ARCHIVES of FOUNDRY ENGINEERING

ISSN (1897-3310)
Volume 10
Issue Special1/2010
391-394

76/1

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

Geometrical precision of 3DP casting form for founding gears

T. Markowski [a], G. Budzik [a], B. Kozik [a], T. Dziubek [a], B. Sobolewski [a], M. Zaborniak [a]
[a] Department of Machine Design, Rzeszów University of Technology, Al. Powstańców Warszawy 8, 35-959 Rzeszów
*e-mail: tmarkow@prz.edu.pl, gbudzik@prz.edu.pl, bogkozik@prz.edu.pl, mzab@prz.edu.pl

Received 05.03.2010; accepted in revised form 23.03.2010

Abstract
The article presents analysis of geometrical precision of casting form made by means of 3DP method. Three dimentional printing is a universal method of rapid prototyping which can be used to make tools – castings forms as a Rapid Tooling method. By means of this method in direct incremental process a casting form of spur gear was created. Precision of creating the form by 3DP method depends on different factors. Technological factors depending on machine operator include: the thickness of the layer and placing the model in working space. The precision of creating the model also depends on preparing the printer for work: the condition and calibration of printing heads, the condition of the printing unit slide guides and preparing the working space. Three dimentional printer Z510 Spectrum was prepared for work in a way assuring the greatest precision of created models. Technological parameters responsible for precision were set on maximum values. The aim of the research was defining the precision of casting form generated by 3DP Rapid Prototyping Method. The research was made by means of coordinate measuring machine Wenzel LH87. The measuring machine software was used to compare the outcome of the measurement to nominal model 3D-CAD. The problem of tool precision of casting forms generated by Rapid Tooling is rarely considered in literature covering rapid prototyping and casting technologies. That is why the research presented in this article is an original work in the technological and practical aspect.

Keywords: gears, casting form, geometrical precision, rapid prototyping

1. Introduction

Rapid prototyping methods including rapid tooling (RT) are used more and more frequently for fast creation of casting prototypes [1-11].

Fast creation of tools – casting forms is a method allowing for making casting prototypes made of low – fusible alloys. 3DP method makes it possible to generate a form (2-4 layers a minute). In this method a process of preparing the printing machine [12] has a big influence on the precision of the model. In case of Z510 Spectrum printer technical service includes: cleaning and oiling the slide guides of carriage, cleaning and oiling the slide guides of working platform and powder container, calibration or changing of printing heads. All of these were made before printing. To obtain the greatest printout precision of the spur gear casting form, the model was placed in the working space in a way that axis of its rotation was parallel to the printer z axis. Thickness of the printed layer was set on minimal value g=0,0875mm.

Precision of making the cast depends a lot on the precision of making the casting form. That is why the research subject mentioned in the title of the article has been considered.

2. Making the casting form

2.1. 3D-CAD models of gear and casting form

The first stage was creating 3D-CAD model of the gear. Toothed wheel rim with involute tooth profile teeth was made by means of thee dimensional simulation of machining in Autodesk Inventor program. Virtual simulation of machining made by Maag method was done by slight changes of mutual placement of tool and wheel and the movement was forced by kinematics of real working. Then a model of gear was created by means of subsequent operations of solid modelling

(fig. 1a). The next stage was making two-pieces CAD model of the form which was recorded in STL format in order to use it in RP process.

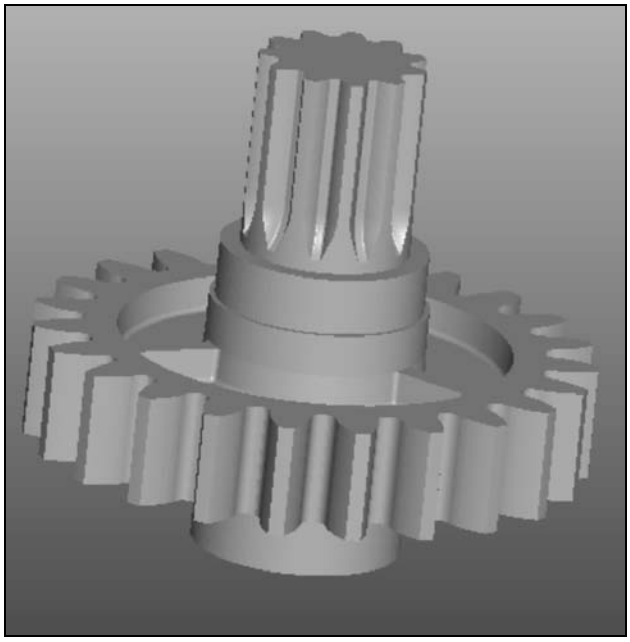

Fig. 1. 3D-CAD model of the gear

2.2. Printing the casting form

The form was made by three dimensional print using Z510 Spectrum device (fig. 2). The form was printed in two pieces which allowed accurate cleaning of the inside surfaces and removing excessive amount of powder.

