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Improved Degassing In Laser Beam Welding Of Aluminum Die Casting By An Electromagnetic Field

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Abstract

An electromagnetic system was used to reduce the porosity in laser beam welding of aluminum die casting. The difference of electrical conductivities between gases and molten aluminum is used by an electromagnetic system to displace the included gases to the top during a laser beam welding process. It bases on generating Lorentz forces within the weld pool via an oscillating magnetic field. A partial penetration laser beam welding of standard die-cast aluminum alloy AC-AlSi9MnMg in flat position is used. An optimized laser beam process was taken to investigate the porosity content and the surface smoothing by applying an electromagnetic field. The produced weld seams were analyzed in cross section views, by x-ray imaging and by computer tomography (CT). Depending on the magnetic flux density, a significantly reduction of the porosity down to 75 % can be achieved. Especially big pores can be removed successfully. A surface smoothing of up to 75 % can also be reached by using this system.

Keywords: laser beam welding; die-cast aluminum; porosity reduction; electromagnetic influence

1. Introduction

Aluminum die casting is an ideal manufacturing process for lightweight components. Complex and load-optimized geometries can be produced with high dimensional accuracy. Hence, aluminum die casting is suitable for large series production of automotive and aircraft components. Apart from the possibility of using mechanical joining processes, the challenge of the present investigation is to create a joint by laser beam welding. In contrast to these techniques, laser beam welding is considered to be inappropriate for aluminum die casting due to the relaxation of dissolved gases. The die-cast manufacturing process leads to a gas absorption of the aluminum. Nitrogen, Oxygen will get into those pores, together with large quantities of hydrogen. Dissolved hydrogen as well as hydrogen bounded in hydrides are the greatest challenge in fusion welding of aluminum die-cast materials. The predominant sources of hydrogen in the manufacturing process are the organic piston lubricant, Pries et al. (2002), and the mold release agent, Wiesner et al. (2001). Currently, these phenomena can be handled by using inert-gas welding processes as MIG or TIG welding. The lower the welding velocity, the more the weld pool can degas, although there is a comparable high energy input. Friction stir welding is also a used method to join die-cast aluminum, but a complex clamping fixture is needed due to the high process forces, Ruhstorfer (2012).

Nevertheless it is desirable to apply the advantages of laser beam welding as low distortion and high productivity for joining of die-cast aluminum. Previous investigations show that laser beam welding is inadequate for aluminum die casting materials, Pries et al. (2002). If the laser beam hits a zone of higher hydrogen content, a high quantity of hydrogen is released suddenly. Due to the high solidification velocity and the abrupt decrease of the hydrogen solubility of aluminum with falling temperatures, the formation of pores occurs as the hydrogen cannot form back into hydrids again, Pries et al. (2002). A further problem is the sudden appearance of unwanted full penetrations which causes process instabilities or interruptions. Apart from metallurgical pores there is the issue of a keyhole-tip instability in partial penetration laser beam welding of aluminum alloys. If the solidification front overtakes these