

The Analysis of Molding and Modification of the Ceramic Surfaces and Its Impact on the Roughness of Castings

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Abstract

The article presents an analysis of changes in the outer surface of the casting made in a modified ceramic form. The introduction of the modification in the inner surface of the form, as a metallic coating was intended to produce a high quality of the casting surface. To describe the results, the three parameters have been chosen to characterize the surface roughness, i.e. Ra, Rz and Rq. In implementing the popular method of casting was used, so – called the lost polymer models. The models made from different plastic materials are chemically and electrochemically coated with a layer of nickel. The next step was to remove the model from the form and pouring the liquid metal over it. The observation of the casting surface was performed by using the scanning electron microscope and a profilometer. As a result of these attempts a number of castings have been obtained with an outside layer generated of lower roughness than the casting made in the normal gypsum form. The proposed method can be called an innovative one because it reduces the technological cycle by one processing operation of investment casting. During the process of casting both the cast and the outer layer improving the properties of the manufactured product is being produced.

The key words: Nickel coating, Roughness of casting surface, Aluminum alloys, Ceramic mold, Polymer materials.

1. The introduction

To improve the condition of the surface casting the variety of modifications were used related to the material model or the molding material. The proper gradation of the ceramic material as well as the right type of the plastic used for the model had a significant impact on the final status of the product surface. The aim of this study was to introduce an additional interlayer between the material form and the performed casting. This layer determines the final condition of the product's surface.

In this case, the condition of the casting and its external surface is very close to the roughness obtained on the coating

formed. The possible changes depend on the material from which the model has been made and the temperature which the ceramic mold was fired at. The nickel coating, due to the high temperature interacting on the form (while burning and pouring) does not significantly change the condition of the outer surface. The main reason for such behavior of the layer is the high melting point of the coating material and the resistance to oxidation of the nickel at the elevated temperatures.

In this work comparison of castings was made in the ceramic mold modified by various methods and analysis of surface roughness of the nickel -coated model with the roughness of castings made on the basis of such models. There were tests

performed on the samples subjected to two annealing temperatures of the mold after the casting process: 750° C and 800°C. The obtained results were compared to the castings, where the models have not been covered yet with any layers [1-7].

2. Research methodology and results

On the basis of previously conducted studies and the analysis two polymeric materials were selected, such as ABS and high – impact Polystyrene HIPS. These materials have shown the most beneficial characteristics of the possibilities of removing them from the ceramic molds using the thermal processes.

The test samples with dimensions of 20×20×2mm were made from each of the used materials (Fig.1). In the first phase, a thin coating of nickel was prepared by using the autocatalytic method. Then the coatings were subjected to electrochemical nickel coating, in order to achieve a layer of a certain thickness (in the case of the test samples the coating was 40 μm). There was a nickel sulfate -based bath used, so-called the Watts bath.



Fig. 1. Examples of the samples coated with nickel

The next step was to the inclusion of the model applied in the form of a ceramic coating. In order to facilitate the gravitational pouring process to the maximum the upper layer was removed. Then the sample was placed in a barrel in order to pour the ceramic mixture. The full access to the casting cavity after the burn-out was possible due to placing it on the bottom of the barrel (Fig.2 and Fig.3).

