TEKNOLOGISK
INSTITUT

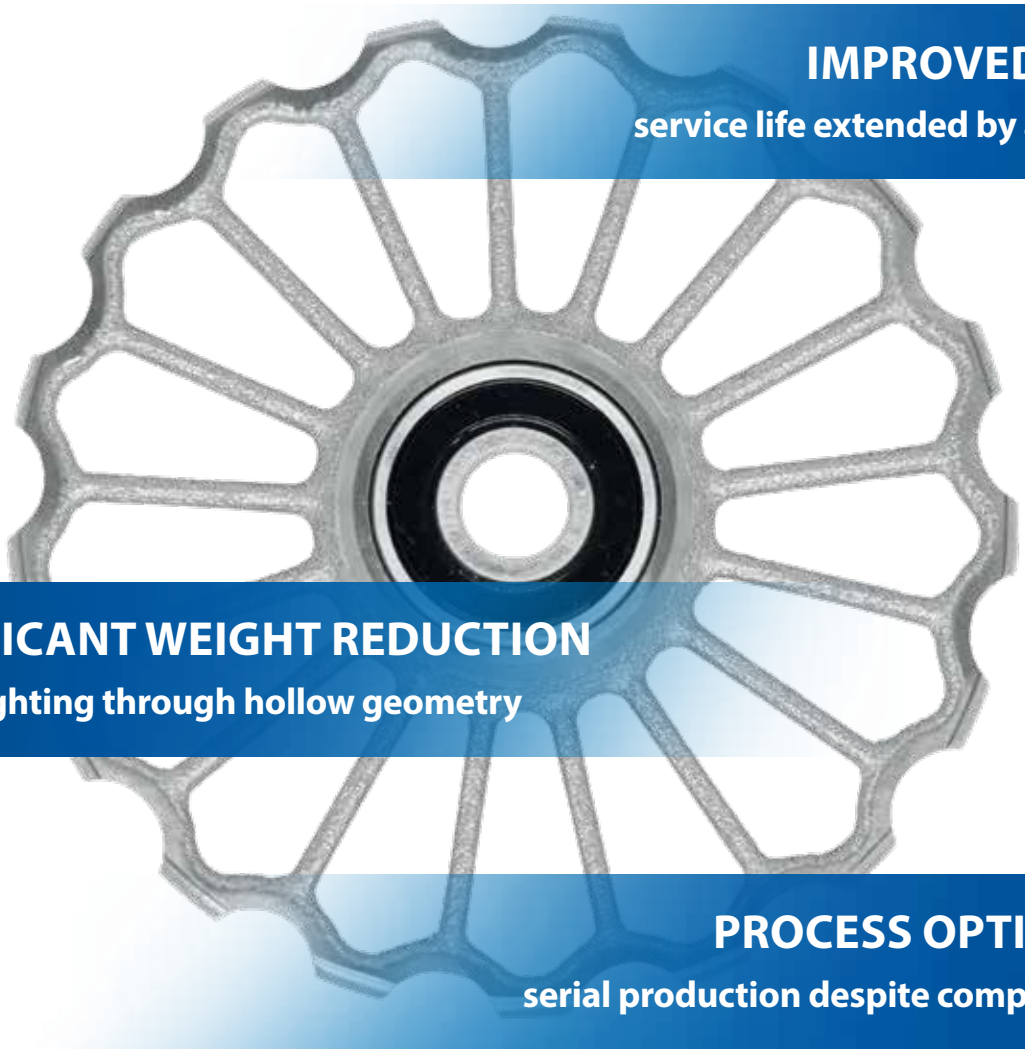
SLM SOLUTIONS

Case Study

Additively Manufactured Pulley Wheels

Innovative solutions using 3D printing in race cycling

3D-Printing Success Story



IMPROVED QUALITY

service life extended by a factor of 3-5

SIGNIFICANT WEIGHT REDUCTION

lightweighting through hollow geometry

PROCESS OPTIMIZATION

serial production despite complex structures

Part Data

Name:	Pulley Wheel
Industry:	Cycling
Material:	Titanium
Layer Thickness:	60 µm
Build time:	21,5 h (full load, 120 pieces)
Machine:	SLM®500

SLM® 500

Current Situation

Innovative Technologies in Race Cycling

Cycling applies the same lightweighting requirements as the broader mobility sector and long-haul races, like the 3,460 kilometer Tour de France, offer unique engineering challenges to optimize weight while maintaining resiliency over the course of the race. In cooperation with the selective laser melting experts at the Danish Technological Institute (DTI), the cycling innovating company CeramicSpeed developed a lightweight, yet durable pulley wheel used by professional cyclists for improved performance.

The global cycle market is driven by innovations and to stay at the forefront of the industry CeramicSpeed, who revolutionized races by introducing ceramic bearings to professional cycling, entered into a partnership with the DTI. With a quad-laser SLM®500 and twin-laser SLM®280 metal additive manufacturing system, the institute has been successfully utilizing selective laser melting for years, making them the perfect partner to optimize development. The results yielded the world's lightest gear wheel, the so-called titanium pulley wheels, developed by the two partners working together with race-condition testing from professional riders racing in the Tour de France.

