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The Production of Plaster Molds with Patternless Process Technology

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Abstract

The work deals with technology Patternless process that combines 3 manufacturing process mold by using rapid prototyping technology, conventional sand formation and 3D milling. It's unconventional technology that has been developed to produce large-sized and heavy-duty castings weighing up to several tons. It is used mainly in prototype and small batch production, because eliminating production of models. The work deals with the production of blocks for making molds of gypsum and gypsum drying process technology Thermomold. Into blocks, where were made cavities by milling were casted test castings from AlSi10MgMn alloy by gravity casting. At machining of the mold cavity was varied feed rate of tool of cemented carbide. Evaluated was the surface roughness of test castings, that was to 5 micrometers with feed from 900 to 1300 mm/min. The dimensional accuracy of castings was high at feed rate of 1000 and 1500 mm/min did not exceed 0.025 mm.

Keywords: Innovative foundry technologies and materials, Automation and robotics in foundry, Patternless process technology, Plaster thermomold, Aluminium alloy

1. Introduction

By the technology Patternless process can be produced large size and heavy-duty castings weighing up to several tons. In such castings oftentimes the emphasis is not placed on increased size and geometric accuracy, considering the large metal allowance for cutting operation. Although, currently the researches are conducted in improving quality and dimensional accuracy of molds made by Patternless process technology. The quality of the casting surface depends on several factors such as the grain size of the sand mixture. Using plaster molds can be achieved surface roughness Ra in the range 1.6 to 12.5 μm.

Plaster molds do not have just very smooth surface, but also a great accuracy. For the curing, water is used. Technical gypsum resists to temperatures of 800 ° C, suitable for the production of mild to moderate castings from 30 g to 7 kg with a minimum wall thickness of form 0.6 mm. It is suitable for casting a low-melting materials such as zinc, aluminum and magnesium alloys. A disadvantage in the solidification of the gypsum block is formation of large pores, which impair the quality of the mold surface.

In the production of gypsum block there is a large consumption of material, and this is why new specific methods for frothing gypsum have been developed, allowing the reduction of consumption thus reducing the weight of the block while increasing breathability form.

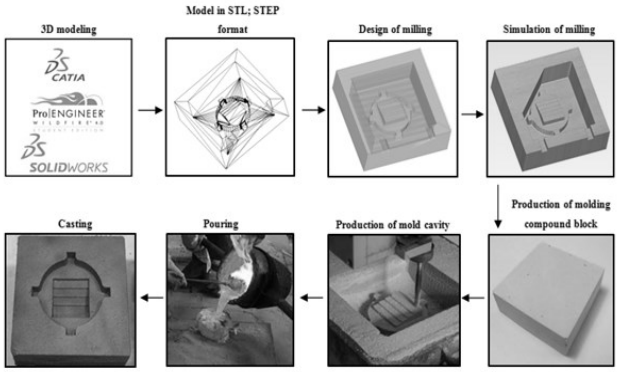

Fig. 1. Casting production technology Patternless process

Department of Engineering Technology (KTI) University of Žilina has available equipment which is designed for the machining of molding compounds used in the production of molds by Patternless process technology. Overall dimensions of the 3-axis CNC milling machine is 1600 x 1200 x 965 mm. On the device can be machined surface with dimensions of 700 x 800 mm with an accuracy of 0.05 mm. The maximum speed of rotation of the spindle of type TEKNOMOTOR 3140 is 18000 rev. / Min with performance of spindle 0.73 kW. In Fig. 2 shows a plant for the production of prototype molds.

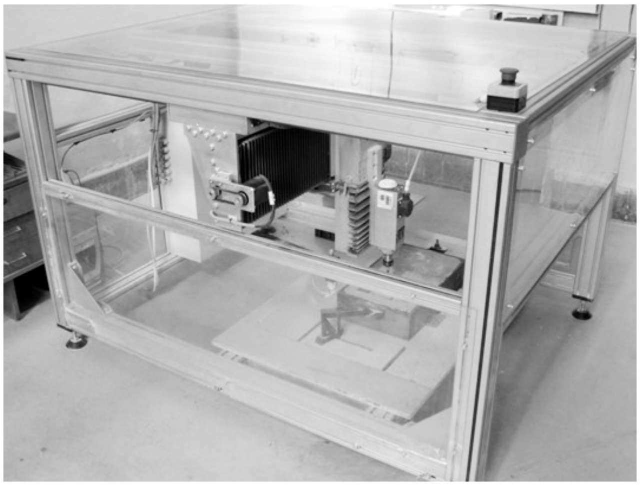

Fig. 2. 3-axis CNC milling machine

2. Description of achieved

For the experimental tests were made blocks of technical plaster type Thermomold. This plaster is intended for the production of prototype castings of aluminum alloys. Selected technical properties of technical gypsum Thermomold are showed in Table 1. For the experiment, the technical Thermomold gypsum was mixed with water in a ratio of 100: 92.

