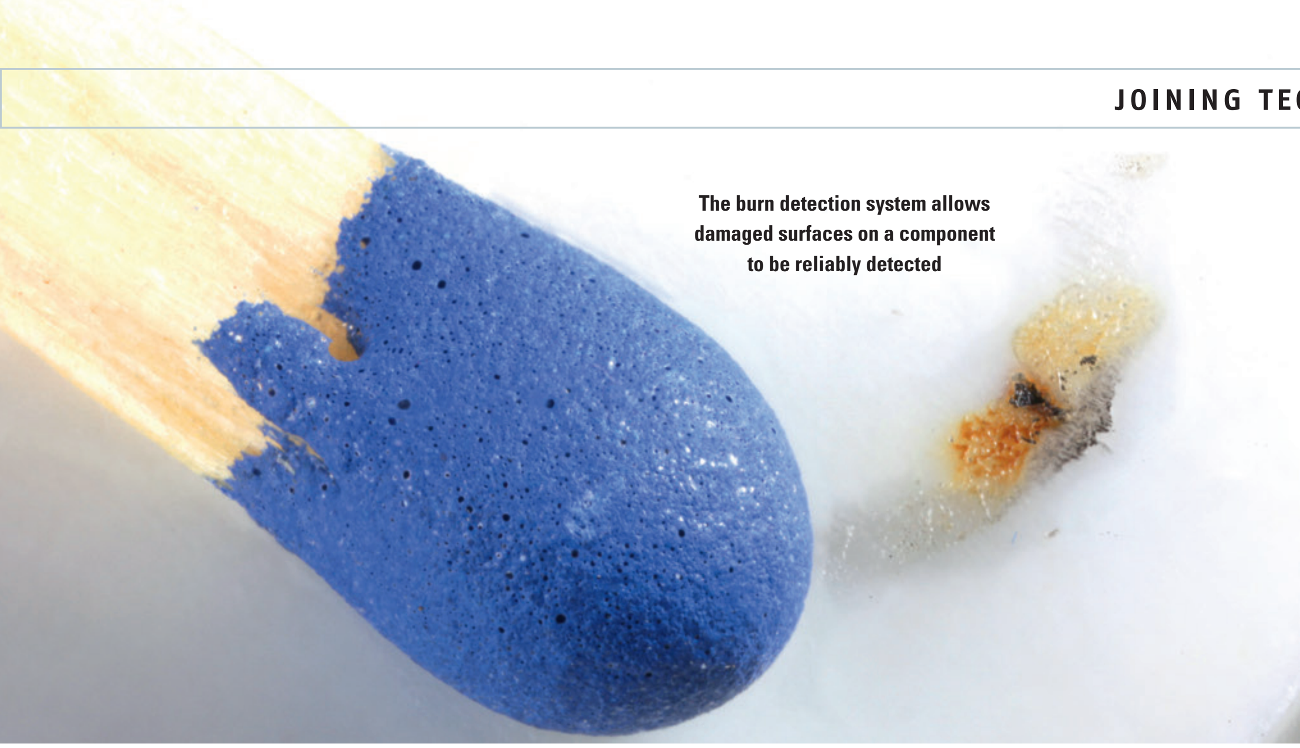

The burn detection system allows damaged surfaces on a component to be reliably detected

Quality-Controlled Joints

Quality Assurance. Apart from the cost-effectiveness of laser welding, further benefits are the quality and the possibilities of continuous process monitoring. Laser technology shows new possibilities here.

FRANK BRUNNECKER

Laser welding of plastics has already established itself in the automotive and medical technology sectors with their "zero tolerance for faults" demands. It has proved to be particularly cost-effective, is technically superior to the traditional methods and provides new quality options.

During laser welding, the laser beam penetrates the upper, laser-transparent component and partly melts the lower joint partner. Moderate clamping pressure ensures the heat transfer to the upper component so that a common weld seam is produced. This method has several system-immanent advantages compared with classic joining technologies. The components are subjected to less stress during welding, visually high-quality weld seams are produced, welding is particle-free, there is no marking or damaging of the surface, and better quality control is possible with online process monitoring.

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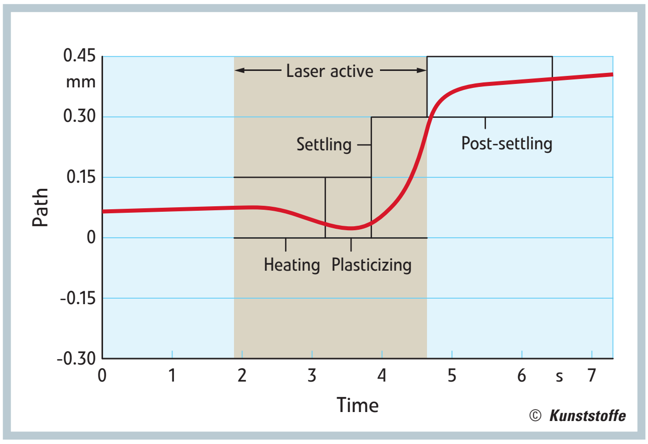

Fig. 1. Joining path monitoring measures the amount of settling of the complete weld seam (figures: LPKF)

Online Process Monitoring

Products and production processes are becoming increasingly complex, and consequently production faults are becoming more and more problematical and costly. It is therefore important to avoid faults completely, if possible, or to detect them as early in the process as possible so that corrective measures can be taken. Here laser welding of plastics can win big points with its continuous process monitoring.

