MINING AND METALLURGY INSTITUTE BOR
TEHNICAL FACULTY BOR, UNIVERSITY OF BELGRADE

IOC2012
International October Conference

44th International October Conference
on Mining and Metallurgy

PROCEEDINGS

Editors:
Ana Kostov
Milenko Ljubojev

1st – 3rd October 2012
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APPLICATION OF POLYMER MATERIALS FOR PRODUCTION OF EVAPORATIVE PATTERN AND DEVELOPMENT OF NEW CASTING PROCESS

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ABSTRACT

In this paper, results of the investigation of the polymer materials for evaporate patterns and their application in the new casting method (EPC process), are presented. The basic characteristic of EPC process is that patterns and gating of moulds, made of polymers, stay in the cast till the liquid metal inflow. In contact with liquid metal, intensely, in relatively short time, polymer pattern is been decomposing and evaporating, accompanied by castings crystallization. In order to achieve qualitative and profitable castings production by the EPC process it is necessary to reach the balance in the system: evaporable polymer pattern-liquid metal-refractory coat-sandy cast in the phase of metal inflow, decomposition and evaporation of polymer pattern, formation and solidification of castings. Results of this investigation of this process relate on application of puffed polystyrene of various densities (kg/m3): 18; 20; 25. Application of lower density polymer (20kg/m3) gave positive results on structure and properties of silumina castings obtained using this casting method.

Keywords: *EPC casting process, evaporable polymer pattern, refractory coatings.*

1. INTRODUCTION

Technological possibilities for evaporative pattern casting are examined and basic laws of the influence of number of parameters on the process flow and castings quality are determined by monitoring and analysis. The process includes a large number of insufficiently examined phenomena in connection with physiochemical and thermodynamic changes in the evaporative pattern - refractory coating - liquid metal -sand system, Fig. 1. [1, 2]

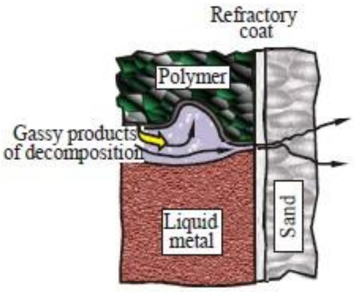


Fig.1. *EPC casting process*

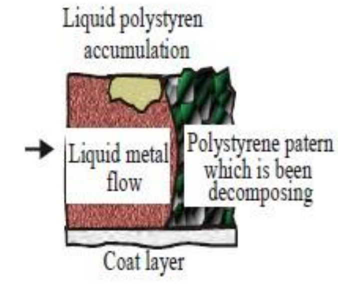


Fig.2. *Decomposition process of pattern*

Solid, expanded polystyrene pattern – chemical formula $(C_6H_6)n$ – of the molar mass of 300.000, in contact with liquid metal is subject to decomposition and forming of liquid and gas products, Fig.2. At the same time, formation and solidification of castings process is in progress. Decomposition process is extremely endothermic so that solidification of castings develops in under-cooling conditions. The conditions of solidification are not uniform by the cross-section of castings which results in inhomogeneous structure, specific surface appearance and volume fraction defects [3].

Important factors on patterns decomposition and evaporation process, besides temperature and patterns density, are also the type and refractory coat layers 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 patterns 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. [4,5] 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 EPC casting process and obtain the castings of a priori specified properties.

2. EXPERIMENT

For casting, various polystyrene models with different density (kg/m^3) were used: 18 (series I); 20 (series II) and 25 (series III). Models were merged into "clusters" and coated with layer of refractory coating based on talc. After coating was dried, models were made. Models with inflow system were placed into steel mold and were poured by unbounded sand applying vibrations during the process. Prepared liquid metal was poured into "full mold". In Table 1, EPC parameters for the casting process in the experiment are presented.

Table 1. Experimental parameters of EPC casting process

Parameter	Parameter description
Tested alloy	AlSi10Mg
Preparation method 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	735 °C - 795 °C
Evaporable polystyrene pattern, grain size 1-1,5mm	-density (kg/m^3): 18; 20; 25 -pattern construction: plate (200x50x20)mm
Mounting pattern for casting	"cluster" with four patterns-plates set on central runner gate
Gating of moulds	-central runner gate (40x40x400)mm, -ingots (20x20x10) mm, 2 pieces.
Sand for molding	-dry quartz, grain size (mm): 0,17; 0,26; 0,35.
Refractory coating	-refractory filler: talc, grain size of 35μm, 90-91% -binding agent: bentonite 3%; bindal H, 5,5%, -suspension maintenance agent: dextrin 0,5%, -solvent: water -parameters of coat suspension: temperature 25°C; density 2g/cm^3; mixing velocity: 1 rev./min; drying of layer: first 2h; final 24h; layers thickness (mm): 0,5; 1; 1,5.

