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The Element and Thermal Profile in Laser welding process

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ABSTRACT

In this paper, the laser beam welding is studied and Aluminum temperature field is gained in this process. The thermal effect of laser beam that specially depends on the laser type and temperature field of it in workpiece, is the main key of analysis and optimization of this process, from which the main goal of this paper has been defined. Utilizing laser as a method to join plastic components is growing in popularity. There are two laser welding mechanisms, keyhole mode and conduction mode. Keyhole welding is widely used because it produces welds with high aspect ratios and narrow heat affected zones. However keyhole welding can be unstable, as the keyhole oscillates and closes intermittently. This intermittent closure causes porosity due to gas entrapment. Conduction welding, on the other hand, is more stable since vaporisation is minimal and hence there is no further absorption below the surface of the material. Conduction welds are usually produced using low-power focused laser beams. This results in shallow welds with a low aspect ratio. In this work, high-power CO2 and YAG lasers have been used to produce laser conduction welds on 2mm and 3mm gauge AA5083 respectively by means of defocused beams. Full penetration butt-welds of and 3mm gauge AA508 using this process have been produced. It has been observed that in this regime the penetration depth increases initially up to a maximum and then decreases with increasing spot size.

Introduction

Laser welding and arc welding methods have been used in many industries for a long time, and their application is being continuously developed. Laser welding has many attractive features: laser beams can be focused to a very small diameter, and can melt only very small portions of materials. For this reason, laser welding can be conducted without affecting nearby materials, thus, the heat-affected zone (HAZ) is usually very small. This makes laser welding suitable for the precise welding of small parts. Laser beam power and profile can be adjusted or modified easily to make keyholes, thus, deep penetration welding is possible.

Perhaps the most important aspect that has led to the growing use of lasers for welding is the ability to make spot welds. A laser beam focused down to a spot can heat, melt, and solidify metals in a matter of milli-seconds with minimal disturbance to adjoining volume of material and components. Consequently, laser spot welding is finding ever increasing applications in all segments of manufacturing including medical devices, sensors, batteries, and microwave enclosures. Along with growth in applications, there has been substantial improvement in laser power supply capabilities including closed-loop feedback and pulse shaping. As laser pulse welding is pushed to its limits in new and unique applications, it will be increasingly important to have good understating of the laser pulse and its effect on the parts being welded. This paper presents insights into the anatomy of a laser pulse and its effect on weld size, shape, residual stress, and defects.

This fields equations are solved together. Finally by writing codes with FSI (Fluid solid Interface) and SIMPLEC way, the process is optimized. For this simulation design parameter are introduced then condition function parameters are introduced as function of design parameters. And objective function that is the temperature field of Aluminium, for achieving to the optimized fields is derived. That has suitable condition like cooling rate, the control of expanding HAZ (Heat Affected Zone) and optimization of consumed energy, for doing the process[1].

Numerical simulation

Modeling special techniques for a finite elements

1-Finite elements modeling ,types and properties for model different parts.

2-The definition of material properties

3- Parameter definition

4- Loading

5- Boundary and initial value definition

6- Common interfaces definition

7- Control parameter definition

Semi-quantitative analysis

It has been observed that penetration depth increases with spot radius during low-speed laser welding in the conduction mode regime. The laser beam is defocused. Below is a 1D semi-quantitative analysis of the phenomenon. Experiments were carried out to establish the dimensions of the fusion zone in laser welding as the laser beam diameter incident on the sample was increased. The increase in the laser beam diameter was achieved by increasing the standoff distance between the lens and the work piece.

Location of Beam Focus

Most of the data reported here are obtained using a beam focus position at or above (~2.5mm) the workpiece surface. Martukanitz, et al. found that using beam defocusing produced better welds and avoided hole formation but beam irradiances were not measured precisely. Park et al. located beam focus below the surface and obtained good welds. We have observed that locating the beam focus inside the weld increased the welding efficiency in that substantially higher weld speeds (16.9 instead of 12.7 m/s) can be used to obtain the same penetration if

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the irradiance is controlled. The effect of high irradiance on weld quality will be discussed in the next section[2].

The tube seam line is slightly opened, and this gap plays a roll as a V-groove in butt welding joints, as in Fig. 6a. This V-groove enhances absorption of the laser beam by the mechanism of multiple reflections within it. To simulate this process in laboratory experiments, the jig makes two strips be positioned slightly inclined and brought into contact with each other, like conventional butt joints. The cross section of the designed jig is shown in Fig. 6b, which shows two strips inclined at an angle of 5°, and the laser beam is irradiated onto the V-groove joint. Therefore, the seam welding of small-diameter pipe can be successfully simulated by butt joint welding of thin stainless steel strips.

