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COMPARING THE ACCURACY OF MASTER MODEL AND THEIR REPLICAS PRODUCED BY RAPID TOOLING USING VACUUM CASTING

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Summary: *In this paper we compared the accuracy of an original master model which was used to make the silicone mold and mold cavity and its replicas obtained by the vacuum casting technology. This technology allows us to create small batches of parts based on the master model in a relatively short time. The aim of the paper is to compare the accuracy of replicas produced with the OEM part using a reversible engineering technique, that is, CAD to part.*
Key words: OEM part, Vacuum Casting, Reversible Engineering, CAD to part

1. INTRODUCTION

Vacuum casting technology has become a widely accepted technique for rapid tooling and rapid production of small batches. Vacuum casting represents a newer version of precision casting, differing in the mold making process. The most important feature of vacuum casting is significant reduction of production time and costs compared to traditional methods. This is especially important due to high competition in the global market and the continued need for rapid development, improvement and placement of new products [1].

Vacuum casting is one of the flexible rapid tooling techniques due to the range of material properties that can be produced using this techique, which is especially important in the process of developing new products. At this stage the appearance and properties of the produced part must fully satisfy the set requirements. Most commonly used materials include high quality polymers such as ABS plastic, polycarbonate, polypropylene and elastomers [1].

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2. CASE STUDIES

2.1. Rapid tooling using vacuum casting technology

Vacuum casting technology has a huge importance in the fabrication of a limited amount of precise parts in as short time as possible.

The process of vacuum casting consists of the following steps [2], according to Fig. 1:

1. Preparation of OEM part for the casting process. Setting the parting tape on the blinker negative that will facilitate the separation of silicone mold.
2. Bonding plastic gates on the blinker negative which has a role to form an inlet channel in the silicone mold and to facilitate the positioning and fixation of the negative in the silicone casting frame.
3. Calculation of the necessary quantity of silicone mixture to form a silicone mold to be used for molding the blinker. The silicone mixture is poured into the frame with fixed blinker negatives and then the frame with the negative submerged in silicone is placed in a vacuum chamber in order to remove the residual air bubbles from silicon.
4. Positioning of the silicone mold in a vacuum chamber. After solidification of silicone, silicone mold is cut to parting line, during which we relieve the negative and get a silicone mold for casting a replica of a given negative
5. The molding halves are then combined and the next step is to calculate necessary quantities of resin for molding of the blinker. The amount of resin is commonly determined by weighing the individual master model which is increased by 20-30%, taking into account the loss of material in vessels and inlet channels. In this case, to cast the blinker, components made by Axson Technologies were used, thus by mixing them in the casting process the parts with physical characteristics according to Tab. 1 are obtained.
6. After a certain quantity of the material needed for molding and the proportion of the individual components of the material in a total amount are determined, then vacuum casting process follows. The casting process takes place in a vacuum chamber under conditions that are recommended for corresponding elements and components of the material.
7. After solidification of the molded material in a vacuum chamber, mold halves are separated and, if necessary, post-processing of the molded item follows.

Table 1 *Physical characteristics of components used for casting of the blinker*

Composition		ISOCYANATE PX 521HT A	POLYOL PX 521HT B	MIXING
Mixing ratio by weight		100	55	
Aspect		liquid	liquid	liquid
Colour		transparent	bluish	transparent
Viscosity at 25°C (mPa.s)	Brookfield LVT	200	1,100	500
Density at 25°C Density of the cured product at 23°C	ISO 1675 : 1985 ISO 2781 : 1988	1.07 -	1.05 -	- 1.06

