The analysis of the possibility of the application of the casting waxes in the process RP

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Abstract
The article presents analysis of possibility of application of casting waxes in process of rapid prototyping of casting models in silicone the matrices. The researches were made on casting waxes applied to the manufacturing of precise casting models and also the model system. Testing waxes are intended nominally to the processing in process of the injection. The determining of possibility processing of waxes in silicone forms was purpose of researches. Researches concerned of whole manufacturing process i.e. the preparation of the form and wax, the filling of form and also the deforming. As a result of made researches the temperature of filling of matrix was determined. The main part of research process concerned determining of temperature of deforming for every with kinds of waxes. This is especially important in case of manufacturing of casting models of precise elements, which can be destroyed easily. In this purpose researches of the bending of waxen forms were made in the range of temperature 20-37ºC. The processing parameters of casting waxes were determined as a result of made researches.

Keywords: mechanical properties, casting waxes, rapid prototyping, silicone matrices.

1. Introduction
Rapid manufacturings of prototypes of cast elements requires application of modern research and productive technologies [1, 2, 3, 4]. One from indirectly methods of rapid prototyping is technology of manufacturing of models in silicone forms. Silicone forms manufactured by means of methods of the Rapid Tooling under lowered pressure in the technology Vacuum Casting. Silicone matrices enable on the production of prototypes with the different materials such as: casting waxes, the resins of the polymers, chemically hardenable and also the low-fusible alloys [5, 6, 7].

The works concerning of application of systems of rapid prototyping in casting processes concern mainly of manufacturing of casting models with application of the additive methods and also indirect methods in it silicone forms [8, 9]. The problems resulted with technological process are omitted most often in these works [10, 11, 12, 13, 14, 15]. One from such problems is possibility of the occurrence of the waxen damages of casting models during process of deforming of silicone matrix.

2. Researches of processing parameters of casting waxes
Researches of processing parameters were executed on five kinds of casting waxes. In the first stage they contained determining of temperatures and the time of the warming of forms before filling of them and also temperatures of the fusion of waxes. Tests of filling of silicone matrix by means of chosen kinds of waxes were executed in next part of researches. The list of results of researches presents table 1. First three kinds of waxes (1W-CZ, 2W-BR, 3W-SZ) have similar processing parameters. There are waxes intended to manufacturing of helpful elements of model system. Waxes 4W-JZ and 5W-CZ about structure of the composite with polymer filler are intended to
manufacturing of models of the blades by means of technology of injection.

Table 1. Processing parameters of casting waxes

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<tbody>
<tr>
<td>Model system</td>
<td>1W-CZ</td>
<td>130</td>
<td>85</td>
<td>2</td>
<td>good</td>
</tr>
<tr>
<td>Model system</td>
<td>2W-BR</td>
<td>130</td>
<td>85</td>
<td>2</td>
<td>good</td>
</tr>
<tr>
<td>Model system</td>
<td>3W-SZ</td>
<td>130</td>
<td>85</td>
<td>2</td>
<td>good</td>
</tr>
<tr>
<td>Models</td>
<td>4W-JZ</td>
<td>140</td>
<td>90</td>
<td>2</td>
<td>weak</td>
</tr>
<tr>
<td>Models</td>
<td>5W-CZ</td>
<td>140</td>
<td>90</td>
<td>2</td>
<td>average</td>
</tr>
</tbody>
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Next part of research process concerned of determining of temperature of deforming for determined the type of wax.

In this purpose researches of bending were made on forms about dimensions 110mm x 10 mm x 4mm. Forms applied in researches were casted in silicone forms with five kinds of wax (tab. 1). Research process came according to norm PN-EN ISO 178 with using the durability machine (fig. 1). Researches of bending were executed on the patterns for every kind of wax in temperatures: $T_z=20^\circ\text{C}$, $T_z=25^\circ\text{C}$, $T_z=28^\circ\text{C}$, $T_z=31^\circ\text{C}$, $T_z=34^\circ\text{C}$, $T_z=37^\circ\text{C}$. Bending tensions were calculated with the following formula:

$$\sigma = \frac{3FL}{2bh}$$  \hspace{1cm} (1)

where:

- $\sigma$ – the bending tension [MPa],
- $F$ – the applied power [N],
- $L$ – the span of props [mm],
- $b$ – the width of form [mm],
- $h$ – the thickness of form [mm].

The value of the maximum of the diffraction’s arrow accepted according to the norm PN-EN ISO 178 with the following formula:

$$s = 1.5 \cdot h$$  \hspace{1cm} (2)

For executed researches respective parameters had following values: $F$ – the reading with machine, $L=60\text{mm}$, $b=10\text{mm}$, $h=4\text{mm}$, $s=6\text{mm}$, the speed of bending was equal 2mm/min.

Results of researches were presented graphically on the charts 2 to 7.

Fig. 1. The test of bending of waxen form.

Fig. 2. Charts of bending tensions of waxes $T_z=20^\circ\text{C}$.

Fig. 3. Charts of bending tensions of waxes $T_z=25^\circ\text{C}$.

Fig. 4. Charts of bending tensions of waxes $T_z=28^\circ\text{C}$.
Achieved results showed, that in temperature 37ºC patterns from all waxes achieve set diffraction’s arrow. Temperature 20ºC is the smallest set temperature of deforming of waxen models (1W-CZ, 2W-BR and 3W-SZ) with silicone matrices. Patterns with waxes 1W-CZ, 2W-BR and 3W-SZ achieve set diffraction’s arrow in whole range of temperature of researches. In temperature 20ºC all patterns of waxes characterize the largest values of bending tensions. Waxes 4W-JZ and 5W-CZ characterize larger values of bending tensions, but are however more crisp.

Additionally the X-ray analysis was made of the phase composition and also microscopic researches of waxes. As a result of X-ray analysis it was noticed for waxes 1W-CZ, 2W-BR and 3W-SZ the presence only n-paraffin (CH₂)ₓ. It was noticed for waxes 4W-JZ and 5W-CZ presence only: the n-paraffin (CH₂)ₓ, the tereftal acid C₈H₆O₄, the sodium stearate C₁₈H₃₅NaO₂, the twobenzyl’s succinate C₁₈H₁₈O₄.

The exemplified fissures of patterns with wax 1W-CZ, 2W-BR and 3W-SZ presented on figure 8 and also wax 4W-JZ and 5W-CZ on figure 9.

The microscopic photographs shows the homogeneous structure of crisp fissure of waxes 1W-CZ, 2W-BR and 3W-SZ, for waxes 4W-JZ and 5W-CZ is perceptible structure of composite (wax and filler). The capacity of filler raise durability parameters of waxes, however causes simultaneously increasing of the crispness.

3. Conclusions

Produced in vitro casting waxes can be applied to manufacturing of casting models in silicone matrices. However it is necessary to determine processing parameters for every wax
enabling on deforming of silicone matrices without damage of model.

It is possible to formulate following conclusions as a consequence of considering of results of researches in the relation to process of deforming:

- Temperature of deforming of waxes 1W-CZ, 2W-BR and 3W-SZ can contain in the range of temperature 20-31°C. The restricting of temperature of deforming to range 28-31°C influences on the decreasing of damage, what is important for manufacturing of models abort complex forms.
- Temperature of deforming of waxes 4W-JZ and 5W-CZ should contain in the range 34-37°C.

Presented results of researches have special application in the case of manufacturing of waxen model about complex shapes applied to production of casts of blades of the aircraft’s engines or the sprockets.

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Bibliography