Evaluation of wax pattern properties in the lost-wax process

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Received 11.04.2011; accepted in revised form 26.04.2011

Abstract

This article present achieved results of examination of wax pattern properties (wax compounds) which are used in lost wax process. Evaluation of those results was made with approach as it is taken in foundry. Evaluation included: evaluation of wax compound shrinkage, bending strength test, hardness test using penetration method, and resistance to creep of wax patterns in precision foundry environment.

Keywords: Quality of models, Technological properties of models

1. Introduction

In lost wax process three technological phases have the major influence on surface quality (surface micro geometry) and dimensional accuracy of precision casts.

One of those technological phases is manufacturing of precise wax patterns.

Main properties that need to be investigated are:
1) shrinkage of the wax pattern compound
2) bending strength of wax patterns
3) hardness of wax patterns
4) creep resistance in temperature function

During making of precision casts there are usually two main problems: first, when there is an introduction of new materials and wax patterns to the manufacturing process, there need to be solution for chemical composition problem and previously mentioned investigation. Second major problem, occur when there is known sample wax pattern mass and there is a need to use another wax pattern mass with known composition, this can be solved by comparison analysis of technological properties of both masses.

Moreover for lowering production costs purposes recycled wax pattern compound is used with the addition of new material and in this case examination of only few technological properties is needed.

In production process desired is to use comparison analysis of those wax pattern masses with already wax pattern masses which already proved there reliability in practice.

Most of the time this inspection methods need to be chosen, which has appropriate strength and is resistant to the temperatures which usually occurs in foundry.

Inspection method should be simple, low cost equipment should be used and examination condition should be as similar as possible to those in foundry in which patterns and molds are made.
2. Methodology and results of technological properties examination

2.1. Evaluation of wax pattern compound shrinkage

Important issues which decide about precision of wax patterns are the shrinkage properties of wax pattern compounds used to produce those patterns.

According to [1], [2], [3], [4] literature sources, precision of wax patterns is mostly determined by injection of wax pattern compound in to the die, injection pressure, individual time of injection, intensity of wax pattern compound flow in die. All of those parameters have major influence on shrinkage of wax patterns.

Quality of precision cast highly depends on their dimensional accuracy. Important phase of technological process which determines dimensional accuracy of casts is quality of wax patterns.

Factor which decides about dimensional accuracy of wax patterns is shrinkage of wax compounds used to produce them.

In this research paper examination of shrinkage properties of wax pattern compounds based on hard wax will be presented in comparison with wax based on paraffin and stearin. In the same time value of recycled hard wax was determined.

Examination station (fig. 1) was build from certain components:
1. Injection molding cylinder with wound heater
2. Actuator control valve
3, 4 Rotameter
5. Strengthen unit “Peltron” do Ptx100
5.a Displacement transducer Ptx100 “Peltron”
6. Measurement of temperature inside of sample (sensor 12)
7. Displacement measurement
8. Computer
9. Multimeter – temperature measurement inside of cylinder
10. Multimeter – temp. measurement of water in the exit of die (14)
11. Autotransformer to power cylinder heater
12. Temperature sensor in injection mold
13. Entrance of cooling water
14. Exit of cooling water
15. Die (for injection of wax pattern compounds)

Fig. 1. Examination station for shrinkage testing of wax compounds [6]

Sample shape is shown in fig. 2. Results of already examined samples are shown in graph (fig. 3 and fig. 4).

Shrinkage examination methodology require specialized equipment including die, measurement devices and require ability to withstand high pleasure of injection even up to 20 MPa.
2.2. Bending strength test

Banding of roller samples with ø 7,8 mm diameter was made, those samples were placed between two knife-edge support points and initiating a load at the midpoint of the sample. Distance between supports is 50 mm.

Results of those tests are presented in table 1.

