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RESEARCH ARTICLE

A qualitative correlation between friction coefficient and steel surface wear in linear dry sliding contact to polymers with SGF

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Abstract: In this paper we tried to present a qualitative correlation, based on extensive experimental determinations between the value and the evolution of the friction coefficient, wear, and contact temperature, in the case of linear dry contact, for thermoplastic material reinforced with short glass fibers (SGF) and various steel surfaces. The aim was to highlight the evolution of the wear process depending on the evolution of the friction coefficient. As a result, it was possible to graphically illustrate the evolution of the friction coefficient and the change of the wear process, emphasizing the abrasive, adhesive and corrosive wear. The evolution of the plastic material transfer function of the contact temperature, namely of the power lost by friction (product between the contact pressure and sliding speed, p and v) was aimed and it was highlighted. It has been demonstrated that in the case of a 30% SGF content it can reach and even exceed contact temperatures very close to the flow limit of the plastic material. We tried, believing successfully, the graphic illustration of the evolution of the steel surface wear and of the contact temperature, depending on the friction coefficient. The influence of the normal load and sliding speed was evaluated in detail, but also the influence of the metallic surface roughness on the friction coefficient was discussed.

Keywords: friction coefficient evolution; steel surface wear; contact temperature; plastic material transfer; hardness of steel surface influence

1 Aims and background

Composite thermoplastic materials are biphasic materials consisting of a mass of polymer and the reinforcement embedded in it. The polymer provides the compressive strength of the material, while the reinforcement improves the tensile strength. Homogeneity of the material and its cohesion has an important role in obtaining some good mechanical characteristics. Thus, the disposal of the reinforcement considerablely influences the tensile strength feature. The elasticity of the polymer can also improve the compression resistance or bending resistance of the reinforcement material. The role of the basic polymer is first of all mechanical and is to provide the bond with the reinforcement fibers. It is the one that transmits the efforts between the reinforcement fibers. Therefore, it is necessary to ensure a minimum adhesion between these two phases.

The adhesion cannot be achieved by mechanical means. It is necessary to achieve a chemical bond for the polymer coating with the basic polymer. The treatments performed for this purpose are specific to each thermoplastic material.

Basic polymer acts as a bridge between the reinforcement glass fibers. If the binder is slightly deformable, the fibers cannot move, so only a small number of them support loading. The polymer must allow a balanced distribution of efforts between the reinforcement fibers, but in the same time must limit their movement to prevent an excessive deformation

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of the product. Also, the basic polymer ensures the tightness against humidity, because most of the reinforcement fibers have a high affinity for water, resulting in the loss of some of the properties. The glass nature has importance on the time constancy of mechanical, electrical, and chemical properties of reinforced thermoplastic material. Alkali-free glass is used in order to obtain stable products, because all of the fibers with a high content of Na or K have characteristics that decrease rapidly in time, as a result of their superficial hydrolysis by the action of humidity. Glass containing metal oxides is used in certain proportions in order to improve the mechanical properties, in particular elastic modulus.

The glass fibers used to reinforce the thermoplastic materials, when they are free of defects, have a minimum tensile strength of 25 MPa, and with their usual surface defects achieve maximum 15 MPa, although the glass itself has a resistance of 0.5–0.6 MPa. Elastic modulus achieves 750–790 MPa. Fibers have elongations of 2%–3%, total elastic elongation. No permanent deformations occur before breaking and no hysteresis at normal temperature.

Also, the presence of the glass fibers leads to reduction of the factor time in the creeping process. Dimensional changes due to water absorption remain a problem of hygroscopy, polymers inherent. By incorporating glass fibers in the thermoplastic materials their mechanical properties are preserved, in a wide temperature range.

Thermoplastic materials with glass fibers structurally present a mechanical association of glass and polymer fibers. Thermoplastic compounds are characterized by high plasticity under certain conditions of temperature and by their returning to the initial stage by cooling. In the plastic stage they can be processed into finished products.

Ever since the year 1964 Bowdon and Tabor [1] experimentally found that the values of the friction coefficients of the "clean" metals couples on plastic materials and in the presence of some moderate loads are similar to those of the plastic material/plastic material friction couplings. They considered that the shear force is due to friction of the micro-junctions formed on the contact surface of the two samples.

In the specialty literature there are works which give values of the friction coefficient of plastic material/metal, plastic material/plastic material, reinforced or unreinforced samples, operating both under dry friction and in the presence of lubricants. Jacobi [2] presents for polyamide reinforced with glass fibers, values of the friction coefficient ranging between 0.04 and 0.5. Bilik [3] determined for the friction coefficient of the polyamides/steel, values up to 2.0. All the mentioned works emphasize the fact that the value of friction coefficient is not constant, and it depends on the relative sliding speed, contact pressure, surface roughness, temperature, etc.

Clerico [4] studying the friction behaviour of the polyamide/metal couple found that the friction coefficient values are higher for short periods of operation, than for long term operation of the couple. He indicates friction coefficient values from 0.1 up to 0.65 for the first three hours of couple's operation, values that decrease up to 0.42 in the next 67 operation hours. He explains this by the viscoelastic properties of the polymer.

Hrusciov and Babicev [5, 6] show the growth of microcutting component of the friction force for plastic material reinforced with glass fibers/steel couples, with increasing the polymer content.

Bely et al. [7], Bartenev and Laventiev [8] studied the influence of the polymer's nature and of the glass fibers orientation in its mass, on the friction coefficient. They found that the friction coefficient values increase when glass fibers have not the same orientation in the basic polymer.

