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Possibilities of utilizing 3DP technology for foundry mould making

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Sumary
Possibilities of application of three-dimensional printing (3DP) technology for making casting prototypes are discussed. Three-dimensional printing enables making of foundry moulds for elements of complex shapes. The mould presented in the paper was printed with the use of Z510 Spectrum unit in the Car Technology Sp. z o.o. *(Ltd. Co.)* in Kraków. The basic material for printing foundry moulds is the ZCast 501 powder. This powder is a mixture of traditional molding sand, gypsum and supplementary ingredients. The mould is made in ZCast technology, and it enables casting of zinc, magnesium and aluminum alloys at max. pouring temperature of 1100°C. The paper describes research on the possibility to utilize a standard ZP14 powder for building a rotor blade casting moulds. The research has showed that the ZP14 powder may serve for printing foundry moulds, which should then be subjected to thermo-chemical treatment. Application of the basic ZPrint system powder permits a reduction in mould manufacturing costs.

Key words: innovative foundry materials and technologies, foundry moulds, rapid prototyping systems, three-dimensional printing, ZCast

1. Introduction

Making of prototype castings with traditional methods is very time consuming [1,2,3]. Rapid Prototyping (RP) systems ensure a reduction of the time required for prototypes [4,5,6,7]. The RP systems enable making of foundry patterns as well as foundry moulds. One technology that enables making of foundry moulds for casting alloys of non-ferrous metals is the ZCast three-dimensional printing (3DP) technology offered by ZCORPORATION. Moulds printed in this technology withstand pouring temperatures of 1100°C. The ZCast technology permits making shell moulds that are about 12mm thick. If necessary, such shell mould may be complemented on outside with conventional forming material prior to casting. The ZCast technology may also be applied to foundry core making. The three-dimensional printing (3DP) permits generating of moulds with any desirable parting plane [8].

2. Research methods

The ZCast technology enables foundry mould making based on CAD model of an element to be cast. The research methodology comprises making a virtual CAD model of rotor blade. The next stage is making a CAD model of foundry mould with gating system. Such model needs to be exported with assumed precision to the STL format. The STL model will be read by the ZPrint software dedicated to ZCORPORATION printing units. The Z510 Spectrum unit was used to print the foundry mould, which was then used to pour a prototype casting in. Rotor blade was the object of experiments. The criterion for object selecting were the tests performed on a thin-walled model with relatively low consumption of work materials.

3. Preparing of mould model

3.1. CAD model of rotor blade

Rapid Prototyping (RP) systems serve for making physical models on the basis of virtual CAD model [9]. Rotor blade is an element of complex surface geometry and therefore the CATIA software with advanced surface modeling options was necessary to create its model. The CAD model (Fig.1) of blade was created in order to study the course of technological process in the ZCast system.

