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# 3D PRINTING TECHNIQUES OF CERAMIC CORES USED FOR TURBINE BLADES MANUFACTURING

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## ABSTRACT

The investment casting using multi-layered ceramic moulds allows manufacturing of geometrically complex components of the aircraft engine, such as turbine blades, vanes and casings. Operating under harsh condition that include high pressure and temperature above 1000˚C cause that the above mentioned elements are usually called critical components of the jet engines. They are mostly made of nickel-based superalloys. High requirements concerning accuracy of shape and dimensions of the cores significantly limit the possibility of producing high quality injection moulds. Nowadays only a several companies in the world are able to produce them with appropriate dimensional accuracy, tolerances and internal standards characterizing the given foundry (assumed wax and metal shrinkage, ceramics working conditions, etc.). The delivery time of these moulds can reach up to even one year. Thus, this led to use of 3D printing technologies in the manufacturing processes of ceramic cores used during lost-wax casting.

***Keywords:*** rapid prototyping, ceramics, aviation, investment casting.

## INTRODUCTION

The aim of the work was to verify the use of 3D printing technology using the LITHOZ CeraFab 8500 printer to produce ceramic cores for the investment casting of critical components of the aircraft engines.

The study included:

1. Roughness survey to compare conventional cores with these produced using 3D printing techniques,
2. Shape and dimensions control by comparing the geometry with the CAD model,
3. Production of wax casting models,
4. Manufacturing of the multilayer ceramic mould,
5. Implementation of vacuum casting process using previously formed mould.

## RESULTS AND CONCLUSIONS

Colour CAD deviation maps show the comparison between the conventional and 3D printed cores (Table 1).

Table 1 - Summary of roughness parameters

| Tapes | 3D printing | Classic injection technique |
|---|---|---|
| Sq (average square surface roughness deviation) | 2.2639 μm | 2.0039 μm |
| Ssk (skewness of ordinates coefficient) | 0.12775 | - 0.12081 |
| Sp (ordinate distribution concentration factor) | 11.467 μm | 13.050 μm |
| Sv (maximum depth of surface recess) | 8.7347 μm | 15.776 μm |
| Sz (ten point height of unevenness of surface) | 16.585 μm | 20.294 μm |
| Sa (arithmetic mean deviation of roughness) | 1.7816 μm | 1.4799 μm |

Based on the results of the research, the following conclusions were made:

1) The surface quality expressed by the roughness parameters specified in the test is acceptable,
2) Shape and dimensions of the cores are acceptable taking into account the influence of the core geometry on thermal processes that occur in the ceramic mould, and thus on the method of thermal insulation for appropriate control of the solidification front, elimination of the casting defects like porosity,
3) The cores were fully etched using standard techniques,
4) No metal/ceramic reaction was observed- lack of reactivity of core material,
5) It is possible to develop an effective industrial 3D printing technology for the production of ceramic casting cores,
6) There is a prospect of using printed ceramic casting cores in the manufacturing of aircraft engine elements by replacing the cores produced by the conventional method.

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