Welding concept for three-dimensional joining applications

A new concept was recently introduced to eliminate the technical limitations encountered in the use of clamping systems and to facilitate the use of laser for three dimensional joining. With this new process the contact pressure required for the joining process is constantly regulated to act dynamically, selectively, perpendicularly and precisely at the desired joining area.

The welding concept essentially works on the contour welding principle, whereby the laser spot follows a contour and the component is sequentially welded.

A laser spot is focused on the joining plane by means of an air bearing, frictionless, rotating glass sphere as shown in Fig.7. The glass sphere lens serves as a mechanical pressing tool applied perpendicularly at each point on the joining plane. This ensures that the laser beam is only incident at the site where the contact pressure is applied. This process concept offers the possibility of applying the necessary contact pressure concurrent with the laser beam being continuously moved along a welding contour. The air bearing glass sphere lens is fitted in a robust and compact processing head together with the optical fiber connector and other optical systems and process monitoring sensors[2].

Result and Discussions

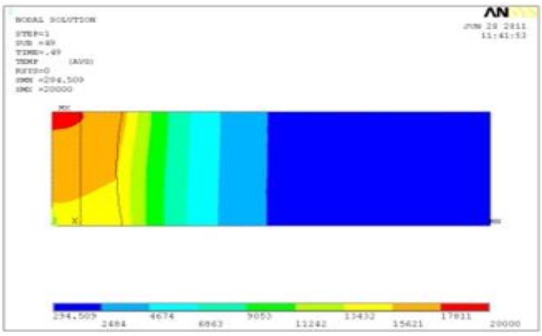
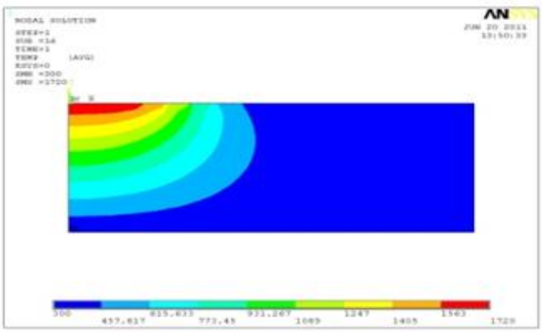


Fig 8. shows two-dimensional distributions of the temperature and flow velocity in 3case thickness



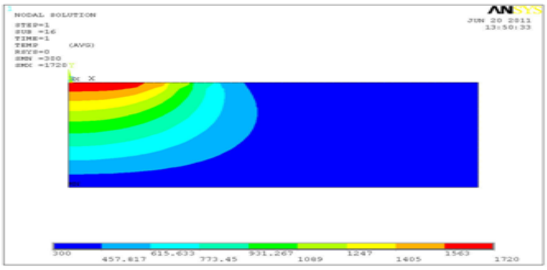


Fig 9. Two-dimensional distributions of Aluminium temperature field and flow velocity in (a) 4.2mm (b) 4.4mm (c) 4.6mm

Conduction welds were produced using high-power defocused laser beams on 2mm and 3mm gauge AA5083. Fig.9 shows micrographs of conduction welds made from 3mm gauge AA5083. The numbering is done in order of increasing spot radius. The expected hemispherical shape characteristic of conduction welds was obtained. The variation of the penetration depth with increasing spot radius or distance from the focus becomes apparent on close examination. In all cases it was found that the aspect ratios (penetration depth divided by weld width) of the welds were less than one. Penetration depth/spot radius curves plotted showed an increase (up to a maximum) and then a decrease of penetration depth with increase in spot radius in the conduction weld regime.

This can be attributed to the interplay between decreasing power density and increasing interaction time, as the spot radius becomes larger. It is suggested that the laser beam distribution and pre-heating due to the interaction of the outer fringes of the laser beam with the work piece also contribute to this phenomenon.

Fig.15. shows micrographs of laser keyhole and conduction welds. Fig.15.a. is a micrograph of a butt weld obtained using the YAG laser at a welding speed of 360mm/min and the work piece situated at distance of 20mm below the focus. This position produced the maximum penetration depth for the laser setup. It can be seen that the weld was a fully penetrating one. Fig.15ii is a laser keyhole weld produced by a CO2 laser at maximum power of 1750W with welding speed of 1600mm/min on 2mm AA5083. The groove on the weld surface constitutes a an area of weakness. Although the surface was wire-brushed and cleaned, a pore was clearly revealed.

Conclusion

According to result achieved from coupling field analysis and comparison of temperature field and heat transfer in laser beam welding with other process, it can be derived the laser welding have more arc length, concentration of higher energy, better a stability and more welding depth to width.(specially for Aluminum tube).

Laser welding is emerging as an important welding technique in plastics processing. The diverse fields of application always call for new techniques and innovative problem solving approaches.

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