beam focusing characteristic

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diameter was obtained at a objective distance of 50.1mm from the focusing lens. The beam profile at the focal point was top-hat shaped. The $1/e^2$ beam diameter was 886μm, and a mean power density of 274kW/cm^2 was achieved. However, the tendency was seen that with increasing distance from the focal point the energy density decreased significantly.

The processing characteristics of the high power density direct diode laser were evaluated for thin plate of SUS304 stainless steel and SS400 mild steel. **Figure 3 and 4** shows the relationship between the welding speed and penetration depth for bead on plate welding of thin plates with various thickness of SUS304 stainless steel and SS400 mild steel. For both steels a penetration depth of 0.85mm was obtained at a welding speed of 5m/min. The penetration depths of conventional CO_2 and Nd:YAG lasers also are shown in order to compare with these results. The penetration depth of 5kW CO_2 laser is 1.5 times deeper than 2kW diode laser. However, it is nearly equivalent to the penetration depth obtained by the diode laser when it is converted into 2kW since their beam diameters are nearly equal. An equivalent penetration depth to that of a 1.8kW Nd:YAG laser was also obtained. It was proven that a high power and high power density diode laser can achieve the equivalent welding characteristics compared with conventional CO_2 and Nd:YAG lasers.

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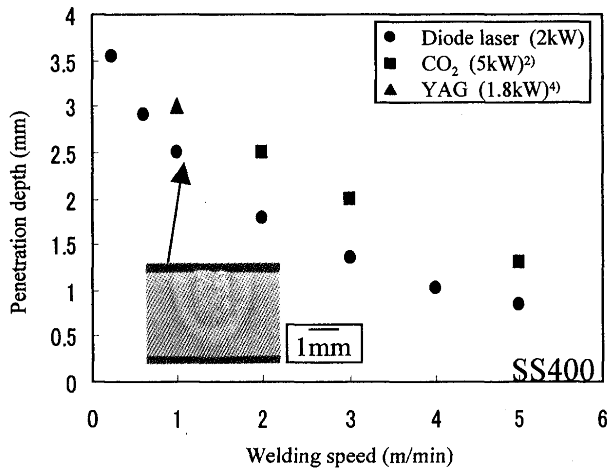

Fig.3 Penetration depth dependency of SUS304 stainless steel on welding speed

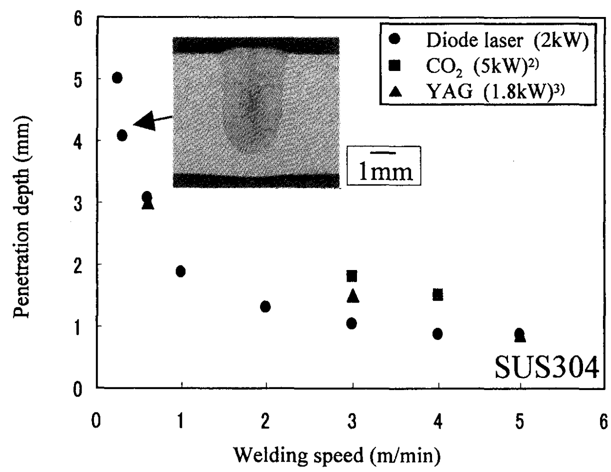

Fig.4 Penetration depth dependency for SS400 mild steel on welding speed