SYNTHESIS OF NEW REFRACTORY COATINGS BASED ON BASALT FOR FOUNDRY APPLICATIONS

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Abstract :*This paper presents the results of research on coatings based on basalt for use in Lost foam casting process. These coatings have not been used in practice so far. The coating compositions and the synthesis process were studied. Test series of casting aluminum alloy castings were made. Positive results of testing the surface, structure and properties of the obtained castings are shown. The possibility of using basalt for the synthesis of coatings in foundry will enable great savings in the production of castings. This is significant considering that Serbia has significant reserves of this type of mineral raw materials.*

Key words: *basalt, refractory coating, quality of castings, Lost foam casting process*

1. INTRODUCTION

Lost foam casting process is a new method for the obtaining of high quality low-cost castings. The process includes a large number of insufficiently examined phenomena in connection with physiochemical and thermodynamic changes in the system: evaporative pattern - refractory coating - liquid metal - sand [1]. The technological parameters important for the process unfolding and obtaining high quality castings are: pattern density; thermophysical features of refractory coating; pouring temperature; granulometric contents of moulding sand (mould permeability) and pouring system [2].

In the Lost foam process, patterns and pouring system made of polymers are retained in the mould until a liquid metal has flown in (″full mold casting″) [3]. In contact with a liquid metal, polymer patterns evaporate and at the same time,

casting solidification takes place. As a consequence of the evaporation of the polymer pattern, a large amount of liquid and gas products is released. These products are a frequent cause for castings defects. To obtain quality castings it is necessary to apply highly permeable refractory coatings [4,5].

Systematic research of the refractory coatings properties have shown that there are some general conditions which must be met by these coatings: suitable refractoriness; suitable gas permeability; low heat expansion coefficient; resistance to liquid metal current with no penetration into the mold wall; inertia towards liquid metal; easy application and attachment to mold and pattern surfaces; easy adjustment of coating thickness; short drying time with no occurrence of coat cracks or erasure; formation of visible thin film of coat [6,7].

Basic role of the refractory coating is to form an efficient refractory barrier between the sand substrate and the liquid metal flow during the casting phase, the solidification and the forming of the castings [7]. This enables obtaining a smooth and clean surface of casting without volume defects on castings. The application of quality refractory coatings contributes to the reduction of cleaning and machining of castings, which contributes to the reduction of production costs [1,4].

The basic ingredients of refractory coatings are filler, binder, additives and solvent, which is usually water. Basalt was used as refractory filler in this work. Until now, basalt- based coatings have not been used to make coatings in foundry [8-10]. The refractory coating on basalt was applied to the casting of samples of the test plates made of the aluminum alloys.

2. EXPERIMENT

Basalt is a hard volcanic rock. Selected basalt rocks from the deposit "Vrelo" Kopaonik were used as a starting material for the production of coating fillers [10]. The sample of basalt rocks was crushed and ground in a vibrating mill with balls to a grain size of $15x10^{-6}$m. XRD analysis was performed by the X-ray diffraction meter, model PW-1710 (Philips Analytical, Almelo, Netherlands). The microstucture of the samples was characterized with the scanning electronic microscope “JEOL” model JSM 6610 LV (JEOL, Tokyo, Japan). In order to improve conductivity, the sample was vapoured with gold powder.

Chemical composition of starting basalt samples were: 55.90% SiO_2; 18.49% Al_2O_3; 7.78% CaO; 3.5% MgO; 2.99% FeO; 1.15% Fe_2O_3. Mineral composition of starting basalt samples is as follows: plagioclase, pyroxene and olivine, Fig. 1.a. Fig. 1.b shows a basalt -based refractory filler. The basalt grains are uniform in size and rounded.

Based on the results of previous research [11], trial samples of refractory coating of orientational composition were made: 92-95% refractory filler based on basalt; bentonite -based binder 4-4,5%; carboxymethylcellulose-based additives 1,2-1,5%; water as solvent to a suspension density of 2000 kg/m^3.

Properties of the refractory coatings obtained were examined in accordance with the standards [13, 14] and the test procedure described in a previous paper [11,12]. The sedimentation stability was tested when the samples of refractory coatings were left idle in a cylindrical vessel with volume of 1×10^{-4} m^3 and height of 2.8×10^{-1} m for 24 hours. The test results are given in percent: the number of ml readings equals the percentage of precipitation.

