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APPLICATION OF LOST FOAM CASTING PROCESS FOR MANUFACTURING PARTS IN AUTOMOTIVE INDUSTRY

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ABSTRACT
In this paper, some of the results of research are presented, by applying casting technology with evaporative pattern for obtaining castings (Lost foam process). This technology of castings enables obtaining complex parts, intended to, for example, automotive industry. It means that it is characterized by large series, low production expenses and high quality of castings. The investment into equipment and space are not high, the process is flexible and high productivity can be achieved.
By research, a satisfactory quality is achieved and necessary, relevant information for industrial production of aluminum alloys casting are obtained.
Keywords: evaporative pattern, castings quality, refractory coating, auto industry

1. INTRODUCTION
Lost foam casting process (LF process) is patented by H.F. Shroyer in 1958. Since then, up to today, development and practical application goes on with changeable success. Mainly, the problems of the development of this process are lack of appropriate materials for making evaporative patterns and refractory pattern coatings. Unlike casting in the sand moulds, the process uses patterns and pouring systems, which remain in the mould after its making until pouring of metal. This justifies the title ″full mould casting″. In the contact with liquid metal, the pattern is split in a relatively short time. At the same time, the castings crystallization takes place. As the consequence of the pattern splitting, a great quantity of gaseous and liquid products is produced. If the conditions of their elimination from the mould are not fulfilled, many defects will appear on the castings, which are considered characteristic for this process. [1-2]

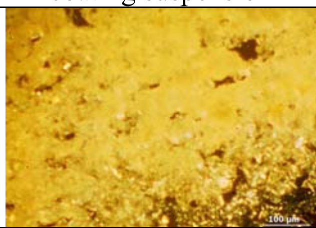
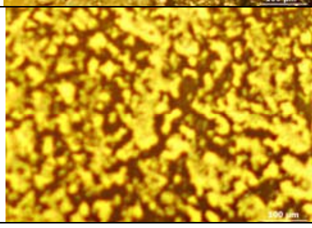
Important factors on pattern's decomposition and evaporation process, besides temperature and pattern's density, are also the type and refractory coat layer's thickness which the evaporable pattern is been covered with, type and size of sand grain for modeling, respectively permeability of sand for modeling, castings and gating of moulds' construction. The pattern's density and permeability of refractory coat and sandy cast determine polymers evaporation velocity. The velocity of liquid metal coming into the cast and its contact with the pattern is regulated by proper defining the gating of moulds. [3-5]

In order to obtain castings of a priori desired quality, critical process parameters should be determined for each particular polymer pattern, as well as the type of alloy for casting. That requires long-lasting researches with a goal to achieve optimization of LF process and obtain the castings of a priori specified properties. In order to understand correctly the LF process optimization it is necessary to know that various types of castings' structure determine their different properties. Besides this dependency for obtaining the castings of a priori specified properties there also should be determined the fundamental structure dependency on technology, which implies critical process parameters' control and control of useful castings' properties, and a special consideration in this paper was given to that matter. [5]

2. EXPERIMENTAL PROCEDURE

It was done over a series of experiments preparations for making mineral fillers and their application within the refractory coatings. Appearance prepared coatings and their composition shows in table 1.

Table 1. The refractory coating for evaporable pattern

Type	Composition of refractory coatings	Micro-photograph of refractory coating suspension
A	- refractory filler (%) with grain size of 20-35µm, 85-90, - binding agent (%): colophonium ($C_{20}H_{30}O_2$), 2.5-3 - additive (%): Bentone 25, 0.8-1 - solvent: alcohol	
B	- refractory filler (%): chromite with grain size of 25-35 µm, 90-96 - binding agent (%): bentonite 3; bindal H, 5-7; - suspension maintenance agent (%): dextrin 1; lucel 0,5 - solvent: water	

As refractory fillers used various minerals such as: talc, zircon, cordierite, mulite, mica, chromite. Grinding and fine grinding of refractory fillers was done in mill with balls of Cr Ni steel, capacity 20 kg/h, with mill load of 70% and grinding time 45-60 minutes.

Important characteristics of refractory fillers are: high melting temperature; low heat spread coefficient; it does not soak up liquid metal; it does not produce gases in contact with liquid metal.

A binding agent within the coating was chosen with regard to the size and shape of the refractory fillers particles in order to enable connection of the particles and to secure good adhesion of refractory particles to the observed surface of either the sandy mold (refractory coat mark: A) or polymer model (refractory coat mark: B). Alcohol was used as a liquid solvent (type coating A), as well as water (type coating B).

