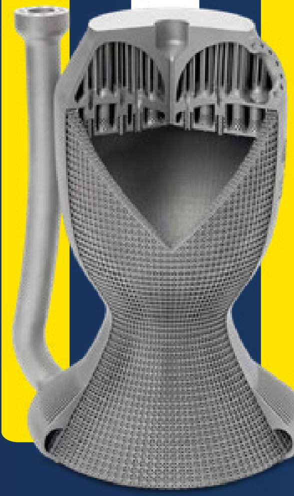


CASE STUDY

MONOLITHICTHRUST CHAMBER

ADDITIVE DESIGN OPTIMIZATION
WITH CELLCORE GMBH

Nikon SLM SOLUTIONS

A Nikon Company Nikon

3D-PRINTING **SUCCESS STORY**

WEIGHT REDUCTION WITH STRUCTURAL SUPPORT LATTICE

IMPROVED FUNCTION **COOLING THROUGH INTEGRATED LATTICE**

PART DATA

Designation:	Monolithic Thrust Chamber
Industry:	Aerospace
Material:	IN718
Layer Thickness:	30 µm
Build Time:	3d 5h 34 min (full load, 1 piece)
Machine:	SLM®280

CURRENT SITUATION

ROCKET PROPULSION ENGINE: SINGLE-PIECE THRUST CHAMBER AND INJECTOR

The manufacture of rocket components requires many criteria factors be taken into consideration. Not only is consequent, lightweight construction, essential, materials must also be able to: withstand particularly high stresses and temperatures. Additionally, the manufacturing costs for their complex geometries are very high when limited to conventional manufacturing processes.

The engine manufactured by CellCore and Nikon SLM Solutions consists of a thrust chamber, the core element of a liquid-propellant engine with a combustion chamber wall, fuel Inlet and an injection head with oxidant inlet. The chemical reaction in the combustion chamber creates gas that expands due to the heat development that is then ejected with enormous force, generating the thrust required to drive the rocket through recoil Extremely high temperatures are created in the chamber during the combustion process, requiring the wall to be cooled to prevent it from burning, too.

To achieve this, the liquid fuel (e.g. kerosene or hydrogen) is fed upwards through cooling ducts) in the combustion chamber wall before entering through the injection head. There, the fuel mixes with the oxidant and is lit by a spark plug in conventional constructions, the cooling ducts are countersunk in a blank and subsequently sealed through multiple working steps. With selective laser melting, the cooling is integrated into the wall as part of the design and created together with the chamber in one process. Due- to the engine's complexity, the traditional. manufacturing process is cost-intensive, requiring half a year minimum. In the 3D printed engine, CellCore demonstrates the possibilities, the Nikon SLM® technology can ofer for the aerospace industry, as the additive manufacturing process takes fewer than five days to build, while creating a functionally optimized component.

INNOVATIONS WITH SELECTIVE LASER MELTING

FILIGREE STRUCTURAL COOLING TO INCREASE EFCIENCY

The single-piece rocket propulsion engine, combining the injector and thrust chamber, reduces numerous individual components into one. with multi-functional lightweight construction achievable only with the selective laser melting process.

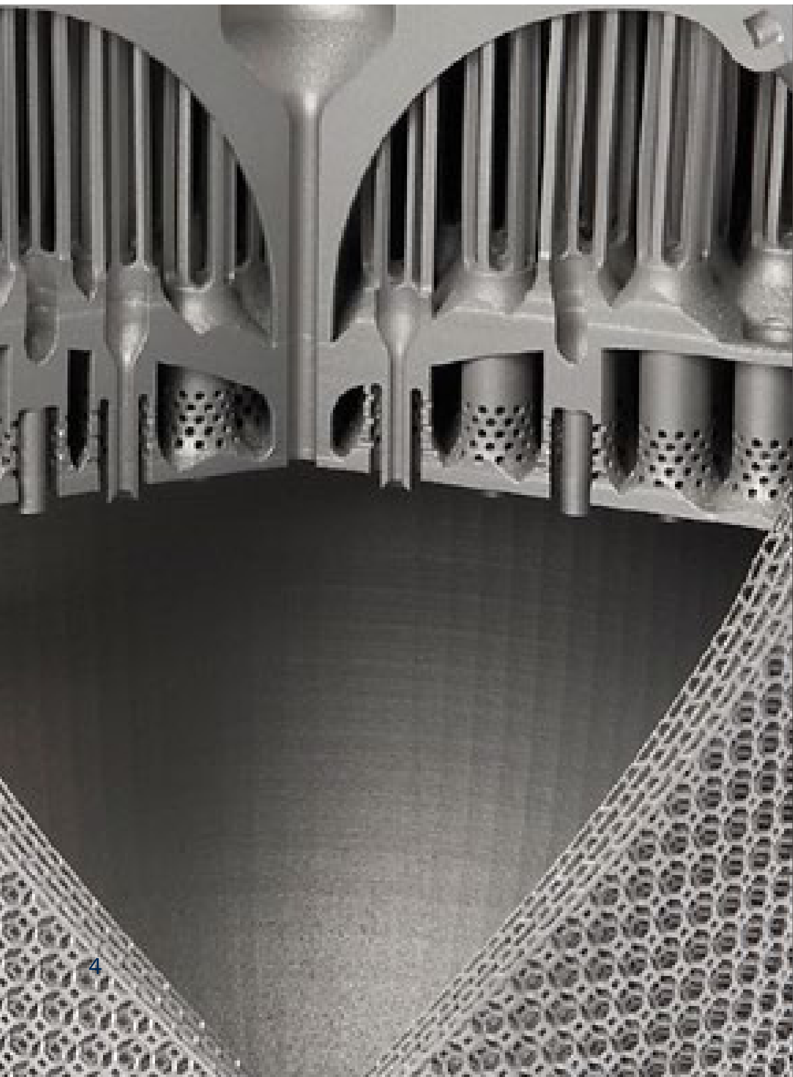
The internal structure developed by CellCore is the fundamental element of the engine and cannot be manufactured by traditional methods. It is not only suited for heat transport, but also Improves the structural stability of the component.