Watanabe et al. [9] show the increase of the friction coefficient with the increase of the normal load. They explain the influence of temperature on the decrease of the friction coefficient value by the intensification of plastic material transfer to the steel.

Lancaster [10] taking care of the friction behaviour of the polymers reinforced with different natures fibers, established the dependence of the friction coefficient of the ratio $\eta v d^3/N$ for lubricated couplings beak (of diameter d) / disc type. He found the decrease of the friction coefficient with the reduction of the metallic surfaces roughness and with the increase of the mentioned report value. The friction coefficient decreases from 0.19 to 0.04 when the ratio $\eta v d^3/N$ increases from 10^{-14} to 10^{-11}, for a roughness of 0.15 μm of the steel surface. For roughness of 0.46 μm, the friction coefficient is constant when the mentioned report increases from 10^{-14} to 10^{-11}. Studying the friction behaviour of the thermoplastic materials, Barlow [11] provides for friction coefficient of these on steel, values of 0.1–0.28, in the presence of a lubricant. He notes the increase in the value of friction coefficient with the increase of the relative sliding speed between the surfaces of friction torque.

West and Senior [12] examining the friction behaviour of the polyethylene/steel couple shows the reduction of the friction coefficient from 1.24 to 0.78, when the normal load increases from 10 to 5,000 N. He demonstrates that for normal loads of 250–1,500 N, the friction force is proportional to the factor ($N^{0.88}$), and the friction coefficient is proportional to ($N^{-0.22}$).

Bartenev et al. [13] establish in the case of plastic materials friction on metallic surfaces, the increase of friction force with increasing the logarithm of sliding speed. This dependence is expressed by Vinogradov, for friction of crystalline polymers on metals. In the case of adhesion processes preponderance, he finds also an increase of the friction force with the normal load.

From the above, it can be concluded that the friction process of thermoplastic materials is extremely complex, a variety of parameters influencing the value of the force and of the friction coefficient. These parameters, physical and mechanical, influence the friction process in the presence of a lubricant in the contact region, and in the absence thereof. Although relatively numerous, the published works do not allow a complete characterization of the process, due to the heterogeneity of the materials tested and the experimental conditions used, as well as of the contact types variety and of the research installations used.

If realized researches and published works on the friction behaviour of the thermoplastic material reinforced with glass fibers/metal couple are quite numerous, not the same can be said about those published in the wear domain. The data presented in the specialty literature concerning the wear of this coupling, refer to certain limited domains of use of the reinforced thermoplastic materials. Most papers treat qualitative aspects of the wear phenomenon, just few presenting and its qualitative side. Thus, Bowden and Tabor [14] have highlighted the importance of the distribution of stresses on the contact surface, showing that in the case of a Hertzian contact with a pressures elliptical distribution, the central area of the contact surface will be more seriously damaged than the marginal areas due to the higher values of the surface tensile stresses (μp) and reach to exceed a certain critical value $(\mu p)_c$.

Jost [15] highlights that adhesion wear predominates for the polyamide/metal couple both in the dry friction conditions and in the presence of the lubricant.

Lancaster and Evans [16] studying the wear behaviour of reinforced polymers under hydrodynamic lubrication, observed the decrease in wear rate with increasing the value of the factor $\eta v d^3/N$ for beak type couples with diameter (d), made of plastic material, in friction on metal discs. The decrease is more pronounced, as the metallic surface roughness is more reduced. He set for polyamide (PA) + MoS_2/steel couple ($R_a = 0.15$ μm) the wear rate of 5×10^{-6} mm^3/(N·m) and for PA + graphite/steel couple ($R_a = 0.15$ μm) the wear rate of 5×10^{-7} mm^3/(N·m), while for PA + glass/steel couple ($R_a = 0.15$ μm) the wear rate reaches 4×10^{-4} mm^3/(N·m), and 3×10^{-6} mm^3/(N·m) for PA/steel couple ($R_a = 0.15$ μm).

Shen and Dumbleton [17] comparatively studying the wear behaviour of high density polyethylene and polyoxymethylene (Delrin 150 commercial type), processed by injection, establish for the wear coefficient values from 7.8 to 28.6×10^{-10}. They propose to calculate the linear wear of high density polyethylene (UHMWPE), a relation of the type:

$$h = kpx$$

where: h—linear wear; k—wear factor; p—nominal pressure; x—sliding distance. Based on the above relation they have established for the wear factor of high-density polyethylene, values ranging from 1.3 to 3×10^{-11} cm^2/N.

Capitanu et al. [18, 19] reported about the behaviour of polyamide and polycarbonate reinforced with glass fibers in friction on steel surfaces. Capitanu and Florescu [19] presented some tribological aspects of the steel surfaces wear in dry friction with polymer composites with glass fibers.

Generally, the results presented in this review of the specialty literature are in accordance with the results of our researches. But no published study has not presented a correlation between friction and wear, which will give an overview, nor theoretical (widely recognized as being impossible) and nor qualitative–quantitative, to provide an overview of the complex process of friction–wear. We tried to present this image in this paper.

2 Experimental

Friction and wear processes were analyzed for a relatively wide range of tribological parameter values that affect it (load, relative speed, and temperature). Range of values used for the parameters mentioned includes both values commonly encountered in industrial applications, as well as some extreme values, less common, but that are of interest from the point of view of the friction and wear mechanism. Thus, although the values of the stresses and the speeds are between 0.2–1 MPa and respectively 1–500 cm/s, attempts were made at speeds and loads greater than or less than the ranges mentioned.