Table 1. Results of bending strength test

<table>
<thead>
<tr>
<th>Type of sample</th>
<th>Average bending strength R_{avg}[MPa]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp. 21°C</td>
</tr>
<tr>
<td>Castylene</td>
<td>6.4^{±0.2}</td>
</tr>
<tr>
<td>Blayson</td>
<td>6.5^{±0.2}</td>
</tr>
<tr>
<td>American Wax</td>
<td>7.4^{±0.2}</td>
</tr>
<tr>
<td>English Wax</td>
<td>5.5^{±0.2}</td>
</tr>
<tr>
<td>French Wax</td>
<td>4.4^{±0.2}</td>
</tr>
<tr>
<td>PSW compound (3 times recycle)</td>
<td>3.2^{±0.2}</td>
</tr>
<tr>
<td>Wax compound (recycle, 1time)</td>
<td>5.1^{±0.2}</td>
</tr>
</tbody>
</table>

2.3. Hardness evaluation of wax patterns based on penetration method

Hardness test was made using penetration method [7], and the standardized penetration needle was used [5]. Evaluation methodology and research station is presented in fig. 5.

2.3.1. Preparing the research station for displacement measurement

Devices that were used in research station include displacement sensor, amplifier from Peltron Company, and signal translator from Labor Aster Company and multimeter from Sanwa Company.

Fig. 5. Scheme of research station for displacement measurement (penetrometer with induction displacement sensor). 1 – Holed for displacement sensor; 2 – Tested sample; 3 – Displacement sensor Ptx100; 4 – Penetration needle; 5 – Transducer, Amplifier; 6 – Multimeter Sanwa PC5000; 7 – Laptop with installed PC-link plus program

Description of research station for displacement measurement which was used for hardness test and resistance to creep deformation (fig. 5).

2.3.2. Methodology of hardness test using penetration method

Hardness of wax pattern mass was tested using penetration method which use standardized penetration steel needle which is described in PN-EN 1426 2001r. Needle is put in to the wax pattern mass in 90 degrees angle, and with 160 G force which take from one up to 5 minutes. Measurement of depression of needle in to the wax pattern mass is described in penetration units (penetration unit – described by needle depression of 0,1 mm in to the mass) and this was made with usage of penetrometer [6], and devices shown in fig. 5.

One of the first conclusions was realizing that time has low influence on hardness results of “hard” wax compounds (fig. 6). Moreover “hard” wax is significantly harder then compounds made from paraffin a stearin (PSCP) with 5% addition of ceresin and 1% of polyethylene.

![Hardness graph for different wax compounds – measurement time 5 minutes](image)

Fig. 6. Hardness graph for different wax compounds – measurement time 5 minutes

2.4. Model Resistance to creep in temperature function

Examination device is presented in fig. 7. Simple device was used in the form of arm with holes (1) in those holes roller samples of ø 7,8 mm diameter were installed (2) and measurement of changing shape in function of time in different temperatures was made.

Fig. 7. Research station for measurement of deflection (creep) of wax pattern masses [6]

Results of those measurements were gathered with usage of computer based device or altimeter (device accuracy is 0,02mm).
Examination was made to determine deflection of roller samples, which were under constant load of 30 G on 150 mm arm. Examination was done in 18 °C and 25 °C. Examination took around 10 to 20 minutes for each sample.

On presented graphs, fig. 8 and fig. 9, small influence of pressure on deflection was seen. PSCP mass is a compound which has the lowest creep resistance under constant small load which equal to 30 G. The highest creep resistance has hard waxes, which is most visible for 25 °C temperature (fig. 9).

3. Analysis of achieved results

Achieved results of wax pattern (fig. 2) compound shrinkage which are very repeatable were further analyzed by following rules from literature [10]. Because of the amount of parameters that need to be considered during this evaluation, none of the pattern shape will be optimal.

Strength test of wax patterns needs special equipment, but achieved results have quite high measurement uncertainty [10].

Results of hardness test were repeatable, but it was realized that influence of temperature not always allow choose optimal wax compound in case of hard mass. To conduct this test special research station is needed (fig. 5).

Wax pattern resistance to creep in temperature function. Results of this test are repeatable. Methodology of this evaluation include influence of temperature and allow choose optimal pattern compound. Research station necessary to do this kind of evaluation is relatively simple, and it’s possible to implement it in precision foundry.

4. Conclusions

1. Taking in consideration possibility of making those tests and evaluation in precision foundry, the most optimal option of testing wax patterns is evaluation of wax pattern resistance to creep in temperature from 16 to 25 °C.

2. If there is a need for quick evaluation of wax pattern properties hardness test using penetration method in temperature function directly on production wax pattern is recommended.

Acknowledgements

Part of the research was granted from European Social Found, as a part of “Development Program of Warsaw University of Technology”

References