ARCHIVES
of
FOUNDRY ENGINEERING

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

ISSN (1897-3310)
Volume 15
Special Issue
3/2015

95 – 98

19/3

The Use of Rapid Prototyping Methods to Perform Flexible Pattern Mold for Compressor Turbine Casting in the Gypsum Molds

K. Wańczyk*, A. Gil, P. Kowalski
Foundry Research Institute, 73 Zakopianska Str., 30-418 Cracow, Poland
* Corresponding author. E-mail address: krzysztof.wanczyk@iod.krakow.pl

Received 26.06.2015; accepted in revised form 20.07.2015

Abstract

There are many different casting technologies and their selection depends on the criteria to be met by a cast made. One of the less frequently used precision casting technology is a technology that uses gypsum block forms. From many years are available pre-mixed gypsum for the various alloys, and mold making technology itself can be based on melted wax models or models permanent removed from the mold after hardening the gypsum mix. In case of use permanent models to produce them may be used various types of flexible materials. This solution allows you to make complicated models that can be removed from the mold only by the fact that they are flexible and at the same time capable of large elastic deformations.

Keywords: Rapid prototyping, Gypsum molds

1. Introduction

Example of the cast, which has developed technology for the production of flexible tooling methods of Rapid Prototyping is currently not more produced the diesel engine compressor rotor, high-capacity and high power. The diameter of the base of the rotor is 191 cm and its height is 70 mm, wall thickness of a single blade ranged from 0.7 to 1.3 mm. This choice allowed the simultaneous use of reverse engineering used to reproduce parts used in regeneration of engines. In the above case, the difference between the reproduction of the selected casting and casting the prototype is only by obtaining three-dimensional CAD drawing being developed element. In this case the casting design documentation were made by using reverse engineering applied by optical scanner Atos III.

2. Methodology

The first stage of the work was to obtain documentation 3D reproduced element. Use of an optical scanner allowed for obtain a point cloud, mapping all visible to camera scanner surfaces of the model. The picture, which is created as a result of the submission of different shots of scanned model that are folded together based on previously plotted reference points. Then, as a result of processing the data obtained three-dimensional virtual model as a triangle mesh mapping the actual rotor. To reproduce the used part the casting method should also make adjustments to the shape as loss of material resulting from the work piece and the larger model casting shrinkage.

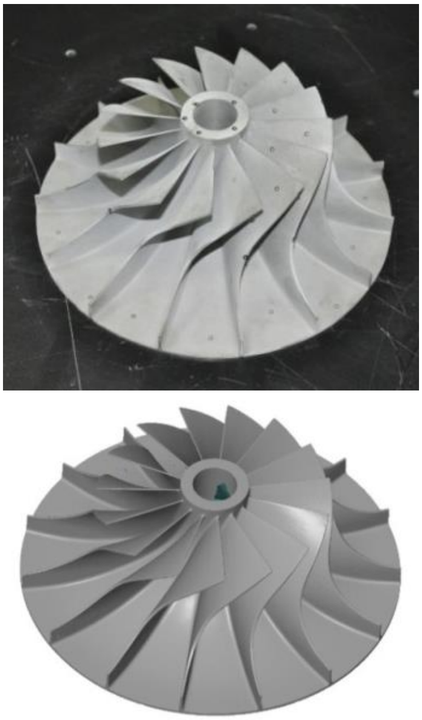

Fig. 1. Scanned the rotor and the resulting 3D model

Creation of a flexible rotor model requires the preparation of a suitable matrix of high dimensional accuracy and surface smoothness. The complexity of the matrix shape requires a segmental structure where one segment reproduced one surface side of two adjacent rotor blades. Thus, in this case should perform fifteen identical segments. Making of virtual model of the segment was based on the previously obtained 3D documentation of the rotor. Side wall section were made in Geomagic and missing elements were drawn in CAD. This way of use the real part to design of tooling is called reverse engineering.