The cooling properties of the CellCore design considerably outperform conventional approaches, such as right-angled, concentrically running cooling ducts. It ofers an optimized relationship between stability and mass application and exhibits low current resistance with a simultaneously high reaction surface, making it more efcient while integrating additional functions and reducing weight compared to conventionally manufactured components.

Nikon SLM Solutions collaborated with CellCore in the preparation of this highly complex component to ensure success by optimizing the selective laser melting process. Nikon SLM Solutions customer success team developed specifc parameters for the geometry, focusing on downskin optimization. Build plate orientation was recommended after consultation with the Nikon SLM Solutions application engineering team and critical sections of the part were identifed for test-builds to guarantee success of the manufacturing job. To satisfy the aerospace industry's high material requirements, the engine was manufactured in the nickel superalloy IN718 on the SLM®280 selective laser melting machine.

IN718 is a precipitation hardening nickel-chromium alloy with exceptional tensile, fatigue, creep and breaking strength up to 700°C, making it an important material for aircraft and gas turbine components, as well as numerous other high-temperature applications, such as rocket propulsion engines. When processed conventionally, the hard material is difcult to machine and causes extreme tool wear. This concern is mitigated through the additive process, as powder material is melted into the end-geometry.

Despite its complex structure, post-processing is minimized, thus avoiding high levels of tool wear. Nikon SLM technology saves considerable costs by reducing expensive, time-consuming manufacturing steps and simplifying the engine's structure. Selective laser melting ofers aerospace companies the opportunity to increase their competitive position by optimizing rocket system functionality while maintaining exceptional quality, as well as lightweighting and drastically reducing development, testing and production timeframes.



SUMMARY

- Simplified manufacturing: Minimal post- processing despite complex structure to avoid tooling wear when processing to difcult to machine nickel based alloy (IN718)
- Innovation: Direct integration of multiple parts and internal features, e.g. internal ducts
- Improved function: Cooling due to innovative lattice structure, which also increases stability
- Efficiency: Minimization of individual process steps while combining multiple individual parts into one component; production time reduced from months to days
- Lightweight construction: Considerable weight reduction due to lattice structures

CELLCORE GMBH

CellCore is a start-up engineering firm from Berlin specializing in a new kind of engineering and design for components and products. Their bionic engineering draws on highly efcient and evolutionarily optimized natural structural principles and applies these to technology. In its role as a development partner, CellCore creates innovative solutions for individual applications and ideas when conventional approaches encounter dead ends. Their core expertise lies in calculating and constructing cellularstructures that combine with form-optimized outer contours that are tailored and adjusted to the specifc application.

Through the design of a thrust chamber for a rocket propulsion engine, CellCore demonstrates the advantages of the selective laser melting process and how they are used in the aerospace industry. Printed in a nickel-based superalloy, the monolithic component was created in collaboration with Nikon SLM Solutions.

NIKON SLM SOLUTIONS

Nikon SLM Solutions helped invent the laser powder bed fusion process, was the frst to ofer multi- laser systems and all selective laser melting machines ofer patented quality, safety and productivity features. Taking a vested interest in customers' long-term success in metal additive manufacturing, Nikon 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 Nikon SLM Solutions' software, powder and quality assurance products, the Nikon SLM technology opens new geometric freedoms that can enable lightweight construction, integrate internal cooling channels or decrease time to market.

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

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

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