

Fiber Laser Seam Stepper Replacing Resistance Spot-Welding

A cost-effective laser based tool to conventional welding technologies

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Resistance spot welding is known in high-volume production environment in the automotive industry since many years. The laser welding technology is also established in this application for more than 20 years, however it could still not capture the majority of the market even the modern laser welding application offers the following advantages:

- Higher process speed (shorter cycle times).
- Increased component strength via longer seams and resulting higher torsional stiffness.
- Effort and cost comparable to today's resistance-welding systems.
- Realization of higher job safety requirements with reduced costs.

One of the advantages for resistance spot welding (RSW) compared to laser welding is the integrated clamping technology, which comes nearly for free as well as the safety enclosure is not as complex, not consuming valuable space and therefore not as costly.

The Laser-Seam-Stepper (LSS) from IPG Laser GmbH which has been devel-

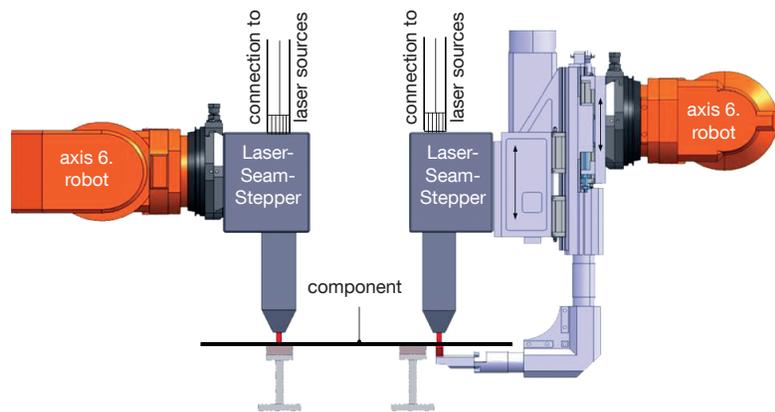


Fig. 1 The Laser-Seam-Stepper is shown here with a "picker" (left) and a C-gun (right).

oped in the last few years is designed to combine the advantages of a fast laser-welding process as well as the integrated clamping of the components.

The new tool is integrated in a standard robot cell a Class 1 laser device, meaning it can be used on production lines without the need for additional laser-safety mechanisms.

Laser-Seam-Stepper concept and design

The concept of the Laser-Seam Stepper (LSS) is to have a maintenance free fiber

laser combined with an easy clamping tool where the X-Y-movement is realized by the integrated welding head. To release the laser power, the housing has to contact the component to be welded which will guarantee the laser safety (Fig. 1).

Laser welding with or without the weaving function (± 1 mm) can be effected within the range determined by the housing (standard = 40 mm). The easiest application is an LSS mounted, for example, on the sixth axis of an industrial robot (with 50-kg handling capacity). The robot moves the LSS to the

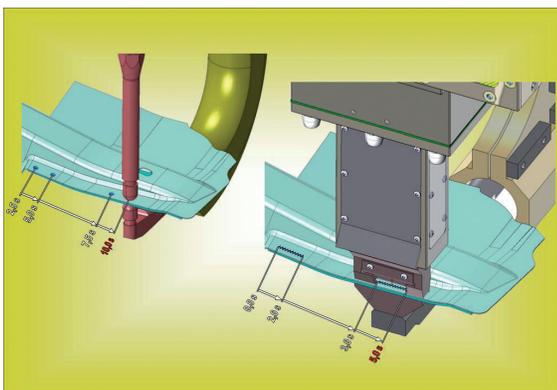


Fig. 2 Resistance spot welding vs. laser welding with the LSS module.

Company

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IPG Photonics Corporation is the leading developer and manufacturer of high-performance fiber lasers and amplifiers for diverse applications in numerous markets. Its diverse lines of low, mid and high-power lasers and amplifiers are used in materials processing, communications, medical and advanced applications. The products are displacing

traditional applications in many current applications and enabling new applications for lasers. IPG has manufacturing facilities in the U.S., Germany, Russia and Italy, and regional sales offices in France, Spain, United Kingdom, Turkey, Poland, Singapore, Japan, Korea and India.

