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STUDY COMPARATIVE OF TRIBOLOGICAL BEHAVIOUR OF POLYAMIDE AND ABS POLYMERS AFTER PROCESSING BY INJECTION

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Abstract: *ABS and PA6.6+15% GF are polymers. Their specification is that they are thermoplastic. Tribotesting was used to find out whether or not this is the case. The basis for tribological testing is the Pin-on-Disc method, and this measurement was also used to obtain the information in this research.*

The main objective of this work is to study the influence of the injection process on the tribological behaviour of the ABS polymers and the PA6.6+15% of glass fibres. Initially, two parameters, the operating pressure and the time for applying it, were studied in the injection process. The initial surface parameters were measured in order to study their influence on the friction coefficient. The wear of the polymers was studied in the tribometer using the Pin-on-Disc method.

Key words: ABS polymers, PA6.6+15% glass fibres, Tribotest Pin-on-Disk

1. INTRODUCTION

In the technical, social and natural sciences there are many unresolved issues and problems that scientists are looking for the answers to, either in the form of answers at the theoretical level or in practical embodiments. After a period of massive development of research and development in the last century, when energy efficiency and environmental protection was not taken into account, over the last few decades, and especially at the advent of the third millennium, there has come a sobering awareness of the need to save all kinds of energy. This is occurring against the background of expansion and development of many disciplines relating to the quality of human life, human needs and the desire to discover.

To fulfil these goals, machine and system builders are armed with a fairly deep knowledge of many disciplines, such as flexibility and strength, engineering technology, mechanics and thermodynamics. This allows them to solve many problems of static and dynamic loading of machine parts, short and long term thermal stress and the choice of materials for given operating conditions. [1]

The situation in the durability and wear of machine parts exposed to friction and wear is completely different. In many cases they are lacking because engineers need the knowledge and especially the necessary technical documentation. The problem stems primarily from the complexity of the interaction of the functional material on the surface of the machine components, the variability of the operating conditions, which are determined by the dominant factors, friction and wear. And whether there is contact between moving parts standing metal on metal or metal on an alternative material such as a polymer [2].

To demand ever higher specific outputs from machinery and equipment, promoting continuous production technology, the emphasis is on increasing reliability and longer service life. Practice as a criterion for the correctness of the theory, proved that the current level of technology and companies does not necessarily lead to the desired success and rapid individual and isolated approach to problem solving. Emphasis should be placed on close cooperation between engineers and technologists and the tribology issues to be addressed. [1]

It is important to note that the development of ambitious materials, which include polymers, not over-counting to occur extrusion or completely replacing traditional materials such as e.g. steel, but these materials must be as fully equivalent.

2. POLYMERIC MATERIAL

Polymeric substances are basically divided according to their properties for elastomers, thermoplastics and thermosets. Thermoplastic elastomers are polymeric substances which can be deformed by very little force into large elastic deformations without the material being compromised, and after unloading returns to its original state. Thermoplastics are generally relatively hard and brittle polymeric materials, which when heated become very elastic. This process can be reversibly repeated unlike thermosets, which can be heated only once, and after cooling take the desired end properties, due to chemical reactions that take place at higher temperatures.

For this test, two samples of polymeric materials used in the field of thermoplastics were selected:

ACRYLONITRILEBUTADIENESTYRENE (ABS)

POLYAMIDE 6.6 with 15% GLASS FIBRE (PA6.6+15%)

POLYAMIDE 6.6 (PA 6.6)

POLYAMIDE 6.6 with 30% GLASS FIBRES

And why polymeric materials? Because ever since they were discovered people have been trying to use them in different applications. Replace them other materials which are either limited in the world or polymers having advantageous properties for use. Properties that polymeric materials have over conventional materials are numerous. Among the most interesting features that polymers have include:

- Lightweight - polymeric materials have a lower density than metal materials
- Electrical insulating properties - very widely used in plants with an increased risk of explosion or ignitable environment
- Low thermal conductivity - does not transmit as much heat to the surrounding parts such as metals
- Corrosion resistance - used with high moisture or water
- Resistance to some chemicals - for example, oil, gasoline, etc.
- Flexibility / elasticity - widely used in flexible couplings
- High resistance to fatigue
- Aging resistance

The test was to compare the above mentioned materials. But also to compare how to change the resulting properties such as coefficient of friction, frictional forces and wear volume between two contact surfaces. With this test we can evaluate and use parameters when changing the injection conditions or different surface structures of the surveyed sample.

