CASE STUDY

NIKON SLM SOLUTIONS AND WÄRTSILÄ WITH NTOPOLOGY AND OQTON

THE CREATION OF A CUTTING-EDGE AM-BUILT IMPELLER FOR THE MARINE INDUSTRY

OQTON

Nikon SLM SOLUTIONS

WÄRTSILÄ

nTopology

A Nikon Company Nikon

WÄRTSILÄ

Wärtsilä required a robust impeller that would push the limits of design and functionality. Today, after being tested for 500 hours under incredibly rigorous testing, the results are clear — They have made a lighter, more efficient, AM-built application that opens up new business potential for the engineering giant.

Figure 1: The final impeller built with Free Float on SLM®280 PS.

THE **CHALLENGE**

Pump impellers are widely used in the energy industry for fluid transportation. The varying use cases — depending on their needs — require a significant level of customization. Because of this, they are produced in large numbers and kept in storage as backups. This avoids long lead times of up to 20 weeks in case of failure and guarantees uptime for a part crucial to the company's capital.

THE **SOLUTION**

With additive manufacturing, applications can be printed on demand, reducing waste from having to overproduce to make things financially viable. This also reduces lead times, and the need for storage can be minimized through digital inventories, on-premises manufacturing, and higher part-performing parts. In addition, additive manufacturing can disclose new business models and solutions in the spare parts business, such as cutting out prototyping by casting.

THE **COLLABORATION**

To create the impeller, the project used the synergy of four major players in their respective fields: Wärtsilä, Nikon SLM Solutions, nTopology, and Oqton. Together, they empowered a modern innovation that would create an exceptional solution. On top of this, the four companies opened the door for new possibilities through their collaboration, allowing each other to learn from their expertise and knowledge.

WÄRTSILÄ + nTopology + OQTON + Nikon SLM SOLUTIONS

THE **APPLICATION**

AN AM-BUILT IMPELLER FOR THE MARINE INDUSTRY

There was a shared interest between the companies involved in pushing the technology's boundaries. It began with a functional redesign that would create weight reduction provided by nTopology software and the decision to realize the application on an SLM®280 PS. Further, the geometrical accuracy was increased through the pre-deformation of the simulated model with Amphyon. Combining the power of these technologies, the pump impeller was not only as light and resilient as the existing part but massively reduced the lifetime cycle/lead-time.

In addition to the quick availability, the new part design will allow improvements to the system. This efficiency update can play a significant role in the energy sector by extending its technologies using additive manufacturing. Wärtsilä is open to new business opportunities arising from this.

While avoiding the need for prototyping by casting — which includes the requirement of tooling parts that cost tens of thousands of euros — the fast design and printing process allowed Nikon SLM Solutions to overcome the traditional life cycle and led to an early testing phase.

During this phase, the requirements of the pump impeller were tested in a real-scale laboratory engine with multiple measurements to indicate the performance level of the part. Real environmental conditions, such as 120 °C temperature and rotational speed over 2600 rpm, were applied to validate the prototypes.

The impeller was tested at different engine loads for more than 500 hours. After the test, no signs of wear and defects were detected, demonstrating the high performance of the material used.

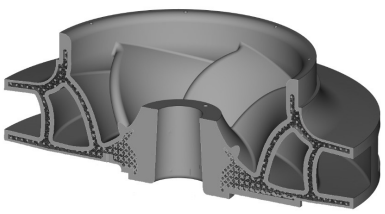


Figure 2: Cross-section of the second iteration of the impeller (light design)with a **40% weight reduction.**

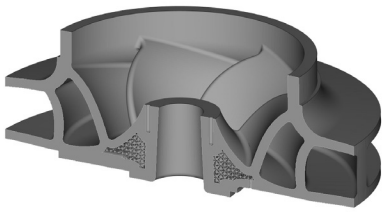


Figure 3: Cross-section of the first iteration of the impeller (heavy design) with a **5% weight reduction.**

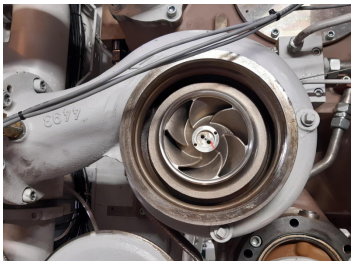


Figure 4: Picture of the tested impeller (heavy design) with a **5% weight reduction** after 500h testing on a real-scale Wärtsilä laboratory engine.

