The robot guides the laser beam and the halogen light along the contours of the workpiece (photos: LPKF)

Robot-guided Halogen and Laser Light

Plastics Hybrid Welding. Car headlights and other automotive lights in sheet metal and glass are a thing of the past. Today, it is plastics that dictate automotive design. A ready-to-use hybrid welding system has now opened up new scope for the size and design of the lights. The concept behind the system incorporates the full welding technology in an industrial robot – including the quality assurance. In this way, the rapidity and flexibility of the six-axis robot can be exploited by the welding cell in its entirety.

RALF HÖGEL

What would modern cars be like without their sophisticated plastic lights? The production processes available to date, however, have imposed tight limits on designers in respect of size and shape. Low-stress joining was only possible for parts up to a certain size and with relatively flat geometries using the standard vibration and hot plate welding processes that were available. It was also necessary to hide irregular welding seams by means of black injected-on edges on the transparent PMMA lens.

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Laser contour welding overcomes the limits of traditional plastics welding processes and is particularly suitable for joining today's standard light housings in ABS or blends of ABS+PC to the transparent PMMA lens. High-grade 3-D welds can be achieved while imposing just low mechanical stresses on the parts – the secret lies in a precisely tuned energy input. But there's an even better solution still: working together with the Bayerisches Laserzentrum, LPKF Laser & Electronics AG, Erlangen, Germany, has developed the robot-based laser hybrid welding process, which it has been trying out on a number of test systems since 2005. And this patented process has also shown its capabilities in series production already. For some time now, the very large tail lights on the Hyundai Equus have been joined by means of laser welding.

The further development of this technology, employing an integral articulated arm robot (type: Stäubli TX60L), was presented at Fakuma 2009. In the current →

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series solution for its light production, LPKF uses an encapsulated six-axis robot (type: Stäubli TX90L) and a rotary table. This means that the fully automatic LPKF TwinWeld3D welding cell is equipped to achieve shorter process times and considerably lower tooling and material costs, in addition to ensuring a flawless appearance and additional freedom of design in plastics welding.

Laser Welding in a Thermal Field

By contrast to pure laser welding, in the hybrid process the heat energy is applied not only to the laser-absorbing lower component but also to the transparent upper component. To do this, the monochromatic laser beam, which cannot heat the transparent joining partner directly, is combined with long-wave polychromatic halogen light. This means that the temperature selected for the welding process can be precisely aligned to the material-specific melting points of the two parts being joined. This combination of energy sources increases the speed of the process and ensures good-looking, low-stress welds. The more uniform heating and cooling of the two parts being joined makes it possible to get by without the annealing process that is needed to eliminate stresses in the other plastics welding processes

The advantages set out above – and, in addition to these, the feasibility of joining very big plastics lights with bold freeform surfaces – have now prompted three automotive suppliers to order turnkey TwinWeld3D systems. The Stäubli TX90L controls operations inside this air-conditioned, hybrid welding cell with a rotary indexing table. Its precisely guided hand directs the laser beam and the halogen light onto the workpiece. While the robot follows the contour of the workpiece, the pneumatically-sprung tensioning roller applies forces of up to 300 N to ensure a precise positive-locking fit between the two plastic parts being joined. The result is a low-stress, precise and slim weld with no fraying at the edges, which is even welcome as a decorative strip in the visible section of the part.

"Realizing hybrid welding is only possible with the flexibility provided by a six-axis robot with an extremely high path accuracy," explains LPKF Product Manager Manuel Sieben. "The TX90L fulfills this condition with a path repetition accuracy of ±0.035 millimeters, and is also very compact with a reach of 1,200 millimeters even in the "L model", despite the specified payload capacity. The open VAL3 control system also satisfies our stipulations for integration in the cell. This enables us to supply our clients with an all-round, highly user-friendly system."

