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Remote laser welding boosts new Ford Mustang

TECHNOLOGY ENABLES EFFICIENCIES IN TIME, SPACE, AND PRODUCTIVITY

MATTHEW GILLOON and CHRISTINE GROSS

Laser material processing has been established as a modern, automated production method in the automotive industry, where productivity is key. Specifically, remote laser welding meets this requirement. Highest productivity can be achieved

when the laser beam is applied in a Welding-on-Fly mode, where a scanner-based remote laser welding head, working with a robot in a continuous movement, performs very fast three-dimensional beam positioning (FIGURE 1). The time between weld seams is minimized, resulting in an increased laser utilization rate—far in excess of conventional laser welding.

Here, we showcase the benefits of remote laser welding in a high-volume manufacturing environment: the production of the new Ford Mustang (FIGURE 2).

Objective

Ford's goal was to develop a large-scale, single-sided joining method for the new Mustang model's design. The desire to continuously increase crash performance and enhancements in safety standards have driven the increased utilization of advanced high-strength steels in automotive body structures. Many body architectural design advancements include the use

of hydroformed tubes in areas such as the roof rail and A-pillar. Application of these designs drives a need for advanced development of single-sided joining technology to fully realize the benefits. Traditional resistance spot welding requires access to both sides of the joint, but cutting access holes in the hydroformed tube to allow access for this type of welding would create structural weaknesses, countering the design intent of the hydroformed tubes. Single-sided joining provides a method to deliver maximum structural integrity, which benefits the health and safety of customers.

This pointed Ford in the direction of remote laser welding as opposed to spot welding. With the new single-sided remote laser welding approach using II-VI HIGHYAG's RLSK remote laser welding head (FIGURE 3), structural weaknesses could be eliminated and the productivity increased.

Implementation

The project was initiated in 2012, and in 2015, the remote laser welding process of the Ford Mustang was transferred into serial, high-volume production. Four remote laser welding cells were installed in the Mustang production plant in Detroit, MI. In two of these cells, four RLSK welding heads preprocess the body-side inner assembly parts, with dimples in the location where the weld will eventually be placed. In the other two laser cells, eight of the welding heads weld the body-side inner and outer assembly parts.

The RLSK welding head joins 34 structural remote laser welds on the body-side

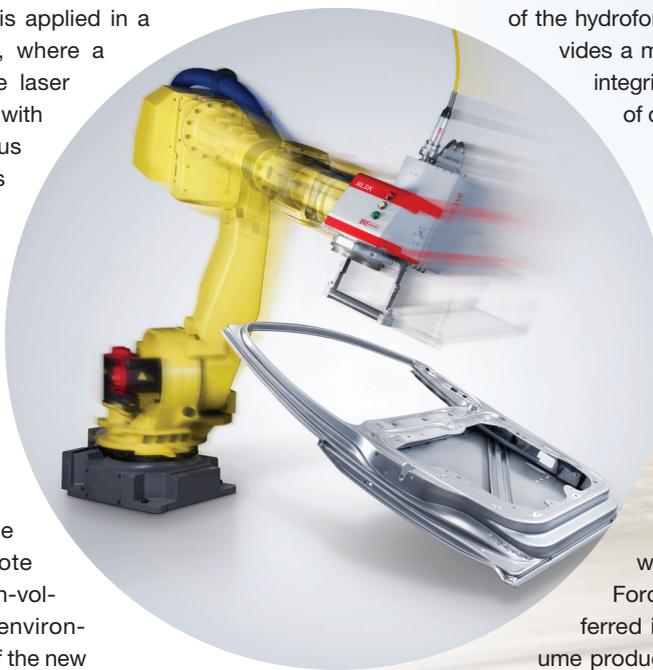


FIGURE 1. In the Welding-on-Fly mode, the welding head works with a robot in a continuous movement to perform very fast three-dimensional beam positioning.

production of

inner assembly, including stack-up thicknesses of up to 2mm (FIGURE 4a). They are performed as stitch welds and C-welds with weaving oscillation to achieve successful s-value results for thick stack-ups. In addition, the body-side outer assembly is remote laser-welded: 79 welds for the coupe model and 61 welds for the convertible model (FIGURE 4b). The 0.7mm mild hot-dipped galvanized iron (HDGI) body-side outer assembly is welded to various materials and thicknesses of the body-side inner assembly using a G-shape weld design to enhance quality robustness.

