Lost wax process – mould properties

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Abstract

Paper present results of moulds properties as follow: permeability and shell Module of Rupture (MOR). Measurement and tests have been made on moulds from two different mould systems: water and alcohol. Mechanical properties measurement was made on standard samples. Permeability measurements required preparing special shape samples [4]. All scope of tests have been realized in WSK "PZL-Rzeszów” S.A. Results showing permeability and mechanical properties of two mould systems in function of quantity layers.

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

1. Introduction

Environmental regulations press precision casting industry to production process change introduction. European Community specifications oblige countries to eliminate technology which produce waste to atmosphere. UE directive No 1999/13/EC related to Volatile Organic Compound (VOC) and UE directive 2000/69/EC related to benzene and carbon monoxide in ambient air, describe new accepted limits.

In practice shell systems should be replace by water shell systems. It is mean ethyl silicate is replacing by colloidal silica sol.

2. Water base shell systems

From the beginning precision casting industry, technology based on hydrolyzed ethyl silicate binders. In cause of environmental regulations industry going to fully replace it by water base binders.

Main differences between water and alcohol are hidden in knowledge of slurries preparation and drying cycles.

Alcohol and water binders are different in solution agent.

Ethyl silicate contains alcohol, colloidal silica contains water. In both system silica sol is a binding agent.

Colloidal silica is a sol of orthosilicic acid, solution agent is water. Colloidal gel is binding agent which combine sand grains. During mould drying water is evaporated to atmosphere like steam which is friendly for environment and workers. Colloidal silica does not required hydrolyze reaction [2]. Water systems contain polymers but they are fired in firing operation and have not impact final mechanical strength of moulds.

Water systems contain polymers (latex) to improve “green” strength. Polymers are fired in firing operation and have not impact for final quality of casting. Fillers and stucco materials can be the same in both systems. Using the same materials reduce after firing properties difference: dimensional and physical.

Alcohol binders have rest of alcohol which is evaporate to atmosphere. Water systems evaporate water only. Both system silica sol is “glue” which join together the mould. Water systems contain polymers but they are fired in firing operation and have not impact final mechanical strength of moulds.

During water mould system implementation very important is to establish optimal parameters like: temperature, humidity, air flow rate, shape of wax patterns (hollow or not hollow). Keep of those parameters stable required to build special drying rooms [1]. According to SMDs (Safety Material Data Sheet) colloidal silica sol distributed by REMET (Sales mark LUDOX SK) and Ultra are not dangerous for environmental and not plant or explosion, storage and fire [2] [3].

Research objective was bend strength and permeability evaluation of mould which was made in two different binder systems: water (with latex) and hydrolyzed ethyl silicate.
3. Methodology

Samples for mould tests was made base on wax patterns. Wax patterns was made in WSK Precision Casting Foundry. Samples for MOR (Fig. 1a) and permeability (Fig. 1b) was prepared on two different shell systems: Water and Alcohol. Methodology of permeability test samples preparation is described in [4].

![Fig. 1. Wax pattern: a) MOR, b) permeability](image1)

Two types of moulds have been prepared, first silica sol binder with latex, second hydrolyzed ethyl silicate binder.

In both zircon sand was used like filler. Coarser grain size was used for following coats. Six samples for each combination of coats numbers and binder type was prepared. 4,5,6,7,8,9, and 10 coats was applied. Wax was dewaxed in boiloclave. From each 6 samples 3 was fired in 700°C, another 3 in 700°C and 1200°C. Both systems shell have been dried in drying room with air flow and process parameters (temp. 20-25°C and 50% RH). Mould samples for MOR and permeability shows Fig. 2a and 2b.

![Rys. 2. Test sample shell: a) MOR, b) permeability](image2)

MOR test was measure on casting 3 points bend strength tester LRu-1 [1]. Permeability was measured using sand die cast permeability tester LpR-1 [4].

4. Tests Results

Tests mould samples have been tested for MOR and permeability. Test results are presented in Tables: 1 and 2, and on Figures: 3 to 5. Results are averages calculated from three measurements.

<table>
<thead>
<tr>
<th>Coat No</th>
<th>Permeability P [m²/Pa·s] 10⁻⁸</th>
<th>MOR [MPa]</th>
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</thead>
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<tr>
<td>A</td>
<td>B</td>
<td>A</td>
</tr>
<tr>
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<td>-</td>
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<td>16,5</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
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</table>

A - hydrolyzed ethyl silicate binder  
B - silica sol binder

<table>
<thead>
<tr>
<th>Coat No</th>
<th>Permeability P [m²/Pa·s] 10⁻⁸</th>
<th>MOR [MPa]</th>
</tr>
</thead>
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<tr>
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<td>10</td>
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<td>15,8</td>
</tr>
</tbody>
</table>

A - hydrolyzed ethyl silicate binder  
B - silica sol binder  
? – no scale

Tests results was compared with MOR and permeability results measured on moulds made in hydrolyzed ethyl silicate binder [4].
Permeability of moulds made with hydrolyzed ethyl silicate binder increased 4 times after annealing. Permeability of moulds made with silica sol binder increased 20-30% (Fig 5).

MOR of moulds made with hydrolyzed ethyl silicate binder increased 20-30% after annealing. MOR of moulds made with silica sol binder increased 70-80% (Fig 5).

![Fig. 3. MOR- $R_g$ and permeability mould - P as function coating mould after firing in 700°C: a) hydrolyzed ethyl silicate binder, b) silica sol binder.](image1)

![Fig. 4. MOR- $R_g$ and permeability mould - P as function coating mould after firing in 700°C and preheating in 1200°C: a) hydrolyzed ethyl silicate binder, b) silica sol binder.](image2)

4. Conclusions

Results show that applying silica sol binder and latex in mould process preparation increased MOR refer to moulds made on hydrolyzed ethyl silicate binder. Moulds fired in 700°C increased MOR by 30%, fired in 700°C and preheated in 1200°C increased MOR by 200%.

Applying hydrolyzed ethyl silicate binder in mould process preparation increased Permeability refer to moulds made on silica sol binder and latex. Moulds fired in 700°C increased Permeability by 30%, fired in 700°C and preheated in 1200°C increased Permeability by 300%.
Fig. 5. Compare of binding strength $R_g$ as function permeability mould $P$ with hydrolyzed ethyl silicate binder (○ after firing in 700°C, ■ after firing in 700°C and preheating in 1200°C) and mould with silica sol binder (◇ after firing in 700°C, ● after firing in 700°C and preheating in 1200°C)

References