The two elements of friction couples (cylindrical sleeve and flat sample) were made of plastic material and metal, respectively. The metallic elements of the examined couples were made of steels of different qualities and with different surface states. Of tested steels only a few qualities widely used in industrial practice have been selected for presentation.

For friction and wear tests polyamides and polycarbonates were selected from the wide range of thermoplastic materials processed in industry, in view of their increased reinforcing possibilities with glass fibers, and high density polyethylene because of its use as a replacement of metals in some practical applications. Experimental tests have been conducted using polyamides and polycarbonates reinforced with 20% and 30% of glass fibers. For comparison, friction–wear tests were performed and with unreinforced polyamides and polycarbonates.

For the experimental tests have been used thermoplastic materials whose characteristics are presented in Ref. [19]. A certain variation of such characteristics according to the various commercial types is observed, which occurs in rather limited ranges. From Ref. [19] it is noted the improvement of physical–mechanical properties of materials reinforced with glass fibers, compared to the unreinforced ones.

Nylonplast AVE Polyamide [20] has incorporated 30% glass fibers having a diameter of 12 μm, resulting in an accentuated decrease of products deformation. Thus, at 50 °C and a compression of 140 daN/cm^2, deformation decreases from 1.4% in the case of unreinforced polyamide to 0.2% for the reinforced one.

Noryl Polyamide [21] reinforced with 20% glass fibers is characterized by a very low water absorption and high value of elastic modulus.

Lexan Polycarbonate [22] reinforced with 20% glass fibers has a high mechanical strength, a very good dimensional stability, and high resistance to shock.

Makrolon Polycarbonate [23], unreinforced, has high resistance to shock, outstanding dimensional stability, low water absorption and low deformability.

Technyl Polyamide [24], although unreinforced with glass fibers, presents due to its high capacity of crystallization, a high consistency of mechanical properties, low deformability, good resistance to bending, strength and shock, and a good friction resistance.

Friction and wear behaviour of the materials above, considered significant for the polyamides and polycarbonates tribological manifestation, has been studied and will be presented in detail in this paper. Figure 1 shows the microstructures of these materials.

Figure 1(a) shows the microstructure of Nylonplast AVE Polyamide reinforced with 30% glass fibers with a diameter of approximately 12 μm [20]. Figure 1(b) presents a cross-section from a dent of a gear wheel manufactured through injection from Nylonplast AVE Polyamide + 30% glass fibers [20].

Figure 1(c) shows the image of a cross section for a sample made of Noryl Polyamide + 20% glass fibers [21]. Figure 1(d) renders the image of the microstructure of Lexan Polycarbonate reinforced with 20% glass fibers of approximately 8 μm diameter [22]. Figure 1(e) shows a cross section of the dent of a gear wheel manufactured from Lexan Polycarbonate reinforced with glass fiber [23].

Figure 1(f) shows the image of the microstructure of non-reinforced Technyl polyamide seen in polarized

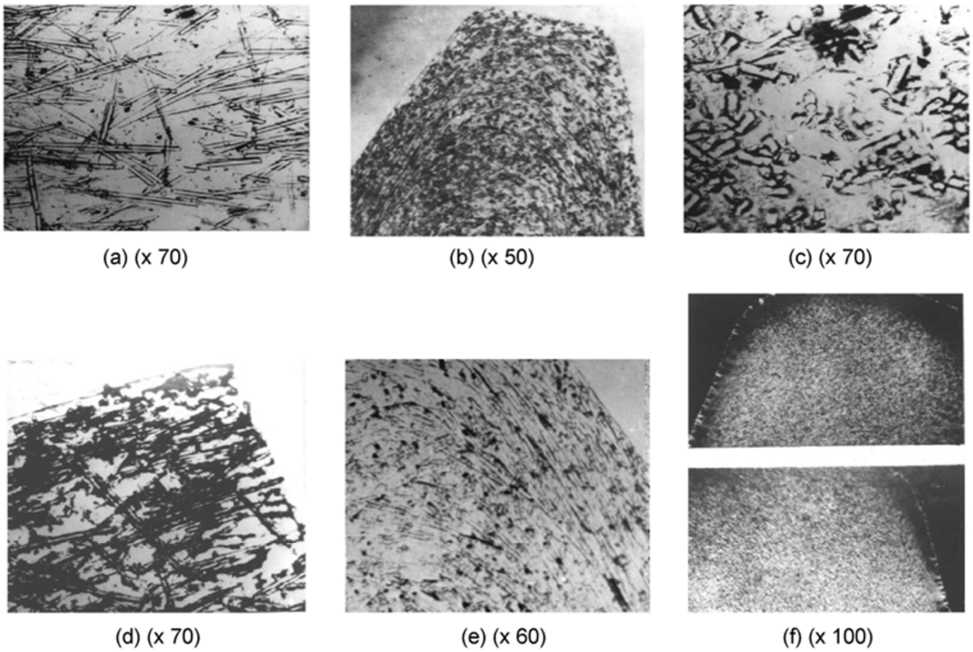

Fig. 1 Microphotographs of the structures of thermoplastic materials reinforced with glass fibers, submitted to friction and wear tests. (a) Nylonplast AVE Polyamide + 30% glass fibers; (b) an image of the cross section from a dent of a gear wheel manufactured through injection from Nylonplast AVE Polyamide + 30% glass fibers; (c) the image of a cross section from a sample made of Noryl Polyamide + 20% glass fibers; (d) the image of the microstructure of Lexan Polycarbonate reinforced with 20% glass fibers of approximately 8 μm diameter; (e) a cross section of the dent of a gear wheel manufactured from Lexan Polycarbonate reinforced with glass; (f) the image of the microstructure of non-reinforced Technyl polyamide seen in polarized light [19].

light. Metallic samples of tribological tested couples were made of the following steels: C 120 steel hardened 59 HRC, Rp3 steel hardened 62 HRC and 33 MoC 11 steel hardened 51 HRC. The mechanical characteristics, chemical compositions and some microstructure considerations of these steels are given elsewhere [19].