THE **INNOVATION**

The design process used the nTopology software, which offered the possibility of generating a complex lattice structure within the impeller and aligning it with the cylindrical axis, complementing the impeller design's rotational nature. Furthermore, it allows field-driven design enabling the performance of structural analysis on the impeller to variably hollow and thicken the interior lattice beam thickness based on stress results. This gave the impeller the identical resilience as the original part, only lighter in weight.

In addition to the advanced modeling software by nTopology, Nikon SLM Solutions used a unique software that has been developed to overcome the barrier of printing surfaces with an angle less than 45 degrees: Free Float. Smart vector enables the capability of printing surfaces with an angle of 20 degrees for the application's chosen material, IN718. Typically, surfaces with such angles require a supportive structure to be removed during post-processing. With a complex part such as a pump impeller, eliminating the supports with tools can be difficult due to nooks. Therefore, less material consumption is needed, resulting in less post-processing, both of which contribute to the productivity of the part.

THE TECH

SLM®280 PS

THE DUAL-LASER TRAILBLAZER

Featuring multiple lasers, closed-loop powder handling, and upgraded process control, the SLM®280 PS is ideal for demanding applications requiring high productivity.

Figure 5: The SLM®280 PS

FREE FLOAT

NOT JUST ANOTHER "ME TOO" TECH TERM

Free Float's breakthrough technology empowers the creation of previously impossible designs and fewer costs by eliminating support structures and allowing more complex designs. It brings together the best of the best, culminating in a fully proven and validated functional part.

INCONEL 718

HIGH STRENGTH AND CORROSION RESISTANT.

Nickel-based superalloys have been specifically designed to withstand extreme conditions in which other materials already fail. One of the most popular nickel-based superalloys is the precipitation-hardenable IN718. Whether static or dynamic loads, close to absolute zero or above 700 °C, corrosion, or creep – IN718 was made for these specifications while maintaining good weldability. This profile of properties makes IN718 an excellent choice for rocket and aircraft components, stationary gas turbines, or automotive exhaust systems.

MATERIAL CHARACTERISTICS

- High strenght
- Good ductility
- Excellent mechanical properties up to to 700°C
- Excellent oxidation resistance

TYPICAL APPLICATION AREAS

- Aerospace
- Energy
- Chemical industry
- Turbine parts

DFAM

UNLOCKING THE TRUE POTENTIAL OF METAL AM

The internal geometry and lattice design followed two goals: to reduce weight while withstanding the required forces and creating stable AM process conditions. With nTopology and its field-driven design, we optimized the design quickly and came up with an optimal solution. The simulations minimize the wall thickness by considering lattices for carrying stresses.

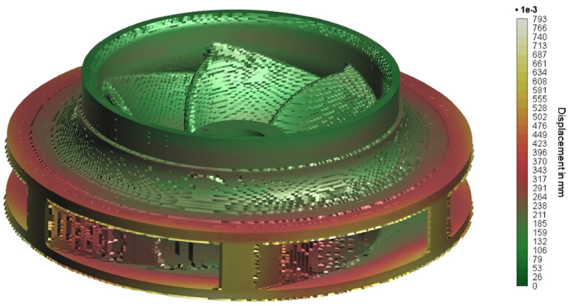
With the field-driven design of nTopology, the lattice's thickness was scaled to these stresses easily. To further maximize the performance of the impeller, the lattice is rotationally symmetric around the rotation axis to keep the part balanced while in use.

nTopology

With the contribution of nTopology, the collaboration included a software company building the next generation of engineering design tools for advanced manufacturing. With their vision that almost every physical object starts with engineering software, the project gained an expert in the design process and enhanced it.

