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Weldability of aluminium alloys for automotive applications

D. Löveborn[a]*, J. K. Larsson[a], K-A. Persson[a]

[a]Swerea KIMAB AB,Box 7047, SE-164 07, Kista, Sweden

Abstract

Restrictions in CO_2-emissions have caused increased demands on decreased weight and increased use of lightweight materials in the automotive industry. Aluminium has shown to be of great interest due to its beneficial weight to strength ratio, and are suitable for hang-on parts such as roof, doors etc. However, the use of aluminium requires reliable joining techniques. This project has been focusing on laser welding of aluminium. It have been reported earlier that hot cracks and porosity are common defects while joining aluminium with laser welding. The aim with this project has been to produce crack free laser welds while joining thin aluminium sheets. Two different optics have been used in this project, oscillating- and triple-spot optics. The results from the experiments show that both the oscillating optics and the triple-spot optics can produce crack free welds. The amount of pores is shown to be low for both cases. The results do also show that the amount of pores in the welds increases with the weld length while the flange length is of minor impact. The mechanical properties are similar for the both optics. The oscillation specimens receive a higher tensile strength while the triple-spot specimens receive a larger elongation at break value.

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Keywords: Laser welding; Aluminium; Oscillation; Triple-spot; Trifocal; Hot cracks; Porosity

1. Introduction

In respect to limited resources of fossil fuels and global environmental concerns, it will be necessary to reduce the fuel consumption for passenger cars. There are different strategies to reach the prospected requirements for

* Corresponding author. Tel.: +46854527453,
E-mail address: david.loveborn@swerea.se

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maximum carbon dioxide emissions, and one obvious solution is to substitute the traditional combustion engine with electric battery technology or other alternative driveline concepts. But another "piece in the puzzle" to solve this challenge is spelled "light weight engineering", which for the car body will mean the introduction of other materials than the traditional zinc-coated steel sheets. Lately we have seen full aluminium bodies as well as complete fiber reinforced plastic solutions. The drawback of these concepts is that they are extremely expensive and will require big modifications of the industrial structure and the body shops. Neither are they suitable for high volume production as they require manufacturing techniques that are rather slow.

Therefore, today's body engineers work according to the principle "the right material at the right place", which will mean that different material types will be mixed in the body structure. A general evolution of steel/aluminium-mixing starts with the manufacture of all hang-on parts, such as doors, hoods, trunk lids and tailgates, in aluminium, while maintaining the body structure in steel. The next step is to introduce aluminium in less load sensitive areas in the body, such as floor pans and roof panels. And finally, also load carrying components are made out of aluminium. In these cases, sheet solutions are not dominating, but instead casting techniques and extrusions are used for the manufacture of e.g. suspension strut towers or floor sills, Figure 1.

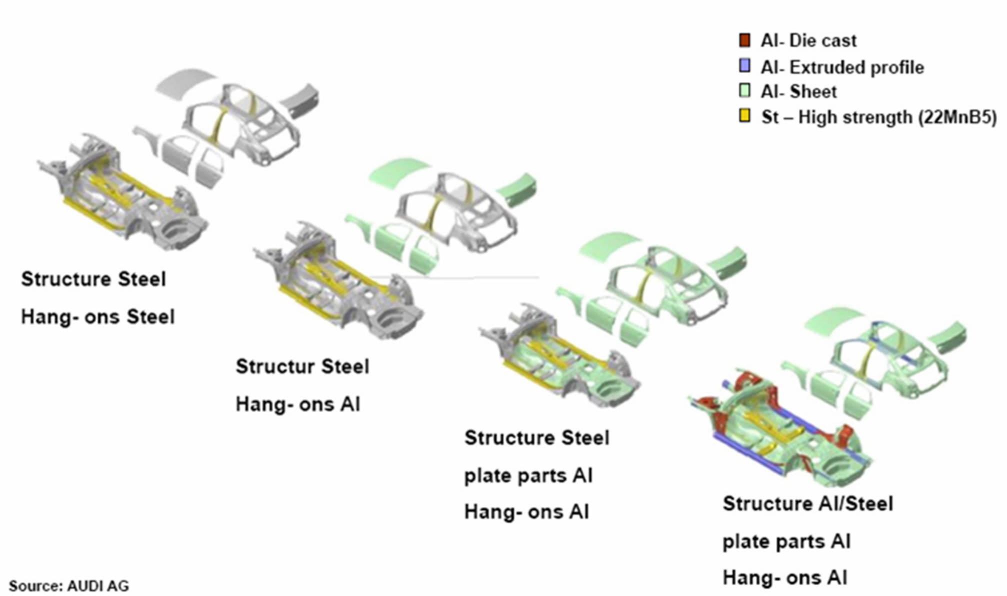

Figure 1. Light weight strategy as proposed by Audi AG.

As aluminium seems to be a natural candidate material to be used in order to reduce the weight of future car bodies, extensive investigations about suitable joining methods for this material have to be carried out. Laser welding, either performed tactile with the help of filler wire, or without additional elements using remote technology in combination with beam oscillation, is an interesting alternative as it is a proven technology in today's body assembly shops, presenting high through put and availability. However, extensive investigations of suitable alloy concepts and joint geometries are necessary to be able to meet the high requirements that apply in high volume automotive production. In the following, some recent results from aluminium welding using advanced optics and processes will be described.

Due to high thermal conductivity, high coefficient of thermal expansion and low solubility of hydrogen welding of aluminium has always been a challenge, regardless of method. In laser welding of aluminium an additional issue is the highly reflective surface, Fahlström and Janiak (2012). The properties listed above generate problems such as hot cracks, porosity and bad weld geometry.