The surfaces of metal samples were processed by grinding, wet polishing with aluminium oxide and polishing with diamond paste for different grain sizes. This technology has allowed to obtain surfaces with R_a = 0.025 μm, R_a = 0.045 μm, R_a = 0.075 μm and R_a = 0.125 μm. Samples with roughness higher or lower than the one mentioned above were used for the experiments, for a more complete characterization of the friction and wear process.

An experimental installation with Timken type friction couple (with linear contact) was used due to the wide range of loads and speeds considered, and the need to achieve the greatest possible variety of working conditions (contact pressures, sliding speeds and temperatures) for a more complete characterization of the tribological behaviour of composite material/steel coupling. This can achieve very high contact pressures (between 16 and 36 MPa).

Testing rig has been presented in detail elsewhere [19].

3 Results and discussion

Tests carried out have had the purpose of determining the influence of the main factors affecting the friction in the case of thermoplastic material reinforced with glass fibers/metal couplings. It is well known the law established by Coulomb (1780) that the friction force F_f is direct proportional to the normal force N:

$$F_f = \mu N \tag{1}$$

More studies conducted later have shown that μ, the friction coefficient, is not only dependent on the normal force.

Relations for variations of the friction force, depending on the applied load can be considered of the form:

$$F_{\mathrm{f}} = aN + bN^{n} \tag{2}$$

or more simply:

$$F_{\mathrm{f}} = a + bN \tag{3}$$

or:

$$F_{\mathrm{f}} = a + bN^{n} \tag{4}$$

Last relationships lead to the conclusion that when the normal force is equal to 0, the friction force has other value than 0 ($F_{\mathrm{f}} = a$). Although this could be explained by the presence of a remanent force of adhesion of the two surfaces, even after the removal of the normal load, however, we consider more accurate the use of a relationship of the form:

$$F_{\mathrm{f}} = kN^{n} \tag{5}$$

where n is sub-unitary.

Friction coefficient, according to Coulomb's Law, has the expression (of Eq. (1)) $\mu = F_{\mathrm{f}} / N$. We can express the friction coefficient for the plastic materials and in the following form:

$$\mu = \tau_{\mathrm{f}} / p_{\mathrm{c}} \tag{6}$$

where τ_{f} represents the shear strength of the softer material, and p_{c} represents the flow pressure of the same material.

Because $p_{\mathrm{c}} = HB/3$, where H, B are Brinell and heightness, respectively, Eq. (6) results:

$$\mu = 3\tau_{\mathrm{f}} / HB \tag{7}$$

Equation (7) is in agreement with the experimental preliminary results.

Increasing the friction coefficient increases the wear rate, but no one managed to establish a mathematical relation between the two quantities, although this is widely recognized. In the following we shall give some suggestive graphical representations that make a qualitative correlation between the two quantities, and tying them to the contact temperature.

The influence of load on the friction coefficient of the Nylonplast AVE PA + 30% glass fibers/ C120 steel couple is shown in Fig. 2 for Timken type coupling (with linear contact), at the sliding speed of 18.56 cm/s. It can be seen the increase of the friction coefficient with the increase of normal load applied to the coupling. The variation of friction coefficient is nonlinear, in accordance with Eq. (5).

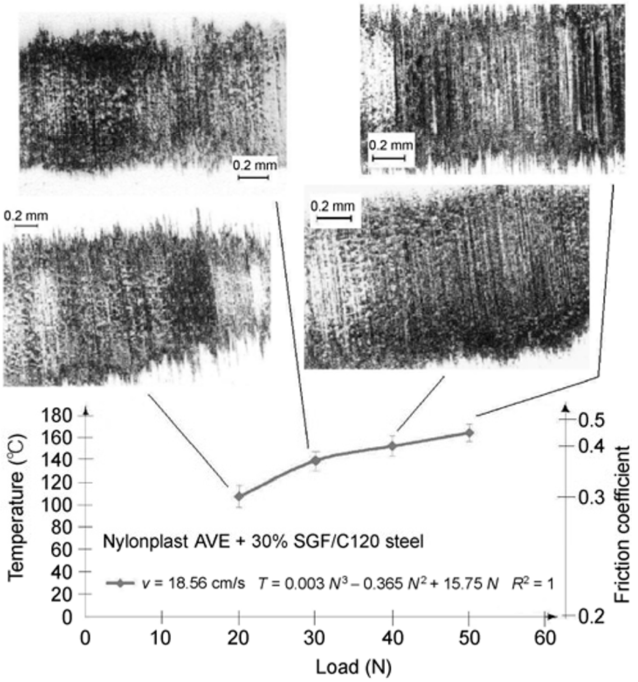

Fig. 2 Variation of contact temperature function of the normal load and friction coefficient at the sliding speed of 18.56 cm/s for Nylonplast AVE + 30% SGF/C120 steel.

