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REINFORCING CAST IRON WITH COMPOSITE INSERT

The paper presents a proprietary method of making composite cast iron (eutectic) locally reinforced with ceramics. The research included making casts with a ceramic layer, its percentage of the surface was 30%. The research included abrasive wear resistance according to ASTM G 65-00. As a result of the research it has been found that the infiltration of the molten metal into the ceramic preform mainly affects the correct production of the cast with local reinforcement. The research results also have proven that the application of a lattice ceramic insert placed in the mould is the most appropriate option, due to the even distribution of the particles in the cast and obtaining a sound cast.

Keywords: composite, cast iron, ceramic

1. Introduction

The composites made with the use of casting technology [1] with ceramic insert form a solution allowing for obtaining casts highly resistant to abrasive wear with higher or comparable properties to material highly resistant to wear. The most important advantage of the materials is the possibility to obtain the finished product in one technological process – casting [2-5]. The process of the elements' wear occurs most of all on working surfaces, i.e. on the outer surfaces, which induces the local reinforcement of the casts [2,3,5]. The production of this element from one material results in obtaining identical properties throughout the entire volume of the cast. In case of joining two materials of different properties, it enables maintaining of contrary desired properties, such as in case of the cast core which is characterised with plasticity and capability to transfer dynamic loads, while the working part should be characterised with higher abrasive wear resistance [6-14].

The method of obtaining composite casts locally reinforced with hard ceramic particles will be presented in this paper [15].

2. The method of obtaining surface ceramic composite insert and its properties

The methods of obtaining composites in casts enable designing casts reinforced on the surface in zones or throughout their entire volume. They allow for obtaining products combining the properties of a selected cast alloy with “phases” (Al_2O_3),

highly resistant to abrasion ceramic. Thanks to such solution it is possible to design elements of machines and devices locally reinforced with a ceramic phase. Its advantage is the limitation of the production costs resulting from the application of several technologies and the cost of the material used. In as much the scientific works on the ceramics-aluminium composites are known, in so far there is no such information concerning the composites of iron alloy – ceramics composites. The issue of producing composites or ceramic materials and iron alloys, and thus, the difficulties with their even distribution in the volume of the molten metal and with high temperature of the iron alloys inducing disintegration of the ceramic preforms and uncontrolled layout of ceramic grains in the cast volume.

The purpose of the research was to develop a technology of ceramic preforms characterised with possibly the maximum effect of penetration of the molten metal deep into the preform, as well as obtaining a ceramic composite characterised with high resistance to abrasive wear in the appropriate part of the cast.

In the tests for the insert production the ceramic grains of artificial corundum (Al_2O_3), where the size of grains fitted within the range from 1,7 to 2,36 mm, which corresponds to the dimensions of F12 to F10 according to FEPA standard. The ceramic grains in the preform are joined by a binder based on water glass. Such preform mounted in the recess of the mould and, gravitationally cast with molten metal (cast iron eutectic), forms a composite layer (iron – ceramic grains alloy) as a result of decomposition of the binder, grains and penetration of molten metal into the pores, tubules and openings of the preform [15].

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The structure of the preform is based on geometric dependencies (Fig. 1):

- side length of elementary cells $b = 30$ mm,
- space between the openings from $= 15$ mm,
- preform length $L = 60$ mm,
- preform width $S = 26$ mm,
- profile lattice work $A = 23\%$.

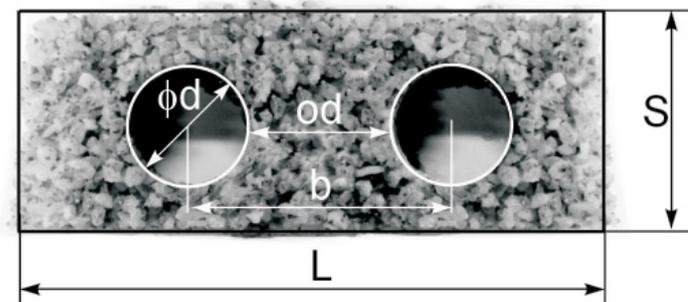
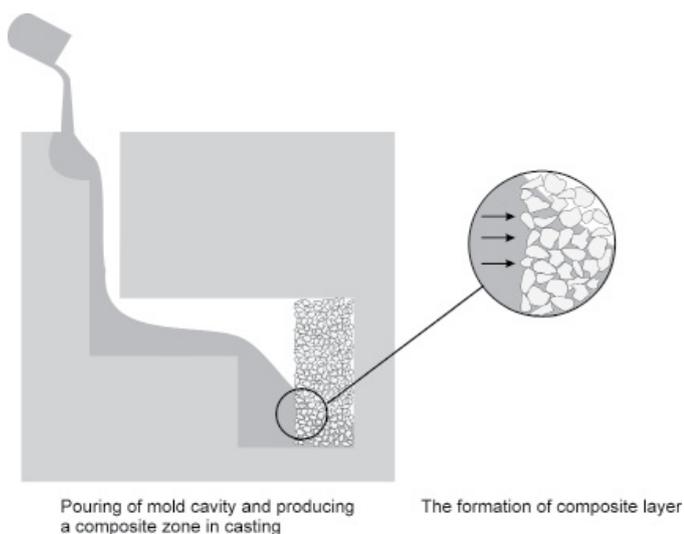


Fig. 1. Ceramic insert to form the composite layer

For the production of a cast with surface composite layer cast iron eutectic was used, which formed the principal part of the cast and Al_2O_3 , of which the insert was made to increase the properties the surface layer of the element produced. The tests included the production of a series of trial casts of varied Al_2O_3 grain size.