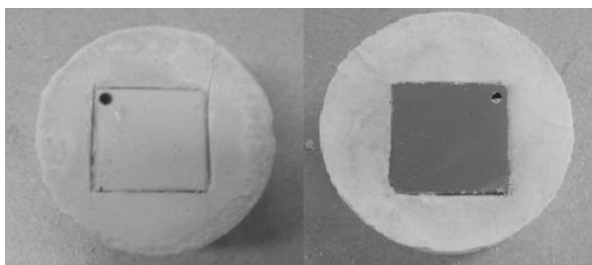


Fig. 2. The arrangement of models with the nickel coatings in the ceramic mold

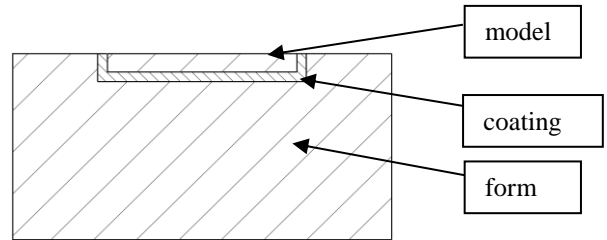


Fig. 3. The cross-section through the modified ceramic mold

The next stage after the ceramic mold was the burn-out of the plastics model and removing any contaminants and moisture contained in the cement. The samples were with-stood in the oven for 30 minutes at 750°C or 800°C. Each temperature forms were burned-out containing both ABS and HIPS.

Gravity casting was carried out at a temperature of firing of the mold. After pouring the liquid metal the mold with the casting was also held in the oven for one hour on order to initiate the reaction of diffusion between the nickel coating and the aluminum alloy casting.

The observations carried out on a scanning electron microscope (Fig.4-8) indicate that the casting layer is uniform and continuous. Furthermore, the morphology of the state of coating of the outer layer applied does have an influence not only the model material but also the subsequent thermal processing.

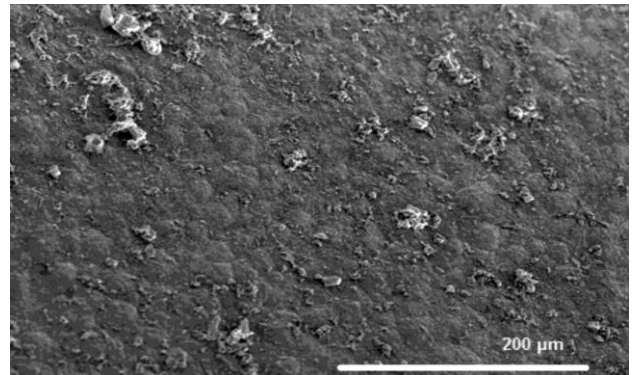


Fig. 4. Surface of the casting with a nickel layer, the model material - ABS, mold annealing temperature of 750°C

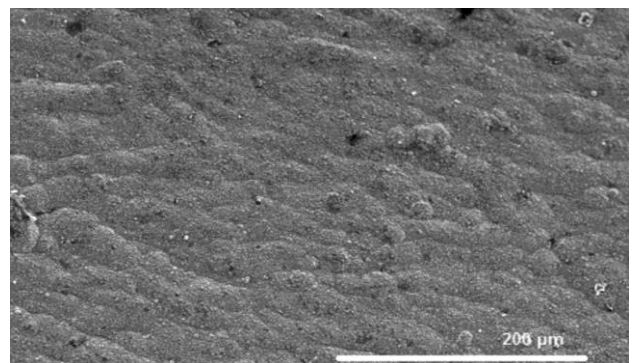


Fig. 5. Casting surface with a nickel layer, the model material - HIPS, mold annealing temperature of 750°C

