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RAPID TOOLING IN SAND CASTING APPLICATIONS

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ABSTRACT
Rapid tooling refers to process and technologies that help shorten time from planning to producing tools and with which the production costs are reduced. Classic technological procedures, such as turning, milling or casting are still the most common way of producing products from a wide range of available materials; rapid tooling is an option how to make those procedures faster, cheaper and better. On the example of the casting model we present the analysis of time and costs savings between separate procedures of rapid tooling according to classic production of casting application with high-speed cutting.
Keywords: Technologies with layer manufacturing, rapid prototypes tooling, sand casting

1. INTRODUCTION
Rapid tooling is a common term, describing production technologies, in connection to shorter time from planning to marketing. There are different ways of using rapid tooling because of its wide range. Tools, made under these procedures, may be used for injection moulding as well as casting of special alloys for astronomy and defence industry. Rapid tooling is different from reduction material procedures, such as turning, milling or electro discharge machining. With rapid tooling the material is not taken off from solid material, because we use special procedures where material is added till the form is perfect. Those rapid tools can be made directly from procedures that mostly look like rapid prototype tooling or indirectly with pra-model copying of sand casting procedure.

Rapid tooling also covers production of soft tools, small series tools, low cost tools and test tools. The purpose of this technology is to shorten preparation time and lower tools making costs. Consumers wish different versions of the same, low cost product, which make the companies to use rapid tooling simultaneously with classic 'hard tools' production. There are numerous business opportunities of rapid tooling, such as shorter time till marketing, tools construction insurance, up to date tools production according to consumers' wishes, tools production with small investments for middle and small companies and remunerative way for construction changes before massive production.

On the example of the heater model we analyse and determine time and costs advantages of rapid tooling procedures in comparison to classic production of high-speed cutting of aluminium model.

2. PRODUCTION OF HIGH-SPEED MILLING OF ALUMINIUM MODEL
To produce a casting application we need a hard and resistant model, because the casting sand is abrasive. In mass production casting sand applications are produced from steel (in low production applications are mostly produced from aluminium) with CNC turning/milling, directly from CAD computer model. For comparison between individual procedures of casting applications production

we chose a heater, produced in ETA Cerkno from EN-GJL-250 grey iron with sand casting procedure [1]. The heater is 145 mm in diameter and 22,7 mm in height, on the inner side there is spiral groove in which a heater is built in.

Aluminium model to produce sand casting applications is made from work piece, dimensions 200x30mm. The whole procedure of application production can be divided into many steps. The first step is font finishing of the work piece and production of external profile with turning. Turning makes handling better and better quality of surface than milling. In the same time six M4 screws are made on the external part of the model. Those screws are used to attach the model on the model board. The second step is deepening of the work piece by milling on the inner side of the model to spiral groove. Deepening is made by front cutter for rough milling with diameter 25mm. The third step is rough production of spiral grooves on the inner side of the model. Grooves are made by cutter with diameter 3mm and rounding up of cutter by 0,5mm. The fourth step is final groove and surface handling on the inner side of the model, also by cutter with diameter 3mm and rounding up of the cutter by 0,5mm.

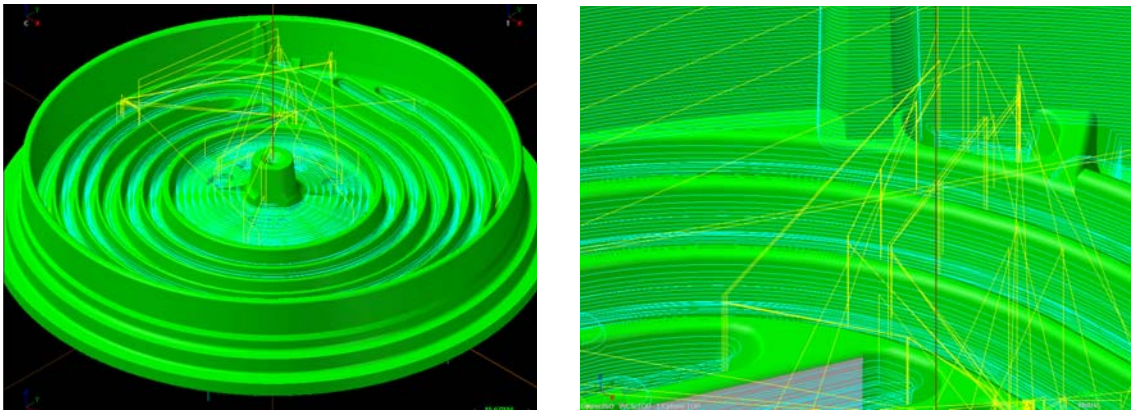

Figure 1. Working and fast movements at aluminium model handling

Time and handling costs are, at classic handling, mainly connected to the amount of material that has to be removed from work piece in order to get a perfect product. The costs of basic material are minimal. In our case, the aluminium work piece costs 16€ which represents minimum costs according to the whole model price. Complications of the product influences handling time and costs. More complicated the product is more time is needed for the production, followed by a higher final price of the product. To make the casting application with high-speed cutting of aluminium, handling time was 8 hours and the production costs were 368€ (60.000 casting applications can be made with this model).

