Breaking new ground

Selective Laser Melting (SLM) is a powerful technology that shapes any desired metal part geometry by melting metal powder layer by layer. Using this digital approach, the optimum shape of complex circulation parts can be produced in a single manufacturing step. Such a part not only delivers better performance, it is also more reliable than the complicated assembly it replaces. Furthermore, SLM is the right choice for small metal products, of which thousands can be produced simultaneously. Using this technology, LayerWise offers favourable unit prices and short delivery times. In addition to countless industrial applications, the company manufactures revolutionary orthopedic, maxillofacial and dental implants. The core of LayerWise is producing high-grade parts in any preferred metal alloy using less material and no scrap, reducing unit weight by up to 80%.

• *Rob Snoeijs* •

Metal cutting, milling, EDM (Electrical Discharge Machining) and other high-quality and efficient metalworking processes have a respectable track record on the production floor. Typical for these subtractive methods is that each in their own way is limited in removing part material, despite many tools and accessories.

Design engineers know metalworking processes inside out and take into account their specific limitations up-front. In a way, they design new parts knowing at the back of their minds the production method that will be applied. It would be better if they could concentrate on the functionality of the part to be produced. The geometric limitations of successive metalworking processes force designers to make choices that devaluate the functionality of the part or lead to a complicated assembly instead.

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Building up parts in layers

"At LayerWise we reverse the entire process", says Jonas Van Vaerenbergh, director of the industrial division of LayerWise, a Leuven-based technology firm. "Our core business is Selective Laser Melting (SLM), a technology developed to build up material in layers instead of removing it in different steps. In the meantime, we have optimised the process for a variety of metals and alloys, such as rust-proof steel, hardenable steel, titanium, aluminium and inconel."

in additive manufacturing

In the machine, a high-precision laser is directed to metal powder particles in order to selectively build up a 20 to 40 micron horizontal metal layer. The metal powder particles pinpointed by the laser quickly and fully melt so that the new material properly attaches to the previous layer, without glue or binder liquid.
The powerful fiber laser with high energy intensity operating in the inert area inside the machine guarantees that metal parts being built up exhibit a dense and homogeneous material structure. CAD directly drives the machine without requiring any programming, clamping or tooling. The SLM approach is capable of simultaneously producing metal parts of different shapes in series of up to 2,500 pieces. As this impacts economics favourably, LayerWise is able to offer favourable unit prices and short delivery times.

Unlimited freedom of shape

In addition to producing small components efficiently and cost-effectively, SLM hardly imposes any limitations in terms of geometry. Van Vaerenbergh explains that the layered approach ensures that the laser gains systematic access to any location while building up parts. In this way, the most complex part shapes can be produced, including recesses, ribs, cavities and internal features; see Figure 1. "Usually, the products leaving our facility can not be produced any other way. This is a different ball game for manufacturers because design rules are packed in, removing all obstacles in favour of extreme part optimisation"; see Figure 2.

Take the burner component LayerWise produced for Diametal. Similar to machine manufacturers for food and pharmaceutical companies, this company is regularly challenged with producing complex circulation pieces such as mixers, inlet and outlet components, dispensers, coupling parts and heat exchangers.
The Diametal burner component contains nine undercuttings and six internal cavities. LayerWise applied SLM to manufacture this component as one unit in a single production step; see Figure 3. This is called function integration, because this SLM-produced component replaces multiple parts manufactured using conventional metalworking processes. Assembling these parts takes time, particularly because they need to be connected hermetically, reducing reliability altogether.

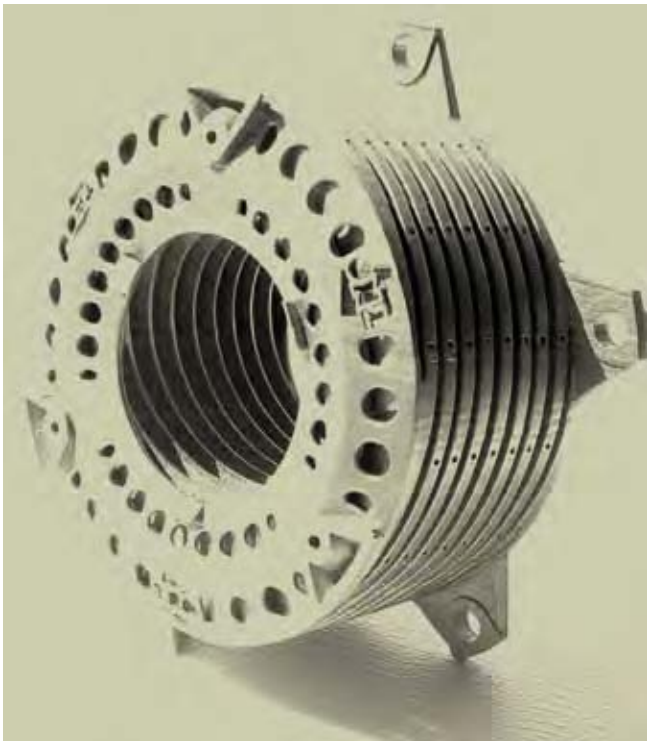

Figure 1. By building up metal parts in layers, the most complex part shapes can be produced, including recesses, ribs, cavities and internal features.

Figure 2. As design rules are packed in, SLM removes all obstacles in favour of extreme part optimisation.

Figure 3. In replacement of a complex assembly, LayerWise produced a single burner component containing nine undercuttings and six internal cavities.

Figure 5. Usually, the products leaving the LayerWise facility can not be produced any other way. Shape complexity is not charged because the production cost is primarily dependent on the weight of the part.

