

Permeability of mould made by lost wax casting process

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Abstract

Paper present results of permeability of moulds which have been made by lost casting wax process. Measurement and tests have been made using typical sand cast permeability tester. Measurement technique required preparing of special shape samples. All scope of tests have been realized in WSK „PZL-Rzeszów” S.A. Results showing permeability of ceramic moulds in function of quantity layers.

Key words: Innovative materials and casting processes, Permeability, Investment Casting, Lost wax casting process.

1. Introduction

WSK „PZL-Rzeszów” S.A. implement modern technology and casting processes. Industrial and production trials required to make a lot of testing in laboratories. These testing to allow evaluate of new materials. One of most important issue in investment casting process is multilayer ceramic mould parameters evaluation.

Testing of mould and cores materials properties are base measurement in casting production laboratories. Proper parameters of mould materials are main features to decide about their production usability. Casting designers required better quality of castings, that force higher parameters for ceramic materials which are used to make moulds. Mould parameters can be switch by suitable choose of mould materials, what is equal to have good casting quality. Control of mould materials parameters in production casting process provide repeatability of moulds and decreased quantity of casting defects (both kind of defects, metallurgical and visual) [1-4].

Investment Casting Industry in Poland is not key Industry and access to permeability tester which is typically used to measure investment casting moulds is limited. Samples are tested in laboratories outside of Poland and time to received results is long. It does not allow make any correction to mould process on time. In opposite to investment casting industry, sand die casting industry is compound very well in Poland. Determine of sand permeability is base kind of testing. Almost each one sand die foundry own permeability tester. If those tester can be applicable in investment casting process, mould permeability results be available in good time to make correction in production process.

Goal of this work was preparing methodology of investment casting mould permeability measurement by using typical sand cast mould permeability tester.

2. Methodology

Sand cast permeability is measure on standardize cylinder shape samples 50 mm of diameter and 50 mm highest. Samples

are prepared using laboratory rammer, measurement are taken using LPIR-1 tester. Fabricating these samples in investment casting process is impossible. Apparatus for determination of moulding sand permeability LPIR-1 is presented in Fig. 1.



Fig. 1. Apparatus for determination of moulding sand permeability LPIR-1 [5]

First trials of measurement have been made on circular samples 50 mm in diameter which were cut off from standard investment casting moulds. It did not bring repeatable results. The main challenge was the design of a special shape of sample which can be produced by investment casting process. Figure 2 shows the shape of the sample wax pattern. The final shape, based on a few trials and the internal part of the wax pattern after moulding, provides a sample which can be applied.



Fig. 2. Wax model for permeability

In investment casting process, the mould is made by coating several layers. Each layer can be applied manually or automatically. Each layer consists of a ceramic slurry based on colloidal silica and ceramic stucco. The layers are dried individually. After coating all required layers, the mould is dewaxed, pre-fired, and fired. Temperatures and times in this work were the same as in normal production.

Samples and moulds have been prepared according to the typical production process in investment foundry of WSK „PZL-Rzeszów” S.A.

The objective of this work was to evaluate the accuracy of this method and define relationships of permeability in function of the number of layers. Samples with the following number of layers: 4, 5, 6, 7, 8, 9 - are shown in Figure 3.



Fig. 3. Mould sample for permeability

3. Tests results

Permeability was measured by the LPIR-1 tester. The measurement consists of making the air at a pressure of 0,98 kPa pass through a specimen of the examined metal sleeve. The results were read out on the scale corresponding to the nozzle which has been used for the test. For each sample, three independent measurements were taken. Measurements were realized in two different steps of the casting process. First, samples were measured after mould pre-firing, second after both mould pre-firing and firing. Results after pre-firing are presented in Table 1, after firing in Table 2.