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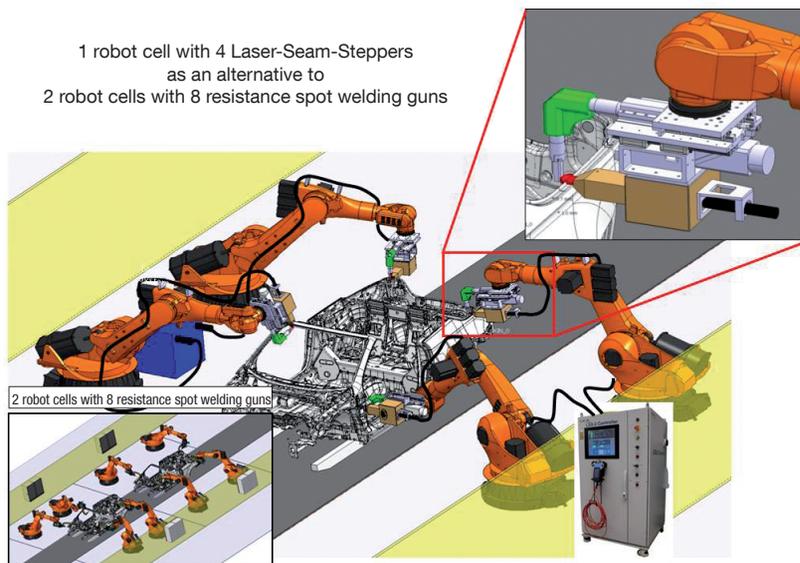


Fig. 3 The LSS with fiber laser requires only one robot cell, whereas resistance spot welding would require two robot cells for the same operation.



Fig. 4 The module is tested during production of a triangle window at the door of a car.

required welding position. In this position, it is placed onto the component only by robot force. Below the component, within the range of the welding seams, a fixed lower tooling is used as counter force or support (Fig. 1).

During a typical stepping operation (30 mm welding seam, 30 mm of free space, 30 mm welding seam), a laser welding seam can be placed with a welding velocity of approximately 30 mm/s every 1.7 to 2.0 s (Fig. 2).

The LSS unit is mounted on a servomotor-driven traversing unit. This is similar to a resistance-welding gun with a compensating module (Fig. 1). This version enables, for example, an industrial robot to move the module into a welding position and to close with a freely programmable force. The lower

tool belonging to the C-gun (Fig. 1, right) is used as a counter force and additional safety equipment against unintended back-reflected laser radiation.

The force-controlled closing of the laser welding system (0.5 to 3 kN) results in a fitting accuracy (gap < 0.2 mm), which is deemed necessary for laser welding.

The system's compensation module compensates tolerances regarding the position and geometry of the components. All joining forces (0.5 to 3 kN) applied in the system are performed within the laser welding tool only; the robot itself is not required for these joining forces. During a typical stepping operation, a laser seam can be placed every 1.7 to 2.0 s.

Typical applications for this sys-



Fig. 5 The module is tested during auto production; here, an interface B-pillar/rocker panel is being welded.

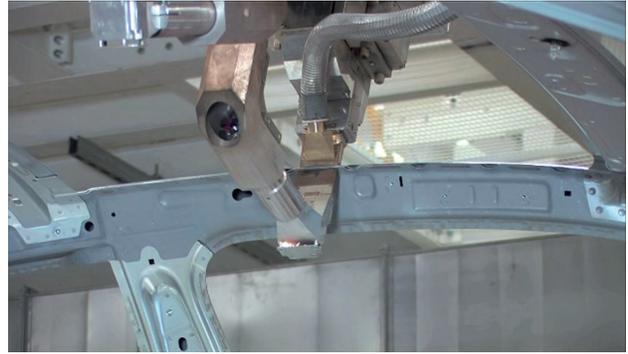


Fig. 6 The module is tested during production of a car roof frame.

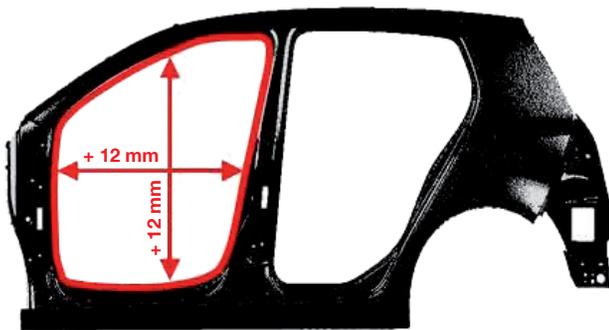


Fig. 7 Entry and weight optimization.

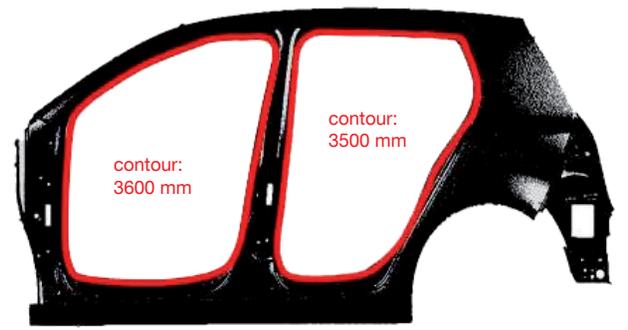


Fig. 8 Weight optimization.

tem are sheet-metal assemblies in the body-in-white automotive production lines (Fig. 3), which until now have been joined with many resistance-welding spots. One laser seam step of approximately 30 mm can replace two resistance-spot welds with a typical spacing of 30 mm.

