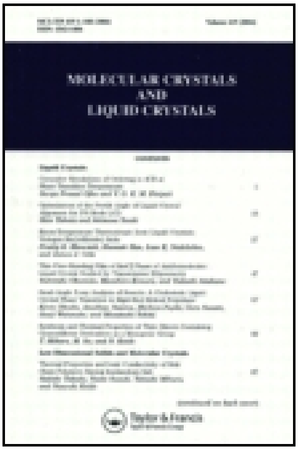

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Microstructure and Friction Properties of Some Tin-Graphite Polyamide Composites

Dorin Condurache [a], Vasile Bulancea [a], Mihai Mares [a], Neculai Foca [a], Costel Roman [a] & Servilia Oancea [a]

[a] Technical University "Gh. Asachi", Iasi, Romania

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MICROSTRUCTURE AND FRICTION PROPERTIES OF SOME TIN–GRAPHITE POLYAMIDE COMPOSITES

Dorin Condurache, Vasile Bulancea, Mihai Mares, Neculai Foca, Costel Roman, and Servilia Oancea
Technical University "Gh. Asachi", 6600, Iasi, Romania

The aim this study consists in a preliminary analysis of some composites based on tin (Sn) and graphite polyamide. We do not intend to elucidate the intimate phenomena of the components interface and not even to establish the optima values of technological parameters of obtaining processes of these composites.

Microstructure analysis offers the results upon the Sn particles dispersion in the polyamide matrix. Tribologically properties (weight losses and friction coefficients) were determined and discussed in correlation with the concentration and distribution of Sn in samples.

Keywords: composites; friction properties; graphite; polyamide; microstructure; tin

INTRODUCTION

The production of new materials has always represented a necessity determined by the dynamic evolution of manufacturing material goods. At present, the production of new materials by replacing the older ones represents an extremely active process [1–3].

The study of the composite materials is part of this tendency.

The objective of composite materials is to solve out problems related to the mechanical properties (elasticity, breaking limit, wear resistance, hardness, etc.) that represent the object of a large number of practical applications [4,5].

We address our gratitude to Prof. Rusu and Prof. Carcea for making the raw matters available for us, as well as to Prof. Olaru for performing the friction measurements in his Tribological Laboratory.

Address correspondence to Dorin Condurache, Technical University "Gh.Asachi", 6600, Iasi, Romania. E-mail: dcondur@ch.tuiasi.ro

The literature that we have studied describes a lot of studies related to various applications of composite in tribology. Although both the raylon (polytetrafluor-ethylene) and polyamides (taken as plastic materials), but also metals or alloys are frequently used for the production of the friction contacts, we could not find references to a composite material based on tin (Sn) and polyamide [e.g. 6–9]. Our study describes some preliminary results on the tribological behavior of several components of the system tin–graphite polyamide.

EXPERIMENTAL PROCEDURE

There have been performed mechanical mixtures of Sn and graphite polyamide, using Sn of 99.99% and polyamide containing 20% graphite. Both materials have been of boring shape. The samples have been obtained by melting the mixture of borings at a temperature of 240°C in inert atmosphere (N_2) using a shaking furnace in order to obtain a thorough homogenization of the material. The mass percentages obtained were the following: 33% Sn – 67% polyamide, 19% Sn – 81% polyamide and 12% Sn – 88% polyamide.

On a macroscopic scale, there have been examined visually sections of the samples, as well as metalographic slides, at a magnifying rate of 100x, at the microscopically analysis.

The samples have been cut too as shoes, which have been subjected to tribological tests.

Tribological behavior of the investigated materials was evaluated in test using composite shoes sliding against a hard steel roll (50 mm diameter), in dry condition, by measuring the weight-loss of the shoes in dependence with the sliding distance. The contact pressure was about 3 MPa. The geometric sizes of the shoes are given in Figure 1.

The curved section (the surface subjected to the friction process) of the shoes has been cut from the inside part of the ingot from all the samples.

For the whole period of stationary support functioning, there have been read every 5 minutes (i.e. 350 m sliding distance) of the values of the friction force momentum. These values have been used in calculating the sliding friction coefficient. After rolling distances of 0.5, 1.5, 2.5 and 3.5 km, the weight-loss by friction wear have been determined by weighting the shoes.