Table 1.
Selected properties of gypsum Thermomold

Ratio of gypsum/water (P S/V)	100 : 90 to 95
Temperature of water	20 °C
Soaking time	1 minute
Mixing time	2 to 3 minutes
Time of workability	4 to 6 minutes
End of solidification	45 minutes
Compressive strength after 2 hours	1,06 MPa (P S/V: 1,05:1)
Expansion during solidification	< 0,08 % (P S/V: 1,05 to 1,11:1)

An important step prior to casting is drying process that is lengthy and can take several dozen hours or days. Temperature cycle drying of plaster mold is influenced by the size of the mold, by moisture, and the way of warm air flow in the oven. Recommended temperature of drying cycle for technical plaster Thermomold is shown in Fig. 3.

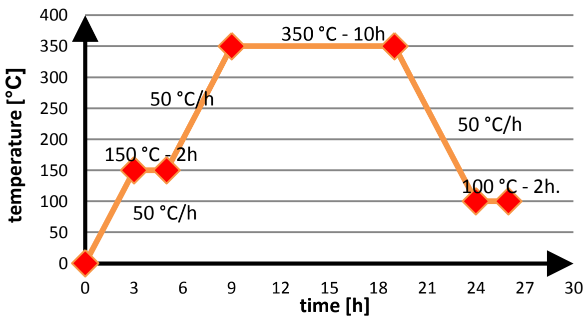

Fig. 3. Drying process

In the experiment was made molds, which cavities had the shape of parallelepiped with dimensions of 30x30x10 mm. As a machining tool was used monolithic shank cutter Ø 8 mm EndMill of sintered carbide manufacturer OptiMill® labeled Uni SCM10. Machining of mold blocks was conducted using cutting conditions listed in Tab. 2.

Table 2.
Cutting conditions in machining of mold blocks

Cutting conditions					
tool diameter	*D* *[mm]*	8	**number cutter teeth**	*Z* *[-]*	2
feed	*f* *[mm/min]*	900 ÷ 1500	**cutting depth**	a_p *[mm]*	1
number of revolutions	*n* *[ot./min]*	2000 ÷ 18000	**cutting speed**	v_c *[m/min]*	50÷ 402

In the experiment value of revolutions was chosen between 2000 and 16000 rpm. Figure 4 shows the milled cavities for the production of test samples. In addition to changing the speed machining tool were also carried out tests with varying feed rate of tool. On the basis of a previous experiment were chosen speed of tool 7000 rpm.

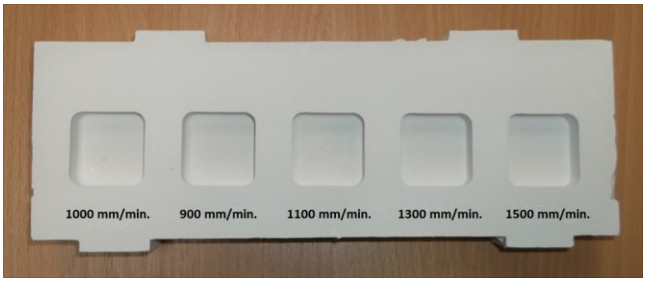

Fig. 4. Moulds for test castings

For casting was used aluminum alloy AlSi10MgMn whose chemical composition is indicated in the Table 3. Experimental casting took place in a laboratory of casting KTI. For casting was usedv electric resistance furnace LAC T15V. After the temperature of casting 720 ± 5 ° C, the melt was casted gravity to the mold.

Table 3.
Chemical composition of alloy used

element	Al	Si	Mg	Mn	Sr	Ti
[wt. %]	89,31	9,837	0,386	0,254	0,0035	0,017
element	**Fe**	**V**	**Cr**	**Ni**	**Pb**	**Sn**
[wt. %]	0,17	0,0097	<0,002	<0,005	<0,05	<0,005

3. Description of achieved results

Made castings were subjected by measurements of dimensional accuracy and surface roughness. Measurement of dimensional accuracy was performed by a mikrometer. From individual measurements were done arithmetic averages. Measurement of surface roughness was realized by roughness meter MarSurf PS1, and was measured roughness Rz.