The cycle time for 30 resistance-spot welds is approximately 75 s. If spot welding is replaced by laser seam welding in the prescribed manner, only 15 laser-weld seams are required. The cycle time can be reduced to a total of 37 s. Additional advantages are that the LSS requires less floor space and less capital investment cost in comparison to resistance spot welding.

The Laser-Seam-Stepper basic version is designed to perform linear seam welds of up to 40 mm and in addition a weaving function with a preset frequency of 3–30 Hz can be switched on in order to spread the welding seam to 2 mm. The overhaul running costs are reduced to a minimum by implementing unique features in the system. As the LSS is laser safe using standard robot welding cells there is no need of using complex and costly laser-protection housings. The system provides a clamping action to join sheet metal plates to be welded, with a defined force. This reduces the normally high requirements for additional clamping during standard laser welding as well as the maintenance of these components. A special designed air flow inside the LSS tool ensures the outperforming lifetime of the cover slide which protects the welding tool. The fiber laser and the LSS module are maintenance-free and the system is controlled via hardware interlock and standard bus systems. Preconfigured settings for length of weld (10 to 40 mm), speed, laser power, ramping, etc. can be selected which makes the programming of parts simple and easy. An optional available handheld LSS can be used for prototyping to produce laser welded parts within a short time

without the need of using a robot. This offers OEM's and suppliers a critical advantage in the form of time to market of parts and platforms.

High-volume production applications

With the experience of more than four years of production in a fully automated car plant the Laser-Seam-Steppers (LSS) is meanwhile used in various applications. The application is overlap welding with different material combinations. This can be zinc coated steel or high strength steel as well as stainless steel or aluminum (for example in the shipyard and rail wagon industries).

The unique design of the upper and lower clamping brackets will allow to reduce the flanges from 15 mm (required for RSW) down to 10 mm or even 6 mm.

This will allow

- much larger viewing angles for example at A-pillars and doors
- larger areas at the car entrance (increasing by 8%), see Fig. 7
- weight savings (14,200 mm total length; 6 mm reduction; 2.8 mm total thickness → 1.87 kg), see Fig. 8

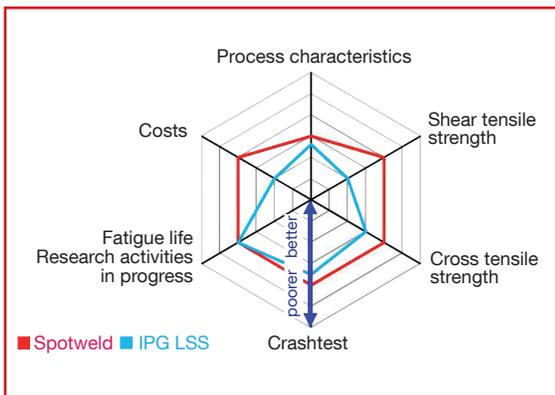


Fig. 9 Overall evaluation of the process comparison.

Economic aspects

In cooperation with INPRO (an innovative company for advanced production systems in the automotive industry in Berlin; its cooperating partners are Daimler AG, Volkswagen AG, Siemens AG, ThyssenKrupp Technologies and SABIC Venture BV), the joining technology of resistance spot welding was compared with laser welding by the Laser-Seam-Stepper using a wobbled beam. Here, physical and technological features, behavior of the part itself and crash performance were taken into consideration, along with economic aspects.

Fig. 9 illustrates the overall evaluation of the considered factors for laser welding by LSS (blue line) and resistance spot welding (red line). The line nearer to the middle for laser welding represents a better result than the one achieved by resistance spot welding. The overall technical result shows that the performance of the wobbled seam produced by the new welding module is comparable to or even better than resistance spot welding and can complete welding tasks in half the production

time. The result of economic comparison shows a total cost reduction of 6 to 10 percent, assuming fully automated production of 800 units in three-shift operation.

Outperforming reliability

A continuous improvement process has taken place since the beginning of car series' production with the LSS, the

result of close cooperation with different car manufacturers. This results in a highly reliable laser welding tool with an availability of 99.9 percent. Due to the high repeatability of the complete system (fiber laser and LSS module), a very high continuous production quality can be guaranteed without any rework at the car body itself.

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