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Using of the Reverse Engineering Method for the Production of Prototype Molds by Patternless Process Technology

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Abstract

The present article deals with the possibility of using the reverse engineering method for the production of prototype molds by Patternless process technology. Article describes method how to obtain virtual model by using a 3D scanner. Article also explains principle of the Patternless process technology, which is based on the milling mold cavity using CNC machining equipment. The aim of the research is the use of advanced technologies that speed up and facilitate the process of production prototype mold. The practical result of the presented experiment is bronze casting, which serves as a foot rest bracket on historic bike.

Keywords: Patternless process, Reverse engineering, 3D scanning, Molding compound, Bronze casting

1. Introduction

Production of prototype mold by conventional technologies requires previous production of model. Its production is often financially and time-consuming. To speed up the production of prototype casting various technologies have been developed, which makes possible to produce mold cavity without using the model. The principle consists in obtaining the virtual model by 3D scanner. Consequently, it is necessary to design a mold cavity for casting by using CAD software. With CAM software is created a machine program that is inserted into the CNC milling machine. The real mold is subsequently milled to block of molding compound. Choice of the molding compound is dependent on the casting temperature and various other parameters. During the experiment was used a molding compound based on silica sand and gypsum, which is heat resistance up to 1200 ° C.

2. Obtaining a 3D model by reverse engineering

Method of Reverse Engineering (RE) begins to be increasingly used in the manufacture of molds in foundry and it's based on obtaining a 3D CAD model from an existing part. Technological process of mold production by RE method is shown at Fig.1. After identifying the part by computer scanner, digitization process begins in which the 3D digital data are obtained by scanning spatial coordinates of points on the surface of the part. They are scanned by a 3D measuring and scanning centers and the output is a set of points defined by 3D coordinates (x, y, z). Number of scanned pixels depends on the complexity of the components, the method used to scan and the desired accuracy. During a contactless scanning can be scanned circa 10,000 points in a few seconds, by a contact scanning method it is just a circa 100 points The advantage of contact scanning is

particularly high precision, lower cost and the possibility of measuring shiny and translucent surfaces. The disadvantage is time-consumption and distortion of dimensions during scanning of softer parts. Contactless scanning main advantage is the speed of the process, possibility to scan even soft materials, and also very complex objects. By this method it's not possible to scan shiny or transparent materials, because of lower accuracy. The obtained data has to be further adjusted to polygonal mesh (STL, STEP format). Program that is compatible with recorded data "cloud of point" converts them into lines, arcs, curves and surfaces. Thus, the data are transferred to the 3D model, whose geometry can be modified in the CAD software.

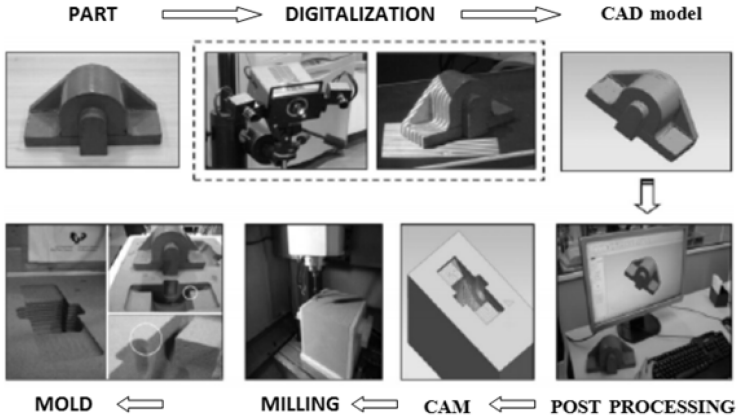

Fig. 1. Process of obtaining a mold cavity by using the method of RE and Patternless process

3. Production of prototype molds using Patternless process technology

Principle of Patternless process method consists in direct creation of mold cavity by milling into a block of hardened molding compound. It is mainly used during the production of large molds for production of heavy castings.

Using 3D CAD software is created a virtual design of mold and cores. Created 3D design is an essential input to generate machining program, which is then placed in the 3 axis or 5 axis CNC machine, which mills desired shape into the block of molding compound. During production is used one or more types of tools for roughing and finishing operations. At fig. 2 is a schematic representation of a process for producing a casting by Patternless process method.

This method is very flexible, since it is possible to make design changes using 3D CAD programs that can be installed directly in the control computer of CNC machine. All of these changes can be made until CNC machine starts the machining process. By this way of creating molds may be the time required for prototype production reduced by half.

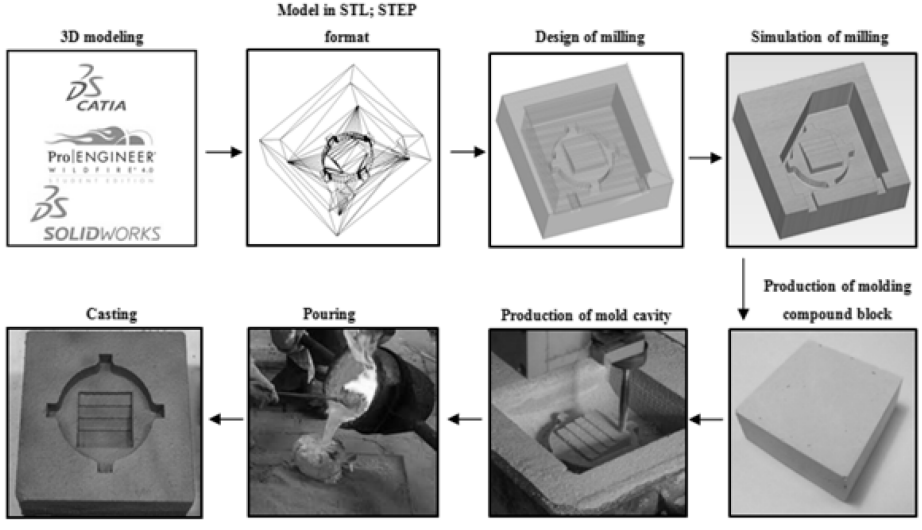

Fig. 2. Technological process of casting production by using Patternless process method

3. Prototype casting production process

Prototype casting production process, which serves as a foot rest bracket on historical motorcycle (veteran), was based on real scan of the damaged part. To obtain the 3D model was used non-contact scanning. The real component was scanned from multiple angles in order to obtain the most accurate virtual form of scanned part. Fig. 3 shows the two outputs from the scanning device, which subsequently had to compress into a single part.

