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Research status and development prospects of laser welding under vacuum

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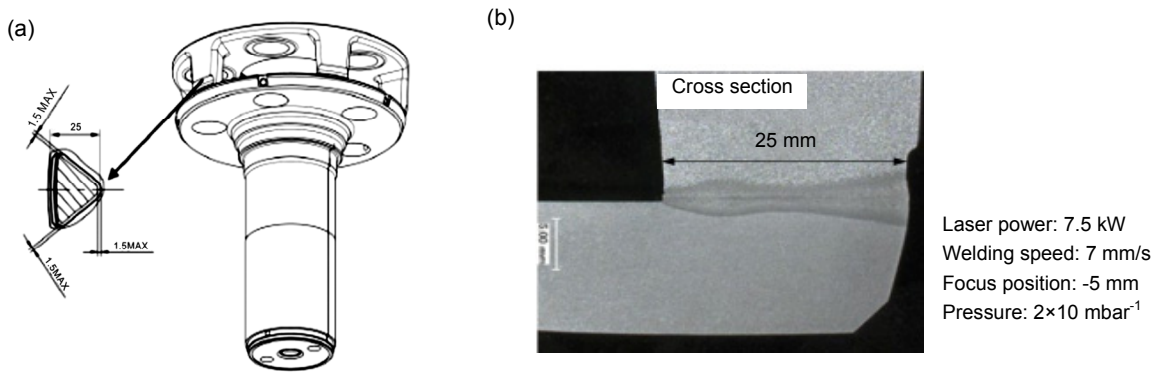

Laser welding of planet wheel carrier under vacuum. (a) Schematic diagram of welding position. (b) Cross-section of weld seam.

Abstract: Compared to electron beam welding, the penetration depth of high power laser welding is smaller due to the attenuation effect of the plasma plume on laser power deposition. To date, numerous researches on the suppression of laser plasma plume had been undertaken, such as pulse laser welding, weaving laser welding, change the shielding gas compositions, and apply the side-assistant gas and electromagnetic fields. However, the increase of the penetration depth and the improvement of the weld quality were inconspicuous. Compared with conventional laser welding, the welding formation and quality was improved significantly while the laser welding was conducted under vacuum. In this work, the influences of ambient pressure on the laser welding penetration depth, surface formation and porosity defect were summarized. The domestic and overseas research findings on mechanism of laser welding under vacuum were elaborated from the aspects of plasma plume, keyhole and molten pool behaviors. In addition, the applications of laser welding under vacuum in the industry were introduced. Finally, the problems of reported researches were analyzed and the prospects of the technology were discussed. The previous researches on the laser welding under vacuum indicated that the penetration depth of the weld seams increased sharply, the welding formation was improved and the porosity defects were suppressed effectively. Critical vacuum degree enough for improving the weld penetration depth and quality was detected for aluminum alloy, titanium alloy, nickel-base alloy and steel. The laser welding characteristics under vacuum was related to the plasma plume, keyhole and molten pool flow behaviors. The planet wheel carrier in the power station had been welded successfully by applying this technology. The laser welding under vacuum exhibits the wonderful application prospects to weld the thick plates in the shipbuilding, nuclear instrument and pressure vessel industries. In the future works, the authors suggest that the laser power deposition mechanism should be investigated systematically by considering the physical properties of the materials and the collision characteristics of the ions in the plasma plume. Besides, the heat and mass transfer characteristics, solidification behavior of the molten pool should be studied. In order to expand the application fields of laser welding under vacuum, the low vacuum and local subatmospheric pressure laser welding equipments should be developed towards higher adaptability and integration. Local subatmospheric pressure laser welding equipments with the excellent pressure maintaining property should be developed. Moreover, the feasibility of laser welding with filler and laser hybrid welding under vacuum is of vital interest for the development this technology.

Keywords: vacuum; laser welding; plasma plume; application prospects
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See page 945 for full paper.