3. SLS AND POLYJET MODEL PRODUCTION

To produce our model using EOS P 385 under the process of selective laser sintering of plastic powder dust we chose polyamide material PA12 strengthened by glass pieces (40% glass balls) PA 3200 GF because of excellent mechanical characteristics and resistance to usage. Material is appropriate for highly temperature burdened products, such as castings in car industry [2]. Model test on the casting application machine showed, that the model surface made of PA 3200 GF material was too rough because the model tore the sand from the sand application. We tried to fix the quality of the surface by grinding, similar to final handling of the metal models. Repeated test showed that the model still had too rough surface and thus tore the sand from the sand application [3].

PA 2200 material is made of polyamide 12 and used for prototype and final product production that need good surface quality directly from building chamber with no need for additional handling. Mechanical characteristics and resistance to usage of PA 2200 are a bit worse than with PA 3200 GF material [2]. The model test from PA 2200 material on the casting application machine showed that the model still tore the sand from the sand application, nevertheless we changed the material. Again we tried to smooth the surface by grinding but the model still tore the sand from the sand application

[3]. With classic handling, the time and costs are mainly connected to complications and the amount of the product that needs to be removed from the work piece, but with rapid tooling the complications of the product has no influence to the time and costs of the product (production time is 2,42 h, costs 254€). Using the model, made by selective laser sintering technology, it is possible to produce approximately 20.000 sand applications.

PolyJet procedure offers great accuracy at relatively short production time and is rather cheap. The first material, used on QuadraTempo machine and from which we produced our casting model was translucent polymer under the name of FullCure M-720 (for moulding material) and FullCure S-720 (for support material). Both are stored in 2kg containers that can simply be put into the machine [4].

PolyJet procedure production is one of the fastest, as well as the complication of the model has no impact on the costs and the production time. The price is influenced by model height that needs to be injected. Nevertheless our model could be produced without support material (it does not have inclinations, cavities …); its use is recommended because we get better surface quality of the model. The use and the support material costs are negligible (production time 8,5h, costs 438€).

Production price of the heater model with PolyJet procedure is higher than high-speed cutting of aluminium production. PolyJet procedure enables the production of lesser sand applications than the aluminium heater model. Rapid tooling is appropriate mainly for complicated model production and where classic production would not be economically justified or even impossible. Our heater model was not complicated, so the PolyJet procedure was not economically justified.

4. DIRECTCAST AND VOXELJET METHOD OF CASTING SAND PRODUCTION

EOS Company developed a procedure for direct sand casting applications production under the name of DirectCast. Using EOS S 750, working on the principle of laser sintering, it is possible to automatically produce casting sand applications directly from CAD computer program. This enables us to produce very complicated casting applications in a very short time (a few days). These casting applications have similar characteristics, like classic casting applications and are suitable for casting most of the alloys (aluminium, magnesium, steel and grey iron) [2]. The machine enables application production, with which the production under classic procedures would be time consuming, economically unjustified or not possible to produce with conventional procedures. In this manner we are able to produce high quality castings for motors, pumps or hydraulic devices. Applications may be used for quick and cheap prototype production as well as low serial casting production.

According to the production time (2h) and costs (203€), DirectCast procedure is not appropriate for the production of our heater because the costs to produce a single casting sand application are too high for serial production. Our heater model is not complex enough to make the production economically justified. DirectCast is suitable for prototype production of highly complex castings that could not be produced under classic methods. At the same time Direct Cast is appropriate where the final product is needed within a few days.

VoxelJet procedure is technologically similar to DirectCast procedure in producing casting sand applications. The production price of casting applications in VoxelJet Company is influenced by numerous parameters. The first parameter is the number of ordered casting sand applications. Higher number of the same applications makes the price per application lower. The second parameter that influences the price is date of delivery. Shorter date of delivery makes the price higher and vice versa. According to the price (247€), the casting sand applications order is under VoxelJet method economically unjustified in our case.

5. CONCLUSION

In the article we present and compare time and cost production of casting sand applications using classic procedure, high-speed cutting of aluminium, rapid tooling of selective laser sintering and PolyJet procedure. On the same time we compare DirectCast and VoxelJet procedures of casting sand applications production. The comparison was made using the heater model produced in ETA Cerkno.

Rapid tooling procedure to make relatively simple casting sand applications was not appropriate in our case because they do not give economical and time advantages in comparison to classic handling. Main advantages of rapid tooling would be seen with complex casting sand applications production. This is the opportunity of further research.

The results show that casting applications, produced from polyamides, have too rough surface and thus unusable for sand applications. The model surface could be improved by using paint workers glazier which is widely used in car industry. Paint workers glazier closes the pores and enables the surface to be smoothened by grinding. In further research the characteristics of different layers, ways of surface smoothening and time and costs should be tested. The practice shows that the surfaces are normally formed where the car paint workers glazier is used, so there is great probability of satisfactory results.

6. REFERENCES

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