One example is the production of speed sensors on the transmission controllers for automatic transmissions. Each module already has a value of several hundred euros even before processing. The aim is therefore to detect any problem during welding as early as possible by means of online monitoring so that every step is directly inspected and immediate corrective action can be taken in the event of problems.

Demands on the Quality and Process Monitoring

Two main demands are made on a weld seam: It has to be leak-tight (e.g. to IP67) →

and sound. Assured quality therefore presupposes that both demands are satisfied and monitored even during the process. In order that the demanded strength is achieved, for example, the material must not be overheated. The temperature in the joint zone is therefore constantly monitored using a pyrometer. This method also detects if the temperature at the weld point of the upper joint partner is not high enough for reliable welding.

For the necessary leak tightness, 100 % of the intended contour has to be welded. The process monitoring therefore checks whether the two components are uniformly melted. But process monitoring also fulfills a second function: It provides the documentation on the actual production process necessary for the traceability of the welded component.

Process Monitoring and Traceability

On lines by LPKF Laser & Electronics AG, Erlangen, Germany, all the parameters of the welding process can be documented by continuous tracking and tracing. They ensure the later traceability, e.g. in the event of questions of product liability. In other words it is possible even five years later to retrace, for example, how a medication dosing pin was produced. For this, the corresponding data on the pin are stored in a two-dimensional barcode (data matrix code).

Using these process parameters and by evaluation of the process monitoring it is then possible in the event of liability disputes to determine whether the data from the product production process correspond to the values for the process qualification.

There are different approaches and configurations for implementing this tracking & tracing in practice. The LPKF welding lines have an integrated scanner that reads out the already assigned barcode when the unwelded parts enter the line. The module is then welded together by laser. The process settings and the result of the process monitoring are then transmitted together with the barcode to a higher-ranking host system where they are archived.

From its technological basis alone, laser welding is already a particularly safe method. In addition, LPKF has also developed a process monitoring system with five different test methods which are used, depending on the material and welding method employed.

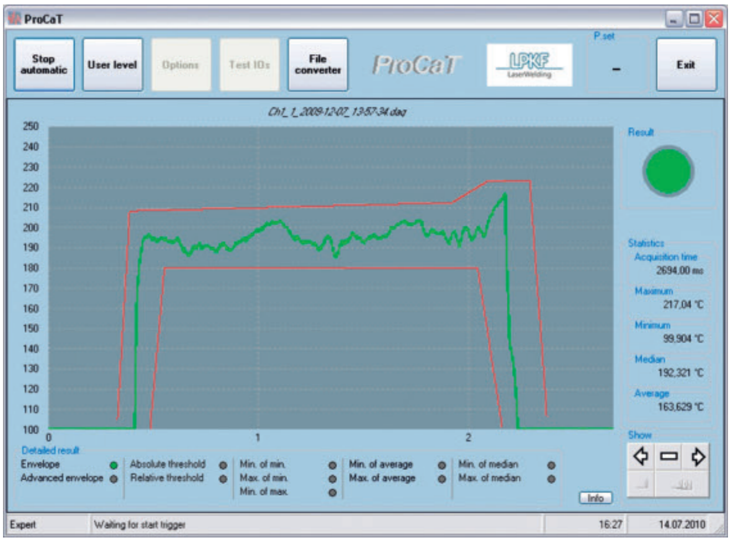

Fig. 2. Pyrometer monitoring allows the process to be not only controlled, but also regulated during contour and quasi-simultaneous welding

Joining Path Monitoring

Joining path monitoring is the most stable monitoring means during quasi-simultaneous welding processes. It allows direct and indirect faults to be detected. The principle is based on melting just enough material that the manufacturing tolerances of the individual components are compensated. Leak-tight weld seams are reliably produced that satisfy the demands of protection classes IP67 and IP69K. Depending on the process variant, the welding process stops after a set time or distance, or on reaching a fixed stop **(Fig. 1)**.

Pyrometer Monitoring

The monitoring of laser welding processes by means of pyrometry when using the contour welding method provides significantly enhanced detection rates. A specially developed method offers a short reaction time to changes in temperature and thus permits automatic evaluation of the weld seam quality. A pyrometer records the electromagnetic radiation in the infrared range (heat radiation) and monitors the quality of the weld seam. The welding is considered to be successful as long as the temperature curve remains within a zone between maximum temperature and lower limit (envelope evaluation). Surface flaws such as burns or scratches in the area of the weld seam result in anomalies and corresponding corrections. The pyrometer signal also allows material fluctuations or different glass fiber concentrations along the weld seam to be detected **(Fig. 2)**.

