WEAR RATE OF ALUMINUM ALLOYS REINFORCED BY MEANS OF DISPERSED INTERMETALLIC COMPOUND FE-CR UNDER DRY FRICTION

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ABSTRACT
Method of obtaining of cast composite materials (CCM) on the basis of aluminum reinforced by $\sigma$-phase (FeCr) is proposed. The wear rate of specimens from CCM is depended on the height of casting, which these specimens were cut out from. The average size of particles FeCr 27.5-35.5 $\mu$m and their quantity 184-263 pieces/mm$^2$ make the greatest positive influence on wear rate of CCM under dry friction.

INTRODUCTION
Aluminum alloys, due to their unique characteristics, are widely used in many branches of industries (automotive, aerospace industry etc.). For improvement of service characteristic of aluminum alloys basically three technologies allowing to obtain composite materials (CM) on the basis of aluminum are used: powder metallurgy, mechanical dispersion, and impregnation.

All these processes are effective enough, but demand significant expenses. Shynysh has offered [1] a method of obtaining of cast composite materials (CCM) on the basis of aluminum (Al-FeCr) by means of Lost–Foam Process [2]. In this case the reinforced $\sigma$-phase (FeCr) is implanted in gasification pattern made of polystyrene foam and then, at horizontal casting it is distributed in volume of casting. By means of this process a cast composites (Al-10FeCr) were obtained. It is experimentally established [3] that by the filling of the mould by means matrix melt an arise both the convection and turbulent streams take place, which due to the temperature gradient and the hydrodynamic of process cause. These streams are the reason of non-uniform distribution of dispersed phase in matrix melt that, probably, can influence on tribological characteristics of reinforced CCM of system Al-FeCr. With this purpose the wear rate of samples from the CCM cut out from various height of casting are investigated.

EXPERIMENTAL DETAILS
The base aluminum alloy AK12 and an experimental cast composite (Al-10FeCr) on the basis of alloy AK12 which were obtained by means of Lost–Foam Process were selected as a subjects of study. The wear rate of the specimens of base alloy and experimental CCM, which have been cut out from identical height of castings, was studied. The wear tests were performed on block-on-ring machine. The ring (counter-specimen) was made of steel containing 0.36-0.44-wt.% C and 0.8-1.1-wt.% Cr with surface hardness 52 HRC.

Studied CCM were tested under dry friction. The sliding velocity and specific load were 1 m/s and 0.5 MPa respectively. Microstructure of samples by means of optical microscope MIM-9 was studied. The wear rate as the relation of weight loss of a specimen (g) to a friction distance (km) was determined.

RESULTS AND DISCUSSION
The analysis of a microstructure of specimens containing reinforced particles FeCr and cut out from various height of casting has shown that the size of inclusions and their quantity considerably differ. The microstructure of cast specimens which have been cut out from the top and bottom part of casting it is possible ascertain, that the reinforced particles FeCr have the least size in the top part of casting and their quantity is maximum. Some physical-mechanical characteristics of CCM and the base alloy AK12 depending on height of casting are submitted in table 1. The carried out wear tests of experimental cast composites have allowed to note, that the greatest influence on wear rate the particles FeCr with the average size 27.5-35.5 $\mu$m and their quantity 184-263 pieces/mm$^2$ make. In this case the wear rate of CCM is in 1.3-2.2 times less than the base aluminum alloy AK12.
Figure 1. Micrographs of the initial structure of specimens of Al-10FeCr, which have been cut from the top (a) and bottom (b) part of casting

Table 1. Physical-mechanical characteristics of studied CCM of Al-10FeCr system

<table>
<thead>
<tr>
<th>Height of casting, mm</th>
<th>Average size of particles FeCr, µm</th>
<th>Quantity of particles, pieces/µm²</th>
<th>Microhardness, MPa</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Matrix: Composite Al-10FeCr</td>
<td>FeCr</td>
</tr>
<tr>
<td>275</td>
<td>28.0</td>
<td>195</td>
<td>624</td>
</tr>
<tr>
<td>225</td>
<td>26.6</td>
<td>263</td>
<td>619</td>
</tr>
<tr>
<td>175</td>
<td>35.5</td>
<td>184</td>
<td>669</td>
</tr>
<tr>
<td>125</td>
<td>50.9</td>
<td>74</td>
<td>668</td>
</tr>
<tr>
<td>75</td>
<td>57.1</td>
<td>63</td>
<td>730</td>
</tr>
<tr>
<td>25</td>
<td>45.4</td>
<td>68</td>
<td>683</td>
</tr>
</tbody>
</table>

The size increase of particles FeCr does not result already in stable decrease of wear rate of CCM (Figure 2).

The obtained results are agreed with the date of work [4] were is shown, that the reinforcing of aluminum alloy A2024 by means intermetallic inclusions Fe/Al, Ni/Al, and Ti/Al to wear rate decrease of reinforced alloys under dry friction is resulted.

The analysis of friction surfaces of specimens and counter-specimens have shown, that in given wear conditions two main mechanisms of wear take place which as adhesion wear and delamination wear [5]. The adhesion is accompanied by the transfer of Al-10FeCr block material to the steel ring surface. This is because the CCM is the cohesively weaker material while steel is the cohesively stronger material [6]. It is established also [7], that the material with smaller surface energy has the larger transfer probability. As adhesion proceeded, the material kept transferring, forming layered material adhering to the steel surface. The growing layered transfer material would break off the steel surface when it reached a critical size.

Figure 2. Wear rate of cast composite Al-10FeCr and alloy AK12 under dry friction (V = 1 m/s, P = 0.5 MPa)

CONCLUSIONS
On the basis of the studies it has been established:

- The opportunity of obtains of CCM by means Lost-Foam Process is exists.
- The wear rate of specimens from CCM depends on height of casting from which they are cut out, thus upon size and quantity of reinforced particles FeCr.
- Wear rate of CCM under dry friction in 1.3-2.2 times less than the base aluminum alloy AK12.

REFERENCES