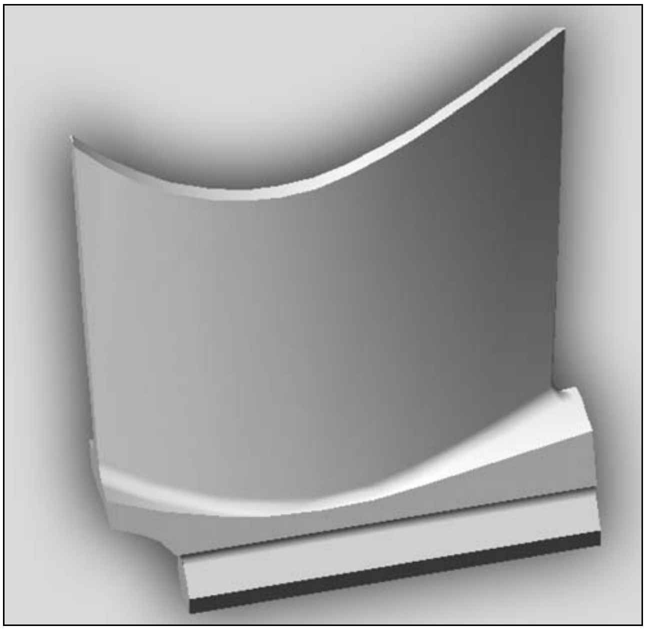

Fig. 1. CAD model of rotor blade

3.2. CAD and STL models for rotor blade mould

The CAD model of blade was complemented by gating system and overflow system model and foundry mould model was made on this basis (see fig. 2). The mould for subject blade was designed as the entire object without any parting plane. The CAD model was exported to STL format suitable for the ZPrint software that serves for operating three-dimensional printing units (fig. 3) [10,11,12]. If STL model has any errors or faults, they should be repaired with the use of the program in which the model was made or with the specialized software for the edition and modification of STL files (MagicsLite, Geomagic) [13].

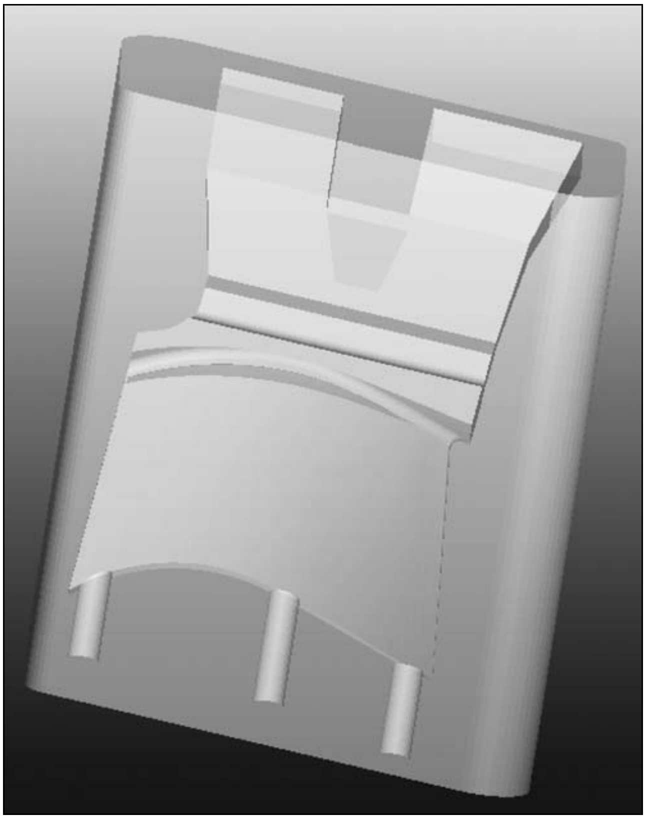

Fig. 2. CAD model of foundry mould

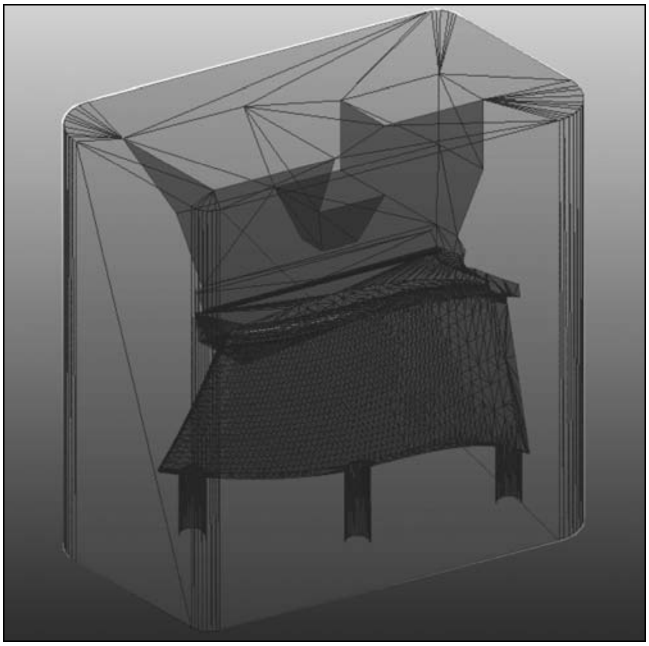

Fig. 3. STL Model of foundry mould

A correctly prepared STL model is ready for printing. The ZPrint software enables STL model placing in the printer work space as well as model splitting into a suitable number of printout layers [14,15]. For the Z510 Spectrum printer the work space dimensions are 254x356x203mm. The placing of an element in the work space affects the printout time and precision (Fig. 4).