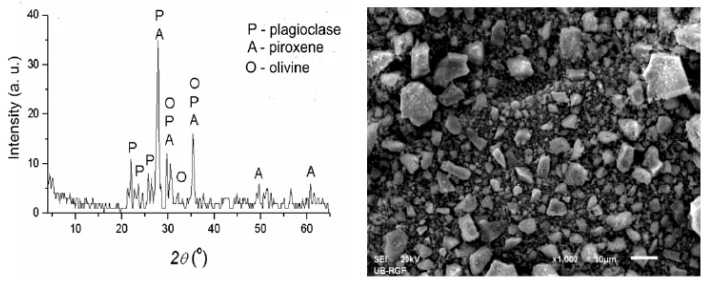

Figure 1: XRD diffractogram and SEM micrograph of a basalt-based refractory filler.

The determination of penetration was investigated using the test tubes made of mould mixture and polystyrene. After the application and drying of the coating, the test tubes were broken and the coating penetration depth was measured at the breaking point and was expressed in $1x10^{-3}$ m.

3. RESULTS AND DISCUSSION

The microphotographies of filler and suspension of Lost foam refractory coatingsbased on basalt are shown on Fig.2. The figure shows the even distribution of the filler in the coating suspension. During the synthesis of the basalt-based refractory coating, the following parameters were applied: suspension density 2000 kg/m^3; suspension temperature 25 ^{o}C; suspension stirring speed 1 rpm; thickness of dried coating layer 0,2-0,5x10^{-3}m; applying coatings to patterns by dipping and with a brush.

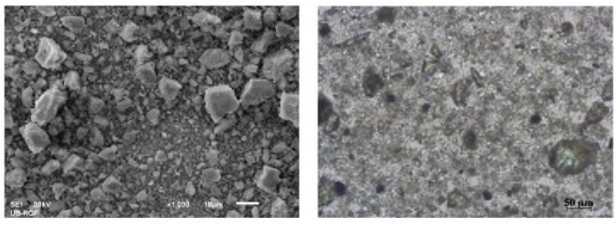

Figure 2: Microphoto of filler and suspension of the Lost foam refractory coatings based on basalt.

An important characteristic of the coating is the sedimentation stability of the coating suspension. The preparation of the refractory filler by the process of fine grinding to a grain size of $15x10^{-6}$m, the application of various additives in the composition of the coating enabled the synthesis of coatings of high rheological properties. Carboxymethyl cellulose (CMC) in amount of up to 1.5% was added as an additive in order to increase the coating suspension stability. Sedimentation for 24h was 4,5%, which according to the standard [13,14] is satisfactory for this type of refractory products.

Figure 3 shows thinner and thicker layers of dried refractory coating on a polymer pattern. It has been shown that thinner layers of coating adhere better to the surface of the pattern, crack less and fall off the surface.

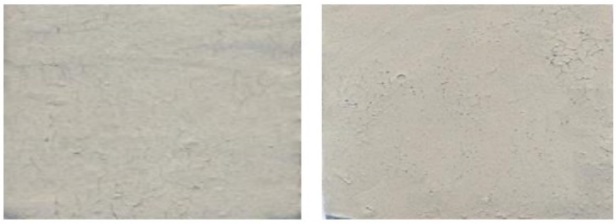

Figure 3: Dried coating layers on a polymer pattern (thinner layer, left and ticker layer, right).

The application of these refractory coatings based on basalt for casting test plates made of aluminum alloys contributed to obtaining a clean and shiny surface of the casting. This will contribute to the reduction of cleaning and machining of casting, and the reduction of production costs in the foundry.

4. CONCLUSION

The result of this research is the determination of the optimized compositions of the water - based Lost Foam refractory coatings with basalt -based filler (with grain size from 15 $x10^{-6}$ m). The preparation procedures for the coating suspension were defined to accomplish the pre-defined coating properties in terms of refractoriness, gas permeability, easy application and adherence to mold and pattern surfaces, easy adjustment of the coat layer thickness, no bubbles, no cracking or erasure of the dried coat layers. The coating suspensions with density of 2000 kg/m^3 presented high sedimentary stability (precipitated matters below 4.5% during 24h).

In the practice of foundries, refractory coating based on basalt has not been applied so far. The obtained results of research on the composition of coatings and the procedures for their production will contribute to the possibility of their application in the casting processes of various casting.

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