2.1 Production samples

As shown in Fig. 1 the testing materials were shaped into a disk about Ø 60 x 3 mm. Disk size was chosen considering the space for performing all tests.

Fig. 1 Sample shape

2.2 Preparation of samples

Injection moulding was selected for the preparation of samples for testing.. Injection was performed on an Engel Victory 28 in, which is located in the indoor laboratory of the University of Vigo, Spain. Parameters shown in Tables 1 and 2 were used. All parameters were selected according to the parameters specified in the parameter table from the machine manufacturer. Injection pressure in Table 2 was selected as a variable parameter in the assay and is marked by the yellow line. These conditions were the same for both tested materials.

Furthermore, the material PA6.6 + 15% GF was placed in a drying box before injecting. Drying was carried out at 80°C for 10 hours. This is due to the hygroscopicity of the material despite additive glass fibre PA 6.6 maintains a very high hygroscopicity. Drying was carried out because of the difficulties in moulding materials with higher moisture content. When heating the feed material, moisture is converted to steam which forms bubbles in the mouldings.

Table 1 Temperature for injection

Set max. temperature in the cylinders /°C/	265	255	240	220	40
The actual temperature in the cylinder /°C/	249.7	249.5	239.7	220	45.7

Table 2 Injection parameters

Injection volume	17 cm^3	17 cm^3
Max. pressure	160 bar	160 bar
Piston diameter	30 mm	30 mm
Injection time	2 s	2 s
Cooling time in the mould	20 s	20 s
Injection pressure	100 bar	150 bar
Volume of the mould	11 cm^3	11 cm^3

2.3 Identification of test samples

The samples were tested with regard to:

- Types of material
- Altered parameters in production
- The actual structure of the sample surface

It was set up and labelled as shown in Table. 3

Table 3 Identification sample

Material	Injection parameters	The resulting surface structure	Marking Test
ABS	100 bar	Poor roughness	ABS-1-b
		Good roughness	ABS-1-a
	200 bar	Poor roughness	ABS-2-b
		Good roughness	ABS-2-a
PA	100 bar	Good roughness	PA-1-a
	200 bar	Good roughness	PA-2-a

Poor roughness – Ra over 0.4 µm
Good roughness – Ra to 0.4 µm

2.4 Testing of samples

Tests were carried out in collaboration between the laboratories of University of West Bohemia in Pilsen and laboratories of the University of Vigo.

2.4.1 Tribological tests

The variability of this test allows examination of different possibilities for the materials tested. Tribotest setting options are almost limitless. The possibility of adjusting the size and shape of the body to be tested, with / without lubricant, choosing the size of the load of the test bodies, test time by selecting the length of the distance covered or the speed of the test sample and for the possibility of continuous speed changes during the test. Only limited options were used for this test because it is only a preliminary test before many other tests.

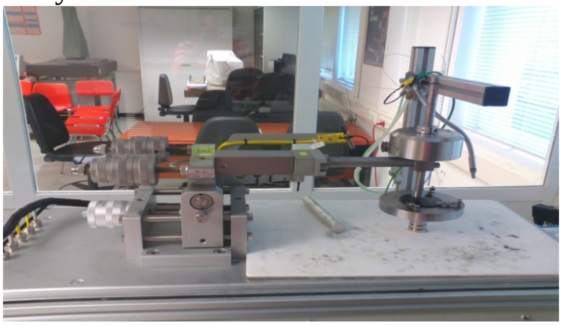

Fig. 2 Tribotester

Test parameters were set on the basis of previous tests performed in the field of research as e.g. in [3] [4] and subsequently validated by performing a preliminary test for commencing testing. The parameters used for the final tests are given in Table 4.

Table 4 Testing parameters

Material	Speed test /rpm/	Radius test /mm/	Load /N/	Time test /m/	Radius test bodies /mm/
ABS-1-a	200	9	20	200	4
ABS-1-b					
ABS-2-a					
ABS-2-b	300		30		
PA-1-a					
PA-2-a					

2.4.2 Friction coefficient

This parameter is the most important value for this test. On the basis of information about the value of the friction coefficient, one is able to predict how the material will behave under load. Thus, both will be wearing, how will heat up or how it will deform...

