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THE APPLICATION OF GOM MEASUREMENTS FOR THE DETERMINATION OF ACCURACY OF GEAR CASTS MANUFACTURED IN THE RT/RP PROCESS

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ABSTRACT: The article presents possibilities of using optical measurements for defining the geometric accuracy of gear wheels casts manufactured in the rapid prototyping and rapid tooling process. The tested gear wheel prototype was cast using an aluminum alloy. The casting mould was made by means of the three-dimensional print method (3DP) with the use of a Z510 Spectrum device. The aim of the tests was to determine the geometric accuracy of the cast made by the ZCast technology in the rapid tooling process. The tests were conducted with the use of the coordinate optical measuring method and a GOM measuring device. The prototype measurements were made in the scanning mode. The results of the measurements, saved in the STL format with the use of the scanning device software, were compared with the gear wheel 3D-CAD nominal model. The measurements enabled the determination of the real accuracy of prototypes manufactured in RP/RT process.
KEYWORDS: Rapid Prototyping, Rapid Tooling, gear, optical measuring

INTRODUCTION

Rapid prototyping (RP) and rapid tooling (RT) systems are increasingly used in the production of casting components [1-3]. RP systems can be used directly for manufacturing casting moulds. The spectrum of rapid prototyping uses can be expanded by the application of the rapid tooling methods [4]. One of the RT techniques is the direct manufacture of casting moulds using the ZCast technology [5]. The accuracy of gear wheels casts made in printed moulds depends on a variety of technological factors [6]. The accuracy of the cast fabrication quality can be assessed with the use of the coordinate optical measuring technique [6-11]. Literature describes the methods for manufacturing moulds in the ZCast technology, usually omitting the aspect of their dimensional and shape accuracy [12].

The paper presents methodology of proceedings in the process of geometric analysis of gear wheels casted in the forms produced by method RT – Zcast. Measurements were performed using optical measuring method and a GOM measuring device. From respect of the paper capacity the methodology of defining accuracy of RP/RT casted gear wheels prototypes was described omitting numeric and statistical data processing processes in CAD/RP and CMM systems. The results presented in the paper are the part of research period realized within the project "Modern material technologies in aerospace industry", No POIG.0101.02-00-015/08.

CAST MANUFACTURING

The first stage of manufacturing the casting mould was the creation of a gear wheel 3D-CAD model. Next, the gear model was supplemented with a gating system. The mould shape and its parting plane were defined. The last operation was the removal of the gear wheel model (fig.1A) and the gating system from the mould solid. This way, a two-part mould 3D-CAD model was made (fig. 1B and 1C), which was saved in the STL format.

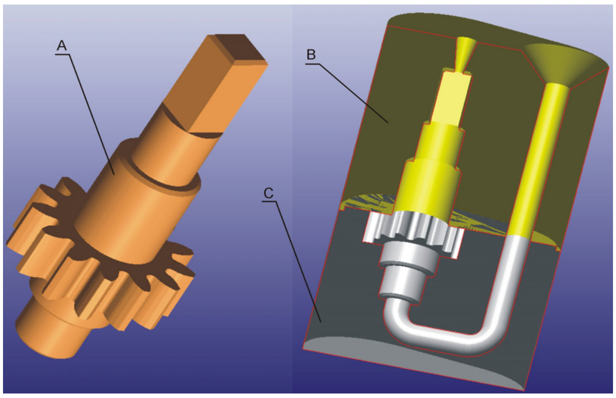

Figure 1 – CAD model of gear wheel (A) and two part of mould model (B and C)

The mould was made with the application of the three-dimensional print method, using a Z510 Spectrum device. The mould was hardened with epoxide resin in the process of infiltration.

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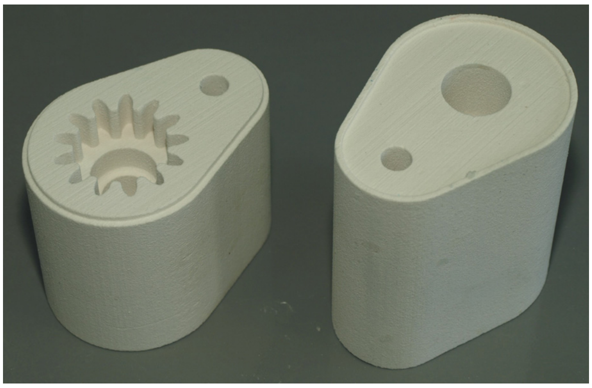

Figure 2 – Casting mould made by the 3DP ZCast method

Figure 3 – Casting process

The preparation of the casting process included heating the mould in 70°C, which caused water to evaporate. Next, the mould parts were joined together and filled with an aluminum alloy (fig 3). After the alloy solidified, the mould was broken and the cast cooled (fig. 4 and 5).

