Additive manufacturing has experienced rapid development in recent years. The topic appears on the agenda of virtually every laser technology conference, and the large number of trade fairs dedicated to additive manufacturing worldwide is indicative of its growing significance.

Initially, additive manufacturing was mainly used to manufacture prototypes and special components that could not be made using conventional processes. However, it very quickly established itself as a process suitable for small-series production. Today, additive manufacturing has come to play an important role in the manufacturing of turbine blades for the aerospace industry, burners for energy technology and hip implants in the medical technology field, to name just a few applications. Additive manufacturing technologies are also gaining importance in the automotive industry, e.g. for additively manufactured cooling components, battery holders or wheel bearings.

That’s because, until now, the laser-based additive processes of selective laser sintering (SLS) and selective laser melting (SLM) of metals in particular have lacked the essential productivity and ability to meet the most stringent requirements in terms of component quality and sustainable process stability.

“The degree of industrialization is not yet satisfactory”, states Wolfgang Lehmann, Product Manager at RAYLASE, who goes on to explain: “The parameters that characterize a robust industrialized machine, such as an automated calibration option, as well as precision and stability, have not yet reached the level that industry requires for cost-efficient production. In addition, downtimes are still too long. In other words, there’s still plenty of potential to improve.”

Part of the key to overcoming these challenges is to use fast deflection units that are also capable of adjusting the laser beam focus with maximum flexibility during the manufacturing process.

One such deflection unit is the AM-MODULE NEXT GEN, specially developed by RAYLASE for manufacturing metal components in powder-bed systems. The AM-MODULE NEXT GEN enhances productivity significantly, while simultaneously improving the quality of the components.

However, the challenge is that what may work for small-series production cannot automatically be applied to high-volume industrial manufacturing. Therefore, to meet the rigorous efficiency requirements of mass production, some innovative ideas are called for in relation to scanning heads.
Only a decade ago, 2-axis deflection units with F-Theta lenses were considered state-of-the-art. These are perfectly adequate for processing small fields up to 250 mm x 250 mm. As mentioned earlier, however, the market situation has evolved considerably in recent times. RAYLASE has been supplying customers in the additive manufacturing sector for years. As part of its restructuring and the new strategic direction, RAYLASE has focused to a greater extent on the additive manufacturing market since 2015, as well as exchanging information with customers about the challenges this market presents. One result of this extensive collaboration with customers was that RAYLASE was able to clearly identify that additive manufacturing in connection with large working fields and simultaneous parallelization of laser beams and homogenized power input is one of the largest growth markets.

As Wolfgang Lehmann explains: “That’s why we decided to include this market as the strategic jewel in the crown of our product portfolio. We worked with customers to create a requirements specification, which served as a basis for developing our AM-MODULE. It was with great pride that we presented the first prototype at FORMNEXT 2016.”

The zoom axis in the AM-MODULE NEXT GEN offers extremely dynamic magnification control for the spot diameter, enabling the adjustment of fields between 250 mm x 250 mm and 600 mm x 600 mm.

**THE SIZE OF THE LASER BEAM FOCUS CAN BE ADJUSTED**

The benefit of the new technology in the AM-MODULE NEXT GEN is that, in selective laser melting, the deflection unit directs the laser beam track-by-track over a powder bed. The laser beam melts the powder, which fuses with the layer below and solidifies. The desired component thus gradually emerges layer by layer.

Lehmann describes the manufacturing process as follows: “It’s like painting. First, you draw the contours in pencil, and then you paint the whole picture with thick brush strokes. In a figurative sense, our scanner adjusts the “brush thickness” of the laser beam by changing the focal diameter. However, the power density in the spot remains constant at each point in the working field. As a result, the edge precision of the finished workpiece is no more than a few µm, even for large components.”

**USING MULTIPLE LASERS SIMULTANEOUSLY ENHANCES PRODUCTIVITY AND COMPONENT QUALITY**

If you combine four AM-MODULE NEXT GEN, 4 laser beams can run in parallel and simultaneously process fields measuring 400 mm x 400 mm. This increases manufacturing speed by a factor of four.

Another major advance is that, with this kind of setup involving multiple AM-MODULE NEXT GEN, a second or third laser beam can be used to accelerate the process by heating up the melt product. Currently, a single laser melts the metal powder selectively at a melting temperature of 1,500°C, for example. Just a few millimeters away, however, the temperature is still around 500°C – giving rise to a temperature gradient, which increase the risk of crack formation during cooling. The risk is reduced if energy is emitted by multiple lasers, making the gradient less steep.

"We can place the laser tracks next to one another with a very high degree of precision – less than 5 µm", says Lehmann.
The width of the tracks depends to a large degree on the grain size of the powder particles. This is normally between 15 µm and 60 µm. Accordingly, the spot size must be adjusted. This will be between 40 µm and 150 µm, depending on the size of the working field. With the AM-MODULE NEXT GEN from RAYLASE, you can adjust the spot diameter during the process and double or triple it with maximum flexibility.

**PRECISE ON-SITE PROCESS MONITORING WITH SENSOR FOCUS TRACKING**

The quality of the components depends on the parameters of the laser beam and the smelting process itself. The AM-MODULE NEXT GEN can be enhanced with an optional sensor module, comprising two sensors, to monitor the melting process. What’s unique about this module is that one of the sensors has integrated focus-tracking to compensate for the longer path length the deflected laser beam must travel to reach the material. The focusing unit has more or less the same function as an autofocus lens in a camera.

"No matter what kind of sensor a customer wants, whether it’s pyrometers or photodiodes, a monochromatic camera or a hyperspectral camera – we can offer a suitable autofocus lens for any of these,” Lehmann points out.

A control card – the SP-ICE-3 card from RAYLASE – supports and implements the extensive functions of the AM-MODULE NEXT GEN. It ensures that all necessary axes in an AM-MODULE NEXT GEN, including the optional SENSOR-Module, work in synchronization.

Lehmann highlights that: “The control card works with a 20-bit protocol and can control all necessary axes of an AM-MODULE NEXT GEN with maximum resolution. That makes RAYLASE the only manufacturer to offer a solution package that incorporates:

- Ultradynamic laser focus adjustment,
- processing of large working fields with constant energy input and
- additional process monitoring with focus tracking, enabling inline observation.”

The corresponding software on the SP-ICE-3 control card from RAYLASE reduces laser power when the beam is moving slowly around a sharp curve. If the spot size increases in the corner of the field, the software on the card increases laser power. As a result, the laser power density remains constant.

The control card also serves as an interface card for the software modules that are available for additive manufacturing. An optional converter can transfer the construction job file to the control card. It contains all data that divides the workpiece to be manufactured into many thin layers and which must be processed during the manufacturing process.

At FORMNEXT in November 2017, RAYLASE unveiled the AM-MODULE NEXT GEN, a new digitalized version that has been optimized in response to customer feedback and will be available as of Q2/2018.

**CONCLUSION**

To sum up, the AM-MODULE NEXT GEN can replace existing laser deflection unit systems or be integrated into new generations. These work with several deflection units simultaneously to enable cost-efficient production of large components also. New-generation systems like these offer a high degree of industrialization, stability and failure safety. Inline monitoring can be used to verify the required component quality.