RESULTS AND DISCUSSION

The visual examination of the ingots cut after casting has shown a segregating trend of Sn to their external side.

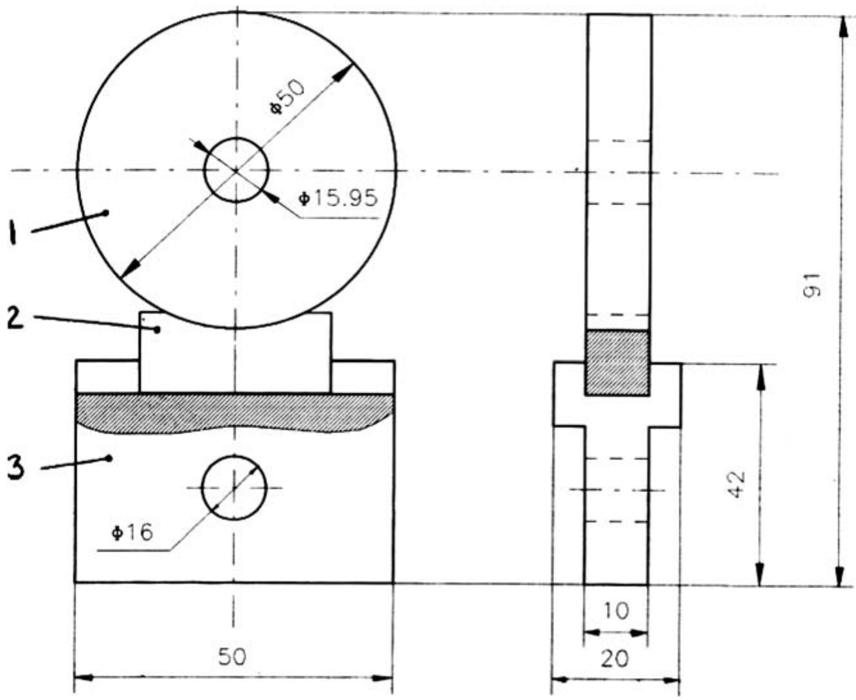

FIGURE 1 ■

This tendency is not induced by the difference between the densities (5.85 g/cm^3 in the case of Sn [10], compared to 1.38 g/cm^3 for the polyamide [11]), because the segregation process does not go along with the vertical direction of the ingot.

The separation takes part in the same direction as Sn particles migration to the margins of the founded sample and increases with the polyamide concentration. Figure 2 illustrates this situation at the microscopically level. The black regions are pores.

We believe that this tendency is associated to the Sn particles migration, dissipated in the polyamide matrix together with the migration of the solidification front, being a frequently met situation in a large number of composites [12–14].

Figure 3 indicates the distribution of Sn particles in polyamide matrix for the three compositions. The influence of Sn percentage is evident.

In order to obtain a better homogenization of Sn in polyamide matrix, we laminated an ingot with 81% polyamide, heated at 100°C. In Figure 4 one remarks the elongate aspect of polyamide in laminated direction and a good