Figure 4 – Breaking ZCast form

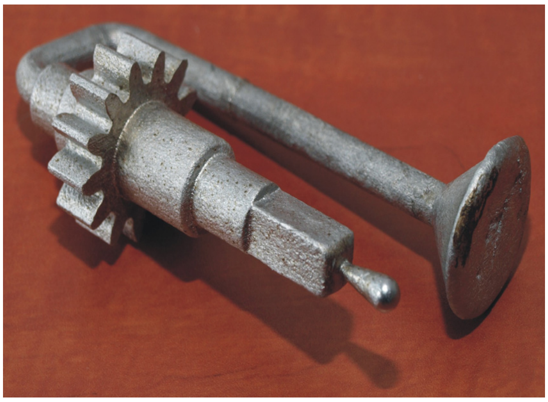

Figure 5 – Gear wheel cast

MEASUREMENTS

The measurements of the gear wheel cast accuracy were made with the use of the optical coordinate scanner GOM ATOS (fig. 6). The average accuracy of the measuring method was 6 μm.

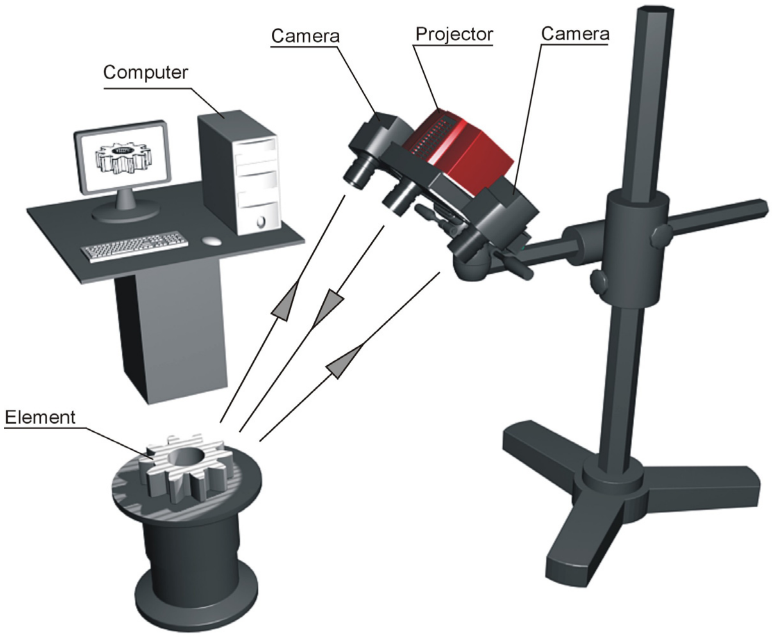

Figure 6 – Optical coordinate scanner - schema of scanning process

Before taking the measurements, an anti-reflection coating was applied on the tested gear wheel. The thickness of the coating ranged from 0,8 μm do 1,2 μm. The measurements were taken at the Department of Machine Design, at Rzeszow University of Technology and Institute of Metrology and Measuring Systems, at Poznań University of Technology.

The methodology of the tests consisted in scanning the gear wheel cast and comparing the surface received as a result of the measurements with the 3D-CAD model. Next, the real deviations of the cast shape were defined at all points with reference to the nominal CAD model for the purpose of determining the real model construction accuracy.

Optical measurement enables a precise recreation of the geometry of complex-shaped objects and the scanner specialized software makes it possible to compare the measurement results with the 3D-CAD mathematical model. The GOM ATOS scanner specialized software allows for a full metrological 3D analysis of the measurement results. At the first stage of the measurements results analysis, the gear wheel cast surface image was compared with the casting mould 3D-CAD model (fig. 7a). Next, the measurements results were compared with the gear wheel 3D-CAD nominal model (fig. 7b).