At this sliding speed the dry friction coefficient on C120 steel has values between 0.27 and 0.47, the contact temperature ranging between 101 ℃ and 160 ℃. In the case of friction on C120 steel, dry friction coefficient values (Fig. 3) are between 0.27 and 0.47, the contact temperature ranging between 101 ℃ and 160 ℃.

At the onset of friction process (temperature around 100 ℃) glass fibers are ripped from the array of plastic and expelled on the surface of steel with plastified polymer (left). Around the contact temperature of 140 ℃ the transfer of the polymer occurs on the output of all of the wear (center), at a temperature of 160 ℃ to protect the cross-bridges of polymer (right) that interrupt the direct contact of the composite sample with a metallic surface.

In the case of friction on steel Rp3, dry friction coefficient values (Fig. 4) are ranging between 0.25 and 0.38, contact temperature ranging between 100 ℃ and 155 ℃.

Comparing images in Figs. 2, 3 and 4, are easily mixed character, adhesive and abrasive wear of metallic

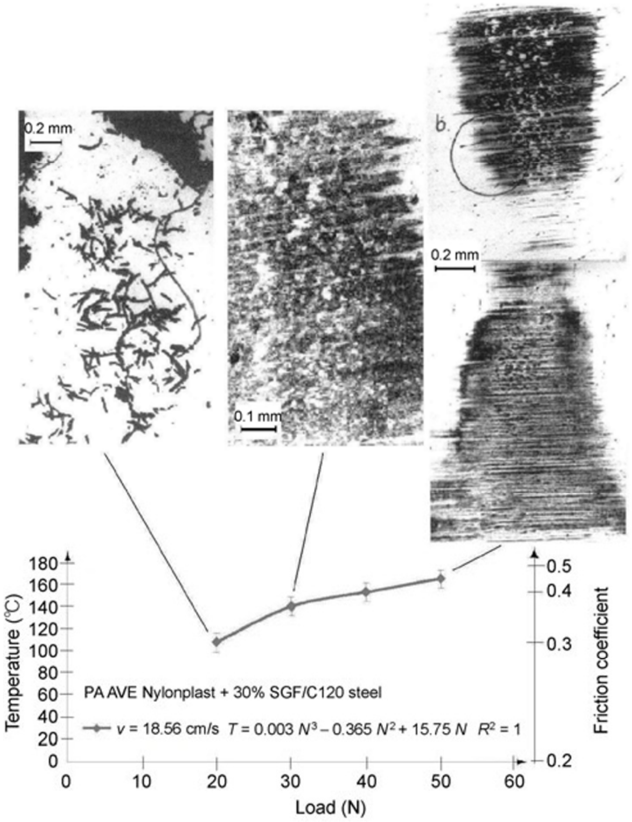

Fig. 3 The variation of wear mode depending of the contact temperature and normal load, at speed sliding of 18.56 cm/s for Nylonplast AVE + 30% SGF PA /C120 steel.

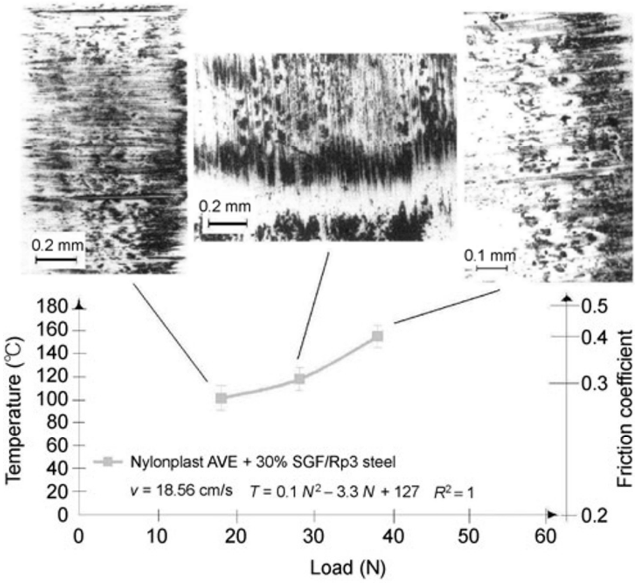

Fig. 4 The variation of wear mode depending of the contact temperature, friction coefficient and normal load, at speed sliding of 18.56 cm/s cm/s for AVE Nylonplast 30% SGF/Rp3 steel.

surface (Figs. 2 and 4) at low load (20 N), followed by one powerful plastic transfer at 30–40 N loads, with the formation of bridges at 30 N and even plastic flow at 40 N, metal surface when the temperature reaches 150 °C (Fig. 4).

At the beginning of the wear process, glass fibers are ripped from polymer matrix, broken and expelled on the output of the wear scar.

Figure 5 shows the variation of the friction coefficient and contact temperature function of the normal load for Nylonplast AVE + 30% glass fibers/C120 steel coupling, at sliding speed of 27.85 cm/s.

