



Automatic Contour Recognition in Laser Welding

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Sulzer Innotech offers a wide range of laser welding services for applications ranging from medical technology, through mold production, to gas turbine components. The computerized numerical control (CNC) programming for laser build-up welding on unknown geometries is complicated. A tactile contour-recognition system integrated into the laser welding system helps to reduce the setup time and thereby to lower costs.

▶ Laser build-up welding is related to the conventional tungsten inert gas (TIG) and plasma transfer arc (PTA) build-up welding processes. In place of the electric arc or the plasma, however, a laser is used as the heat source. The powdery build-up material is transported in an inert carrier gas, and is brought via a powder nozzle to the melt pool created by the laser. The good focusing ability of the laser allows

power densities that are hardly possible with conventional thermal procedures. Thus, the desired component processing can be carried out on a limited area with low overall power—the component and the material are only subject to minimal thermal loading. Laser build-up welding is thereby particularly suitable for applications in tool and mold manufacturing, in which only minimum deformation can be tolerated, as well as for

materials that are difficult to weld using conventional methods, for example, high-temperature resistant nickel-based alloys in gas turbines.

Welding with CNC Accuracy

As the laser is integrated into a CNC-controlled portal robot (Fig. 1), it must be suitably programmed for the welding operation. This programming achieves a precise, near-net-shape build-up that will only require minimal reworking. However, the setup effort is considerable for complex welding surfaces if no precise geometrical data is available. If the powder stream misses the welding point of the laser due to a deviation in the workpiece geometry, the build-up rate decreases, the heat input into the base material increases, and the process reliability is lost.

The numerical control (NC) program of the laser welding system takes a range of variables into consideration. The laser process parameters resulting from an examination of the welding procedure

have been stored in a parameter database, while the most suitable welding strategy is the result of many years of experience, and must be tested on components if necessary. If no CAD model is available for complicated machining surfaces, however, the geometry will have to be digitized, for example, through the scanning of surface points.

Possibilities for Contour Recognition

The geometrical determination of the welding surface and the welding strategy is possible in all cases through a "teach-in." The operator moves the laser head in the manual mode so that the focus of the laser moves along the intended welding path over the workpiece. This type of setup requires the greatest care and is a lengthy and thereby costly process.

Parameterized NC programs are suitable for simple geometries, such as triangles, rectangles, circles or rings, in which, for example, the geometric parameters describe the corner points of

the rectangle to be welded. The machine control then independently calculates the position of the welding path. A collection of standard solutions of this type considerably facilitates and shortens the setup process. However, it is not possible to setup complex free-form surfaces this way.

An automatic contour-recognition system, on the other hand, permits the fast digitizing of the component geometry while simultaneously determining the welding strategy, and thereby reduces the necessary setup times.

Integration of a Contour-Recognition System

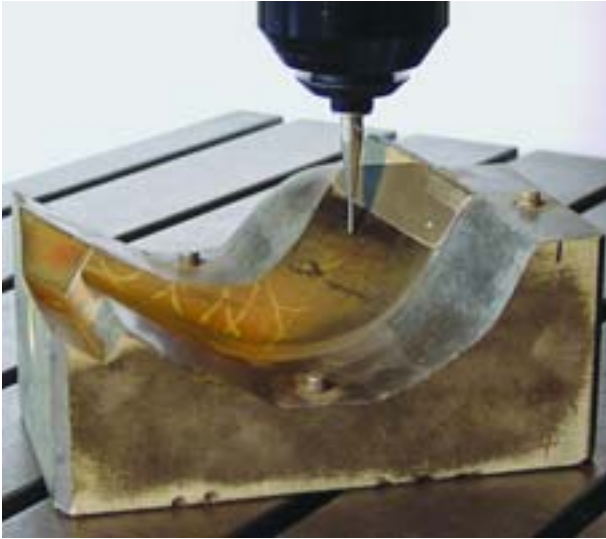
The digitizing of unknown geometries using a contour-recognition system can take place using optical or tactile sensors. The former require a comparatively high investment, and their accuracy is dependent on the surface quality. Sulzer Innotec has therefore given preference to a tactile recognition system with continuous measurement for applications in a workshop environment. In digitizing mode, the PC-driven control of the contour-recognition system takes over the machine control of the laser welding system. A digitizing head with a tracer pin is secured to the laser head and connected to the controller by a cable. The digitizing head must be removed for welding in order to avoid any damage from reflections of the laser light.

Contour Recognition and Build-Up Welding

For the digitizing procedure, once the digitizing head has been fitted, the machine control is handed over to the contour-recognition

1 The laser welding system from Sulzer Innotec consists of a 2 kW CO₂ laser and a six-axis portal robot with a working space of 2.7 × 1.8 × 0.9 m.





2 Near-net-shape build-up welding requires precise recognition of contours. A digitizing head with a touch-sensitive tracer pin makes rapid automated digitization possible, even for complex geometrical shapes.

system in the machine reference point of the portal robot. The digitizing process and the subsequent welding process both run in the same coordinate system, thereby rendering coordinate transformations superfluous. In the digitizing mode, the laser head is simply guided by hand onto the compo-

3 Once the geometry has been digitized, the tracer pin is replaced by a coaxial powder nozzle, and the build-up welding can begin.



nent to be welded by following the excursion of the tactile sensor. The edge of the surface to be digitized is programmed by running along it with the tactile sensor, and this data is then scanned line by line. The tactile sensor thereby remains in constant contact with the workpiece (Fig.2). Finally, the path traced by the tip of the sensor is calculated from the data obtained, and is output from the digitizing software in a CAD data format. A post-processor that was developed in-house translates the geometric information of the digitizing path into CNC path information; this information is then integrated into the NC programming of the laser welding system. The welding path of the laser is identical to the digitized path of the contour-recognition process, supplemented with a height adjustment, in order to make welding in several layers possible. Once the NC program has been read into the machine control, the digitizing head has been removed, and the powder nozzle has been mounted and adjusted, the build-up welding can be started immediately (Fig.3).

Lower Setup Costs, Improved Setup Quality

A laser welding system for build-up welding with powder is a complex machine tool. The advantages of CNC-controlled precision welding must be weighed against the setup effort necessary for the accurate programming of the system. In general, setup time is significantly greater than welding time. In the case of large-area free-form surfaces in particular, the integrated contour-recognition system in the laser welding system from Sulzer Innotec helps to reduce the setup effort and thereby the setup costs, as well as improving the setup quality. Moreover, the portal robot can be used as a large digitizing system, for example, in reverse-engineering applications. ◀

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