Tribological properties of the PA46 and Teflon added PA46 polyamides

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Abstract. In order to increase the efficiency of the mechanical transmissions, one of the actually research directions is oriented to develop new materials characterised by high endurance, small friction coefficients and internal structure stability with the temperature. One of these materials is represented by the polyamides which are used in mechanical industry, food industry and medicine. The paper provides the results of tests performed on a tribometer for a PA46 and a Teflon added PA46 polyamide materials being on contact with a PA46 polyamide disk, in lubricated conditions. The tests are achieved for a set of temperatures of the oil bath, a set of rotational speeds of the PA46 polyamide disk and a continuous variation of the local pressure. During the running-in process there are measured the evolution of the dynamic friction coefficient and of the wear. After this, it is studied the variation of the dynamic friction coefficient with the contact pressure, the rotational speed and the temperature. Finally there are given conclusions regarding the tribological behaviour of the tested materials and regarding their applications.

1. Introduction

Increasing the efficiency of the mechanical systems represents a new actually trend in their optimization process. The increase of mechanical systems efficiency is oriented in two main directions: finding new solutions in the case of the mechanical systems structures and using new materials with low-frictional properties.

Applications in the first direction are referring on a wide area of mechanical systems as: robotics where the friction of a new class of robots with flexible joints it conducts to energy loses [1]; mechanical systems as speed increasers used in the wind systems, where the power coefficient can be improved by increasing the mechanical efficiency of the speed increasers [2, 3, 4]; solar tracking systems where the energy consumption used to orient the solar panels or the solar collectors can be reduced by designing new mechanical trackers [5, 6].

The second direction of optimization the mechanical systems efficiency is using new materials with low-frictional properties. In this case, the researchers are looking for materials characterised by low friction, low wear and stabile structures (depending on temperature). A class of these materials is represented by polyamides. The literature shows the high endurance and small deformation of the polyamides in the case of loadings [7, 8, 9]. Their mechanical properties, with good performances at high temperatures are presented in [10, 11, 12, 13, 14, 15]. The frictionless behaviour of polyamides is tested under different testing conditions in [16] for sliding-rolling contacts; even in dry conditions [17] the polyamides shows their slow frictional behaviour and their reduced wear.

The limits of polyamides applications in the construction of the mechanical systems are represented mainly by the heavy industry. In medicine, food industry, fine mechanics their usage is wider and wider. Due to this, the paper investigates the tribological properties of two polyamide type materials being in contact: PA46 with PA46 and Teflon added PA46 with PA46.

2. The tests

The tests are performed on a tribometer which is connected thought an acquisition plate to a computer as it can be observed in figure 1. The tribometer is equipped with a two dimensional force sensor which allows force measurements in an interval of 0.1 ... 1000 N with the resolution up to 50 mN [18]; the measured forces are oriented about the vertical axis and about a direction tangent to the rotational motion of the lower disk. On the force sensor is mounted a suspension in order to damp the oscillations. On the base plate of the force sensor is mounted a holder which allows the mounting of different pieces as ball, pins, plates. The vertical stroke is equal with 150 mm and it can be reached with a speed situated in an interval of 0.001 ... 10 m/s.

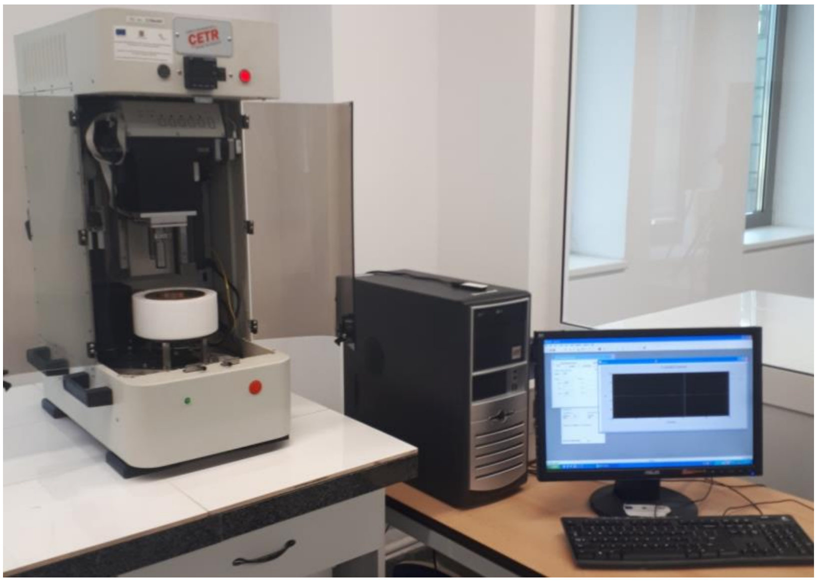

Figure 1. The tribometer.