At this sliding speed the dry friction coefficient has values between 0.32 and 0.47, the contact temperature

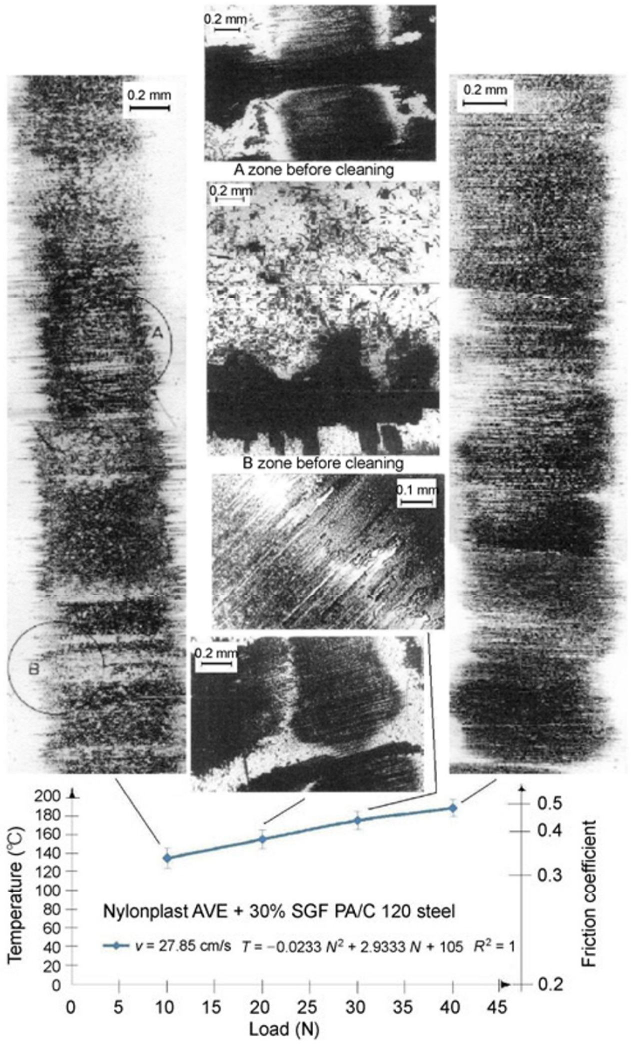

Fig. 5 Contact temperature variation based on normal load and friction coefficient at the sliding speed of 27.85 cm/s for Nylonplast AVE 30% SGF PA/C120 steel.

ranging between 135 °C and 188 °C. In the case of friction on Rp3 steel, dry friction coefficient values (Fig. 4) are between 0.27 and 0.38, the contact temperature ranging between 100 °C and 155 °C, function of the applied normal load.

At the 37.13 cm/s sliding speed, the feature of metallic surface wear visible change is becoming mostly abrasive, adhered material being removed and deposited on the output of wear scars (Fig. 6), and the corrosion wear manifested through pits in the centre of wear traces begins to appear. Figure 6 shows the traces of wear and tear after 60 min of testing at this speed, when the friction coefficient is between 0.27 and 0.48, and the contact temperature is between 110 °C and 180 °C.

Evolution of contact temperature and friction coefficient of C120 steel surface and wear appearance at the speed of 55.70 cm/s, for the same friction torque, is shown in Fig. 7, when the friction coefficient varies between 0.27 and 0.40 and contact temperature is between 150 and 267 °C. The wear character becomes visible adhesive when the applied load increases at the value of 30 N (contact temperature 238 °C).

At the highest sliding speeds used for testing, 111.4 and 153.57 cm/s, in the case of C120 steel friction coefficients between 0.37 and 0.48 are reached, the measured contact temperatures ranging between 229 °C and 295 °C. This makes the wear to manifest mainly by adhesion and corrosion (Figs. 8 and 9).

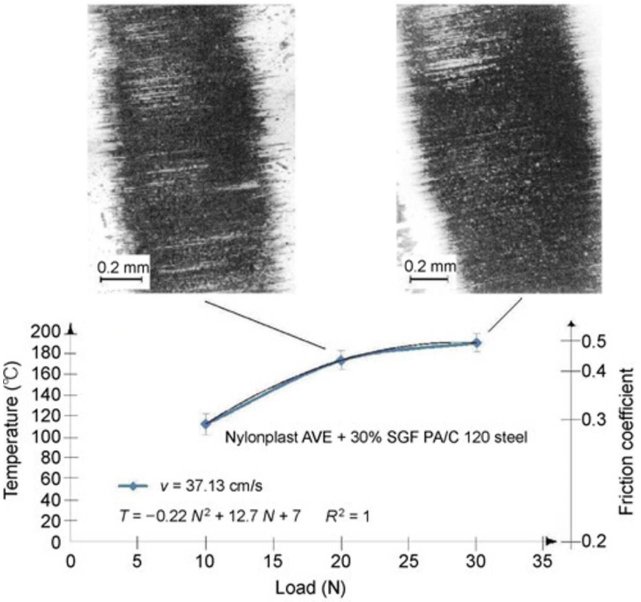

Fig. 6 Contact temperature variation based on normal load and friction temperature at the sliding speed of 37.13 cm/s for Nylonplast AVE 30% SGF PA/C120 steel.