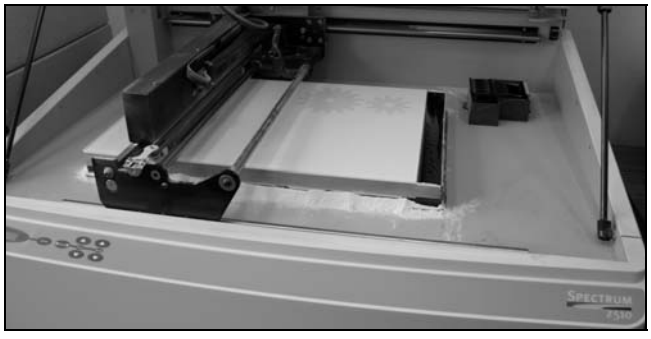

Fig. 2. 3D Z510 Spectrum printer while working

Subsequently the form was hardened by means of infiltration by Z-Max™ Epoxy resin (fig. 3).

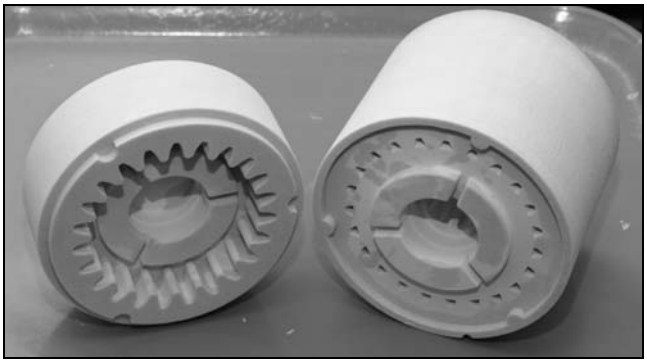

Fig. 3. The casting form after infiltration

3. Execution of measurements

3.1. Preparing the measuring machine

The analysis of geometrical precision of the gear casting form was done by means of WENZEL LH 87 measuring machine (fig. 4) having the standard Metrosoft CM3.8. software. The measurements were carried out in accordance with recommendations presented in appropriate works [13-15].

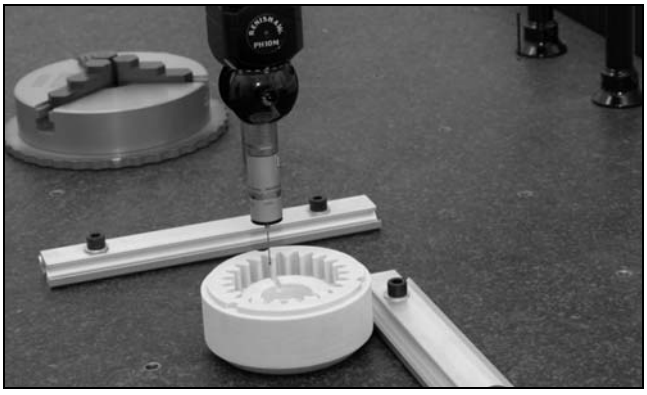

Fig. 4. View of measuring post

The measuring process included: recording 3D-CAD model of the form to the machine software, placing it in measuring space, defining measuring paths and execution of measurements.

3.2. Analysis of measurements results

Software of coordinate measuring machine Metrosoft CM 3.8. Wenzel Metromec enables the observation of the deviations during executing the measurement. It also enables the geometrical interpretation in relation to nominal CAD model [15]. Analysis of measurement was executed on base of measuring protocol (fig. 5 and 6).

