ARCHIVES of FOUNDRY ENGINEERING

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

ISSN (1897-3310)
Volume 14
Special Issue
1/2014
87-90

18/1

The Application of VoxelJet Technology to the Rapid Prototyping Gear Cast

G. Budzik[a]*, T. Markowski[a]*, B. Kozik[a]*, Ł. Przeszłowski[a], A. Rzucidło[a], O. Markowska[a], M. Zaborniak[a], T. Dziubek[a], J. Bernaczek[a], P. Turek[a], J. Traciak[a], M. Cader[b]*, M. Tutak[c]

[a] Rzeszów University of Technology, Al. Powstańców Warszawy 12, 35-959 Rzeszów
[b] Industrial Research Institute for Automation and Measurements, Al. Jerozolimskie 202, 02-486 Warszawa
[c] WSK PZL Rzeszów, ul. Hetmańska 120

* Corresponding author's e-mail: gbudzik@prz.edu.pl, tmarkow@prz.edu.pl, bogkozik@wp.pl, mcader@piap.pl

Received 31.03.2014; accepted in revised form 14.04.2014

Abstract

The article presents the scope of application of incremental Rapid Prototyping/Rapid Tooling (RP/RT) – VoxelJet methods to the process of manufacturing casting moulds and casts of gear. The additive Rapid Prototyping methods (SL, FDM, 3DP, JS) are predominantly used for the production of models and model sets for casting moulds. The Rapid Tooling methods, such as: VoxelJet, ZCast-3DP and ProMetalRCT, enable the fabrication of casting moulds in the incremental process. The application of the RP/RT methods in cast production makes it possible to speed up the prototype preparation process. This is particularly vital with elements of complex shapes. The time required for the manufacture of the model, the mould and the cast proper may vary from a few to several dozen hours.

Key words: Rapid Prototyping, Casting, Rapid Tooling

1. Introduction

The Rapid Prototyping (RP) and Rapid Tooling (RT) technologies are utilized in the process of fabricating prototype casts with the use of metal alloys [1-3].

One of the first additive Rapid Prototyping methods to be applied in foundry was the Laminated Object Manufacturing (LOM) technique, which consists in the formation of the casting model from paper layers. Another group of methods of casting model prototyping is based on the formation of the model from layers of thermoplastic materials (ABS, wax) [4-9].

Another group of Rapid Prototyping methods is comprised of Rapid Tooling additive systems that enable the fabrication of casting moulds using powdered moulding materials (VoxelJet, ZCast-3DP, ProMetalRCT) [10-13].

The selection of the Rapid Prototyping method for the casting process requires an understanding of its technological parameters and knowledge of the areas of its application as well as the role of the method in the casting process. For this reason, an attempt has been made to conduct an analysis of the incremental Rapid Prototyping methods which are most commonly applied in casting technologies [14-16].

2. The casting mould manufacturing

2.1. 3D-CAD models of casting form

The first step of mould manufacturing is to create it 3D – CAD model. 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 modeling (fig. 1). The next stage was making two-pieces 3D-CAD

model of the form which was recorded in 3D-STL format in order to use it in rapid prototyping process (fig. 2).

