High performance production of innovative laser cut and welded products

WISCO Lasertechnik GmbH produces a wide range of laser cutting and welding equipment for use in the automotive and steel processing industries. An overview of the main products is given, together with a detailed description of a laser joining system used in a coil processing line.

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WISCO Lasertechnik GmbH is a leader in the development and manufacture of laser welding and cutting applications for the steel and automotive industries. Based on our knowhow in plant construction, our laser systems have been developed for production of optimised piece costs.

Our engineering performance in the laser welding area is carried out in close cooperation with our customers, using all the resources provided by the WISCO group of companies, field-tested system concepts and the development of alternative system concepts.

The range of products is extensive, including:

Conti laser welding machines for tailored blanks
WISCO Lasertechnik offers production systems the highest productivity and cost-efficiency worldwide for tailored blanks with linear seams. More than 200 million blanks have been produced since 1985. Figure 1 shows a typical system.

Gantry type systems
These are specifically for tailored blanks with non-linear seams, as the overlay of the movement of the laser head (y-direction) and the movement of the clamping table (x-direction) allows production of all possible seam shapes.

Ablation weld system
This is a new concept developed to meet the challenges that arose due to the increased application of Hotform blanks in the automotive industry (see Figure 2). Hotform blanks are tailored blanks designed for the hot stamping process. They are made from manganese-boron steels, which achieve strengths of up to 1,500MPa after hot stamping.

The hot-dip aluminised coating required to prevent scaling and corrosion normally prevents laser welding and has to be removed for tailored blanks production. The ablation weld system combines the removal (ablation) of
the AlSi coating of the Hotform blank and the welding of the part in one system.

**Tailor welded coil systems** These are marketed under the name TWC (tailor welded coils). WISCO Lasertechnik is the only supplier to have developed a production system for longitudinal welding of coils. Two of these systems have been in operation for more than three years. TWC is a unique product for innovative lightweight construction. TWCs bring tailor welded blank advantages to coil-fed operations such as: progressive dies, roll forming, blanking and coil fed transfer press lines.

**Laser orbital welding systems** These cover applications of welded rotational symmetric parts, which are applied in the powertrain, exhaust systems and other automotive and non-automotive components. In these systems the laser head is fixed and the parts are moved (rotated) as needed.

**ROBLAS** is a laser cutting system designed to meet the demands of the cutting of hot formed components, ie, cutting in three dimensions, such as on curved surfaces. A characteristic of hot formed components is a very high strength. The conventional cutting of holes and trimming of the component by cutting or punching tools is almost impossible and is replaced by laser cutting. The very compact ROBLAS system is an alternative to the expensive conventional 3D laser cutting systems.

**Joining systems for coil processing lines** In recent years, high strength steels (HSS) and advanced high strength steels (AHSS) have become more important as the automotive industry is forced to reduce carbon dioxide emissions. Use of AHSS imposes significant challenges to production lines, such as hot dip galvanising lines (HDGLs), not only because of their wetting behaviour, but also due to their poor weldability using compression welding machines. This means that AHSSs, such as transformation induced plasticity (TRIP) steels, could not be satisfactorily welded. To circumvent this problem, the so-called 'Zebra production' method can be used. This involves alternating production of AHSS and soft interstitial free (IF steel), or welding 2m long intermediate plates of IF steel at the starting end of each TRIP coil during a maintenance shift. Neither of these methods is desirable, as they lead to poor plant flexibility or significant downtime.

When using a laser welding machine, these drawbacks can be avoided, so the trend towards AHSS is, therefore, also a trend towards increased use of laser welding machines.

However, laser welding machines come with different challenges and demands. Most important is edge
preparation, as the laser welding spot is extremely small (<1mm) and laser welding machines usually use the butt welding principle. If the cutting edges are uneven and/or not rectangular, the weld seam is likely to suffer from underfilling or other geometric defects. This is a real challenge for laser welding machines using a mechanical cutting device, not only because of the large product mix which has to be cut precisely, but also as the AHSS increases wear and tear of the hydraulic shears.

WISCO Lasertechnik GmbH has, therefore, developed a laser welding machine where the laser is used not only for welding, but also for cutting, hole cutting, weld seam detection and notching. Moreover, all process steps are done by a single laser head equipped with a multi-purpose nozzle. This makes the laser welding machine unsusceptible to all issues related to the absolute position of the weld joint, which leads to very stable level of high quality weld seams and helps reduce unscheduled downtime for maintenance and repair.

In this article, the technical characteristics of the WISCO Coil Joining Machine installed at ThyssenKrupp are described to illustrate, in more detail, the advantages of this system.

HOT DIP GALVANISING LINE #7 AT THYSSENKRUPP STEEL EUROPE, BOCHUM, GERMANY

HGDL technical details Some facts and figures are shown in Table 1. The laser welding machine (see Figure 3) was commissioned in April 2009 during a 23-day maintenance downtime.

Laser cutting and welding machine (LWM) The laser source is a 5kW CO₂ slab laser mounted at a fixed position at the side of the line. Although this requires an additional deflection mirror when compared to alternative designs where the laser unit is usually mounted on the C-slide, this design has considerable advantages. The laser unit is enclosed in an acrylic cage (optically thin for optical wavelength, optically thick for CO₂ laser radiation), which shields the operator from stray radiation and from automatically moving parts, while still allowing the operator to see what is happening inside the machine. This cage also allows for much larger movability of the laser head, and air conditioning and heating ensure stable working conditions.