Standard way to do this metal matrix would be milling, which due to the complex shape of the segments of variable geometry is time-consuming and costly solution.

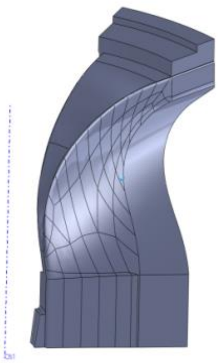

Fig. 2. 3D model of a segment of the matrix

Use of rapid prototyping methods requires consideration of how best to achieve the same matrix and the die-cast model of choosing other materials. One of the disadvantages of incremental technique is surface roughness obtained prints. This is a consequence of the fact that the models are built in layers, the quality of the surface depends on the printing technique. The desire to achieve a smooth surface model is inextricably linked with the need to use mechanical finishing, consisting of smoothing the surface of the print. This operation introduces the possibility of losing the required dimensional accuracy of the model in the case of performing what in case matrix consisting of many of the same elements, was important that everyone have the same dimensions. Considered two methods of producing a set of matrix segments. The first method would be to printed all the necessary elements and then finishes each one and dimensional inspection. The second method consist on that only one element is printed and exact finish its surface and then the execution of its fifteen copies are through the casting resin. After analyzing workload and dimensional accuracy the second option was chosen. To print segments in technology 3D was used a dedicated printer, where the layers of the print are obtained by bonding thin layers of ink-adhesive powder.

Fig. 3. Printed segment tooling with visible layers print

3D printing technology is based on the combustion of powder requires hardening of printed models by soaking them. The present model has been pre-cut and then impregnated with a resin in a vacuum chamber and allowed to harden to. Then the model was sanding with fine sandpaper and luting, the final stage was polishing.

After the surface treatment of the model, it was necessary to check in what stage has managed to maintain its dimensional accuracy. To verify the shape of rotor model segment form was used optical scanner ATOS III. Examination proceded in two stages: digitization (scanning), inspection (inspection dimensional).

Digitization is a process gathering point clouds from the surface of a model. In this measurement technique uses the line distortion effect as the light beam illuminating the surface of the object (so-called. Moire fringe effect). In this case uses a set of lines of white light generated by the projector. Object being scanned object is illuminated grid of given parameters (set of lines with known density). Straight lines are distorted depending of the size of the measured object surface deformation, and the image of the illuminated object is captured by the camera and analyzed on a computer. Based on the triangulation formed between the light source, camera and the surface of the object being measured, are the locations of the points located on the surface of the object. For research used a set of lenses, which results is area of measurement contained in a cube with sides of about 150 millimeters. The result was to achieve a small measurement error, which in this case is ± 0,01 mm.

