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SHEET METAL FORMING USING VACUUM CAST POLYMER TOOL

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Abstract: Sheet metal forming technology has a significant practical application and is applied in almost all branches of industry. Tool plays a crucial role in the forming process due to direct contact with the material. Since this is a deep drawing tool, special attention was paid to the fabrication of the drawing die, punch, and blank holder. The possibility of applying polymer deep drawing tool elements were analyzed. The main elements of the deep drawing tool were produced using vacuum casting technology..

Key words: Rapid Tooling, Deep Drawing, Sheet Metal Forming, Vacuum Casting

1 INTRODUCTION

The modern market constantly requires manufacturing companies to adapt to increasingly strict requirements regarding the degree of digitalization, product quality, reduction of product development time, and shortened product life cycle. A large percentage of sheet metal parts are produced using deep drawing technology. This technology allows for forming sheet metal, whereby we obtain spatial configurations such as containers, boxes, car body parts, etc., from a circular, rectangular or other shape sheet metal [1].

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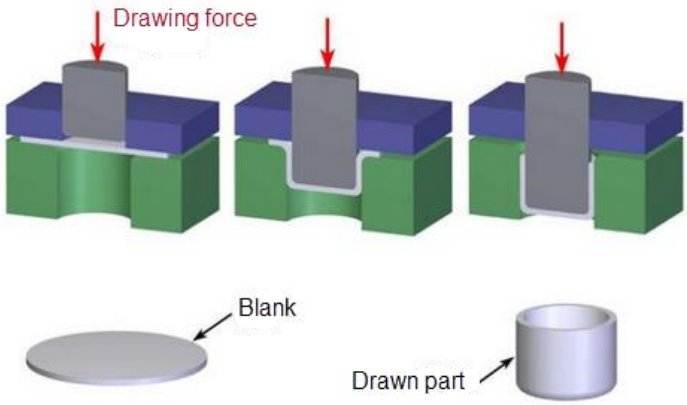

Figure 1. *Deep drawing process [2]*

The characteristic of deep drawing technology is the high cost of designing and producing deep drawing tools, but also the low production cost of parts produced using this technology in mass production. There is an increasing need for small batches of parts made with deep drawing technologies, which is often justified if the production of the tools is fast and cheap [3]. The production of classical conventional metal deep drawing tools generally does not meet these requirements. This paper analyzes the possibilities of using plastic elements of tools for deep drawing, i.e., using plastic to make the main elements of the tool, which are in contact with the material. The punch, die, and blank holder, which is in contact with the material, is made by vacuum casting technology using a two-component casting resin.

2 RAPID TOOLING USING VACUUM CASTING TECHNOLOGY

Vacuum casting technology is one of the adaptable techniques of rapid tooling due to the range of mechanical and physical properties that can be achieved using this technology, which is particularly important in the process of developing and manufacturing a new product. In addition, 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 and making molds and tool parts consists of the following steps [4]:

1. Preparation of tool parts for the casting process. Setting the parting tape on the tool parts negatives that will facilitate the separation of silicone mold.
2. Bonding plastic gates on the tool parts negatives 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 deep drawing tool parts. The silicone mixture is poured into the frame with fixed tool parts 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 deep drawing tool parts. 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 deep drawing tool parts, 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.

Casting resins from the manufacturer Axson Technologies were used to produce the deep drawing tool elements. A casting resin combination of PX 223/HT was used, which consists of two components and their combination gives the mechanical and physical characteristics of the molded components according to Table 1 and Table 2.

Table 1. *Mechanical properties of vacuum casting resin PX 223/HT [5]*

Mechanical properties at 23°C for PX 223/HT			
Flexural modulus of elasticity	*ISO 178:2001*	*Mpa*	*2300*
Flexural strength	*ISO 178:2001*	*Mpa*	*80*
Tensile strength	*ISO 527:1993*	*MPa*	*60*
Elongation at break in tension	*ISO 527:1993*	*%*	*11*
Charpy impact resistance	*ISO 179/2D:1994*	*kJ/m^2*	*>60*
Hardnes at 23°C	*ISO 868:1985*	*Shore D1*	*80*
Hardnes at 23°C	*ISO 868:1985*	*Shore D1*	*> 65*

Table 2. *Physical properties of vacuum casting resin PX 223/HT [5]*

Physical properties for PX 223/HT				
		Part A	*Part B*	*Mixing*
Composition		*ISOCYANATE*	*POLYOL*	
Mixing ratio by wight at 25°C		*100*	*80*	
Aspect		*liquid*	*liquid*	*liquid*
Color		*colorless*	*black*	*black*
Viscosity at 25°C	*BROOKFIELD LVT*	*1.100*	*300*	*850*
Density of parts before mixing at 25°C	*ISO 1675:1975*	*1.17*	*1.12*	*-*
Density of cured mixing at 23°C	*ISO 2781:1988*	*-*	*-*	*1.14*