A dimpling pre-process is another critical aspect to ensuring successful weld quality and robustness when laser welding coated materials. The use of galvanized steels results in an

emission of zinc gases as the material coatings burn off during welding. Zero-gap conditions between the sheets to be welded result in porosity inclusions in the weld because the only escape route for gases is through the molten weld pool. This failure mode requires the implementation of a very small controlled gap between the two sheets to be joined to create an escape route for zinc outgassing between the two metal sheets. The development of dimpling provided Ford with the capability of consistently controlling these sheet metal gaps. The dimples are created on the body-side inner assembly by quickly pulsing the laser to raise the metal surface approximately 0.1–0.15mm. Location alignment between the dimples and welds is critical for successful outgassing and preventing porosity.

Plume suppression is another critical quality control factor. Plume is a plasma cloud emitted from the weld pool above the keyhole. This plasma cloud absorbs laser energy while welding, which results in decreased power at the workpiece and less weld penetration. The plasma cloud varies weld-to-weld, creating inconsistent energy absorption, increased quality variability, and decreased process robustness. These results caused Ford to develop a resolution that would control the plasma cloud

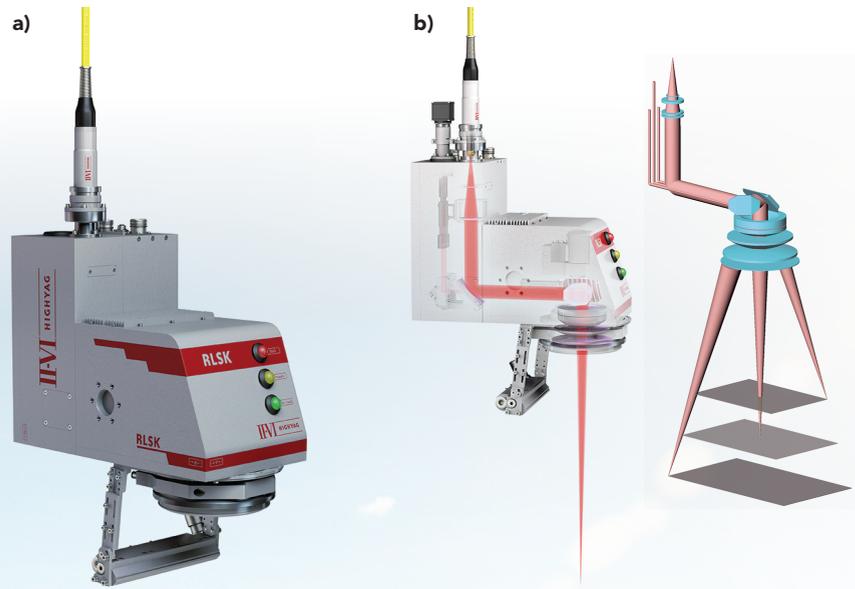


FIGURE 3. II-VI HIGHYAG's RLSK scanner-based remote laser welding head (a), with its sectional view and functional principle (b).



FIGURE 2. The new Ford Mustang.

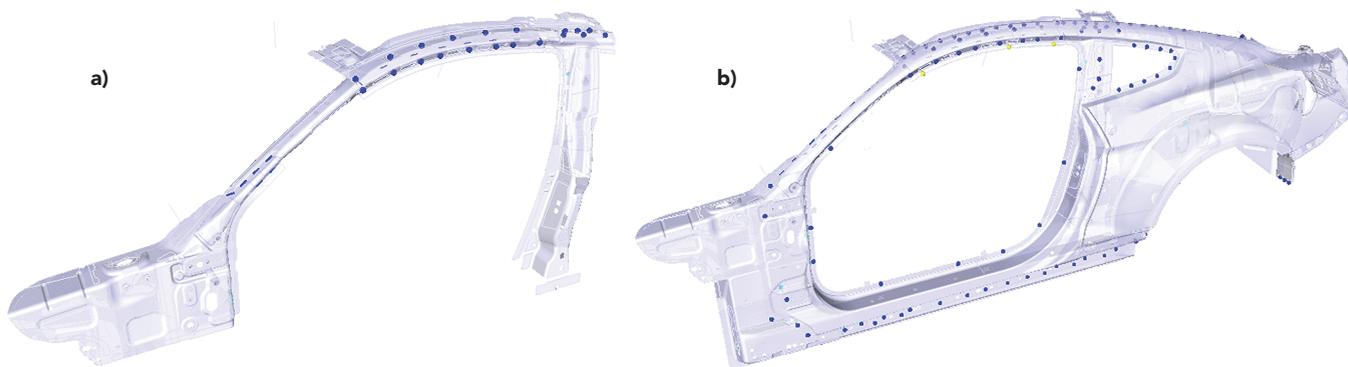


FIGURE 4. Structural welds on the body-side inner assembly (a) and body-side outer assembly (b) of the Ford Mustang.

in a fashion that would allow full and consistent power of the laser beam. The solution was to suppress the plume by manipulating the plasma cloud with airflow to bend the cloud out of the path of the laser beam. This was implemented by installing a complex piping system integrated into the clamping tools that delivered airflow 25mm above each weld location. This allowed for successful plume suppression, resulting in robust weld quality and weld penetration.