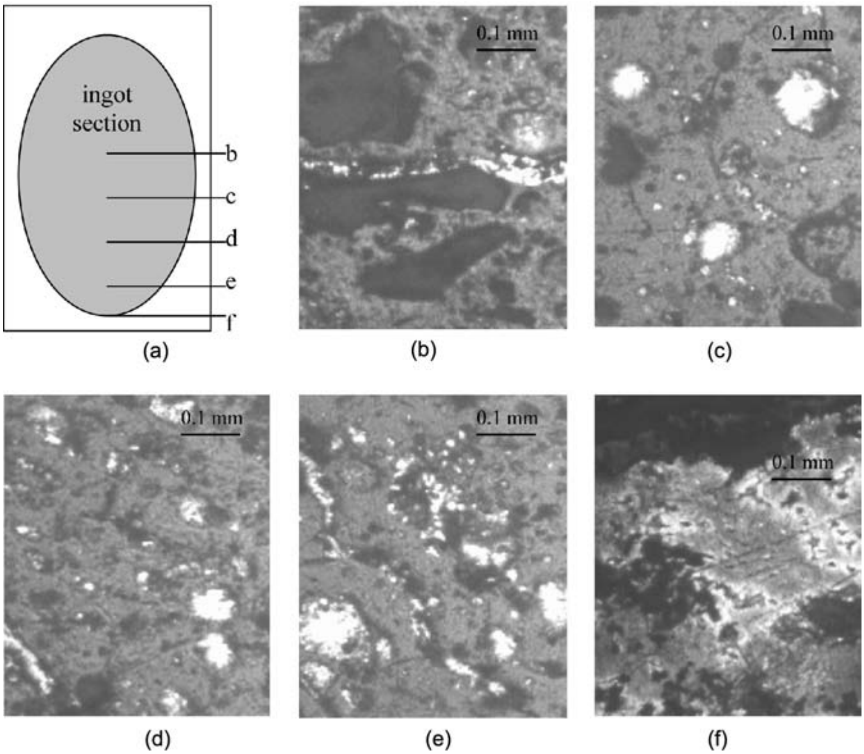

FIGURE 2 The microstructure of sample with 33% Sn along the analyzed surface. The photos were performed in steps of 1 mm: (a) indicates the places of images (b)–(f).

dispersion on Sn in the matrix. Unfortunately, the laminated sample was stratified, with important tendency of cleavage. We can't obtain the shoes from this sample.

The tribological tests report on the measurements of weight-losses due to sliding friction and on friction coefficient calculation. These data are available in the prediction of some mechanical properties [15].

The results of the tribological tests are shown in Figure 5 and Figure 6. Figure 5 presents the loss of material from the shoes depending on the sliding distance by using the three compositions. The plotted weight losses are registered after 500 m and after every 1000 m. There are not added to the before.

The smallest wearing rate has been determined for the sample containing 19% Sn; the rate corresponding to the sample containing 12% Sn has given a close value than the before. That containing 33% Sn has lead to a value 2 times higher for the weight loss on the same sliding distance.

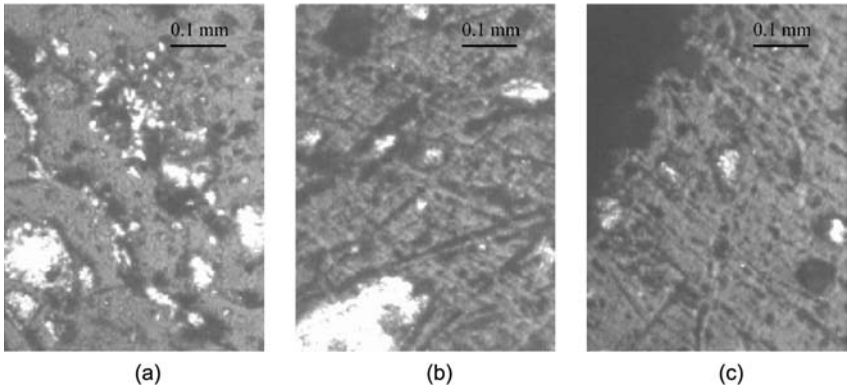

FIGURE 3 The microstructure of composites with 33%Sn(a), 19%Sn(b) and 12%Sn(c).

Figure 6 presents the variation of friction coefficients in dependence with sliding distance for the tested composites.

The sample containing the highest percentage of polyamide presents an increase of the friction coefficient after a sliding distance of 0.3 km, having a stabilizing tendency after 2 km. The sample containing the highest percentage of Sn has a friction coefficient that decreases to 1/2 of the initial value after 0.6 km, then increases again after 2 km to a value at which it settles afterwards. The sample having an intermediate content of Sn is

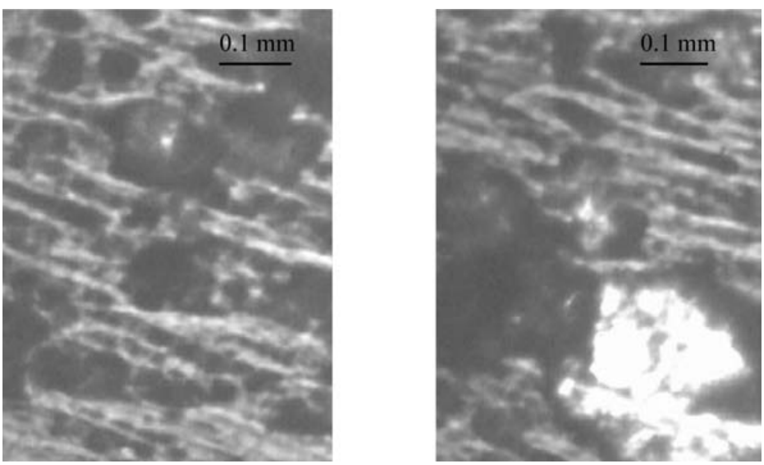

FIGURE 4 The microstructure of laminated sample with 19%Sn.