After casting was finished, the castings were taken released from the mold and visual inspection of their surface quality was performed, along with structural and mechanical properties testing.

3. RESULTS AND DISCUSSION

To produce high quality castings, the pattern density must be uniform (Fig. 3-4). Higher density gives harder pattern, resistant to cracking and folding at molding, but they produce more gas and liquid when metal is poured which must be prevented if high quality castings are to be obtained.

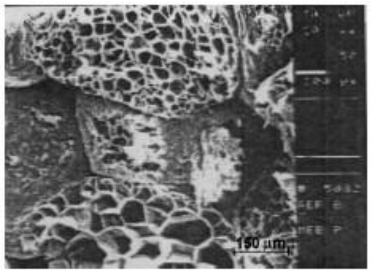


Fig.3. *Fracture surface of foam pattern*

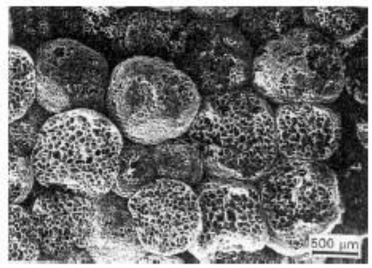
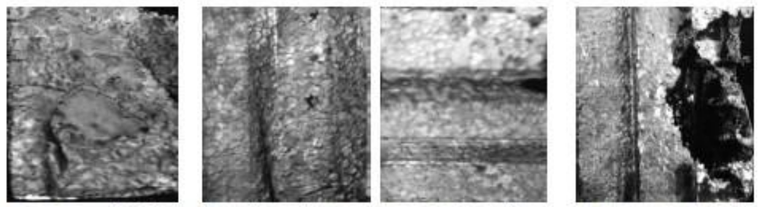


Fig. 4. *Cellular structure of expanded polystyrene*

Results of the investigation showed that the best distortion and spalling resistance during molding showed models from series III. However, obtained castings had superficial defects, namely superficial and volumetric porosity which is unacceptable. Models from series I had lower strength and they frequently spalled during molding. The best results showed models from series II: there were neither warping nor spalling of "clusters" during molding, and there were no defects like pores, folds or cracks on the castings.

Polymer patterns decomposition is endothermic staged process, which starts at liquid metal inflow. The patterns decomposition kinetics is the function of liquid metal temperature which the pattern comes to contact with. During the inflow phase, while metal passes through polymer pattern, 70-90% of products of metal decomposition are liquid. During the process, the decomposition liquid products are been pushed toward the casts cavity upper surface, afore the liquid metal front. In case of minor permeability of refractory coat and sand for modeling, those liquid products of pattern decomposition stay in upper parts of castings and cause appearance of surface, subsurface and volumetric errors. Further decomposition of liquid phase is done by evaporation (boiling phase layers creation) with formation of solid residue of polymer chain, monomer, and also benzole, small quantities of toluene and ethyl benzene. During application of models from series III, a larger quantity of gas products from models decomposition was noted. That increased volumetric porosity of the castings. The best result considering compactivity showed castings from series I: there san no porosity, however the problem of warping and spalling during molding was still present. Results of the investigation showed that models from series II, using thinner layers of the talc based refractory coating (below 1 mm), and give silumina castings with excellent quality. The castings had fine-grained structure without visible surface porosity, folds and cracks. Volumetric porosity was not present. Huge problem concerning surface quality of the casting obtained by EPC casting method is "granular" superficial quality of polystyrene models which is often reproduced on thus obtained castings, Fig. 5.



a. uneven and rippled surface *b. grain castings surface* *c. appearance of porosity and folds* *d. short poured casting*

Fig.5. *Surface errors on castings reproduced from patterns surface*

In order to obtain castings with shiny and even surface in is necessary to use polystyrene models with lower density and finer grains.

4. CONCLUSION

Results of this investigation showed that quality of the polymer models have major role in obtaining castings with even and shiny surface without visible porosity, folds, cracks and other defects which could be formed during EPC method of casting. For further investigation it is necessary to obtain raw materials for production of the polymers with low density.

