Better aluminium welding with fast laser mirrors

Silicon micromirrors are capable of guiding laser beams extremely quickly, making it possible to perfectly dose the heat applied to workpieces. But to date they have not been resilient enough for laser beam cutting and welding. Now a Fraunhofer team has succeeded in developing fast and durable mirrors, which are ready for demanding cutting and welding tasks, particularly for aluminium.

In vehicle and aircraft construction today a variety of materials such as aluminium or special high-strength steels are used to reduce weight, and thus also fuel consumption. However, these new materials or their combinations confront processors with new challenges. This is especially true when it comes to the cutting or welding of metals with the help of lasers. Up to now it has been necessary to invest a lot of effort into adapting the laser systems to suit the individual materials. Special optics are necessary in many cases, which are installed specifically for a certain process.

But now there are laser mirrors that allow more flexibility in laser processing. These were jointly developed by engineers at the Fraunhofer Institute for Silicon Technology ISIT in Itzehoe and the Fraunhofer Institute for Material and Beam Technology IWS in Dresden. At the heart of the flexible laser system are micromirrors, which are etched from silicon. These are referred to by experts as microelectromechanical systems (MEMS). These MEMS mirrors are tilting mirrors, whose task it is to deflect the laser beam and guide it precisely over the workpiece. To date it has only been possible to use these small mirrors with laser outputs of merely a few milliwatts. This was adequate for use in head-up displays on car windshields, but not for laser beam cutting and welding. Higher outputs would have melted the mirrors. But thanks to a new protective coating, developed in the project collaboration as well as a special mounting, now the mirrors can even withstand output levels in the kilowatt range – enough to process aluminium.

The advantage of the fine MEMS mirror is that it can be swivelled extremely quickly, achieving frequencies of up to 100,000 Hertz. This makes it possible to distribute the laser energy much better than conventional laser systems, whose mirrors swivel at roughly only 1000 Hertz. At their focal point lasers have a certain energy profile and always input the same amount of energy. If the mirror swivels slowly, the energy is not distributed and dosed as effectively on the weld seam.

“On the other hand, because of the quick swivelling of the laser beam, we can distribute the heat of the laser beam much more effectively and adapt it to the specific task,” says Dr.-Ing. Andreas Wetzig, specialist in the laser ablation and cutting department at Fraunhofer IWS.

As lab tests show, MEMS mirrors open up all kinds of possibilities – for cutting, welding and also surface hardening. “For example we can weld together aluminium and copper and use the heat input to precisely control which metal heats up the most, and hence comprises a larger proportion of the melted material,” says Wetzig. Even the welding of aluminium alloys

on their own will become easier. Today, aluminium weld seams are often porous, because certain materials emit gas out of the alloys, forming bubbles. With the micromirror the heat input can be controlled in such a way that the melted material stays liquid long enough for all the gas to escape from the substances.

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