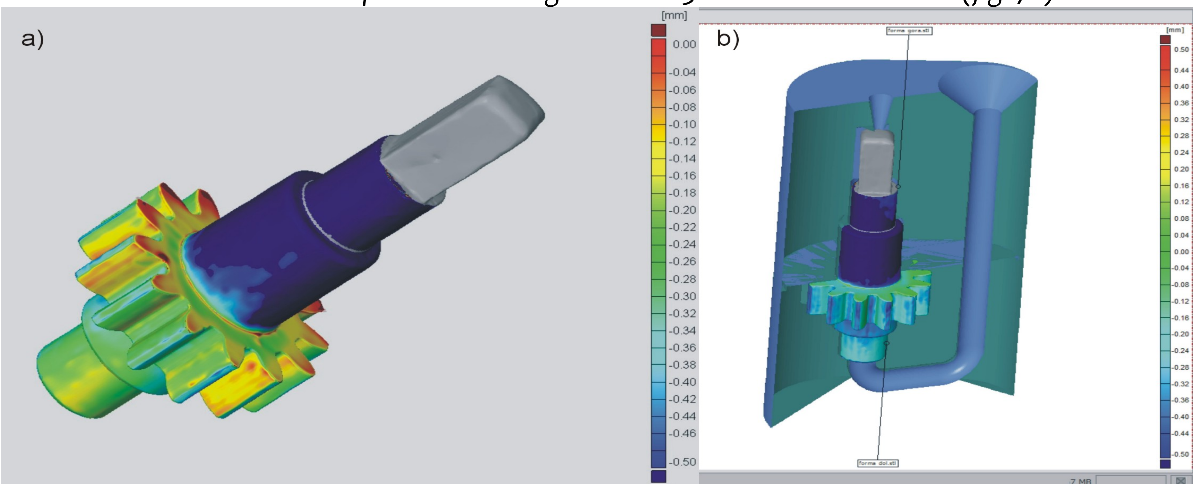

Figure 7 – Wheel cast surface image was compared with the casting mould 3D-CAD model (a) and 3D-CAD nominal model (b)

Displayed in the software window is a spatial three-dimensional map of the measured gear wheel deviations relative to the nominal model. An analysis was carried out of the deviation values at the selected points of the cast longitudinal section (fig. 8a) and at the selected points of the toothed wheel rim section (fig. 8b).

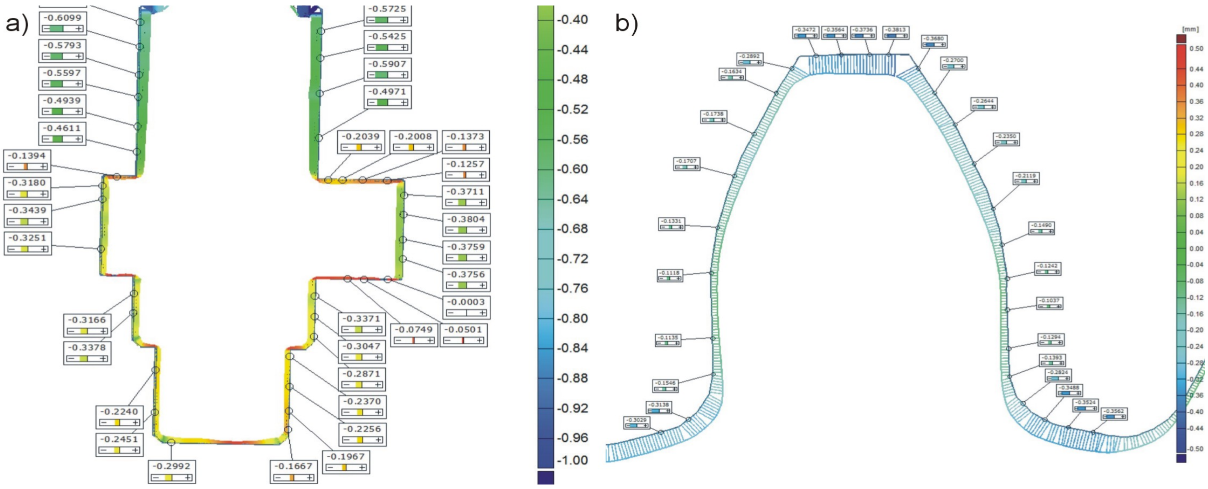

Figure 8 – Deviation values at the selected points of the cast longitudinal section (a) and at the selected points of the toothed wheel rim section (b)

CONCLUSIONS

The coordinate measuring technique enabled the assessment of the dimensional and shape accuracy of casts manufactured with the application of the rapid prototyping process. The measurements results show that there is a significant difference between the cast real dimensions and the nominal dimensions. The discrepancy stems largely from casting shrinkage. The casting mould was made based on the gear wheel 3D-CAD nominal model.

The measurements results indicate that casting moulds manufactured with the use of the 3DP method should be individually modified based on the measurements results, applying the coordinate measuring technique. The information from the measurements allows for the definition of the *compensation coefficients, which should be taken into consideration while constructing the 3D-CAD model. The coordinate optical measuring method ensured a sufficient accuracy of the casts evaluation, a short measurement-taking phase and fast results processing.*

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