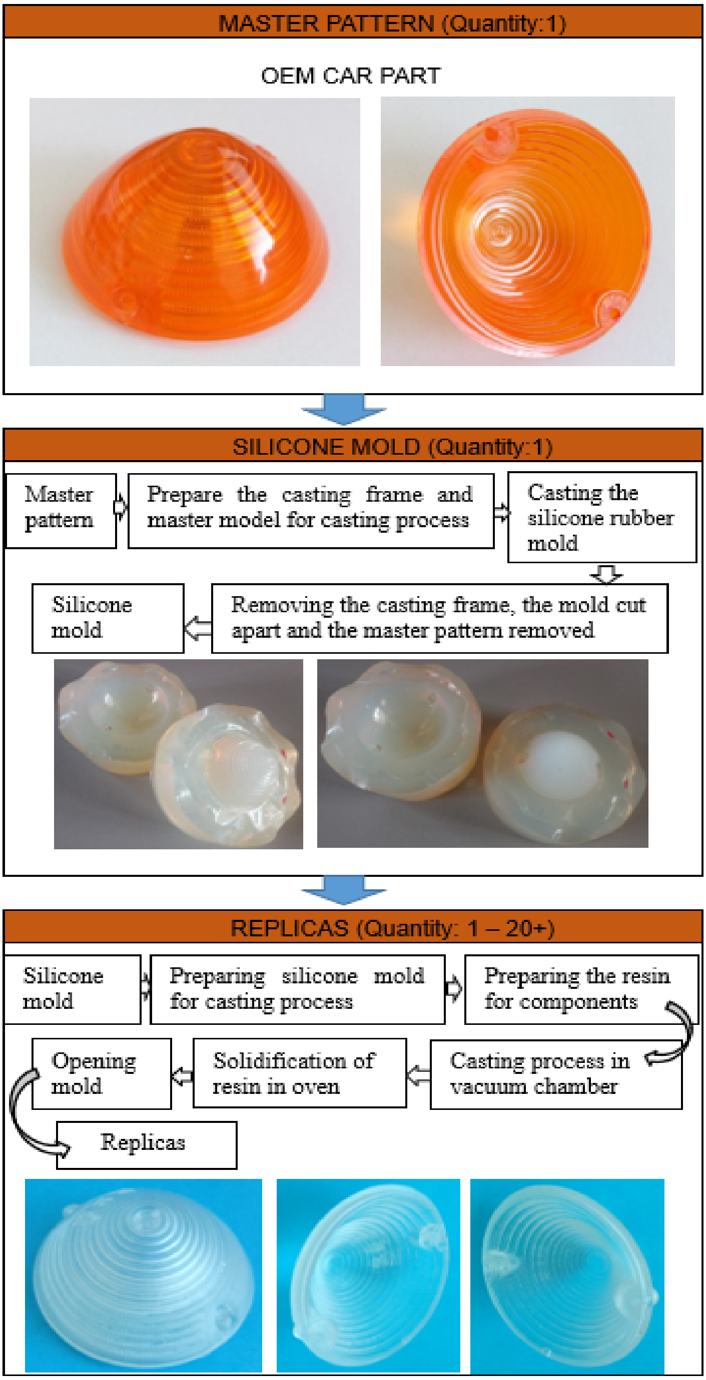

Fig. 1 *Fabrication of small batches of blinkers using vacuum casting technology [2]*

3. CAD to part

Evaluation of the measurement results implies the calculation of deviation of actual points from the surface of a produced part, in relation to corresponding nominal points and the presentation of results in the appropriate form. In the case of a complex geometric form, the surface-deviation type is commonly known as CAD to part. Such an approach involves a comparison of a digitized model and produced object (a cloud of spots - real geometry) with a CAD model (nominal geometry) [3]. The stages of the CAD inspection process are shown in Fig. 2:

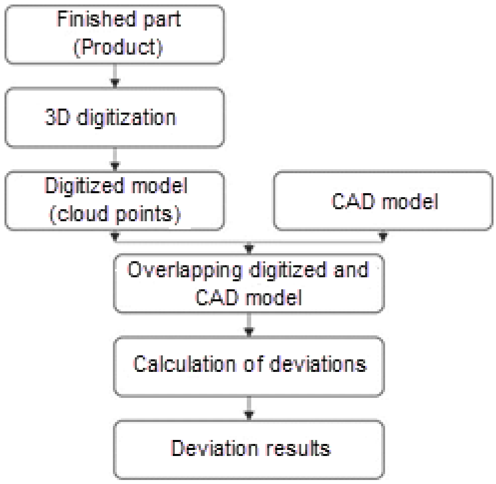

Fig. 2 *The stages of the CAD inspection process [3]*

In order to obtain more credible deviation results, it is necessary to carry out adequate mutual orientation of a digitized and a CAD model (Figure 14). The adequate model orientation is a prerequisite for the implementation of deviation calculations. The deviations are calculated on the basis of comparison with the corresponding points, curves or surfaces on the nominal (CAD) model by determining the distance in the direction perpendicular to the surface of the nominal model at the appropriate point [3].

