

LASER MULTI-PASS NARROW GAP (MPNG) WELDING OF ALUMINUM ALLOYS OF UP TO 50 MM THICK SHEETS

THE TASK

Aluminum is economically the most important lightweight metal. The metal offers very high specific strength, very good corrosion resistance and excellent formability. Its properties make it suitable for an increasing application spectrum of highly loaded lightweight constructions. Aluminum is commercially available in the form of extruded profiles or cast semi-finished products. Ever more applications require aluminum welding.

The high thermal conductivity, heat capacity and large coefficient of thermal expansion of aluminum make it to a hard-to-weld material. With the availability of multi kilowatt lasers it became possible to extend the weldability of aluminum sheets up to 10 mm thickness. However, additional difficulties arise due to insufficient dilution of weld filler materials in the seam root, especially for deeper weld seams. This increases the risk of hot crack formation especially for heat treatable aluminum alloys (e.g. 6082).

The task for Fraunhofer IWS scientists was therefore to develop an industrial solution to laser beam weld thicker aluminum sheets (of up to 50 mm).

OUR SOLUTION

A new welding technology was developed. The so-called laser multi-pass narrow gap welding (MPNG) process works with affordable laser sources to produce deep welds with homogeneously distributed alloying elements.

Solid-state lasers are used with brilliant beam quality. The beam is very well focusable and thus reaches deep into narrow gaps with large aspect ratios. For typical gaps of 2 - 3 mm the beam reaches down to the bottom of the gap. A multi-pass welding process is applied with lower laser power to weld sheets of up to 50 mm thickness.

The homogenous dilution of alloying elements is achieved by oscillating the beam at high frequency perpendicular to the flanks.

The new solution overcomes three traditional limitations for thick sheet welding processes:

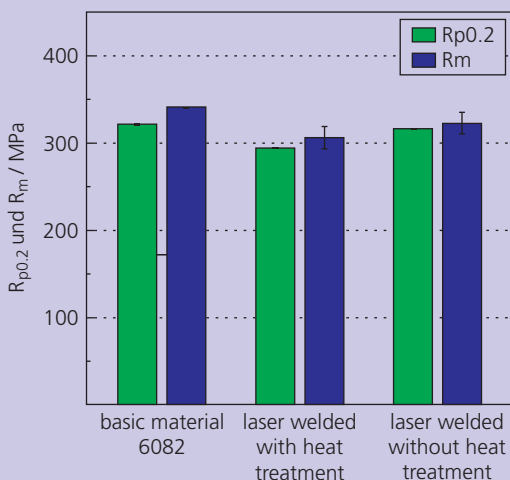
- absence of a technical solution,
- insufficient process safety due to hot crack formation and
- high investment.



RESULTS

The laser MPNG process was tested welding AlMgSi alloy sheets with thicknesses up to 50 mm. The resulting high quality welds were crack-free and nearly flaw-less. The process results were reproducible. The MPNG process ensures homogenous melting of the component flanks, guarantees high aspect ratios and thoroughly mixes the melt with the weld filler material AlSi12. The Si content is on average 7.5 % across the weld seam, which is prone to hot crack formation. The Si content is also sufficient at 3 % in the root of the weld seam.

Tensile strength comparison of MPNG welded test samples from heat treatable aluminum 6082



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This process requires only 2 - 4 kW laser power to weld 50 mm sheets. Therefore the heat impact on the workpieces is low and distortion is substantially reduced.

Of particular advantage is that the distortion does not increase for thicker sheets. In the studied case it was actually shown that the distortion was reduced (Fig. 3). The porosity corresponds to class B (DIN 13919-2). The weld seam therefore meets the highest performance level. There are also no cracks in the weld material.

The very good weld seam quality leads to high static performance numbers (Fig. 4). For welded and polished samples these correspond to 90 % performance of the basic material. Heat-treating the welded material increases the strength of approximately 94 % of the basic material.

- 1 Laser MPNG laser welding head (CAD drawing)
- 2 Prototype of a MPNG laser welding head
- 3 Cross section of weld seams
a) conventionally welded
b) laser MPNG welded

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