Manufacture of decorative castings from highly elastic silicon rubber patterns

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Abstract

An outcome of the cooperation between the "Forma" Studio of Sculpture and Foundry Research Institute in Krakow was presented. The results of investigations of the technological properties were disclosed. Basing on these results, the wax pattern materials and silicone rubbers for master patterns and elastic patterns, respectively, were selected. The technological process of making elastic patterns and decorative castings from these patterns was described in detail.

Keywords: Decorative castings; Plaster moulding mixtures; Silicone rubbers.

1. Introduction

The „Forma” Studio of Sculpture carries out complex activities offering own designs, patterns of decorative castings and castings themselves, poured in various metals, mainly in bronze.

The Studio has its own foundry shop, where thin-wall castings are made in piece or small-lot production. The weight of castings varies from 0.05 to about 60 kg. The castings have different degrees of the shape intricacy and surface development.

Castings are made by the investment process using wax patterns and moulds with synthetic plaster as a binder.

The wax patterns are produced in dies made of silicone rubber by pouring in the molten wax until the required pattern wall thickness is obtained.

The patterns, after attaching the wax gating system and vents, are poured with liquid plaster composition prepared according to a genuine formula developed by the Foundry.

According to the technical solution applied so far by the Foundry, moulds after seasoning at ambient temperature for 24 hours are dried at a temperature of 150\textdegree{}C and baked at 720 – 750\textdegree{}C in a reverberatory oven with indirect heating system. When moulds are drying, the wax patterns melt out and the chemically unbounded water is removed. During baking, the rests of the wax pattern material are removed from moulds along with the chemically bounded water, while the pattern material melted out during drying undergoes thermal destruction. In the case of some small and medium-size castings of highly intricate shapes and designs, the cavities of moulds get soaked with the pattern material while drying, and in spite of later baking the obtained castings have unsatisfactory surface quality and incorrect shape. This makes the casting finishing operation last longer and consume more work and energy, resulting - in some critical cases - in the rejection of castings. Moreover, this method restricts the production of castings of the above mentioned types to the short batches only, mainly because of the high labour- and time-input necessary to produce and repair single wax patterns and high cost of the wax pattern material.

The object of the present studies was development and implementation in production of decorative castings of highly-elastic, multiple-use, patterns made from silicone rubber and replacing with these patterns the single-use wax patterns applied until now.
The research and development studies were conducted in parallel by Foundry Research Institute and the „Forma” Studio of Sculpture.

2. Choice of materials for elastic patterns

The developed technique of making elastic patterns consists of two stages:

A. making wax master pattern,
B. making proper elastic pattern from silicone rubber.

The wax master patterns, which serve for the manufacture of proper elastic patterns, should reproduce very faithfully the shape and texture of the designed patterns and offer high strength combined with dimensional stability. These properties can be achieved through proper choice of pattern materials used in the investment process. Basing on the results of the investigations of the properties of pattern materials, like deformability, strength and linear contraction, the following composition of material used for master patterns has been established:

Paraffin RII 55 wt.%
Beeswax 30 wt.%
Rosin 10 wt.%
Polyethylene wax 5 wt.%

In the case of elastic patterns, the silicone material should have low viscosity, high strength, low contraction and stability of dimensions. When choosing the type of rubber, the individual features of the reproduced patterns and design should be taken into consideration.

The above described requirements are satisfied by the rubbers crosslinking without heating, based mainly on methylpolysiloxanes with free silanole groups, manufactured by the Silicone Division of Pilot Plant at Nowa Sarzyna. The materials manufactured in several grades (Polastosil and Gumosil) are characterised by different utilisation properties. Curing of rubber takes place at ambient temperature during the time of several till several dozen hours under the effect of catalyst.

Using the results of the investigations of the properties of these rubbers, like castability, hardness and linear contraction, as a material for elastic patterns reproduced from the previously made master patterns, Gumosil WW was selected. For patterns of very high degree of the shape intricacy and high requirements of the dimensional accuracy, it has been decided to use Gumosil AD-1 (the high price restricts the scope of its application).

3. Making elastic patterns

The trials with elastic patterns were carried out on two models, viz. a statuette of Lajkonik (A bearded man resembling a Tatar in a characteristic pointed hat, dressed in Mongol attire, with a wooden horse around his waist – an unofficial symbol of the City of Cracow in Poland) and a miniature building of Cracow University of Economics. The plaster patterns are genuine designs made by the „Forma” Studio of Sculpture.

From plaster patterns, silicone dies in plaster casings were made for the wax master patterns of both designs. Master patterns were moulded in the die by repeated pouring in and out of the liquid pattern composition. In this way hollow patterns of 3-4 mm wall thickness were produced. The ready patterns are shown in Figure 1.