Innovations with Selective Laser Melting

High Performance Through Additive Manfuacturing

Built in titanium on the SLM®500 metal additive manufacturing machine, the pulleys are equipped with 17 spokes, each with a diameter of 2 mm and a wall thickness of only 0.4 mm. Due to the hollow design, it was possible to reduce the total weight of the sprocket to 8.4 grams. The overall power savings system reach 30%-60%, or more in some cases, over a stock setup. The optimized pulley wheels have 3-5 times longer lifetime than the commonly used standard pulleys on the market. Thor Bramsen, Industrialization Manager at the Danish Technological Institute is enthusiastic about the possibilities of the SLM® technology, stating, „The hollow geometry of the objects cannot be produced with conventional methods, and the 3D printing in combination with subsequent specialized processes leads to a unique, innovative product." Despite the complex geometry, DTI is able to reliably build the same quality parts in serial production.

„3D printing technology has given us a lot of leeway to experiment creatively with design, while at the same time being able to optimize a product's function," Carsten Ebbesen, R&D Manager at CeramicSpeed stated. "The collaboration with DTI has led us to develop and produce gears in a radically new design form that is only possible with 3D printing."

The gears produced with the selective laser melting process have also withstood rigorous tests to prove their quality. The pulley wheels are placed on the outer gears in the gearshift and subjected to wear. CeramicSpeed's R&D department have tested the wear on the printed

titanium parts, which proved to be more durable, corrosion resistant and yielded a higher strength at a lower density than traditional aluminium parts.

To offer serial production of a high-quality, additively manufactured product, the entire process chain must be coordinated. This includes the robust, reliable, additive manufacturing machines from SLM Solutions, but the process begins with the component redesign for the additive process. DTI utilized Design for Additive Manufacturing (DfAM) to optimize the original product design from CeramicSpeed for serial production with the selective laser melting technology. This process is a delicate mix of not changing function of the customer's design while adding material for surfaces that require CNC machining after the print, optimizing support, and minimizing wall thickness and weight. After successful production, the equally challenging, yet important post-processing steps take place, where the Danish Technological Institute uses its entire range of manufacturing knowledge, ensuring that the only assembly required is when the finished product is delivered.

The first ceramic bearings from CeramicSpeed were introduced to the Tour de France less than 20 years ago. The innovation of design provided by selective laser melting and their partnership with the production experts at the Danish Technological Institute help the company continue to push boundaries of cycling technology and are helping set new standards as riders test the latest advancements in their training to be the next to debut new innovations at future races.

Fig. 1
The gears produced with the selective laser melting process have also withstood rigorous tests to prove their quality

Summary

Additively Manufactured Pulley Wheels

- In cooperation with the selective laser melting experts at the Danish Technological Institute, the cycling innovating company CeramicSpeed developed a lightweight, yet durable titanium pulley wheel
- The hollow geometry reduces the weight of the sprocket
- The printed titanium parts proved to be more durable, stronger at low density and suitable for corrosion resistance than traditional aluminium parts
- Despite the complex geometry selective laser melting enables the pulley to be built in a reproducable quality in serial production

Danish Technological Institute

The Danish Technological Institute - DTI - is a leading research and technology institute employing more than 1,000 specialists that help over 10,000 customers from 65 different countries each year. DTI prides itself on being a multi-disciplinary institute where challenges are approached in an innovative manner, tapping into their various specialties to find the best-suited solution. The Institute is structured into seven divisons of expertise; production & innovation, materials, life science, energy and climate, agro technology, building and construction and meat research.

In the DTI Center for Industrial 3D printing, 30 years of experience with additive manufacturing is available, from the development of prototypes and small series to the use of additive manufacturing as an integrated part of the production chain. The modern laboratory in Aarhus offers 3D-printed components in a range of materials, from metal and plastic to ceramics and wax, utilizing a wide variety of additive manufacturing technologies to tailor a solution that perfectly fits customers' needs.

SLM Solutions - Technology Pioneers, Innovation Leaders

SLM Solutions helped invent the laser powder bed fusion process, was the first to offer multi-laser systems and all selective laser melting machines offer patented quality, safety and productivity features. Taking a vested interest in customers' long-term success in metal additive manufacturing, SLM Solutions' experts work with customers at each stage of the process to provide support and knowledge-sharing that elevate use of the technology and ensure customers' return on investment is maximized. Optimal paired with SLM Solutions' software, powder and quality assurance products, the SLM® technology opens new geometric freedoms that can enable lightweight construction, integrate internal cooling channels or decrease time to market.

A publicly traded company, SLM Solutions Group AG focuses exclusively on metal additive manufacturing and is headquartered in Germany with offices in China, France, India, Italy, Russia, Singapore and the United States and a network of global sales partners.





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