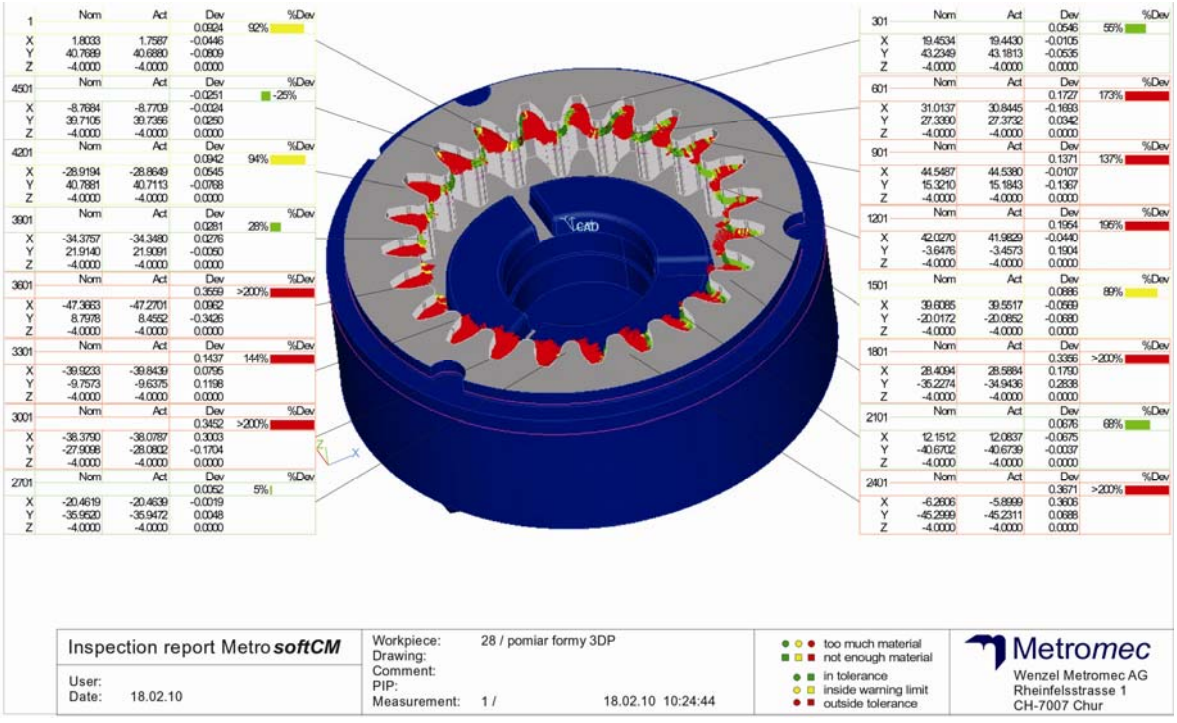

Fig. 5. Protocol of toothed wheel rim form measurement

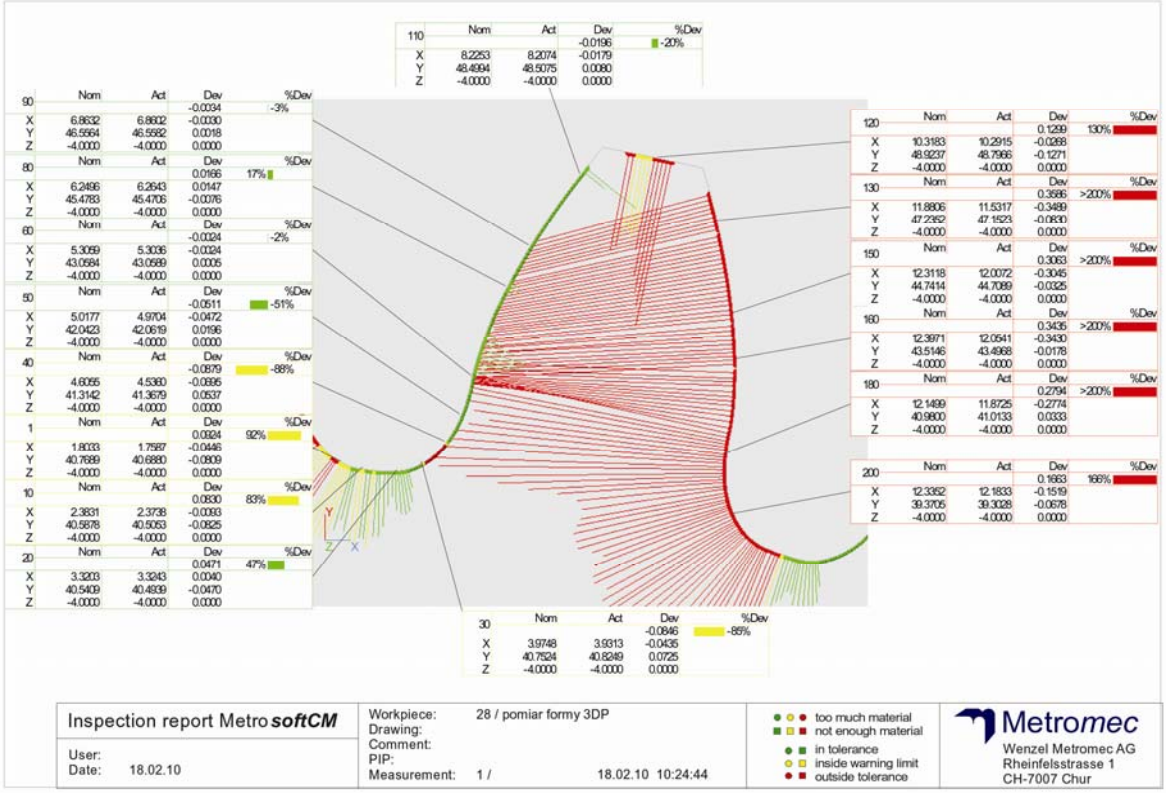

Fig. 6. Detailed protocol of tooth profile measurement

4. Summary

The accuracy of making casts is determined mainly by the accuracy of making the casting form. Applying coordinate measurement method in the process of creating casting forms of gears is aimed for improving the process of constructions design and technology.

