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Effects of diode laser superposition on pulsed laser welding of aluminum

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Abstract

Pulsed laser welding of thin aluminum sheets is common for housing, where welding defects are detrimental especially in terms of hermetic packaging as well as electromagnetic compatibility. This paper shows investigations on laser welding of aluminum by superposition of a pulsed Nd:YAG laser with a diode laser in order to improve the weldability of aluminum. This configuration allows to enhance the absorption of the Nd:YAG welding laser due to preheating by the diode laser. Furthermore the effects of temporal pulse shaping have been studied experimentally. Deeper penetrations as well as an increased weld quality in terms of cracking were observed in welds manufactured with diode laser superposition. Besides this the modification of the thermal cycle by the combination of the two laser beams promotes advantageous solidification conditions and therefore hot cracks were efficiently reduced or avoided. Additionally solidification conditions can be actively influenced. The results show a decreasing number of defects and additionally an increase of the welding quality.

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Keywords: laser welding; aluminium alloy; diodelaser superposition; Nd:YAG laser; cracking

1. Introduction

Laser welding achieved in the last years to be one of the most applied metal joining methods, as it can provide high productivity, high weld quality, high welding speed, high weld aspect ratio, low heat input, low distortion, manufacturing flexibility and ease of automation. Because of the high welding speed, reduced heat

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affected zones can be achieved, which leads to low distortion compared to TIG or GMA. Pulsed laser welding is compared to cw-laser welding a further way in order to reduce heat input and is used for example for seal welding of aluminum housings for electrical applications or for titanium welding in medical application. Due to the high reflectivity of aluminum at wavelengths above 1000 nm high laser power when coupling is needed for laser welding, as a big part is lost by reflection. This causes an increase of energy and investment costs. For thin metals sheets pulsed laser sources have been established industrially, since the heat input is lower than continuous wave lasers. The low absorption of a Nd:YAG laser radiation causes difficulties to weld aluminium efficiently. A large part of the laser radiation is reflected at the surface. Figure 1 shows the absorption of aluminum as a function of the wavelength. Aluminum absorbs only 5% of the incident laser radiation from an Nd:YAG laser with a wavelength of 1064 nm. Therefore, a laser source with high peak power is necessary in order to obtain sufficient penetration depth and weld width. A disadvantage of pulsed lasers is the low welding speed. The welding speed when welding with a pulsed laser is limited by the required frequency and overlap of the welded “points”. The low travel speeds during pulsed laser welding and the formation of pores and cracks leads to defective components.

The temporal pulse shaping is a technique to reduce or eliminate defects in welds. It allows to modify the laser beam power during the pulse in a defined time. Thus, the laser power can be adjusted to the material. A conventional rectangular pulse shape leads to a high cooling rate in the material. Through a defined change in the pulse shape the temperature gradient in the melt pool can be controlled directly, so that the solidification process can adapted to the material behavior.

To overcome these disadvantages, the pulsed Nd:YAG laser can be superimposed with a continuous wave diode laser. The diode laser with the wavelength of 808 to 980 nm supports the welding process of the pulsed Nd:YAG laser. The absorption coefficient of aluminum shows a peak around 800 – 815 nm. In this area, the absorption of laser radiation is up to 3 times higher than that of Nd:YAG. During the diode laser supported welding process, the temperature on the surface of aluminum rises. Thus the absorption for the Nd:YAG laser increases. The phenomenon and mechanism of this welding process with the combination of both lasers are investigated and reported in this paper.

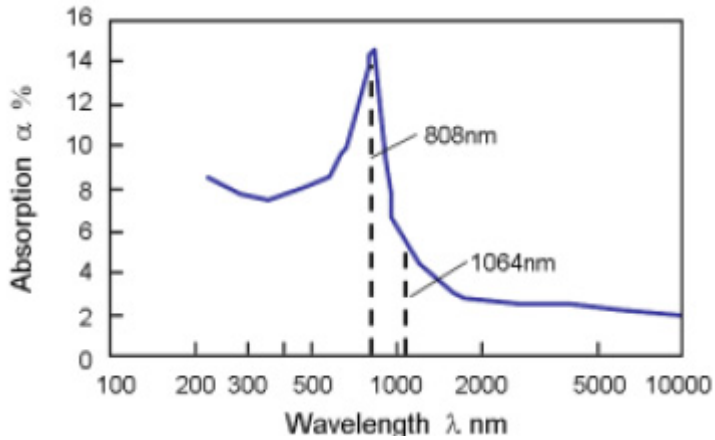

Fig. 1. Absorption rate of aluminum [8]

Weldability of thin aluminum sheets is strongly dependent on process conditions as well as on hot crack and pore formation. Pulsed laser welding with Nd:YAG lasers is an established welding process, with a further