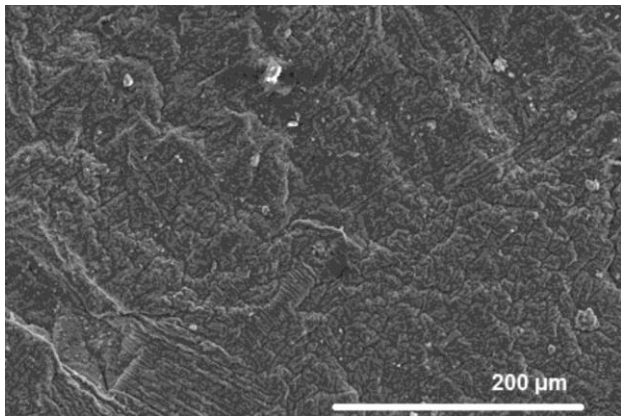


Fig. 6. Surface of the classical casting - aluminum alloy

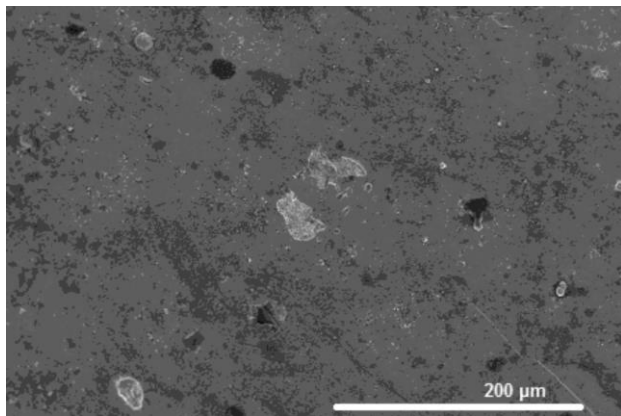


Fig. 7. The casting surface with a nickel layer, the model material - ABS, the form annealing temperature of 800°C

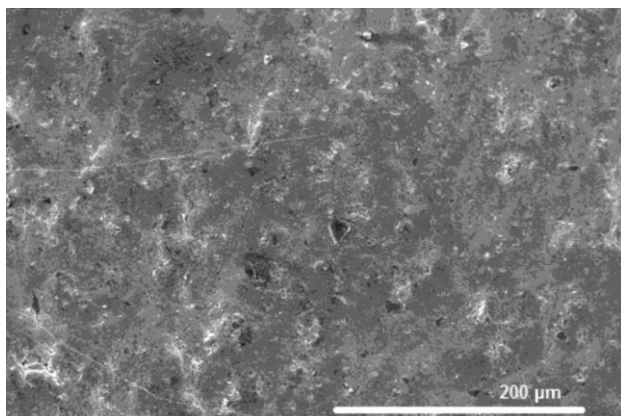


Fig. 8. The casting surface with a nickel layer, the material model - HIPS, the form annealing temperature of 800°C

In addition to the observation of the surface formed on the casting surface the roughness measurement was conducted using a profilometer needle. The measurements were made of Ra, Rz and Rs. Averaged results were shown in table no 1. These measurements were made on the casting formed in a conventional

manner, i.e. without the modification of the mold and the castings with top layer resulting in a modified form, heated at different temperatures (750°C and 800°C).

The difference in roughness of castings with a layer or without the layer is very significant. The Ra parameter for casting made without any intermediate layer is two times greater than for castings made in a modified form for ABS material. Whereas for the polystyrene HIPS the difference is four times greater. It looks similar to the other analyzed roughness parameters Rz and Rq.

These results clearly show the change in the outer surface of the casting under the influence of annealing temperature. It was found that the endurance of the ceramic molds after the process of pouring at a temperature higher than 750°C adversely affected the resulting layer. This process has led to the increase of roughness in the outer surface of the casting.

Table 1 Roughness parameters for various materials with distinguishing the from annealing temperature

Materials	Roughness parameter (average values)		
	Ra [μm]	Rz [μm]	Rq [μm]
Casting aluminum (unmodified)	4,548	28,044	5,717
Nickel coating on the ABS, the temperature of 750°C	2,078	10,562	2,657
Nickel coating on the ABS, the temperature of 800°C	2,189	11,163	2,788
Nickel coating on the HIPS, the temperature of 750°C	0,9835	6,291	1,256
Nickel coating on the HIPS, the temperature of 800°C	1,094	6,892	1,386

3. Summary

The nickel layers formed on the casting model met the objective aim, namely significantly reduced the surface roughness of the outer layer of the casting. It has been found that using this type of technology can avoid the uncertainty associated with the state of the surface layer of the casting.

The layers formed on castings by firing the ABS material have higher roughness parameters than the layer formed after burning the polystyrene HIPS. The coatings obtained on the surface of HIPS materials are very promising in the perspective of further research and development of new technologies as well as from the point of view of future applications.

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