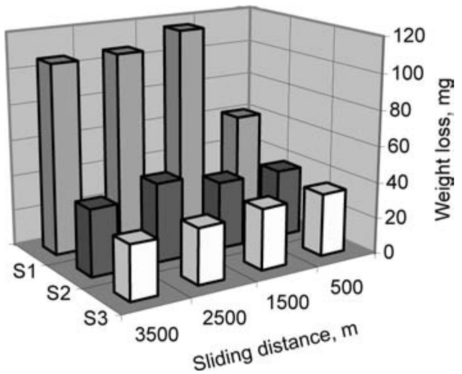

FIGURE 5 Weight losses vs. sliding distances. S1 – 33%S2 – 19%Sn; S3 – 12%Sn.

characterized by a practically constant friction coefficient, maintaining itself at an intermediate value in comparison to the other compositions, if we ignore the minimum registered result after 1.8 km.

Due to the segregating tendency of Sn, correlated to the shoe prelevation mode from the ingot, the surface area subjected to the tribological tests has been the one characterized by the highest concentration of polyamide. It contains more abundant conglomerations of Sn for the sample with 12% Sn and the smallest for the sample containing 33% Sn. As a result of this situation and due to heating occurred of the roll and surfaces

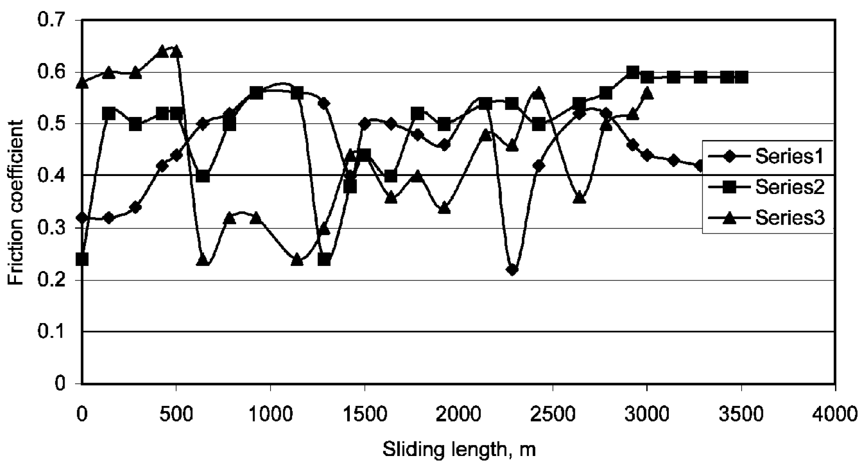

FIGURE 6 Friction coefficients on sliding vs. sliding distance. Series 1 – 33%Sn; Series 2 – 19%Sn; Series 3 – 12%Sn.

subjected to friction up to 70–80°C during the tests, there have been observed polyamide strips on the roll, which have been quickly cleaned by the next rolling. The sample containing 12% Sn (but having the highest quantity of polyamide and being characterized by important separations of Sn on the friction surface) has been wearied non-uniformly and has shown scuffing tendencies during the test.

CONCLUSIONS

1. In spite of all cautions that we have taken, the samples have shown a gradient of the Sn concentration oriented to the external side of the ingot. The gradient has indicated an increase together with the Sn concentration of the sample. Metal conglomerations towards the surface of the ingot have characterized the sample having the highest Sn concentration.
2. The same composite has had the most unusual behavior on the tribological tests, presenting a non-uniform wearing and, as a result, an irregular sliding on the roll during the tests.
3. The sample with the highest concentration of Sn has indicated the best uniformity in Sn particles distribution in the polyamide matrix and the smallest friction coefficient, but the weight loss from the shoes has been twice as large as the other composites.
4. In future, we intend to obtain samples with similar compositions, subjected to an ultrasonic field during solidification and cooling. Another variant we have in view is adding the Sn powder to pre-cursor monomers of the polyamide before polymerization hoping to obtain more homogenous samples.

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