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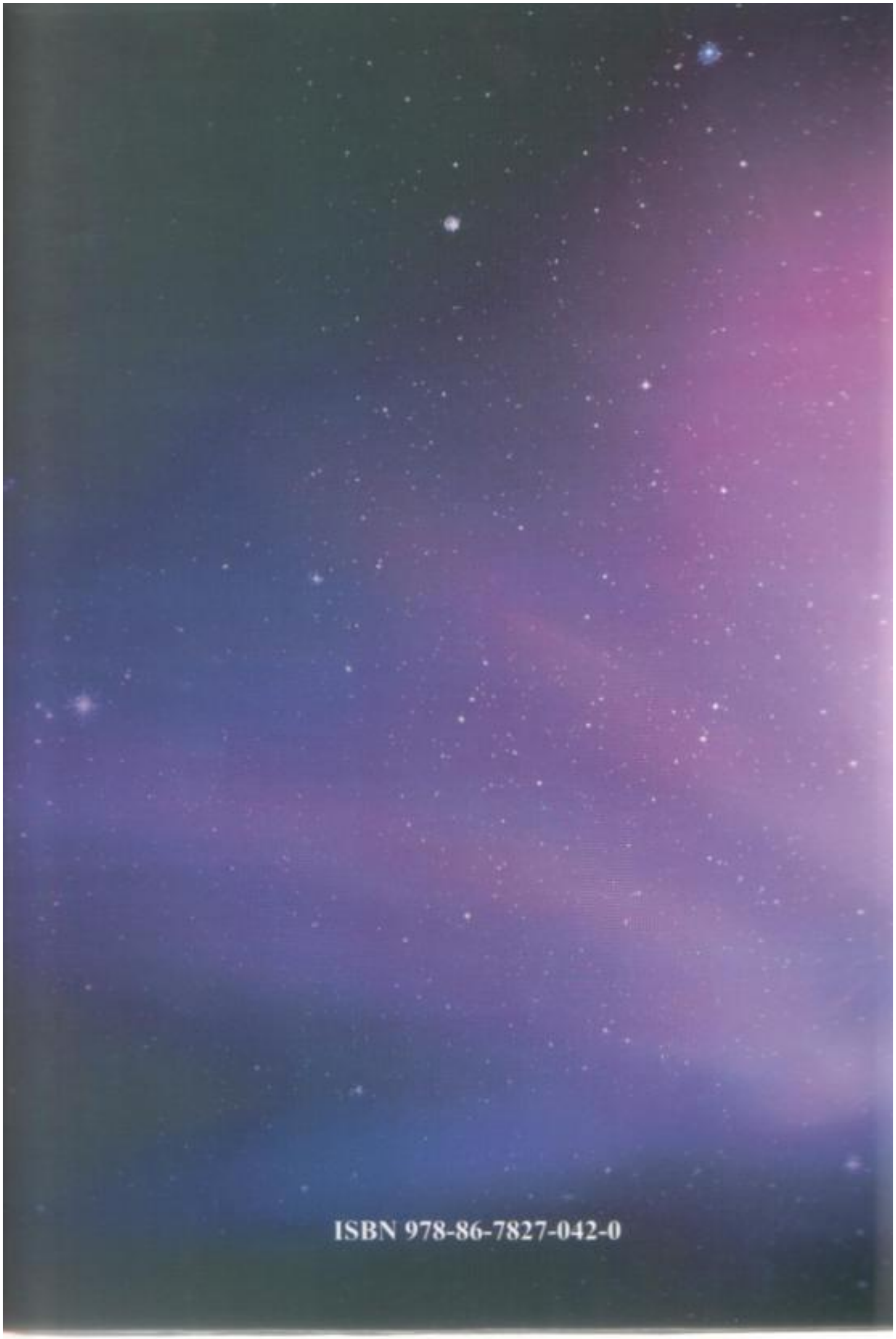
REFERENCES

[1] S. Shivukumar, L. Wang, B. Steenhoft, Phisico-Chemical Aspect of the Full Mould Casting of Aluminium Alloys, AFS Trans. 87-84, 1990, p. 791.
[2] R. Ballman, Assembly and Coating of Polystyrene Foam Patterns for the Evaporate Pattern Casting Process, 92nd Casting Congress, Hartford, USA, Proceedings, 1990, p. 250.
[3] R. Monroe, Expandable Pattern Casting, AFS Inc., USA, 1994.
[4] EN 13018, 2001- Visual testing
[5] B. Smith, S. Biederman, Examining Lost Foam's White Side, Modern Casting, August (2000), p. 30-35.



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