Nikon MCAx20+ measuring arm and 3D Nikon MMDx100 scanner were used for scanning with the basic characteristics shown in Table 2.

Table 2 *Specification of measuring arm and handheld laser scanner*

Specifications of measuring arm Nikon MCAx20+ with handheld laser scanner Nikon MMDx100	
Measuring range	2000 mm
Point repeatability	0.023 mm
Volume length accuracy	± 0.033 mm
Arm weight	8.2 kg
Laser scanning system accuracy	0.048 mm
Working temperature	0 – 50 °C
Shock & Impact	6 ms

Presentation of results in the color map region (Fig. 3) implies the generation of a color region based on calculated deviation levels, where the green color signify regions with a zero deviation level or a very close to zero level, and the red regions are with the greatest deviations in the positive direction (from the measuring object), and blue regions with the greatest deviations in the negative direction [3].

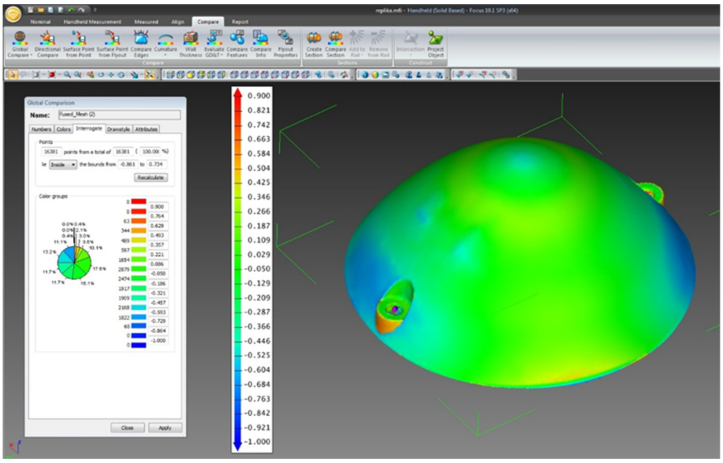

Fig. 3 *Presentation of deviation in the color map region*

When showing the results of deviation in arbitrarily selected color points (Fig. 4), the principle is exactly the same as in the previous case, with the exception that color regions are not generated, but the measurement points are displayed in colors according to deviations calculated in those places [3].

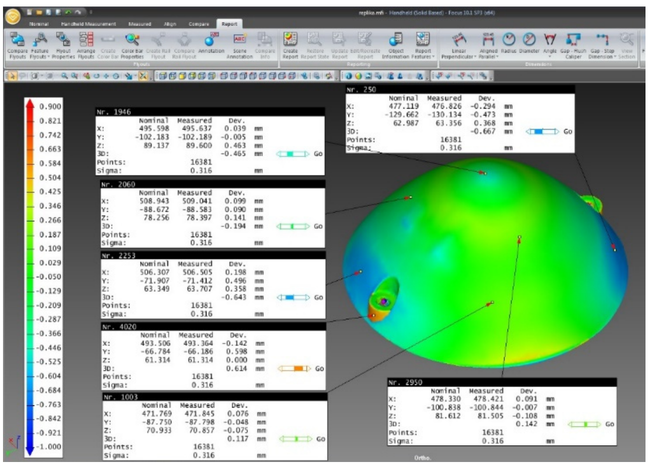

Fig. 4 *Presentation of deviation in arbitrarily colored points*

The advantages of displaying results in this mode is a better overview of the nominal CAD model, but in the case of a smaller number of measuring points a deviation level is less noticeable.

4. CONCLUSION

The comparison of original OEM part and the replicas produced by rapid tooling using vacuum casting showed some differences in terms of achieving dimensional accuracy and surface quality. The results show that special attention should be paid to the preparation of master models, surface cleaning and all other essential details because every detail from the master model will be reproduced on a silicone mold. Also, it is necessary to pay great attention to the production of silicone molds, the installation of the sprue and the parting tape, since all of this leaves a trace on parts. Additionally, thermal deformation is, of course, the cause of deviations, especially if the replica is suddenly cooled or removed early from the silicone mold. If great attention is paid to the preparation of master models and silicone molds, this technology certainly has justification for rapid production of small batches of high precision and quality functional parts.

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