Measurements of the gear casting form which were carried out by Rapid Tooling process allowed for defining real accuracy of making the gear casting form. The accuracy of mapping of the gear tooth profiles were analysed very carefully.

Laminar structure of models in incremental methods is a basic source of geometrical deviation (especially in direction of RP device z axis). That is why the correct placement of the model on working platform allows for increasing the accuracy of created gear casting form. The axis of rotation should be parallel to RP device z axis [1].

Dimensional and shape accuracy is vital in case of creating machine parts' prototypes especially gears and depends on a lot of factors in technological process of rapid prototyping. The whole technological process of making the form including preparing and processing the data, preparing the printer and making the prototypes was formulated so as to obtain the highest quality prototype. It was approved by measurements carried out afterwards.

The coordinate measurement method and Rapid Tooling technologies (3DP) are tools which allow for considerable acceleration in making prototypical casts. Analysis of form shape following from practice and the form measurements outcome allow for correction of 3D CAD model in order to improve the accuracy of final product – the cast.

The research was carried out to define geometrical precision of the form and should be treated as a first stage in defining geometrical precision of the cast. It is planned to define the cast precision made in 3DP formats in the consecutive stages of the research work.

Acknowledgements

Financial support of Structural Funds in the Operational Programme - Innovative Economy (IE OP) financed from the European Regional Development Fund - Project "Modern material technologies in aerospace industry", No POIG.0101.02-00-015/08 is gratefully acknowledged.

References

[1] W. Liou, Rapid Prototyping and engineering applications – a toolbox for prototype development, Taylor & Francis Group, 2008.

[2] A. Gebhardt, Rapid Prototyping, Carl Hanser Verlag, Munich 2006.

[3] N. Homburg, E. Wellbrock, Knowledge – based manufacturing strategy and methods for foundries, Conference and Exhibition for Rapid Technology, Erfurt 2006.

[4] R. Hartym, Dimensional accuracy of investment casting for the burned pattern process, Archives of Foundry, Volume 6, Nº18 (2/2), (2006) 231-236.

[5] R. Haratym, J. Tomasik, The influence of ceramic mould quality on surface geometry of al investment casting, Archives of Foundry, Volume 6, Nº18 (2/2), (2006) 237-242.

[6] T. Wohlers, Wohlers Report 2009 – State of the Industry, Annual Worldwide Pro-gress Report. Wohlers Associates Inc., Fort Collins, CO, USA 2009.

[7] I. Gajdoš, J. Slota, E. Spišák, FDM prototypes virtual modeling, ICAT 2008, 2nd International Conference on Additive Technologies: DAAAM Specialized Conference: September 17th -19th, 2008, Ptuj, Slovenia: Proceedings. Vienna: DAAAM International, 3 p. ISBN 3-901509-72-0

[8] J.C. Feriera, E. Santos, H. Madureira, J.Castro, Integration of VP/RP/RT/RE/RM for rapid product and process development, Rapid Prototyping Journal Vol. 12 No. 1/2006, Emerald 2006, 18-28.

[9] G. Budzik, T. Markowski, M.Sobolak, Hybrid foundry patterns of bevel gears. Archives of Foundry Engineering, Vol. 7, Issue 1/2007, s. 131-134.

[10] G. Budzik, T. Markowski, M. Sobolak, Prototyping of Bevel Gears of Aircraft Power Transmission, Journal of KONES Powertrain and Transport, Vol. 14, No. 2, Warszawa 2007, s. 61-66.

[11] G. Budzik, Properties of made by different methods of RP impeller foundry patterns, Archives of Foundry Engineering, Vol. 7, Issue 2/2007, s. 83-86.

[12] G. Budzik, Possibilities of utilizing 3DP technology for foundry mould making, Archives of Foundry Engineering, Vol. 7, Issue 2/2007, s. 65-68.

[13] PN-EN ISO 10360-5:2003 Geometrical Product Specifications (GPS). Acceptance and reverification tests for coordinate measuring machines (CMM). Part 5: CMMs using multiple-stylus probing system (in Polish).

[14] E. Ratajczyk, Coordinate measuring technique, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2006 (in Polish).

[15] G. Budzik, A. Marciniec, T. Markowski, M. Oleksy, M. Cygnar, The geometrical precision of the silicone matrices to the manufacturing of the models of the gear, Archives of Foundry Engineering, Volume 9, Issue 2/2009, s. 137-142.