Table 1. Permeability of mould as a function of coating mould after pre-firing in 700°C.

| No of layers | Permeability P [m ² /Pa·s] 10 ⁻⁸ | | | Avg |
|--------------|---|-----|------|------|
| | 1 | 2 | 3 | |
| 4 | 13,0 | (1) | (1) | - |
| 5 | 10,5 | (1) | 10,5 | - |
| 6 | 7,0 | 9,5 | 6,0 | 7,5 |
| 7 | 7,0 | 6,0 | 8,5 | 7,2 |
| 8 | 8,5 | 7,5 | 9,0 | 8,3 |
| 9 | 9,0 | 9,5 | 12,0 | 10,2 |

(1) - cracked sample,

Table 2. Permeability mould as function coating mould after pre-firing in 700°C and firing in 1200°C.

| No of layers | Permeability P [m ² /Pa·s] 10 ⁻⁸ | | | |
|--------------|---|-----|-----|------|
| | 1 | 2 | 3 | Avg |
| 4 | 38 | (1) | (1) | - |
| 5 | 34 | (1) | (1) | - |
| 6 | 34 | 40 | 32 | 35,3 |
| 7 | 38 | 38 | 42 | 39,3 |
| 8 | 40 | 38 | 44 | 40,7 |
| 9 | 28 | 24 | 30 | 27,3 |

(1) - cracked sample,

Mould samples with four (4) and five (5) layers have low strength which produced cracks during the test. Measurement results are incredible and we're not been taken to analysis.

Figures 4 and 5 are showing permeability mould as function of number of layers.

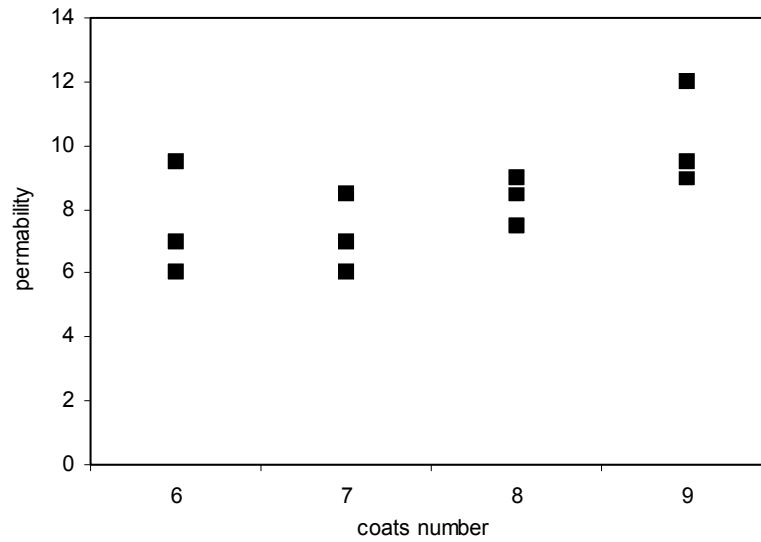


Fig. 4. Permeability mould as function coating mould after pre-firing in 700 st C

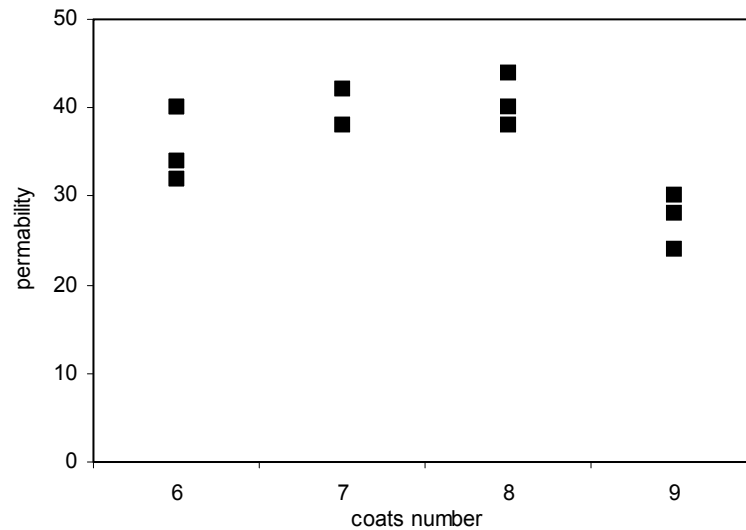


Fig. 5. Permeability mould as function coating mould after firing in 700 st C and 1200 st C

4. Conclusions

Elaborated methodology of mould samples preparing, to allow use typical sand cast permeability tester to measure permeability investment casting molds.

Results let say:

- Sand casting permeability tester can be used to measure investment casting moulds.
- Moulds samples should have six (6) layers minimum.
- Obtained results show considerable range of samples permeability.
- For samples pre-fired in 700°C, permeability increased with numbers of coats.
- For samples pre-fired in 700°C and 1200°C, permeability increased with number of coats until coat No 8. After applying coat No 9 permeability suddenly goes down.

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