On the tribometer is mounted a slider which allows motions in a direction parallel with the horizontal plane. The lateral positioning stroke is equal with 75 mm and can be reached with a speed in the interval of 0.01 ... 10 m/s; the resolution of the lateral positioning motion is equal with 2 μm. The heater allows the control of the temperature in the oil bath up to 150 ^{o}C. The wear can be measured with an accuracy of 50 nm [18].

The tribometer is equipped with three modules: the rotary module, the reciprocating module and the block on ring module; in the paper the tests are performed by using the rotary module. The disk of the rotary module allows rotations about two directions with a rotational speed between 0.001 ... 5000 rpm and a resolution equal with 1 μm [18]. The maximum radius for the contact between the disk and the upper holder is 75 mm [18].

The testing procedure begin with a running-in process which is performed for a period of 2 hours, at a room temperature of 22 ^{o}C, a normal pressure of 10 MPa and the rotational speed of the disk equal with 500 rpm.

In the next step, the tests continue with a set of rotational speeds equals with: 50, 200, 500, 1000 and 2000 rpm; the local mechanical pressure has a linear variation between 5 and 10 MPa. All the tests are performed for a period of 15 minutes and for the following temperatures of the oil bath: 22 ^{o}C, 90 ^{o}C and 120 ^{o}C.

Figure 2. The polyamide plates in contact with the PA46 disk.

3. Results and conclusions

The results present the variation of the friction coefficient with the test parameters: the rotational speed of the PA46 polyamide disk, the normal pressure and the temperature of the oil bath.

The evolution of the wear during the running-in process is presented in figure 3; the value of the wear, for the PA46 polyamide is stabilised after approximately 35 minute at a value around 0.06 mm. The wear for the Teflon added PA46 polyamide is higher (about 0.09 mm) and it is stabilised after 70 minutes.

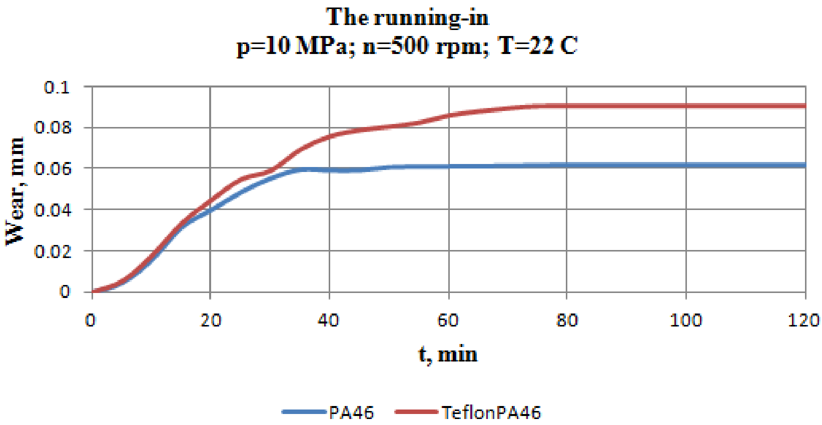

Figure 3. The evolution of the wear during the running-in process.

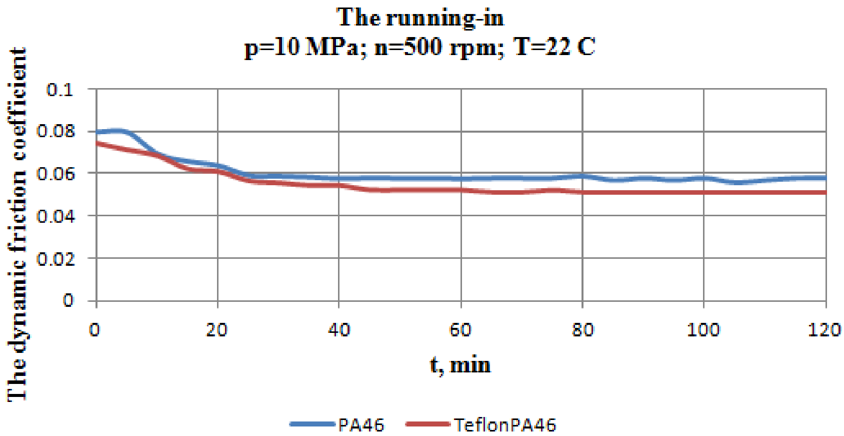

Figure 4. The dynamic friction coefficient.

The variation of the dynamic friction coefficient, during the running-in process, is presented in figure 4; in the case of the PA46 polyamide, after 25 minutes of tests, its value it is stabilised at a value of 0.06. The value of the dynamic friction coefficient is smaller – about 0.05.

Figure 5 presents the variation of the dynamic friction coefficient at a contact pressure equal with 10 MPa depending on the rotational speed and the temperature. The value of the friction coefficients increases with the increasing of the temperature and decreases with the increasing of the rotational speed. In all the cases, the value of the friction coefficient for the Teflon added PA46 is smaller than the value of the friction coefficient for the PA46 polyamide; with the increasing of the temperature, the difference between the friction coefficients of the two polyamide materials decreases.