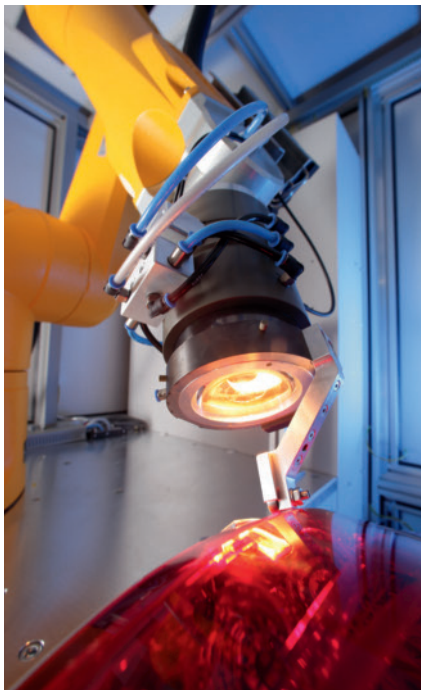
Sixth Axis for Pneumatically-sprung Tensioning Roller

Only at first glance does the high specified payload of almost 15 kg seem surprising. A look at the robot in the welding cell reveals all – in addition to the high pressing force applied by the tensioning roller, the robot also has to shoulder the entire welding system. It carries the laser energy source with its high-performance cooling setup so as to dispense with long fiber-optic cables and all their drawbacks.

"This kind of machine concept would have been impossible only two years ago, because back then the cooling alone of a comparable laser was still the size of a 19″ rack," says Manuel Sieben. "A customized wrist created by the Stäubli development engineers made it possible to mount a complex welding head with a circular halogen source onto the fifth axis instead of a co-rotating housing. This and the laser beam which shines through the center are imaged at infinity via a complex, gold-coated reflector. The two radiation

The fully automatic TwinWeld3D welding cell shortens process times, making for a flawless look and increased freedom of design in plastics welding

In addition to the high contact pressure to be applied, the robot has to shoulder the entire welding technology



A customized wrist created by the development engineers made it possible to mount a complex welding head with a circular halogen source onto the fifth axis instead of a co-rotating housing

sources are then focused onto a single point by a shared lens. These are the new and very sophisticated features of this system," explains Sieben.

The tensioning roller needed for the laser welding technique is also located in the hand of the Stäubli robot – on its sixth axis – and generates the vertically acting clamping force on the components. This is made up of a toothed wheel with planet gears which drive a pneumatically-sprung gear rim with an arm for the cooled clamping roller. The roller is decoupled from the rotary movements of the welding head. The integrated pneumatic-springing guarantees the gentle, surface-protecting guidance of the roller – even where there are large component tolerances.

Integrated Quality Assurance

A process control system based on an assessment of the component's reflection properties can be integrated directly in the welding head. The system measures the height of the component on the one hand and assesses the quality of the weld produced, on the other. The key feature of this system is that the measurement can be made at the full process speed of 80 to 150 mm/s. This measurement allows tolerances in each of the components to be compensated by influencing the control parameters. With the database obtained in the course of this process, it is possible to get by without a subsequent tightness test in many cases.

Manuel Sieben: "A large number of mathematical calculations are carried out during the welding process to control the power output of the laser and the halogen light dependent on the welding speed. A PLC with interfaces to the PC control acts as the master that actuates all the movements. This, in turn, communicates with the robot control. The results are stable processes with very high levels of user-friendliness via the system touch panel. This gives a top view of the product enabling operators to very quickly re-teach the robot path points – as can happen fairly frequently depending on the amount of dimensional deviation of each batch of plastic components. The Stäubli manual controller can also be used if necessary."

No Upper Die

Unlike other plastic welding methods, this system needs no upper die because the whole welding head, including the tensioning roller, is integrated in the robot. The only component-specific tool costs are associated with the lower die which is constructed by LPKF as part of the design support activities. The speed and flexibility of the six-axis robot is therefore passed on to the welding cell as a whole. Together they set new benchmarks, with only around 30 seconds processing time to weld an average tail light, and completely saving the around 30 minute annealing procedure.

The hybrid welding process and innovative system concept, which integrates the complete state-of-the-art welding technology package in the robot, opens up the way to an almost completely unrestricted design of automobile tail lights. Since the lights can even be fitted with LEDs prior to welding, models of this type will doubtless influence the design of the whole vehicle more frequently in future. ■

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LPKF product manager Manuel Sieben: "Realizing hybrid welding is only possible with the flexibility provided by a six-axis robot with an extremely high path accuracy."