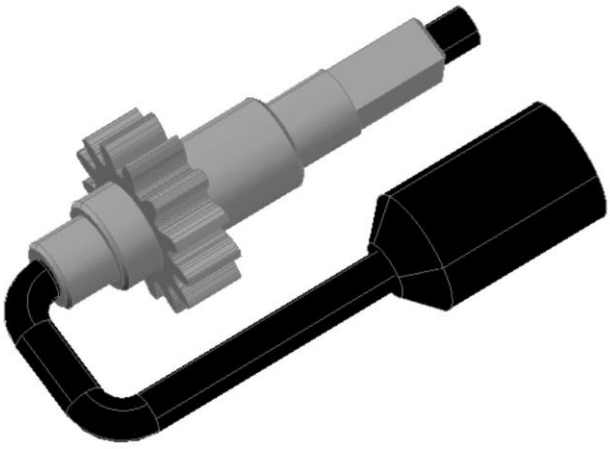

Fig. 1. 3D-CAD models of the gear

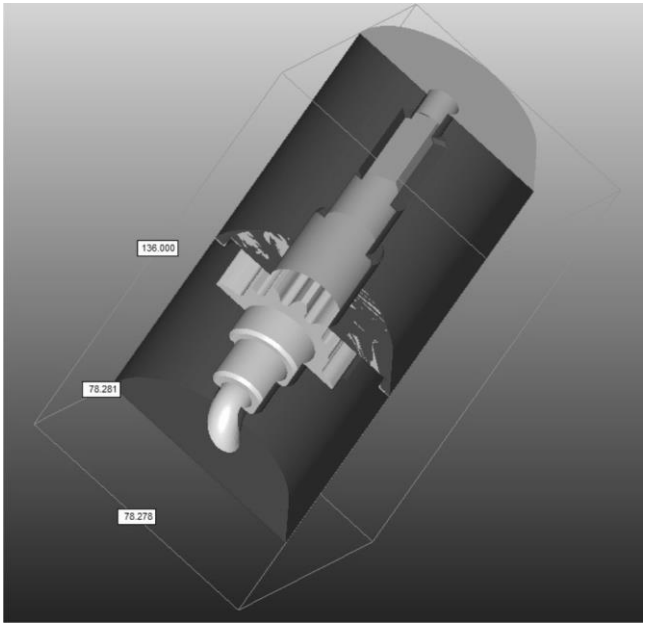

Fig. 2. 3D-CAD models of the mould

2.2. Three Dimensional Printing the casting mould

The mould was made on VoxelJet device by three dimensional printing (fig. 3). The form was printed in two pieces which allowed accurate cleaning of the inside surfaces and removing excessive amount of powder. The bilding process is started when model of mould is placed in the virtual space, and the building process is started (fig. 4). The loose basic material is evenly applied over the entire build width. A print head applies binder in section where the model is to be produced. The binder infiltrates the most recently applied layer and connects it with the layer below.

Fig. 3. VoxelJet machine

Fig. 4. VoxelJet printing process

The VoxelJet technology allows to print models with a 200 dpi resolution (sand material – x, y plane) print head and a layer and thickness about 200-400 μm. The printed models offer a high accuracy of detail and high surface quality. Manufacturing process is done with 100 % inorganic binder, the prototypes are of good resistant bending. Moulds in VoxelJet method are castable with all current alloys and they have a pretty low emission while casting. Accuracy of prototype of mould is 0,2 % (min. +/– layer thickness). Figure 5 shows a view casting mould of a gear.

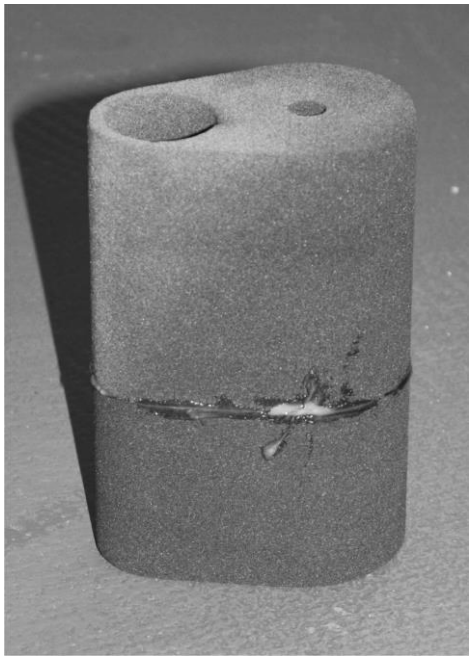

Fig. 5. VoxelJet mould

3. Casting

Preparation of the casting mould cover annealing in temperature 80°C in order to ensure adequate mechanical properties of the material and evaporation of water from mould. The next step is to put the mould into the dry powder. Then, the mould parts are joined together by means of glue. After the mould is prepared it is filed with liquid aluminum alloy which is shown in figure 6. When the solidification process is finished the mould was removed and the cast was tempered.