Figure 2 presents the method of producing a cast with a ceramic layer. The method consists in placing a ceramic insert inside the mould recess, enabling to obtain the surface ceramic layer. Such process allows for obtaining a layer ca. 25 mm thick (in the experiments analysed), assuring reaching high abrasive wear resistance.



Rys. 2. Schematic presentation of the formation the composite layer in the casting

In Figure 3 a sample cast locally reinforced with a composite ceramic layer has been presented.

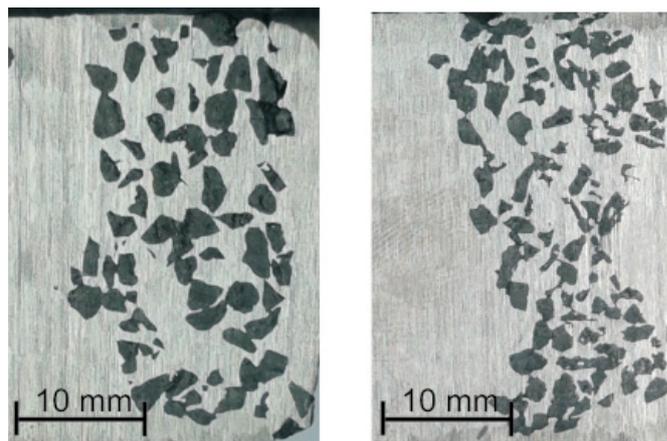


Fig. 3. Casting with locally reinforcement produced layer

Based on the research it has been found that the best volume of particles in the cast is ca. 30% of the surface which has been reinforced with the particles.

The tests included measuring the abrasive wear resistance of the surface composite layer produced. The samples with the composite were tested on a device made according to the guidelines included in the ASTM G 65-00 standard.

Basic technical data:

- engine speed – 600 revolutions per minute ± 10 revolutions per minute,
- rotational speed of the wheels – 200 r.p.m. ± 10 r.p.m.,
- dimensions distinctive wheels: diameter 230 mm, thickness 25 mm,
- load a sample of 130 N,
- intensity abrasive flow of 500 g/min (dry sand).

Such device is designated to test the abrasive wear resistance of the metal-mineral type.

The result of the trials carried out was the reduction of the samples' mass measured with accuracy up to 0,001 g. The test enabled determination of the mass reduction (Δm) for each of the surface composites obtained. The measuring results have been presented in (Table 1).

TABLE 1

The results of abrasive resistance examination

Material	Average mass loss, g
Composite No. 1 (insert – F12, the density of grain 30%)	0,122
Composite No. 2 (insert – F12, the density of grain 33%)	0,117
Composite No. 3 (insert – F10, the density of grain 25%)	0,170
Composite No. 1 (insert - F12, the density of grain 29%)	0,149
matrix composite (cast iron)	0,231

Based on the observation of the composite produced, it has been noticed that the molten metal poured into the mould well penetrated between the insert particles, creating no local

agglomerates and no discontinuation in the combination metal – Al_2O_3 particle have been noticed (good dampening – Fig. 4). Based on the test of abrasive wear resistance a significant increase of this property has been found, it has been noticed that during the tests the matrix (cast iron) was largely exposed to abrasion affecting the test result. More reliable measurements of abrasive wear resistance should be carried out in conditions closer to real ones.

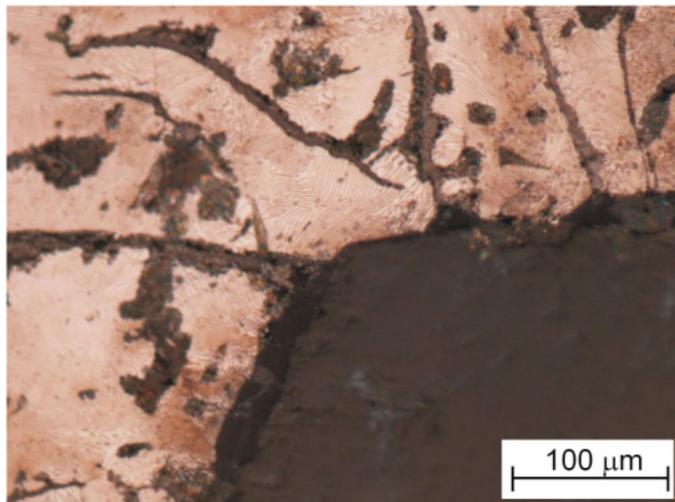


Fig. 4. Microstructure of the composite

3. Summary and conclusions

The method of producing ceramic inserts to create surface composite layer with Al_2O_3 enables to obtain a cast with locally increased abrasive wear resistance. Maintaining some geometric assumptions assures the production of a composite in a desired point of the cast.

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