Four and a half years’ operation have not unearthed any drawbacks of this concept and there have been no problems with the deflection mirrors (neither misalignment nor contamination).

One of the characteristics of the TKSE LWM is that coil edge preparation is done by a laser rather than hydraulic shears. This makes the costly replacement of shearing knives redundant and also leads to stable conditions – in contrast
to mechanical cutting devices where the cutting conditions deteriorate over time (see Figure 4). Cutting with a laser also enables each edge to be prepared with the optimum cut conditions rather than having to use a fixed cut gap and overlap to suit all steel types and thicknesses.

However, laser cutting is neither new nor special. What is new is that this LWM uses a multi-purpose nozzle with one optical system for the entire process, ie, cutting, welding, hole cutting, and notching (see Figure 5).

The joining of the two prepared ends is done by a pneumatic joining cylinder, which press the ends together with a defined and adjustable pressure. This is in contrast to a linear unit, which simply moves towards a predefined position. The combination of the multi-purpose nozzle with the pneumatic joining cylinder greatly improves the stability of a laser welded seam. First, gaps between the two ends are closed automatically by the joining cylinder. Second, thermal expansion of the machine does not influence the process significantly, which makes the laser welding machine non-susceptible to mechanical offsets of the laser head by up to 1 mm perpendicular to the weld seam, as the cutting would be shifted by the same amount as the welding and the joining cylinder would make sure there is no gap between the two ends.

Of course, laser cutting needs more time than conventional mechanical cutting (for example 13 seconds for a 1.2 x 1,200mm strip and 20 seconds for a 2.0 x 1,200mm strip, but from the experience of the HDGL No.7, there is no negative influence on the total cycle time compared to alternative machines.

Quality control systems The LWM is equipped with a quality control station (see Figure 6), which is accessible during production, and where several parameters important to the process can be monitored at regular intervals (theoretically after each weld, and without influencing production). First, the nozzle is cleaned with a rotating brush (1), then the pressure of the proportional valves for laser cutting are checked (2). When notching the welded strip (because of different widths or to check the weld seam), a distance sensor is used to maintain a constant distance between nozzle and strip, and it also compensates for edge ripples or when welding different strip thicknesses.

Due to temperature variations, this distance sensor has to be calibrated from time to time. This is done with the plate (3). In the fourth test, the absolute position of the multi-purpose nozzle is checked by a 3D needle (4).

During the last two tests, the position and intensity distribution of both the focused and the raw laser beam are measured (5). The position of the focus is then compared with the position of the nozzle to confirm that they match.

Each of these tests has set reference values and limits and the operator receives a warning if a violation of the limits occurs. This regular quality control supports achievement of a good weld seam quality and enables slow drifting from optimum process conditions to be identified. Moreover, during a large, but unsolved problem, these measurements help to locate the root cause of the problem.

Whereas the quality control station is used mainly to monitor mid to long term trends, the weld seam quality also has to be checked directly before sending the weld seam into the line. Three sensors – two from the top side and one from the bottom side – are used. The main system consists of two sensors on the top side. One uses the laser triangulation principle to detect geometric defects of the
weld seam like under or overfilling, or a height mismatch. The other sensor is a charge-coupled device (CCD) detector which measures the intensity of the weld plasma. On the underside, a root broadness sensor (RBS) detects the seam from the bottom and also uses the laser triangulation principle to detect height mismatch and root relapse, and to measure the width of the root to judge whether there is sufficient root fusion.

The operator gets an image of the measured signals over the entire seam length (see Figure 7) together with the judgment of the quality system (OK/not OK). Currently, no additional offline tests (like a bending test) are performed.

The weld seam in Figure 8 shows small regions with under filling in the first part of the weld seam (left side), which in this case, however, are not large enough to reject the weld seam.

**Weldability of different steels** Since commissioning of the LWM in April 2009, nearly 85,000 weld seams have been processed, including a significant amount of AHSS.

Other steel grades, which are considered problematic to weld, such as 3mm cold rolled BMn steel for warm forming, austenitic 23wt.% Mn alloyed X-IP® steel or unpickled hot rolled complex phase (CP) steels, have been welded to test their weldability. All tests done in the laboratory (tensile, metallographic, hardness) show that every steel is weldable with any other steel, and in any combination of steel grades or strip thicknesses.

An important motivation for replacing an old compression welding machine with a laser welding machine is to minimise weld seam fractures, especially in the HDGL furnace and when producing thick/high strength material. In these cases, the weld seam fractures can cause much more damage to the line than ordinary grades, and it also takes much more time to get the line running again. As the weld seam – or more precisely, the heat affected zone of an IF steel – usually represents the weakest spot of the entire strip (due to coarse grains which cause a dip in the hardness of the material (see Figure 8), the strip is most likely to tear at the weld seam. This is also in accordance with our laboratory tensile tests of IF steels. Higher alloyed steels, like TRIP steels, do not show this dip in hardness, making the weld seam the strongest part of the strip; the laboratory tensile tests showed that the material tears far away from the weld seam. At HDGL No. 7, there have so far been no weld seam fractures caused by laser welding, and more specifically no weld seam fractures in the furnace itself – an excellent performance.

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