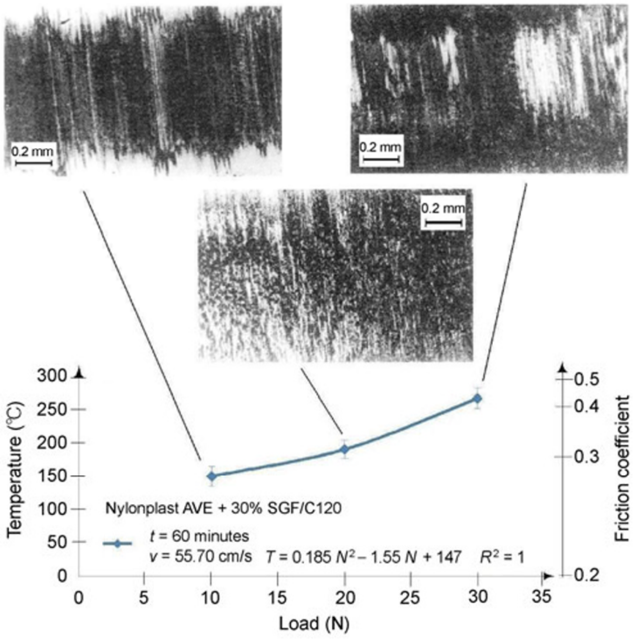

Fig. 7 Evolution of contact temperature and friction coefficient of C120 steel surface and wear appearance at the speed of 55.70 cm/s, for Nylonplast AVE + 30% SGF / C120.

At higher loads (50 N), the tests are inconclusive because the surface of polymeric sample moves into vitrification (transition at the glassy state) due to very high temperature, covering it with a glass layer.

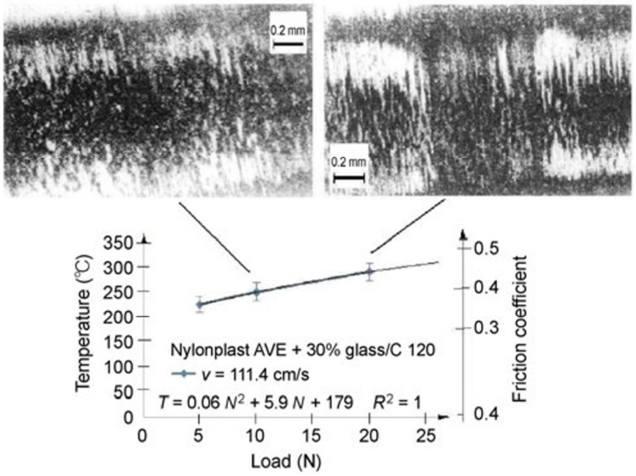

Fig. 8 Contact temperature variation based on normal load and friction coefficient at the sliding speed of 111.4 cm/s to Nylonplast AVE 30% SGF/C120 steel.

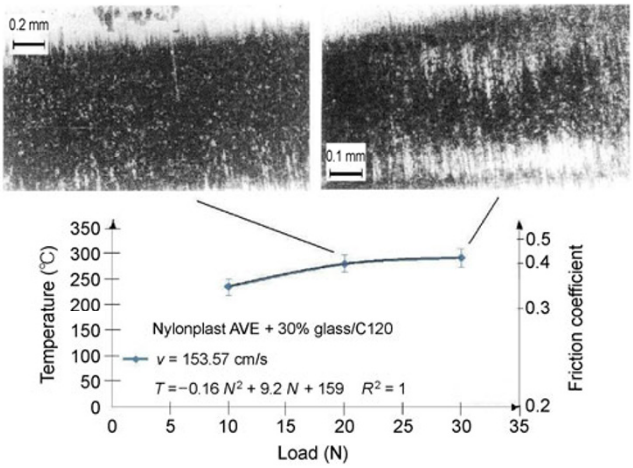

Fig. 9 Evolution of contact temperature and friction coefficient of C120 steel surface and wear appearance at the speed of 153.57 cm/s, for Nylonplast AVE + 30% SGF/C120.

In the case of friction of polymer with 30% glass fibers on Rp3 steel surfaces that are harder (62 HRC) up against C120 steel surfaces, it can make the same findings on wear evolution function of the normal load and sliding speed as in the case of C120 steel (Figs. 10 and 11). Thus, under the same test conditions, the wear increases with increasing the normal load of the sliding speed, and friction coefficients are somewhat lower, ranging in 0.27–0.37 domain, but the contact temperatures are between 164 °C and 249 °C, in used test conditions. For example, Figs. 10 and 11 show the contact temperature variation function of the normal load, at the speeds of 37.13 and 46.41 cm/s, for the friction of polyamide Nylonplast AVE + 30% SGF on Rp3 steel surfaces.

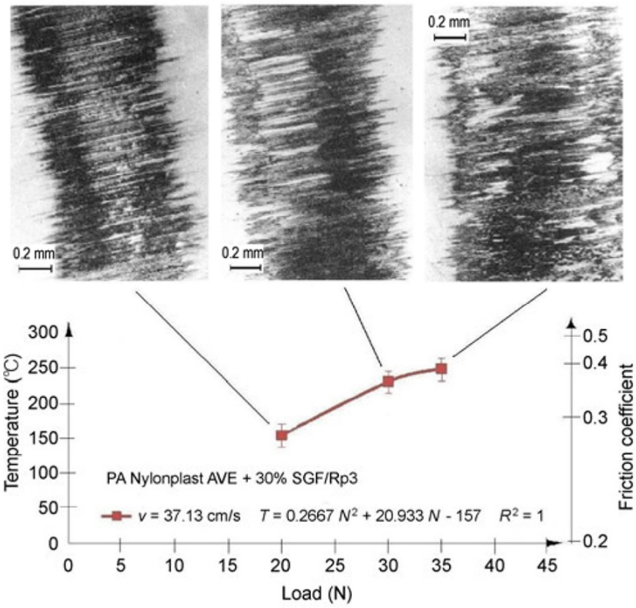

Fig. 10 Evolution of contact temperature and friction coefficient and wear appearance of Rp3 steel surface at the speed of 37.13 cm/s, for PA Nylonplast AVE + 30% SGF/Rp3.