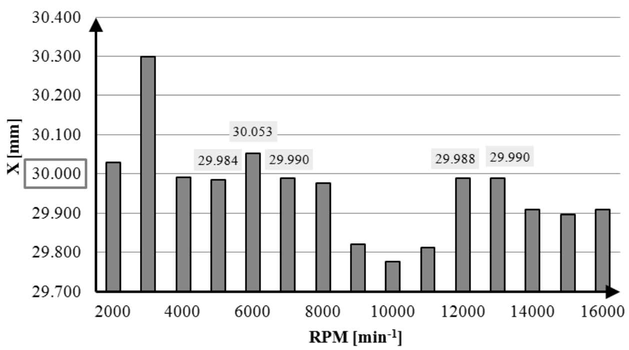

Fig. 5. The dependence of the size of the axis X of rotation tool Ø 8 mm Endmill

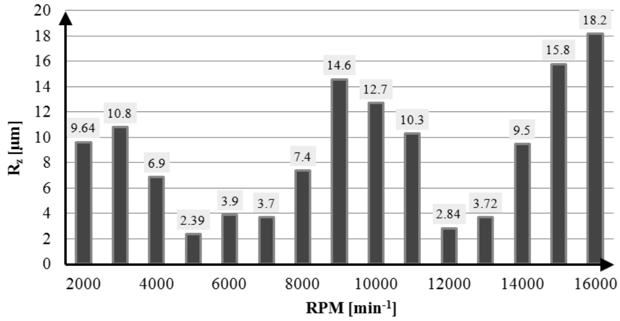

Fig. 6. The dependence of the surface R_z of tool speed Ø 8 mm EndMill

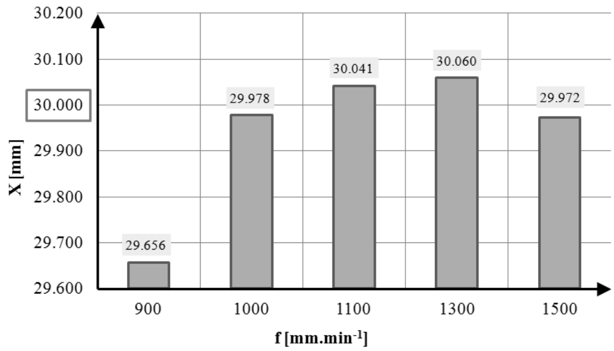

Fig. 7. The dependence of the size of the axis X of displacement f

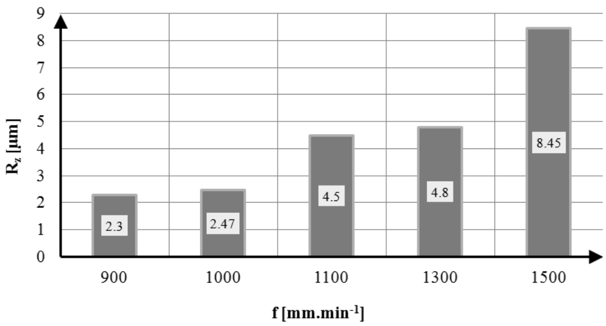

Fig. 8. The dependence of the surface roughness R_z of feed f

The effect of changing the speed to the dimensional accuracy of castings made is shown in Fig. 5 and the effect of changing the speed for the surface roughness is shown in Fig. 6.
At a speed above 8000 min^{-1} occurred to the oscillation tool, what was associated with lack of rigidity of used CNC milling machine. This oscillation resulted in deterioration of the mold surface, dimensional accuracy and surface roughness of made castings.The effect of feed rate on the dimensional accuracy of the manufactured castings is shown in Fig. 7.
The impact of feed on the surface roughness of made castings is shown in Fig. 8. As in the previous experiment occurred to the oscillation of tools which resulted to the deterioration of the particular surface roughness of experimental castings.

4. Conclusions

From the results of the experiment can be concluded that on the dimensional accuracy of castings made to plaster mold has a significant impact stiffness of CNC milling equipment that has KTI.

From the experiments that were made can be selected for the best conditions regarding dimensional accuracy (deviation size from 0.01 to 0.05 millimeters) and surface roughness (from 2.39 to 3.9 µm) the speed in the range from 5000 to 7000 rev./min which represents the cutting speed 126 až 176 $m.min^{-1}$.

When changing the feed rate were the most favorable conditions achieved at 1000 $mm.min^{-1}$, when the dimensional accuracy had an average value of 29.978 mm and a surface roughness $R_z = 2.47$ µm.

These machining parameters were selected for the production of prototype castings cast in plaster molds.

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