Figure 1. Examples of wax master patterns

The trials with making of elastic patterns from the wax master patterns were described on the example of “Lajkonik”. It was the intention of a pattern-maker to produce a hollow pattern with loose elements (the “legs”) additionally assembled to it and to obtain a design that could also serve as a bell.

The sequence of technological operations used in the manufacture of elastic patterns was as follows:

1. In parallel with making a master pattern of Lajkonik, in a proper die the wax patterns of the supporting legs were also made.
2. The master patterns were surrounded with clay and after shaping of the parting line a clay pattern match was produced with patterns immersed in it to more or less one half of their height.
3. Onto the patterns and the pattern match a liquid ceramic slurry composed of crystoballite Giluform plaster mixed with water was poured. After setting of plaster, the whole was turned over by 180°, the clay pattern match was removed and in the place occupied by the pattern match a ceramic slurry was poured. In this way, the matches of the two future mould halves were obtained. In the case of the Lajkonik pattern it was necessary to additionally make in the ceramic slurry also the matches of the core, reproducing the interior of the future casting.
4. The halves of the pattern matches together with the wax patterns remaining inside them were placed in a drier, where at a temperature of 120° the wax pattern slurry was melted out. A set of pattern matches for the Lajkonik mould and legs is shown in Figure 2.
5. Having cleaned very thoroughly the cavities of pattern matches from the wax residue, both halves were put together and clamped with joiner’s clamps, placing next a match of the core with the previously bored gating holes.
6. As a next step, a mixture of the silicone AD-1 rubber with hardener was prepared. The preparation of the mixture consisted in thorough mixing and air removal in vacuum.
7. The ready rubber was poured into a cavity of the assembled pattern matches formed after the master patterns have been removed. After crosslinking of the rubber which takes the time of 12 hours, elastic patterns of the elements of Lajkonik were obtained.

82

ARCHIVES of FOUNDRY ENGINEERING Volume 8, Issue 2/2008, 81-84
obtained. Figure 3 shows the elastic patterns of Lajkonik and legs made in pattern matches.

Fig. 2. A set of pattern matches for the Lajkonik mould and legs

Fig. 3. Elastic patterns of Lajkonik and legs made in pattern matches

Figures 4 and 5 show elastic patterns made from the silicone rubber.

Fig. 4. Elastic pattern of Lajkonik

Fig. 5. Elastic pattern of leg

Preparation of elastic pattern for moulding consisted in a number of operations, i.e. placing the pattern on a core match and next on one of the ceramic mould matches. Then the half mould was encased in a dismountable wooden box and poured with liquid plaster slurry. The elastic pattern ready for moulding is shown in Figure 6.

Fig. 6. A pattern of Lajkonik ready for moulding

The next step was turning the match – half mould system over by 180°, removing the ceramic match and pouring the space occupied previously by the match with plaster moulding slurry. After setting of the slurry, the core match was removed and using plaster composition the mould element reproducing the casting core was made.

After dismantling of the wooden casing and mould elements, the elastic pattern was taken out.

The ready plaster moulds were dried at ambient temperature for 24 hours, followed by baking in a reverberatory oven with indirect heating system at a temperature of 720°C. Plaster moulds ready for baking are shown in Figure 7.

Moulds after baking and cooling were cleaned, the gating and venting channels were fettled, the moulds were assembled and poured with BK 331 silicon bronze. Figure 8 shows moulds ready for pouring, while Figure 9 shows the process of their pouring.

4. Making decorative castings from elastic patterns

The process of making decorative castings consisted in coating of elastic patterns with plaster composition used by the „FORMA” Foundry Shop, removing the elastic patterns from the mould, baking of plaster moulds in a reverberatory oven with indirect heating system and pouring the ready moulds with silicon bronze.
Fig. 7. Moulds ready for baking

Fig. 8. Moulds at the stage of being prepared for pouring

Fig. 9. Pouring of plaster moulds

Figure 10 shows raw castings of Lajkonik after knocking out from plaster moulds

Evaluating the quality of castings made with elastic patterns it has been stated that the reproduction of design and the quality of the casting surface were very good; the rough finishing of casting consisted in removal of small flashes formed on the mould parting plane.

Figure 11 shows castings of Lajkonik after fettling from the residues of moulding mixture, final finishing and assembly.

Fig. 11. The ready castings of Lajkonik after assembly

5. Summary

The use of elastic patterns in production of decorative and artistic castings at the „Forma” Studio of Sculpture gave the following advantages:
- possible production of castings with very exact shape and texture reproduction, minimum level of surface defects and thin walls,
- extending the range of castings made in lot production to include artistic, decorative and useful castings,
- increasing the production capacity to 6t / year
- reducing the material-related costs,
- reducing labour costs during manufacture of patterns and casting finishing,
- reducing the level of emissions escaping to the atmosphere, mainly products of combustion of the wax pattern materials.

References