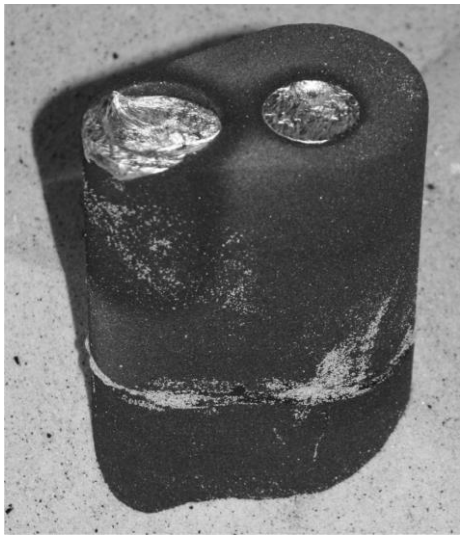

Fig. 6. Pouring mould alloy AK7

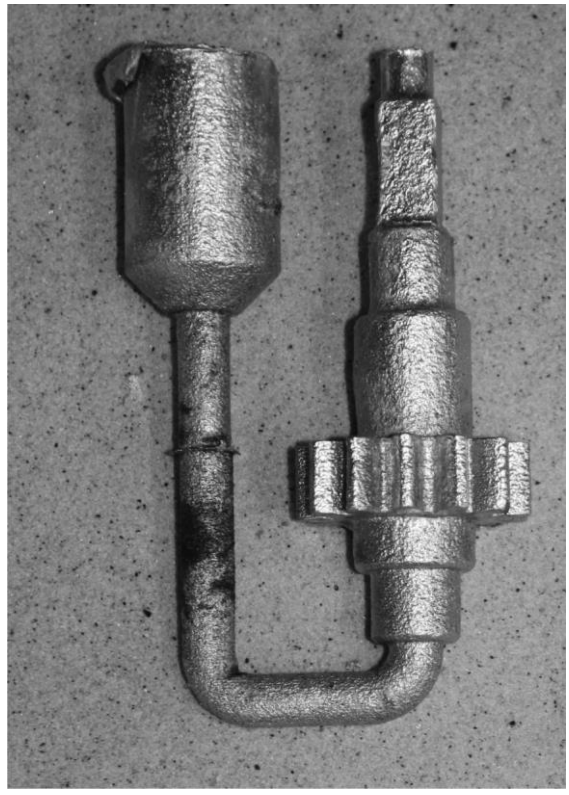

Fig. 7. Gear cast

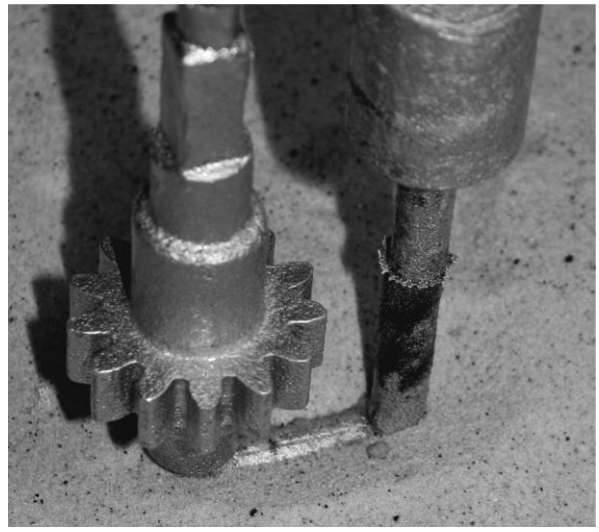

Fig. 8. Gear cast

4. Conclusions

Rapid Tooling technology is becoming more popular in the application of moulding process. It allows prepar a unit mould for

prototype castings or preparing castings test. This type of tests allow to check correctness of the design in gating system without necessary additional tools. These methods may include technologies souch as VoxelJet, ZCast-3DP and ProMetalRCT which produce mould by 3D printing.

VoxelJet device allows to print mould with moulding sand with the possibility flooding any casting alloy. For comparison Z-Cast technology Z-Corporation firm allows to print mould which are use with only low melting flooding alloys to 1100°C. For this reason VoxelJet technology is a more universal method in the field of applied casting alloys.

The article presents gears casting process with VoxelJet technology which was successfully completed. Further analysis confirms the usefulness and versatility of the technology in question.

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] Budzik G., Possibilities of utilizing 3DP technology for foundry mould making, Archives of Foundry Engineering, Vol. 7, Issue 2/2007, s. 65-68.N. Homburg, E. Wellbrock, Knowledge - Based manufacturing strategy and methods for foundries, Conference and Exhibition for Rapid Technology, Erfurt 2006.

[2] G. Budzik, The Use of the Rapid Prototyping Method for the Manufacture and Examination of Gear Wheels. [in:] Advanced Applications of Rapid Prototyping Technology in Modern Engineering., pp. 339-364, Croatia, 2011 INTECH - Open Acces Publisher, Croatia 2011.

[3] G. Budzik, M. Oleksy, M. Grzelka, M. Wieczorowski, M. Magniszewski, J. Slota, The application of optical measurements for the determination of accuracy of gear wheels casts manufactured in the RT/RP process, Archives of Foundry Engineering, 10, 1/2010, s. 395-398

[4] 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.

[5] A. Gebhardt, Rapid Prototyping, Carl Hanser Verlag, Munich 2003.

[6] R. Hartym, Dimensional accuracy of investment casting for the burned pattern process, Archives of Foundry, Volume 6, N°18 (2/2), (2006) 231-236 (in Polish).

[7] R. Haratym, J. Tomasik, The influence of ceramic mould quality on surface geometry of al investment casting, Archives of Foundry, Volume 6, N°18 (2/2), (2006) 237-242 (in Polish).

[8] 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

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

[10] A. Marciniec, T.Markowski, G. Budzik, A. Trytek, B.Kozik, J. Bernaczek, J. Pacana, H. Matysiak, A. Banaś, Application of ZP131 powder for manufacture of casting molds using ZCast technology for Al-alloys castings, Archives of Foundry Engineering 1/2010, s. 423-426

[11] D. Myszka, J. Modzelewski, M. Leśniwski, A. Kerwiński, Introduction to titanium investment casting as implants use, Archives of Foundry, Volume 6, N°18 (2/2), (2006) 237-242 (in Polish).

[12] M. Oleksy, M. Heneczkowski, G Budzik, Composities of unsaturated polyester resins applied in Vacuum Casting technology, POLIMERY 2008, 53, nr 2, s. 60-63

[13] Stankiewicz M., Budzik G., Patrzałek M., Wieczorowski M., Grzelka M., Matysiak H., Slota J.: The scope of application of incremental Rapid Prototyping methods in foundry engineering, Archives of Foundry Engineering, 1/2010, s. 405-410

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

[15] VX800-3D – Printing System – Voxeljet Technology GmbH Augburg Germany 2008.

[16] Voxeljet AG – Gesamtbroschuere – SYSTEMS, Voxeljet Technology GmbH Augburg Germany 2013