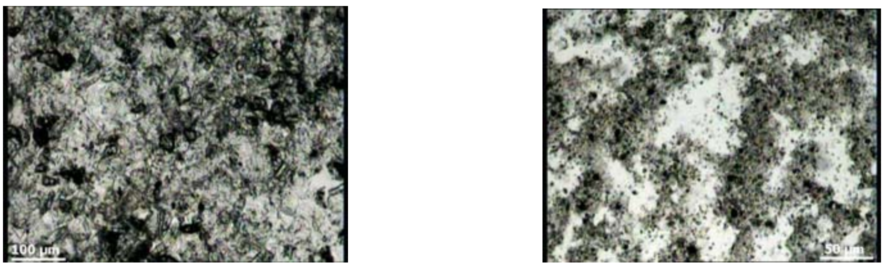
Process parameters of production of refractory coatings: Suspension density 2 g/cm^3; Suspension temperature 25 °C; The way of coat's excess remove from the pattern after pulling out from the tank for lining: patterns are been seeped, in vertical position, 5-10 s, and then set 5 s under 45° angle in order to coat layers on pattern's surface get equally even; Slowly coat mixing in tank during the coat applying on pattern: velocity 1 revolutions/min; Drying: 1 - 2 hours and final layer 24 hours; alcohol-based coatings- by burning after being applied on the sand; Coating layer thickness: (mm): 0,5- 1,5.

Refractory coatings were applied on sandy molds by brush. At applying refractory coat on polymer pattern by techniques of immersion into the tank with coat, overflowing and coating with brush, a special attention was given to coat's quality control.
The experimental parameters of LF process regarding which were done the selection of composition and preparation of refractory coats series A and B, were:

- Tested alloy: AlSi6Mg3
- Preparation methods of liquid die: refinement by compounds based NaCl and KCl in quantity of 0,1% on die mass; degasification by briquette C_2Cl_6 in quantity of 0,3% on die mass; modification –by sodium in quantity of 0,05%.
- Casting temperature: 755-780 °C
- Evaporable polystyrene pattern: density 20-25 kg/m^3; pattern construction: plate (200x50x20)mm and staged probe with different wall thickness (mm): 10 ; 20 ; 30 ; 40 ; 50 ; polystyrene grain size (mm): 1-1,5.
- Mounting pattern for casting: "cluster" with four patterns-plates set on central runner gate and "cluster" with two staged probes set on central runner gate
- Gating of moulds: central runner gate (mm): (40x40x400); ingates (mm): (20x20x10), 2 pieces.
- Dry quartz sand for cast production with grain size (mm): 0,17 ; 0,26 ; 0,35.

3. RESULTS AND DISCUSION

By controlling the critical process parameters for refractory coats' production and controlling the coat's properties it was determined that the coats of all series comply with conditions for appliance in LF process. It was determined that coats were easy to apply on polymer patterns, being equally lining at overflowing and immersion, were easy to been coat with brush, without any mark of brush, leakage, drops and clots' formation.
After drying, the coat surface was smooth; coat's layers were of equal thickness everywhere on pattern's surface, without any bubbles, crazing, peelings or attrition. The coat quality and refractory loader's homogeneity in the coat depends on coat preparation. In order to achieve even coat layers' thickness on pattern's surface it is necessary to slowly constantly mix the coat during its applying on patterns, to maintain defined density (2g/cm^3) and temperature (25°C) of coat. On the contrary, the coat composition's inhomogeneity appears, Fig.1.
In order to observe the effects of casting process, evaluation of certain operation phases and analysis of applied refractory coats' influence, a visual control of the obtained castings was done, testing their structural and mechanical properties. After pulling out the founded "clusters" from the cast, their surface is covered with coat layer which is easy to be broken and removed from it, so the cleaning is not necessary, which significantly reduces the production costs. The refractory coats of all series have demonstrated positive effects on the surface quality – shiny and smooth castings' surfaces were obtained.



a) homogenous composition coats b) non-homogenous composition coats
Figure 1. Refractory coats

The castings are true copy of the patterns (dimensionally are precise) which indicates that the decomposition and evaporation of polystyrene pattern was in totality, and that the gating of moulds' solution was satisfactory. It was noted that the lower castings' parts of all series have flat and sharp edges, clean and shiny surface. At some castings from the series with coat layers of higher thickness (above 1,5 mm) the upper castings' surfaces are a bit uneven and folded, and also on certain castings' parts a surface roughness appears, and more often at the castings from the series with patterns' density above 20 kg/m^3.

The study results of castings' structural and mechanical characteristics were within the limits predicted by the standards for this type of alloys. That would be the castings from series with used polystyrene patterns up to 20 kg/m^3, refractory coats of less thickness layers, below 1 mm, applied quartz sand for modeling with its grain size above 0,26 mm, casting temperature within the limits of 760-780°C and casting velocity which enabled even decomposition and evaporation of polystyrene, with complete elimination of gassy products from patterns' evaporation, without any cast falling in and liquid metal penetration into sand.

On the other hand, castings from the series with applied patterns of densities above 20 kg/m^3 and coat thickness above 1,5 mm have expressed subsurface and volumetric porosity too. This indicates that the reasons for these type of errors are primarily the polystyrene pattern, and next the refractory coat and high casting velocity.

4. CONCLUSION

In order to attain a quality and cost-effective castings production by the LF casting process, it is necessary to attain the balance in the following system: evaporable polymeric pattern- liquid metal- refractory coating – sand mold during metal inflow, polymeric pattern decomposition and evapouration, castings formation and solidification. All this points to complexity of the castings solidification conditions by the LF casting process, as well as to the necessity to determine the corelation between the casting parameters, structure and properties of castings.

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