The parameter is measured during continuous tribological testing and then this value continues to operate. This test measured the coefficient of friction for long term testing since the objective was to determine the mean coefficient of friction.

Label groups:

1-150 bar and roughness poor
2-100 bar and roughness poor
3-100 bar and roughness good
4-150 bar and a roughness good

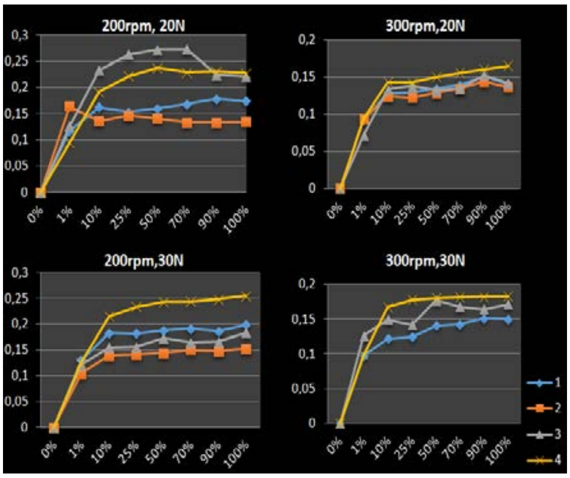

Fig. 3 Friction coefficient ABS

The upward trend of the coefficient of friction is due to the fact that they still rises contact area when pike test specimen and the test sample.

In Fig. 3, graph 200 rpm and 20 N in Category 3 (grey line) shows a decreasing tendency from the value of 70% and is probably due to a problem in the structure of the sample. This sample is currently left to the tests of the material specialist.

Furthermore, this test confirmed that the friction coefficient depends on the value of surface roughness, as shown Fig. 3 in the following figures and example. At 200 rpm and a load of 30 N it has the best surface roughness of the sample group which has poor roughness.

For better orientation, the effect of the load value, and scanning speed (time) is shown in the following Figs. 4 – 5.

It is easy to see how changes the value of the coefficient of friction changes for each load and speed testing. It is seen that the coefficient decreases with increasing load and speed combination testing.

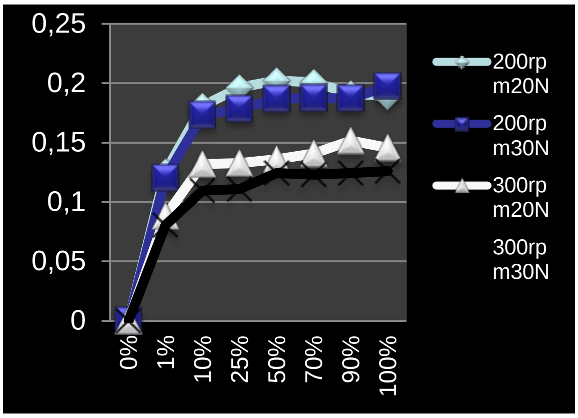

Fig 4. Friction coefficient ABS

Even for this material, comparisons were made between the loads for the groups as in the previous tests. However, for these comparisons nothing unusual was found, therefore only the resulting comparison is given.

This comparison is interesting in that the greatest friction coefficient was achieved at maximum load. This can be anything from previous tests to explain why it is necessary to carry out further tests with those conditions and that both the load and speed of rotation but also the same moisture conditions. Moisture is needed in this case the guard due to the fact that PA6.6 + 15% GF is a highly hygroscopic material.

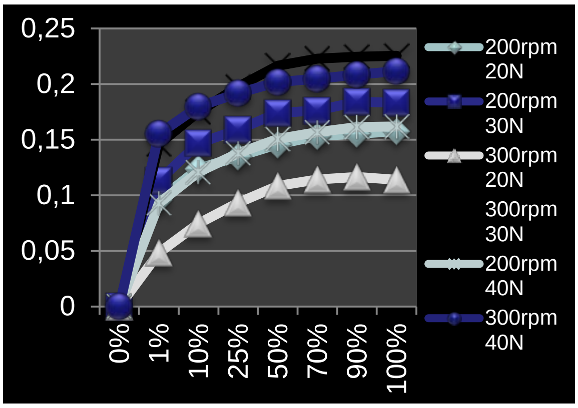

Fig.5 Friction coefficient PA

2.4.3 Change of weight

The changing weight of the sample describes how much the research sample wears under the influence of higher pressure and cyclic effect (rotary) wear.