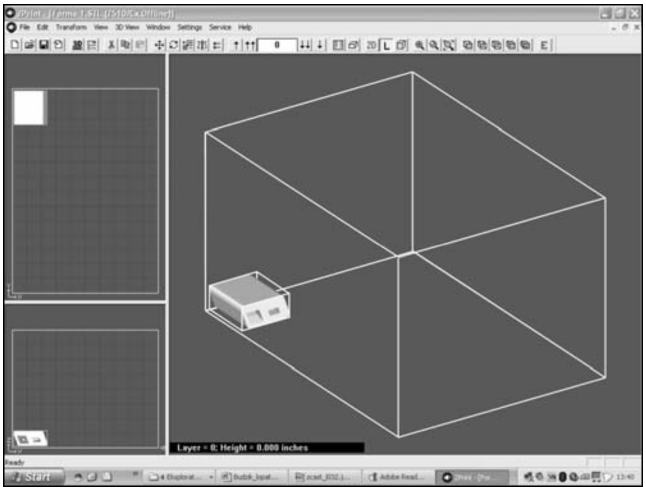

Fig. 4. Mould model in the work space of the program

3.3. 3DP model of foundry mould

The foundry mould model was made with the use of three-dimensional printing unit of Z510 Spectrum type (Fig. 5) in the CAR Technology Sp. z o.o. *(Ltd. Co.)* in Krakow within the cooperation with the Rzeszow University of Technology (Agreement No 2/2006).

Fig. 5. Three-dimensional printing unit, Z510 Spectrum

A Z510 printing unit enables printout of monochromatic or color prototypes from various powder materials.

A three-dimensional model is created incrementally in 3DP units as a result of hardening consecutive layers of powder. Powder is taken from a hopper and leveled in working space by a roller. Consecutive layers are hardened with movable binder application head (Fig. 6 and 7).

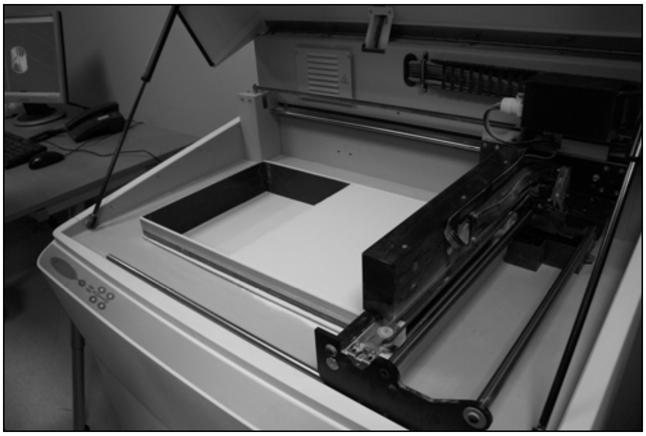

Fig. 6. View of the work space

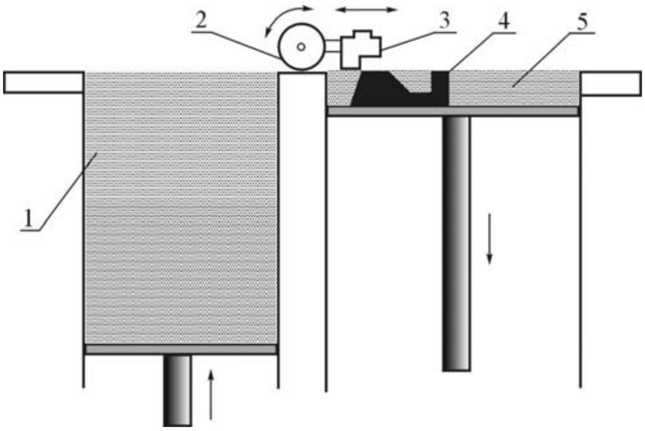

Fig. 7. Functional Diagram of three-dimensional printer: 1- hopper with powder, 2- powder leveling roller, 3- printing head, 4- model being produced, 5- work space

The printed mould should be removed from the work space of the apparatus and then cleaned from excess powder in a special chamber. The cleaned mould is subjected to thermo-chemical treatment. The treatment consists in mould soaking at 200-250°C for 8-10 hours in a suitable atmosphere.