Fig. 3. Scanning of part in a number of positions

Fig. 4 shows individual records compressed into a single part. A color differentiation represents a large number of recorded points that determine the shape and geometry of the model.

Fig. 4. Compression of individual records into final part

During scanning of various parts is often the case that some areas it is impossible to capture details and on created 3D models arises empty spaces that need to be adjusted in CAD software. At Fig. 5 are shown in a black color unscanned areas that needs to be repaired. From the final 3D model is then created the mold cavity and consequently a machine program. Fig. 6 illustrates the mold cavity for the casting. Gating system was subsequently milled into block. Fig. 7 shows a machine cycle made in CAM software. The generated program is inserted into the CNC machine and the cavity was milled into block of molding compound.

Fig. 5. Unscanned places of the part (black color)

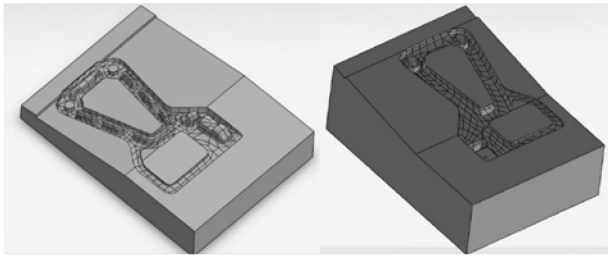

Fig. 6. Virtual design of mold cavity

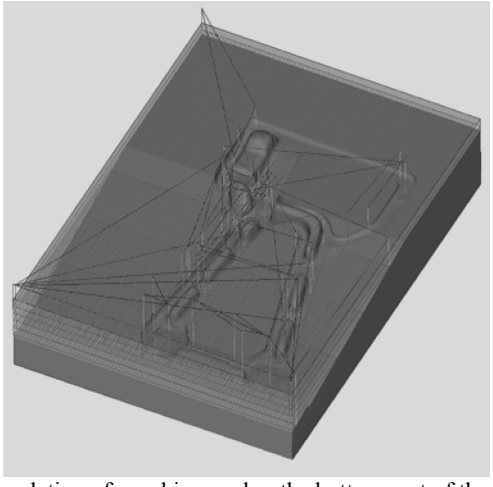

Fig. 7. Simulation of roughing cycle - the bottom part of the mold cavity

To create the block of molding compound was used silica sand and gypsum, which can withstand temperatures up to 1200 ° C. Made block was placed in a CNC machine and then the machine cycle was started. Fig. 8 shows the individual parts of the mold cavities, which were treated with a protective graphite coating to improve the quality of the surface. Mold was after assembly ready for casting. Gravity casting method was chosen and as a material was used copper alloy. Casting temperature was 1150 ± 50 ° C. At fig. 9 is captured final casting.

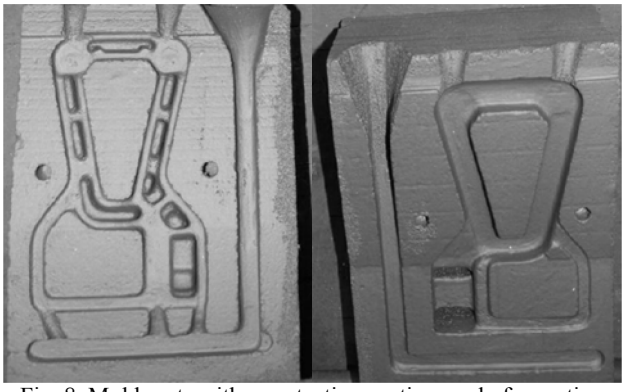

Fig. 8. Mold parts with a protective coating ready for casting

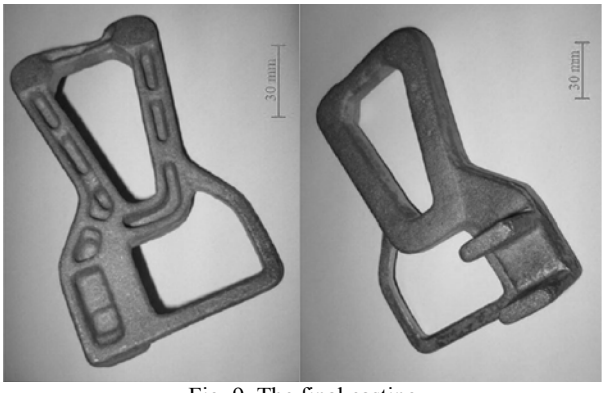

Fig. 9. The final casting

4. Conclusion

Submitted article deals with the use of Reverse engineering method and patternless process technology. The result is a prototype casting. By combination of these two technologies we can speed-up the designing and manufacturing of prototype mold - casting. The main advantage is the great flexibility of the production process, speed of production, and especially low cost compared to competing technologies relying on the principle of 3D printing. Currently, the Department of Technological Engineering at University of Žilina conducts research in order to optimize the production process of the mold cavity by Patternless process technology to achieve increased dimensional and shape accuracy of finished castings. Optimization of the production process will help increase the competitiveness of Patternless process technology for the production of prototype castings.

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