The implementation of remote laser welding on the Ford Mustang promotes further growth in lean manufacturing by creating manufacturing efficiencies in terms of time, space, and productivity, which has increased significantly compared to the traditional spot welding method. These efficiencies include:

- The actual weld time of body-side outer assembly welds is 5X shorter, taking 22 seconds instead of 111 seconds for 79 welds;
- Single-sided access enables handling in one station cycle instead of three station cycles;
- Only four welding robots are required instead of 12;
- Only two material handling robots are required instead of four; and
- Reduced plant floor space.

For easy control of the remote laser welding process, Ford leverages the capabilities of the RLSK Studio software to assist in synchronizing the focus movement of the RLSK welding head with the motion sequence of the robot. In the software's graphical user interface, positioning of the laser focus and process features are visualized. Downloading and uploading of workpiece data and editing of process features, such as welding speed and laser power, are also possible. The entire process setup is handled in a simple, user-friendly way (FIGURE 5).

Conclusion

The welding head is the interface between the laser and the workpiece, and must meet the key requirement in a high-volume production environment—productivity.

Productivity has been increased considerably by applying remote laser welding with the RLSK welding head in building the

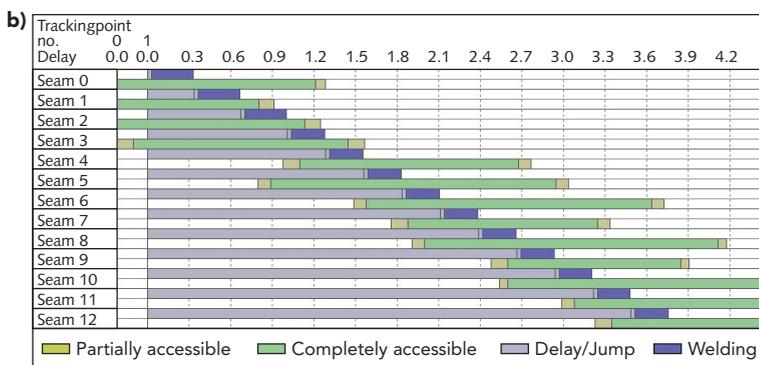
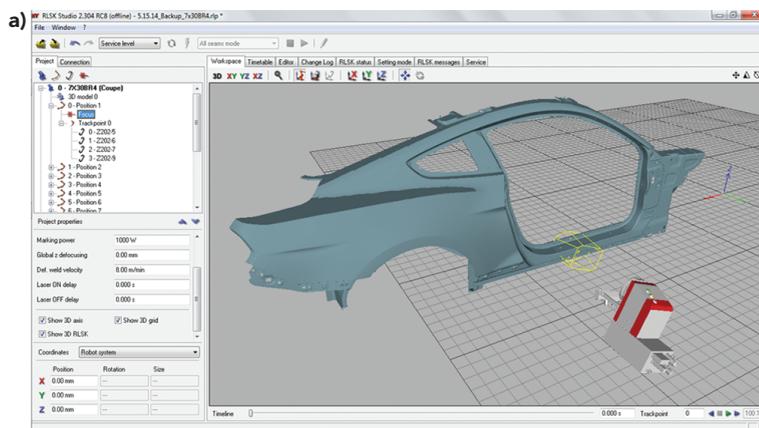


FIGURE 5. User-friendly process control using the RLSK Studio software can visualize the focus positioning (a) as well as the welding process in a timeline (b). The timeline shows that there is only a minimal loss of time between the welding of the single seams (shown in blue). Therefore, maximum productivity is achieved. (Portions of [b] were enhanced for readability)

new Ford Mustang. Production benefits include a much shorter cycle time, elimination of structural weaknesses, reduced plant floor space, laser seam shape manipulation capabilities, and user-friendly process control with the RLSK studio software. ✨

MATTHEW GILLOON (mgiloon@ford.com) is a welding engineer at Ford Motor Co., Dearborn, MI; www.ford.com, while **CHRISTINE GROSS** (christine.gross@ii-vi.com) is in marketing communications at II-VI HIGHYAG, Kleinmachnow, Germany; www.highyag.com.