3D-PRINTED CASTING CORES FOR THE AERONAUTICAL AND INDUSTRIAL GAS TURBINE MARKET

The aerospace and power industries are continually seeking to produce turbine blade designs with more complex internal cooling channels in order to improve the working temperature and hence the engine efficiency.

In order to form the complex internal cooling channels during the casting of metal turbine blades, a ceramic core is necessary. Once solidified, the casting is removed from the mould and the ceramic core is dissolved.

The more recent casting core designs are so complex that the conventional ceramic injection moulding (CIM) technology could not produce them in one piece. The LCM technology allows for the production of more efficient designs that cannot currently be produced by conventional manufacturing technology- thus, LCM technology offers the aeronautical and IGT-market a solution to meet their increasing design demands.

Furthermore, the LCM-technology offers a fast and low-cost production method for prototypes and small scale series, ultimately allowing for a significantly faster time-to-market period in combination with a shorter product life cycle.

Unlike the conventional manufacturing routes of casting cores by CIM, AM is a toolless manufacturing technology, and it therefore by-passes the costly and laborious fabrication of moulds required in CIM.

MATERIALS FOR 3D-PRINTED CASTING CORES

The LithaCore 450 is a silica-based material used for the production of casting cores by LCM technology.

Typical applications include cores for turbine blades made from nickel-alloys in single crystal (SX), directionally solidified (DS) and equiax casting.

LithaCore 450 was developed for the additive manufacturing of precise ceramic cores with fine details and high accuracy. Sintered ceramic cores made from LithaCore 450 have very low thermal expansion, a high porosity, outstanding surface quality and exceptional leachability.

In addition, the composition of the slurries can be tailored to the customer's individual requirements, allowing a wide range of alloy to be casted.

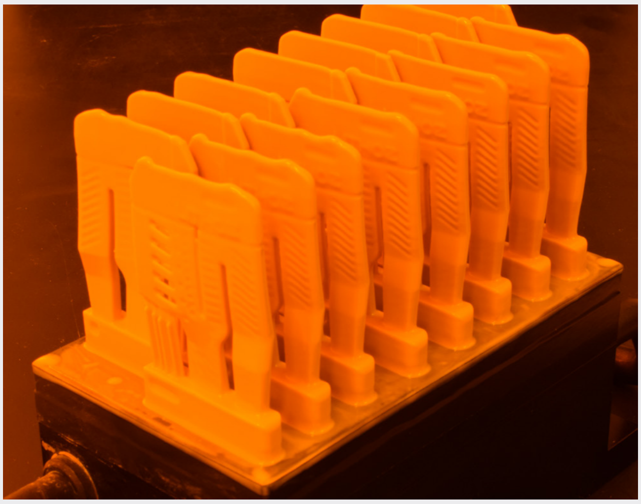

Figure 1: LithaCore 450 casting cores produced on CeraFab System 8500.

KEY ASPECTS OF 3D-PRINTED CASTING CORES

The LCM-technology enables ceramic casting cores to be produced, with complex branching structures and high-precision features such as:

- Outstanding dimensional reproducibility and tolerances
- Sizes up to 300 mm
- Surface roughness of Ra<3 µm, ensuring that internal channels in the final casted alloy have a smooth finish
- Complex shapes with features such as trailing edges at least as fine as 200 µm

DIMENSIONAL TOLERANCES AND REPRODUCIBILITY: A CASE STUDY

LithaCore 450 casting cores were produced using the CeraFab System 8500. The results of a dimensional inspection performed on the cores (Figure 3) reveal a maximum deviation of 0.1 mm from the CAD model, which lies within the expected dimensional compliance for casting cores applications (typically 0.3 mm).
In addition, a comparison of the two casting cores (one with and one without support structures) produced in two different runs was made. The results are shown in Figure 4, and demonstrate an average repeatability in the +/- 0.05 mm range.

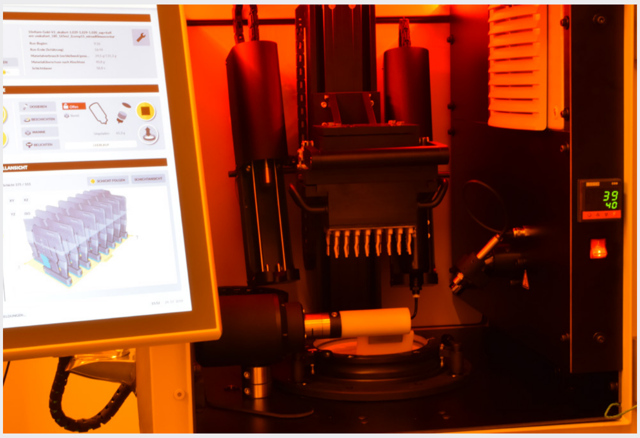

Figure 2: LithaCore 450 casting cores produced on CeraFab System 8500.

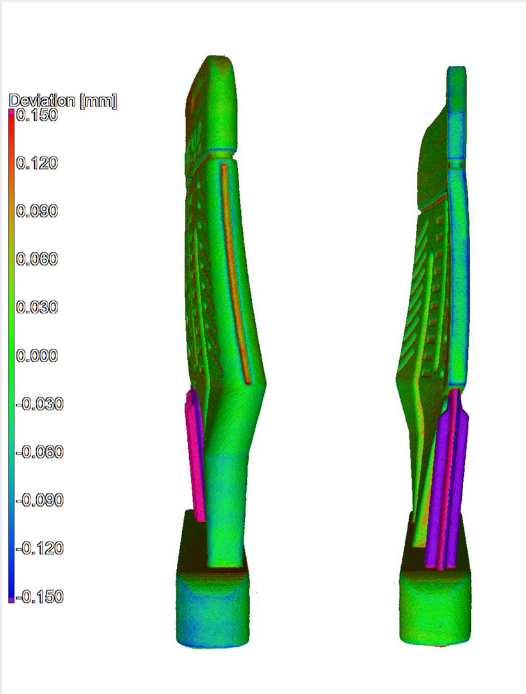

Figure 3: Comparison (side view) between green casting core with supports and STL.

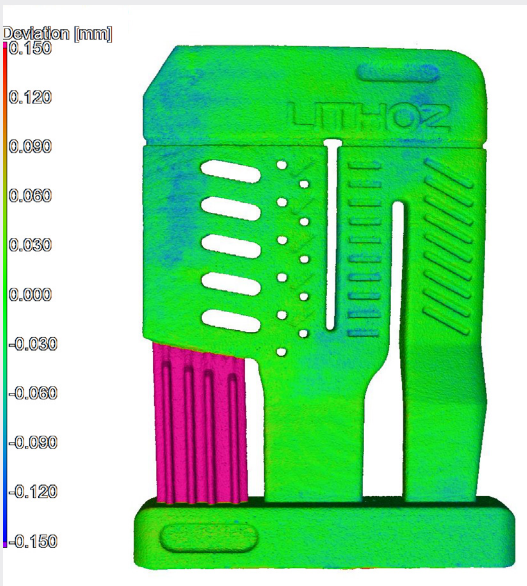

Figure 4: Comparison (front view) of green casting cores with and without support. Casting core without supports used as nominal object.