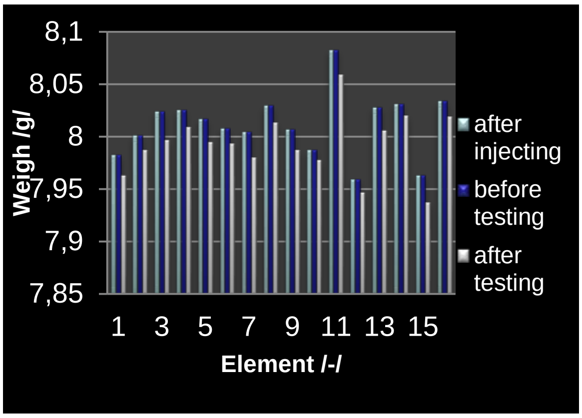

Fig. 6 Change weighs ABS

Here, in the Fig.7 for PA6.6 + 15% GF it is important to note that we changed the mass immediately after injection of the sample and before the test. This is due to the very high hygroscopicity material.

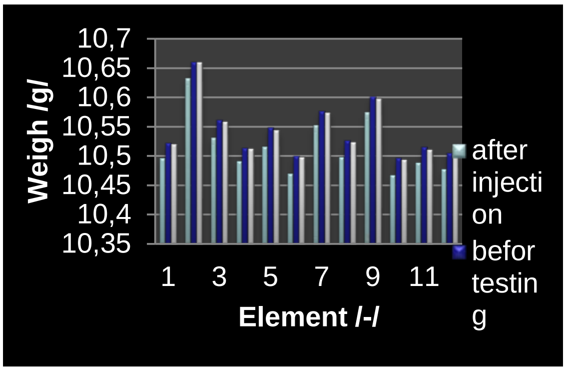

Fig. 7 Change weigh PA6.6 + 15%GF

From Fig. 6 it is already possible to say how the material will behave during further testing and what results can be expected from additional tests, and that material PA 6.6 + 15%GF will better withstand potential stresses than ABS. In numbers, this is expressed by ABS during the test, lost 0.017ga PA 6.6 + 15%GF lost 0.003 g.

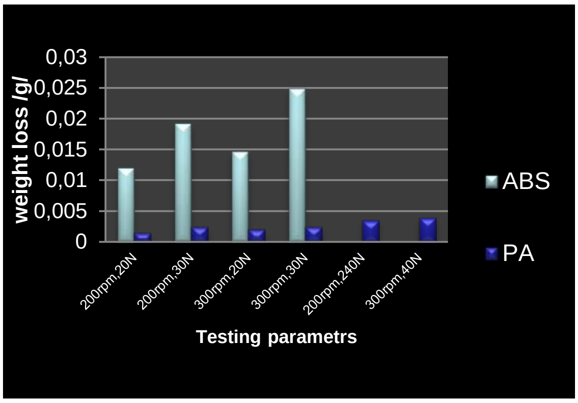

Fig. 8 Corporation change the weigh

3. CONCLUSION

It is very difficult to draw conclusions from tests when we have not yet conducted tests on all the test materials, but even here it is possible to derive some conclusions.

ABS and PA are polymers and are thermoplastics. Therefore, they should have roughly the same properties and characteristics as some specific parameters for these materials. As shown in the following Tab.5 and not everywhere it is. We tested ABS and PA6.6+15GF.

If the resultant product is used as an exposed part, according to the test the clear choice is ABS. This is covered by acquired better visual structures and surface roughness, and after averaging all values amino slightly smaller friction coefficient than PA66 + 15% GF.

However, when used as a loaded component, this material is very difficult to use.

Large wear loss of material occurs when loading, which is adhered in the form of fine dust on all around visibility

Even in terms of comfort for the test were as arm Vibration noise or better based material PA6.6 + 15% GF.

Table 5 Summary of results

	ABS	PA 6.6+15%
Ø surface roughness /Ra/	0.51933333	3.575
Ø weight loss /g/	0.01726667	0.00266667
Ø coefficient friction /-/	0.175655	0.189997

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