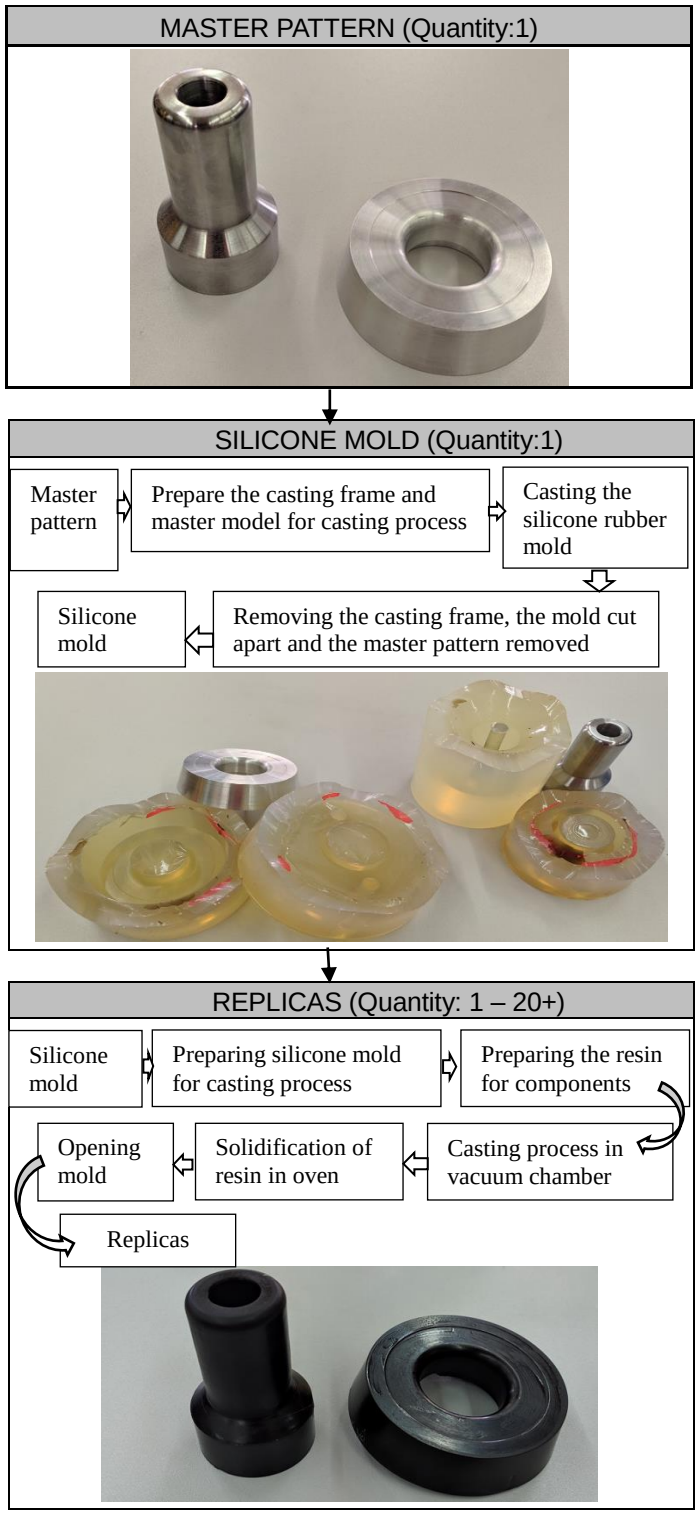

Figure 2. *Rapid tooling using vacuum casting technology*

3 PERFORMANCE OF DEEP DRAWING TOOL WITH POLYMER ELEMENTS

The polymer elements of the deep drawing tool, produced using vacuum casting technology, are into the existing construction of the deep drawing tool, shown in Figure 3.

Figure 3. *Deep drawing tool with polymer elements*

The basic process parameters and dimensions of the deep drawing tool are shown in Table 3.

Table 3. *Deep drawing process parameters*

Material:	DC01
Thickness:	0.8 mm
Blank diameter:	64 mm
Punch diameter:	33 mm
Die diameter:	34.65 mm
Lubricant	without lubricant

Under the mentioned conditions, a small batch of workpieces was made, from sheet metal material DC 01 with a thickness of 0.8 mm. A small batches of fabricated parts on a deep drawing tool located in Laboratory for technology of plasticity at Faculty of Mechanical Engineerig in Banja Luka is shown in Figure 4.

Figure 4. *Deep drawn parts*

4 CONCLUSION

In this paper is presented the possibility of using plastic tool elements in sheet metal forming using deep drawing. The advantages of vacuum casting technology, allows us to use a wide range of materials which is particularly significant here. By using different combinations of casting resins, we are able to obtain deep drawing tool elements with many different mechanical and physical characteristics and choose optimal resin components for individual tool elements. In this experiment, using the component PX 223/HT from the manufacturer Axson Technologies for a production of limited series of DC01 sheet metal parts with a thickness of 0.8 mm, satisfactory first results were obtained. On a series of about twenty drawn samples, there were no visible signs of wear or damage on the tool die, punch and blank holder, which were in direct contact with the sheet. The parts are dimensionally correct and in the tolerance. Although the production process was done dry, without lubricant, and there are no scratches or wrinkles on the samples since the polymer elements of deep drawing tool are less hard than the sheet material. This is particularly important from the point of view of ecology, since we do not use lubricant and therefore saves time and money because there is no need for subsequent degreasing of the workpieces. This experiment shows the possibility of applying this technology to make a small batch of samples. Further research is needed to determine the limit series of samples that can be made using polymer deep drawing tools produced using vacuum casting technology.

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