OQTON

Oqton's simulation software Amphyon (formerly called Additive Works Amphyon) enabled Nikon SLM Solutions to achieve a dimensionally accurate part to maximize its characteristics. The deformation of the component was calculated using the mechanical process simulation, considering the thermal stresses of the build process, stress relief, and support removal. Instead of meshing the complex lattice structures, a new homogenization approach was used, reducing the calculation time significantly. The entire analysis was performed within 1h 35min on a regular CAD workstation.



By creating a distortion-compensated (pre-deformed) model, a near-net-shape lightweight part with supreme properties could be delivered.

THE **FACTS**

- Nikon SLM Solutions successfully built Wärtsilä's impeller on the SLM®280 PS in its application center in Germany using Free Float
- Nikon SLM Solutions stress tested the application under extreme conditions to simulate real-life stress scenarios
- Free Float was used with complex data, allowing the impeller massive weight reductions
- A five percent weight reduction was achieved on IMP1
- A 40 percent weight reduction was achieved on IMP2
- Wärtsilä conducted a 500h testbench run under real-life conditions. IMP1 passed successfully, and IMP2 is currently being tested.
- Free Float and DfAM achieved incredible weight savings and efficiency gains.
- Geometrical deviations were below 400µm due to the usage of the distortion-compensated model.

THE **COMMENTS**

> **This work has demonstrated the power of sharing top-notch expertise of different companies working on a common goal. This impeller has disclosed several technical innovations and provided beneficial values to the final application on marine engines. We have achieved a lightweight component we would have never imagined creating before this project, and this application creates new sparks for more AM applications in the marine industry.**

-Francesco Trevisan, Wärtsilä

> **Nikon SLM Solutions and Wartsila have benefitted from a long-time collaboration to create new parts for the energy industry using innovative additive manufacturing technology. This specific project was one of the first to use this new capability for complex designs of impellers. With this technology, we can now print challenging rotating parts, significantly reducing the manufacturing lead time and post-processing cost.**

-Fabrizio Ragusa, Nikon SLM Solutions

We have achieved a lightweight component we would have never imagined creating before this project. This application creates new sparks for more AM applications in the marine industry.

-Juho Raukola, Wärtsilä

With the shared knowledge of the four companies, we created an application that takes AM in the Energy Sector to the next level. The combination of innovative new tools in the field of design, predeformation and production generated a part that stands out on many levels. Minimized weight, maximized performance and a lead time of just days are all combined in one part.

-Lorenz Kropholler, Nikon SLM Solutions

Free Float is yet another game-changer that allows for breathtaking designs while leveraging AM's intrinsic weight savings. Now proven and validated by a very sophisticated end-user. Relying on the most mature mid-size multi-laser metal AM machine in the market.

-Benjamin Haas, Nikon SLM Solutions

WÄRTSILÄ

Wärtsilä is a global leader in innovative technologies and lifecycle solutions for the marine and energy markets. We emphasize innovation in sustainable technology and services to help our customers continuously improve their environmental and economic performance. Our dedicated and passionate team of 17,000 professionals in more than 200 locations in 68 countries shape the decarbonization transformation of our industries across the globe. In 2021, Wärtsilä's net sales totaled EUR 4.8 billion. Wärtsilä is listed on Nasdaq Helsinki.

NIKON SLM SOLUTIONS

Nikon SLM Solutions is an integrated solutions provider and metal additive manufacturing partner. The company is vested in customers' long-term success with metal additive manufacturing. Robust Selective Laser Melting machines optimize fast, reliable, and cost-efficient part production and Nikon SLM Solutions' experts work with customers at each stage of the process to provide the support that elevates the use of the technology and ensures their return on investment is maximized. A publicly traded company, Nikon SLM Solutions AG is headquartered in Germany, with offices in Canada, China, France, India, Italy, Japan, Singapore, South Korea, and the United States.

Further information is available on
www.nikon-slm-solutions.com