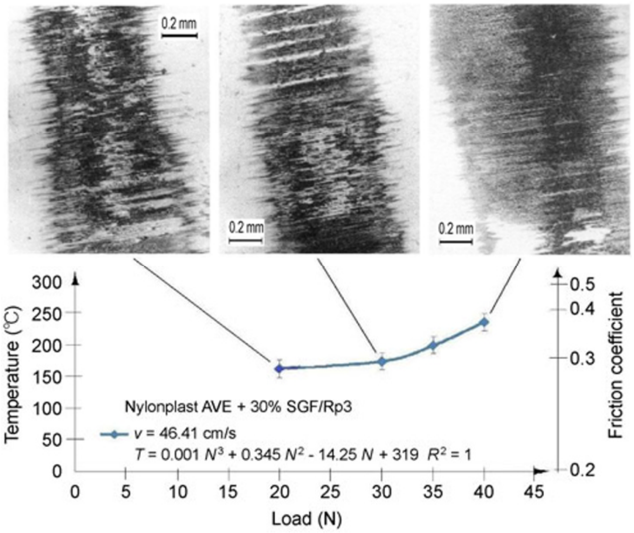

Fig. 11 Evolution of contact temperature, friction coefficient and steel surface wear appearance at the speeds of 46.41 cm/s for PA Nylonplast AVE + 30% SGF/Rp3.

In the case of friction of Noryl + 20% SGF polyamide and Lexan 5412 + 20% SGF polycarbonate (Fig. 12), friction coefficient value varies between 0.37 and 0.47, and contact temperatures vary between 220 °C and 275 °C, function of the test conditions. A massive transfer of polymer removed by abrasion and torn reinforcing fibers manifests on the input side of the wear stamp, and a massive transfer of plasticized polymer from the composite material matrix occurs on the output side of the wear trace. For example, Fig. 12 shows the diagram of contact temperature variation and images of the phenomena described above.

With regard to the correlation between load, and temperature, the regression equations of these factors for the friction couples studied, are presented in Figs. 2–12.

These relationships confirm polynomial form of the relationship between friction force and normal load presented in Eqs. (2), (3) and (4).

Wear mechanism of the steel surface is a dynamic one, the wear type modifying during friction, generally from abrasive wear, in adhesive wear with transfer of material from the polymer matrix and the formation of plastic material bridges, the friction becoming plastic/plastic, accompanied by corrosion wear due to decomposition compounds of the plastic material.

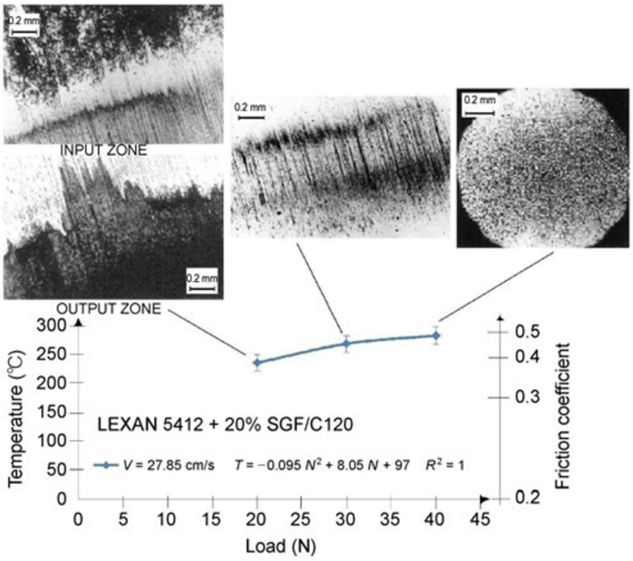

Fig. 12 Evolution of contact temperature and of steel surface wear appearance at the speed of 27.85 cm/s, for PC Lexan 3412 + 20% SGF / C120.

4 Conclusion

From the above, we can draw several conclusions: The wear process of metallic surfaces in dry friction contact against plastic materials reinforced with short glass fibers depends on loading. Contact temperatures increase function of the applied load resulting in plasticizing of material. The friction coefficient values of the reinforced plastic materials, on the surfaces of the C120 steel samples are higher than those on the surfaces of Rp3 steel samples. This phenomenon appears because of the difference in hardness of surfaces made of the two steels. The friction coefficient values of the thermoplastic materials reinforced with glass fibers, on the C120 steel pass through a minimum located between 20–30 N. The increase of the friction coefficient with normal load is quasi-linear for the friction on the Rp3 steel surfaces. This, because under the action of the tension states, the C120 steel undergoes superficial cold hardening manifested by the increase of its hardness in the friction area. The harden layer is destroyed at loads higher than 20 N. Although it cannot establish a mathematical relation between the friction coefficient, contact temperature and metallic surface wear, we believe that the graphical presentation is significant for the plastic material/steel contact.

However, this research has some limitations. At high contact temperatures, it is unlikely that the elastic contact assumption, in which the modelling was made, is valid. Friction coefficient was evaluated over time as an average of the friction coefficient during the test.

To refine conclusions concerning the friction-wear mechanism, comprehensive data about the size of the wear are needed. Volume and depth of the worn material of metallic surface data we have, but some time is necessary for processing and interpretation, for finding ways of unitary presentation of the data related to load.

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