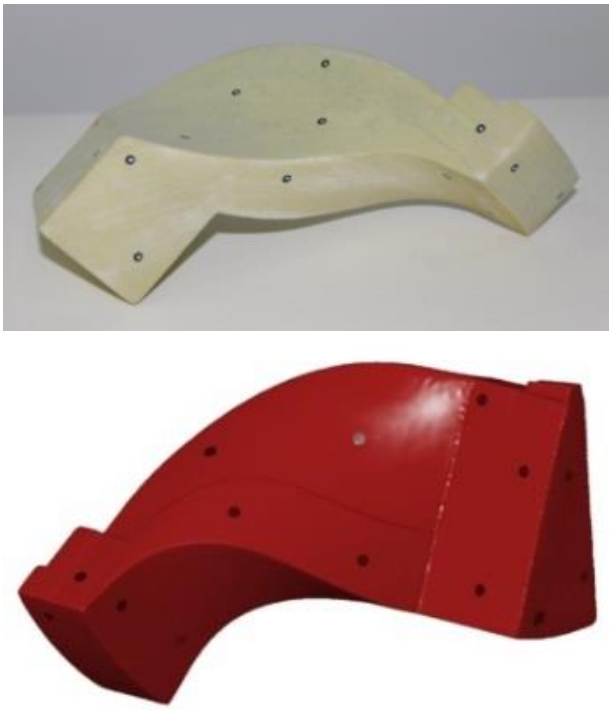

Fig. 4a. Polished model and 3D scanned segment

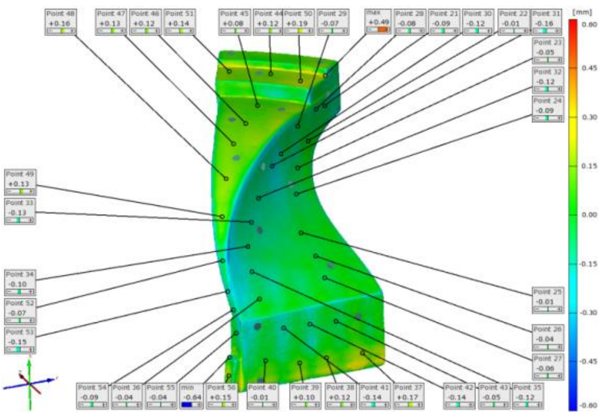

Fig. 4b. The map of deviations

The next step was to verify the dimensional inspection, involves the comparison of polygon meshes, point clouds and sections of CAD data. This is determined by comparing the measured data deviation in the direction of CAD data. That is, the system calculates the shortest perpendicular distance of each data point measured from the surface of the CAD model. Visualization deviation occurs via a color deviation maps, where each polygon point measurement data is colored according to its deviation from CAD data.

After passing inspection model mold segment dimensional was used to made flexible matrix designed for casting in the fifteen copies of the polyurethane resin. Segment matrix form was made as a template contour in the casing. Used a two-component silicone casting models crosslinking at ambient temperature, and plaster of Paris on the rigid cover. The advantage of this design is thin wall of the silicone mold for easy disassembing and taking out from the inside resulting element. The rigid cover ensure correct positioning of flexible silicone and is responsible for maintaining proper shape models made in the matrix. After crosslinking silicone mold was disassmebled and dissected silicone to remove the model along a previously prepared edge.

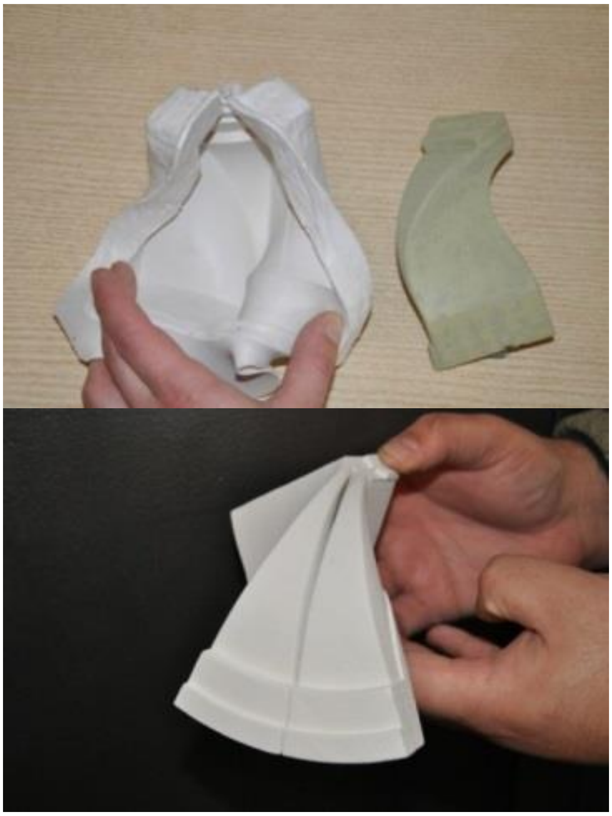

Fig. 5. Silicone matrix and removed out the model and a two assembly models together.