Mould prepared in this way is ready to be poured. In the discussed case the mould was poured with aluminum alloy. Fig. 6 presents a foundry mould made with the use of the Z510 Spectrum unit and a prototype casting of blade.

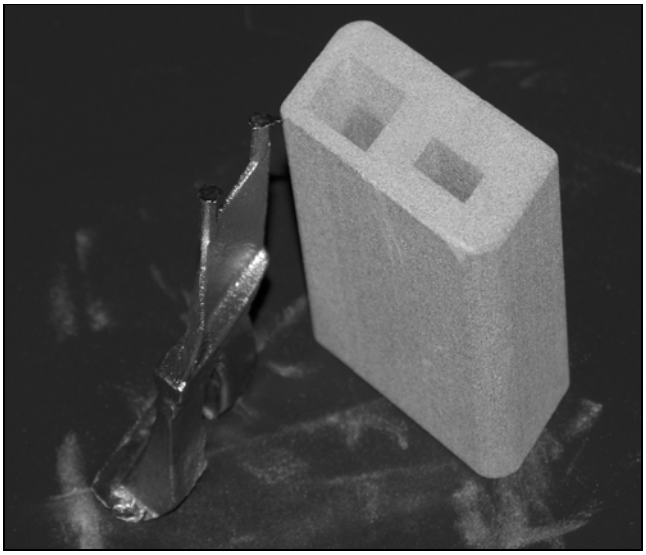

Fig. 8. Foundry mould and a prototype casting

4. Conclusions

The application of the technology of three-dimensional printing of foundry moulds permits a considerable acceleration of works at prototype castings. The application of the standard ZP14 powder enabled a reduction of foundry-mould printing costs. In order to reduce printing costs, a shell mould may be made and then complemented with cheaper molding material. The technology of foundry mould making in three-dimensional printing process offers huge manufacturing potential. That is why, a further research on its application for various cast elements of non-ferrous alloys is advisable.

References

[1] 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)

[2] 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)

[3] 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)

[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] J.E. Shigley, Ch. R. Mischke, T.H. Brown, Standard Handbook of Machine Design, McGraw-Hill Companies, Inc 2004.

[6] N. Homburg, E. Wellbrock, Knowledge - Based manufacturing strategy and methods for foundries, Conference and Exhibition for Rapid Technology, Erfurt 2006.

[7] Y. Song, Y. Yan, R. Zhang, F. Wang, Manufacture of the die of an automobile deck part based on rapid prototyping and rapid tooling technology. Journal of Materials Processing Technology 120 (2002) 237-242, Elsevier 2001.

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

[9] G. Budzik, A. Marciniec, Computer Aided Design of turbochargers rotor, Journal of KONES Internal Combustion Engines, Institute of Aeronautics, Vol.12 No. 1-2, Warszawa 2005.

[10] S. H. Choi, S. Samavedam, Patternling and optimisation of Rapid Prototyping, Computers in Industry N° 47/2002.

[11] G. Budzik, D. Kozdęba, M. Sobolak, Rapid Prototyping method of investment pattern of blade in silicone mould, Archives of Foundry, Volume 6, N°18 (2/2), (2006) 201-206 (in Polish).

[12] G. Budzik, D. Kozdęba, M. Sobolak, Rapid Prototyping technology using for investment casting process, Archives of Foundry, Volume 6, N°18 (2/2), (2006) 207-212 (in Polish)

[13] Geomagic Studio 9, Shape Phase – Quick Start Guide, Geomagic Inc. 2006.

[14] Spectrum Z510/Designmate™ CX 3D Printer, User Manual Rev X, Z Corporation 2006.

[15] ZPrint Software Manual Version 7.4, Z Corporation 2006.