Van Vaerenbergh explains that function integration makes SLM fit for resolving miniaturisation, leakage and assembly issues. “Diametal was not charged for the shape complexity of the part because the production cost is dependent on the weight of the part, showing that SLM offers superior products at a reasonable cost.”

Optimising circulation channels

A perfect example of efficient and flexible design was the production of a component that connects cooling ducts. Firstly, the additive manufacturing process realised 75% weight reduction. Secondly, designers were able to drastically reduce flow resistance by defining channel geometry using freeform surfaces. LayerWise produced the part exactly according to the functional CAD design, resulting in an improvement of the circulation properties by 80%.

According to Van Vaerenbergh, also the manufacture of injection mould inserts yields impressive results; see Figure 4. “Thanks to SLM’s freedom of shape, the cooling channels can be positioned in conformity with the mould shape. This is a major improvement compared to conventionally drilled holes. Optimised channel geometry and location ensure a better controlled cooling process that delivers higher-quality parts that do not warp and contain fewer hot spots. Imagine the economic advantage of reducing the serial production cycle time of moulded plastic parts by 15%.”

Figure 4. Injection moulding quality and speed can be increased by producing injection mould inserts with optimal cooling channels.

Boundaries of technology

LayerWise is the first production centre in Belgium that exclusively focuses on this additive production process for metal parts. The company was founded by Jonas Van Vaerenbergh and Peter Mercelis; both were closely involved in the development of Selective Laser Melting at K.U.Leuven University. LayerWise intensively collaborates with the university, and systematically invests 30% of its resources in Research and Development to push the boundaries of the technology.

“By bringing together technological expertise, production capacity and customer support, LayerWise occupies a unique position on a European level”, Van Vaerenbergh claims. “Our engineers control SLM to such an extent that they are capable of perfecting the technology and realise the most challenging specifications. Today we are able to produce with 15 micron geometric accuracy and build up walls as thin as 0.2 millimeters, which is extremely difficult – if not impossible – using conventional technologies. Also the implementation of process control tools in and around the melting zone is important to guarantee highest part quality”; see Figure 5.

By acquiring full control over the production process, LayerWise achieves a homogeneous microstructure with a relative density of up to 99.98%, for an increasing number of metals and alloys. Research shows that the mechanical properties are virtually the same as those of conventional metals. To prove this, LayerWise systematically carries out mechanical tests regarding density, hardness, elongation and fatigue. In advance, the chemical composition of the bulk metal powders is examined in a chemical laboratory.

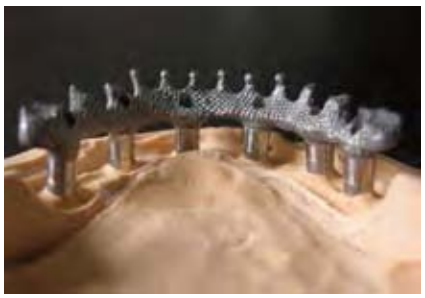

Figure 6. Through patented DentWise technology, geometry and surface retention related limitations set by traditionally moulded or milled suprastructures no longer apply.

Figure 7. The complex shape of a zygoma implant was digitally derived through medical imaging and produced using SLM technology.

Figure 8. Personalised orthopedic protheses are generally produced in titanium, equipped with a fine surface geometry that actively encourages surface retention (Photos courtesy of Mobelife).

Unattended production

The machinery of LayerWise consists of top-quality systems that run around the clock. Quickly producing prototypes is possible, but this activity is usually a leg up to serial production. As CAD files are directly converted into three-dimensional geometry, SLM is a cost-effective metalworking process that allows for unattended production.
After parts are taken out of the production machines, finishing actions start. If desired, conventional metalworking actions can be applied, such as drilling, cutting and EDM. It is also possible to have certain components surface-hardened. As a concluding step, customers can opt for a high-gloss polishing finish.

Dental suprastructures

LayerWise is also heavily involved in medical industries, for which the company manufactures implant-supported suprastructures, for example. On the basis of patient-specific geometry data, acquired through medical imaging or three-dimensional scanning, the personalised structure is designed in software and printed in titanium straight away. As a concluding step, the dental technician finishes off the structure and completes the final prothesis.
“Through digital SLM technology, geometry and surface retention related limitations set by traditionally moulded or milled suprastructures no longer apply”, says Peter Mercelis, director of the LayerWise medical division. “In addition, the implant connections are completed with highest precision”; see Figure 6. DentWise suprastructures are manufactured using ultra-strong titanium alloy (Ti6Al4V, grade V), which outperforms the commonly used titanium grade II in terms of mechanical properties.

Implants

There are more medical applications LayerWise specialises in. During a major maxillofacial (i.e., related to the upper jaw and face) reconstruction, surgeons inserted an implant (the so-called zygoma) manufactured by LayerWise; see Figure 7. The complex shape of the implant was digitally derived through medical imaging and produced using SLM technology. This approach offers the ability to restore the facial symmetry of patients nearly perfectly.

Concerning orthopedic implants, the process of building up metal in layers offers the possibility to design porous bone-replacing structures and integrate them into protheses. This allows for an excellent long-term fixation; see Figure 8. In addition to personalised implants, designed on the basis of medical imaging, SLM technology is used for manufacturing medical instrumentation. For this purpose, LayerWise offers a number of biocompatible metal alloys.

Growing along with the technology

Two years after its inception, LayerWise has grown considerably. Recently, the company appointed a number of European distributors. This is part of the strategy to gradually operate on an international scale. “After propagating the SLM technology and its advantages to different industries, companies now realise that they can truly benefit from the technology”, concludes industrial division director of LayerWise, Jonas Van Vaerenbergh. “Additive metalworking processes change design and production rules completely. By realising projects together with customers, we offer companies plenty of opportunity to create more added value and produce more cost-effectively.”