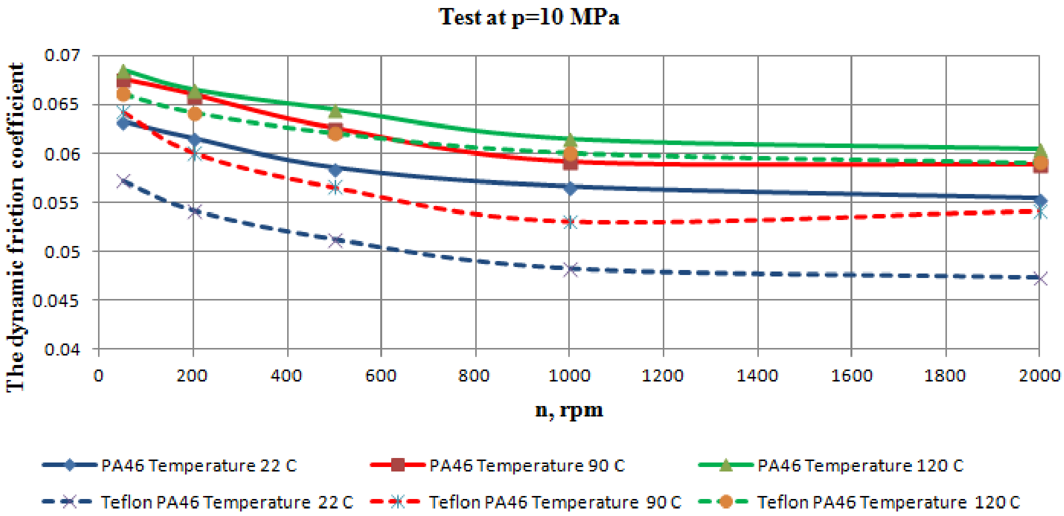

Figure 5. The dynamic friction coefficient.

Figure 6 presents the variation of the dynamic friction coefficient with the contact pressure and the temperature. The value of the dynamic friction coefficient, for the two polyamide type materials, increases with the increasing of the temperature and decreases with the increasing of the pressure. In all the cases, the dynamic friction coefficient for the Teflon added PA46 polyamides has smaller values than the dynamic friction coefficient of the PA46 polyamide; the difference between the two sets of friction coefficients decreases with the increasing of the temperature.

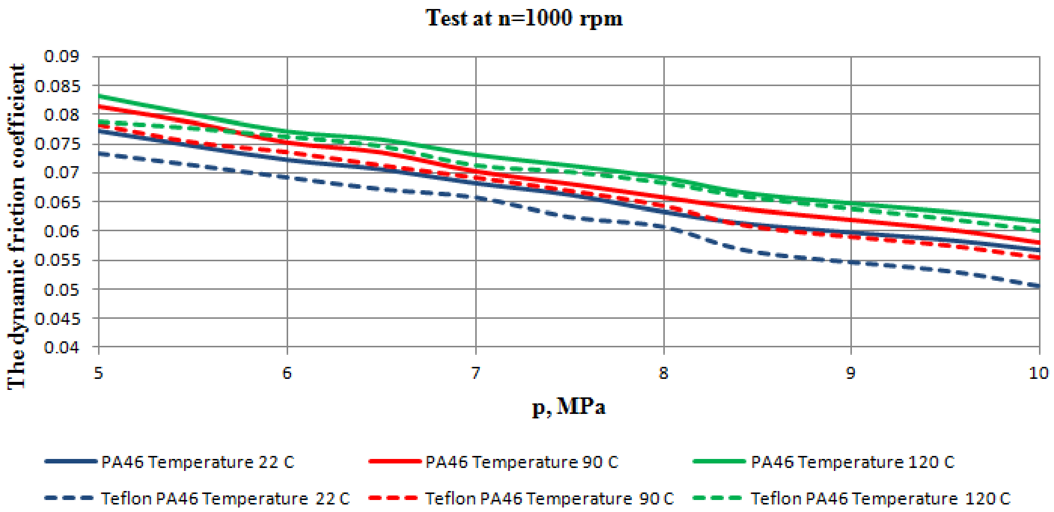

Figure 6. The dynamic friction coefficient.

As a general conclusion, the Teflon added PA46 polyamide has a higher wear than the PA46 polyamide; from this point of view, in the case of high endurance and small wear conditions, the PA46 polyamide it is preferable to be used. From the dynamic friction coefficient point of view, in all the tested cases, the friction coefficient of the Teflon added PA46 polyamide has smaller values than the friction coefficient of the PA46 polyamide; the difference between the friction coefficient of the Teflon added PA46 polyamide and the friction coefficient of the PA46 polyamide decreases with the increasing of the temperature.

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