To made sectional matrix filled up with liquid silicone was use quickly curable polyurethane resin. This resin is characterized by ease of polishing elements made from it, allowing for a smooth surface required for the performance of silicone rubbers tooling. The time required for dissasembly elements was 30 minutes.
The cast elements were milled and planned at the place where the resin was put into the mold and surfaces that reflect the model of the rotor were polished. Then all the components assembly together and pressed onto the band, thereby obtaining a mold.
Selection of materials for the performance of silicon rotor model is based on the offer of Polish producer with a wide range of

products. On the basis of detailed data on the performance of different species of silicone materials were selected for further research. In regard to the selection suitable silicone mainly taken parameters such as: use silicone on the type of mold, flexibility, tensile strength, elongation, hardness of rubber, linear shrinkage value, shelf life after mixing, the viscosity of the mixture.

Implementation of silicone rotor model were performed in a vacuum chamber. The ingredients were mixed together under vacuum and then using a mechanical arm located within the vacuum chamber, the mix were poured into the mold cavity. Then, equalizing the pressure in a chamber with atmospheric press flilled silicone. After a full cross-linking of the mixture model has been disassembled, removed catchment silicone and subjected to qualitative assessment.

3. Conclusions

Rating of the rotor model was positive. The inspection showed regularity filling of the mold cavity surface, model was smooth and did not show any defects. Objections could give only a small stiffness of silicone rotor blades, but not deform enough to deform the model.

Acknowledgements

The work was realized in the project DEMONSTRATOR+ „The family of specialized vehicles to carry out restoration and conservation treatments in aqueous-mud areas". Agreement No: DPA-DEM-1-145/001 co-financed by Innovative Economy Operational Programme 2007 – 2013. Priority 1. Research and development of new technologies, Action 1.5 . System projects of The National Centre for Research and Development.

References

[1] Bubicz, M. (2008). Raport: Szybkie prototypowanie cz. I – przegląd dostępnych rozwiązań. *Maszyny, materiały, zastosowania. / Projektowanie i Konstrukcje Inżynierskie 6(09) czerwiec*, 14 - 21.

[2] Płatek, P. & Kret, M. (2008). Techniki druku 3D – przykłady zastosowań metody FDM, warstwowego osadzania topionego materiału. Seminarium techniki szybkiego prototypowania w cyklu życia produktu. „Mechanik", nr 12.

[3] Dybała, B. (2010). Technologie szybkiego prototypowania i wytwarzania, W: „Raport. Rapid Prototyping & Reverse Engineering",

[4] Sobaś, A. (2010). *Od idei do produktu, czyli rapid prototyping*, Warsztat,

[5] Bubicz, M. (2007). Cyfrowe czy jednak fizyczne? Prototypowanie – wyzwanie XXI wieku, *Konstrukcje inżynierskie, nr 1*

[6] Chojnowska, L. (2008). Model wirtualny wsparty wydrukiem 3D. Desing News w Mechanice i Elektronice, nr 03

[7] Oczoś, K.E. (2008). Zastosowanie techniki Rapid Tooling do kontroli jakości wytwarzanych części samochodowych. *Mechanik 12*, 1022-1028

[8] Plichta, J. Plichta, S. (2006). *Techniki komputerowe w inżynierii produkcji*. Wydawnictwo Uczelniane Politechniki Koszalińskiej, Koszalin.

[9] Fajkiel, A. & Dudek, P. (2003). Odlewy o wysokim stopniu przetworzenia, spełniające wysokie wymagania eksploatacyjne. Cz. 1, Procesy technologiczne. *Odlewnictwo - Nauka i Praktyka. R 5, nr 6*, 11—18.

[10] Fajkiel, A. & Dudek, P. (2004). Odlewy o wysokim stopniu przetworzenia, spełniające wysokie wymagania eksploatacyjne. Cz. 2, Przykłady zastosowań odlewów ze stopów metali nieżelaznych. *Odlewnictwo - Nauka i Praktyka., R. 6, nr 1*, 18 – 22.