Quality assessment of expendable patterns in the investment casting process

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Abstract

The article presents the basic attempts at expendable patterns quality assessment, such as hardness test, creeping resistance tests and the assessment of patterns mixtures contraction as a function of solidification module. These features were verified on step-shaped patterns.

Patterns mixtures made on the basis of hard waxes were selected for tests and compared with the domestic mixture based on paraffin and stearin (PS) as well as with the PS-mixture to which the material of used patterns from the WSK Rzeszow factory was added.

The selected tests enable a quick assessment of whether the pattern mixture quality meets the requirements of optimum size accuracy and good quality of casting surfaces.

Keywords: Expendable patterns; Quality; Investment casting process

1. Introduction

The high importance of pattern mixture properties for obtaining high patterns and then casting quality has been previously presented in [1], [3] and [4-8].

It should be stated [2] that a simple measurement of expendable patterns hardness (particularly in comparative tests of different pattern mixtures) and of their creeping resistance show also whether the patterns are of good strength and will function properly at wide temperature fluctuations from 17°C to 26°C, characteristic for the majority of Polish foundries throughout a year. It should also be noted that the hardness test using the penetration method [2] can be carried out directly on the expendable patterns.

The assessment of patterns contraction tested on step-shaped patterns obtained by the pouring method (solidification modulus between 0.1 cm and 0.6 cm) provides data on the pattern mixture viscosity which is frequently decisive for the patterns quality [9].

2. Testing of pattern mixtures creeping resistance

2.1. Testing method

The testing consisted in the determination of deflection of cylindrical (Ø 8 mm) samples loaded with constant ca. 30 G force on the 150 mm long arm. Samples were made of the following pattern mixtures (injection temperature is given next to the mixture symbols in brackets):
- Blayson mixture – A7-FR60 (65°C) and KC-4017 (65°C)
  Kindt-Collins Co. American wax);
- Remet Co. Castylene mixture – B-405 (65°C);
- Castaldo Co. mixtures – Green (65°C);
- Red (70°C); PSCP domestic mixture (50°C);

The measuring stand shown in Fig. 1 was used for tests. It consisted of the following components: a metallic stand for hori-
Horizontal sample fastening during the test, an inductive sensor, an elongation meter and a portable personal computer equipped with a measurement card. The tests were made at temperatures 18°C and 25°C. Test measurement time amounted to about 10 minutes for each sample. Cylindrical Ø 8 and 20 mm-long samples were tested. Number of pattern samples – 150, 25 pieces for each type of the pattern mixture. Different injection pressures were applied for individual sample types.

2.2. Test results

The graphs obtained on the basis of measurement results were plotted based on the average deflection values (which determine the pattern mixture creeping) at temperatures 18°C and 25°C.

The graphs of Fig. 2 and fig. 3 show little effect of pressure on the deflection value. PSCP mixture has the smallest creeping resistance under low and constant 30 G loading. Hard waxes have the highest creeping resistance, particularly evident at the temperature of 25°C (Fig. 3).

3. Hardness testing using the penetration method

3.1. Testing method

The hardness of pattern mixtures was tested by their penetration with a steel needle of geometry as per the PN-EN 1426 2001 standard.

The needle sinking vertically into the mixture under testing was pushed in with the 160 G force over one to five minutes.
The test method is used mainly for asphalt hardness measurements, but many countries (the Czech Republic, among others) use it for pattern mixture testing. The measurement of sinking expressed in abstract penetration units (penetration unit – 0.1 mm of needle sinking) was performed with the prepared penetrometer with the use of the same equipment as that applied for creeping testing. The view of the stand and the penetrometer is shown in Fig. 4 and Fig. 5.

3.2. Test results
The tests were performed on cylindrical samples of about Ø 50 mm and about 20 mm length. Four sinkings of penetration needle into each pattern mixture at 18°C, 23°C and 27°C were recorded, which translates into 72 sinkings in total. On the basis of measurement documentation, two graphs of averaged penetration values characterizing the pattern mixture hardness at 18°C, 23°C and 27°C were plotted.

The test results concern six mixtures mentioned before in creeping tests. On Fig. 6, the graph of hardness for individual pattern mixtures at 18°C, 23°C and 27°C after a one-minute penetration measurement period is shown. Fig. 7 shows the graph of hardness for individual pattern mixtures at 18°C, 23°C and 27°C after a five-minute penetration measurement period. An insignificant effect of the measurement period on the “hard” pattern mixtures hardness assessment – Fig. 6 and Fig. 7 – was observed. Moreover, “hard” waxes are much harder than paraffin and stearin-based mixture (PSCP) with ceresine and polyethylene added.

4. Assessment of pattern mixtures contraction using step-shaped patterns (for solidification modulus of 0.1 to 0.6 cm)
Contraction of patterns (pattern total length of approx. 105 mm and width 25 mm) made of KC-4017, PSWP and PSRWSK mixtures (hard wax) was compared, where:

PSWP – paraffin, stearin with 10% of polyethylene wax added;

PSRWSK – paraffin and stearin with the addition of 30% wax recycled from mixtures of hard waxes manufactured by the WSK Rzeszów factory.

A considerable effect of solidification modulus on the contraction was noted. A modulus increase of 0.1 cm to 0.6 cm increases the contraction from 0.25% to 0.50% on average. The highest differences characterize the PSWP mixture. The average contraction values for particular mixtures were as follows:

- KC-4017 – 0.88%;
- PSRWSK – 1.10%;
- PSWP – 1.4%.

when temperature of pattern mixtures poured into die (die temperature 50°C) was between 65°C to 75°C.

An extremely wide temperature straggling tolerance for PSWP pattern mixture viscosity was found. An addition of recycled PSRWSK mixture results in higher patterns quality (more stable viscosity).
Conclusions

1. The application of hardness and creeping tests as a function of temperature in the assessment of pattern mixture properties enables a fast assessment of patterns quality. This is particularly desirable when properties of patterns made of different materials are to be compared.

2. A pattern mixture made from recycled pattern mixtures used by the WSK Rzeszow factory can enhance the quality of patterns based on paraffin and stearin.

References