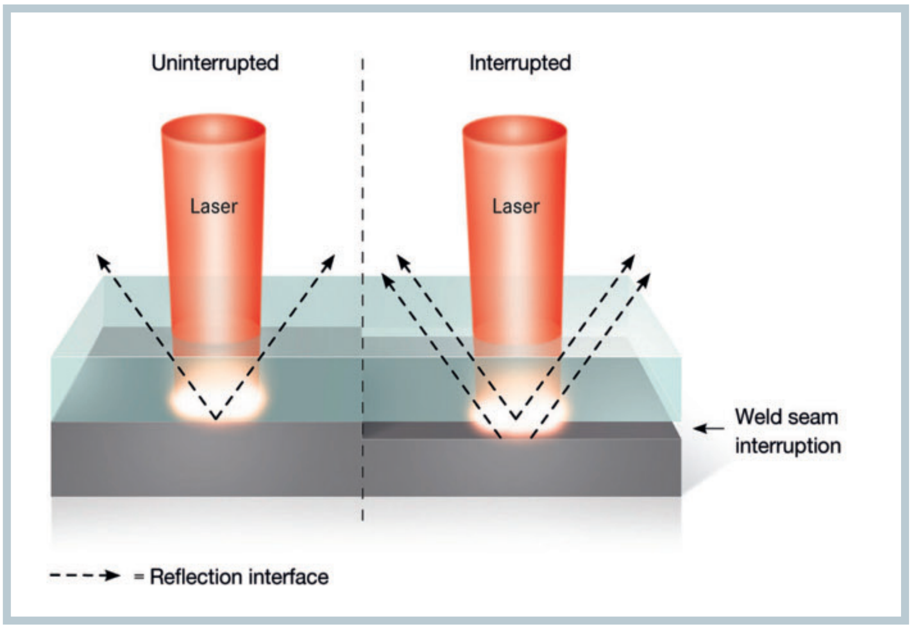

Fig. 3. An incomplete weld generates higher reflection values

Reflection Diagnosis

The principle of the patented reflection diagnosis is based on the incipient light of a test beam (e.g. laser) being reflected at interfaces. In welded state there is one interface less, i.e. the signal is weaker there. An interruption in the weld seam results in a peak.

Reflection diagnosis is suitable e.g. for materials used for the production of automobile lights. The three-dimensional welding method employed there (LPKF TwinWeld3D) uses this diagnostic system to control the processing parameters. Reflection diagnosis will also be available in future for the other laser welding systems in the portfolio. It can also be combined in principle with quasi-simultaneous or contour welding **(Fig. 3)**.

Burn Detection

Burn detection is employed to reliably detect surface burning during laser welding of plastics. The second generation of the burn detection system is based on the detection of flaws on the beam entry side of the upper layer. In practice such burns measure only a few tenths of a millimeter and thus have no demonstrable influence on the seam strength. For functional or aesthetic reasons, however, such burn residues are nevertheless unacceptable in some applications. The radiation emission of such burns extends from the visible up to the infrared wavelength spectrum. If the radiation is detected in this wavelength spectrum, the burn emissions are clearly distinguishable from the background noise in the signal curve **(Title photo)**.

Camera-aided Vision Systems

An already well-established method is on-line CCD monitoring. This can be used with correspondingly high-contrast material pairing such as opaque/black. This type of monitoring system can be easily integrated into the process, particularly with contour welding methods. In combination with a corresponding evaluation routine, even the smallest flaws in the weld seam can be reliably detected. In addition, the monitoring system can analyze the weld seam width and record this as a further quality criterion **(Fig. 4)**.

Conclusion

The broad range of test mechanisms adds an important aspect to the system-immanent advantages of laser welding: The success of the processing is already ascertained and thereby documented during the process. Reliable process monitoring reduces the costs of subsequent component inspection. Even in the event of changing material properties or geometric deviations, a warning is given that prevents costly faulty production. ■

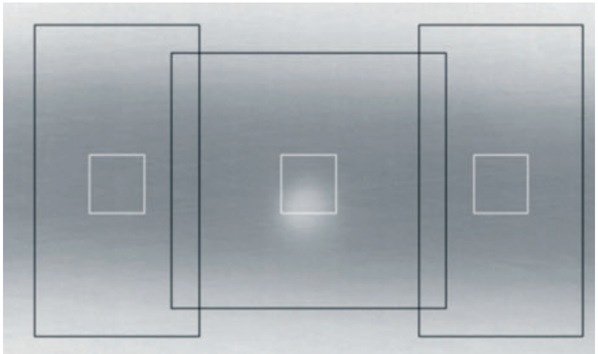

Fig. 4. Image of an air bubble in the weld seam as seen by a CCD camera

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