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WEAR PROCESS OF TIRES

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Abstract: *The issue of wear represents a very important role in the functionality of most products. The description of the wear process for very heavily strained rubber products, for instance off-road tire treads, conveyor belts for stone transport etc., is very essential. Sharp edges of stones and terrain roughness gradually cut (chip) off rubber parts. This wear considerably damages separate parts of the product and destroy it. In technical terminology, we call this type of wear CHIPPING – CHUNKING effect. High-speed video camera, enabling recording and evaluation of the behaviour of ceramic tool when dropped on the surface of revolving testing rubber sample, was used for detailed analysis of the wear process.*
Key words: *Wear, rubber ,High – speed camera, mechanical properties*

1. INTRODUCTION

Rubber industry often faces the problem of wear of rubber parts. Some forms of wear, especially the wear of tyre tread or conveyor belts, are very similar to working itself. The tire tread is the part of tyre which secures contact of vehicle with road and is directly involved in the transfer of driving power. The wear of tire treads of passenger car and freight vehicles moving on usual roads, is characterised by its abrasion. Tire tread of a vehicle is exposed to abrasive effect of the road it moves on. However, the mechanism of wear of tires working in very hard terrain conditions is absolutely different. Sharp stone edges and terrain irregularities gradually cut (tear off) parts of the rubber tread surface, which can be understood as a way of working. There is also some similarity to milling, although under very specific conditions. The mechanism of tire tread wear working in hard terrain conditions is technically called Chipping-Chunking effect and it can be considered as "workability" of rubber surface.

The tests for wear are usually performed on finished products under running conditions, but these are usually very time demanding and expensive. It would be very useful for technical practice to find a quick test of wear which could be carried out on small samples. Creating a model predicting the behavior of tire tread mixtures and specifying the characteristics (tensile strength, elongation, tear strength, hardness etc.) which affect the wear dramatically, would improve the development of wear research in this field.

2. EXPERIMENT

Thirteen kinds of tire tread compounds used for motorcycle treads subjected to high stress, treads for technical, agricultural and multipurpose vehicles were experimented. All compounds represent real products and are produced and machined

The tests of tire (tread) wear are time and money consuming. They are carried out using real tires in testing rooms or directly in the terrain during driving tests. That is one of the reasons for searching a method that would in a very short time (in minutes) and on small samples test the wear for a comparison of the different kinds of compounds.

Based on these requirements an equipment seen on Figure 1 was designed. The Chip – Chunk wear testing machine (J. R. Beatty and B. J. Miksch in RCHT, vol. 55, p. 1531.) was used for basal measurements. A new machine enabling changing the tested parameters and true simulations of the process conditions was designed, see Figure 1.

Arm 1 pivotable around the neck is lifted by lifting part (piston of the pneumatic cylinder) 2. The arm that has a special ceramic edge tool is lifted and dropped 3 on the perimeter of the revolving wheel 4 (testing sample) driven by the electric motor 5. When it drops on the revolving wheel, the ceramic tool gradually chips the material and creates a groove on the wheel. The size of the groove chipped by the ceramic tool in a given time is the scale of wear.

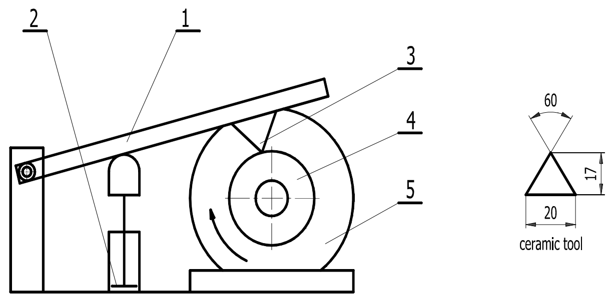

Fig. 1. Design of testing equipment
1 – Arm, 2 – Pneumatic cylinder, 3 – Ceramic tool, 4 – Rubber sample, 5 – Electric motor

For easier preparation of testing samples the form seen on Figure 2 was designed (the outer dimensions correspond to the testing sample of test Luepke).

A groove was made (chipped) by the ceramic tool into the testing sample during the experiment. It was expected from experience with tooling other materials, esp. metals, wood or plastic, that the groove would be regular. Due to the properties of machined rubber – which demonstrated its elasticity – the moment the rotating ceramic tool dropped on the rotating wheel, pieces of material were torn off. For this reason, the initial intension of wear evaluation by measuring the groove diameter was changed to gravimetric evaluation.

The influence of drop of the ceramic tool on the surface of the testing sample is crucial. If the sample were rigid, the evaluation of the impact of dropping force would be quite easy.

The elastic properties of the testing sample however cause a series of other effects of smaller intensity (jumping on the surface) apart from the main effect (the first drop of the ceramic tool on the testing sample).

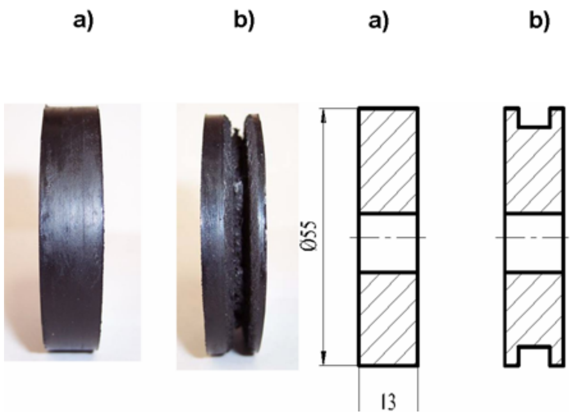

Fig.2. Testing sample for fast wear test
a) before the test, b) after the test

The main effects of the ceramic tool have only partial influence on the total wear. It turned out that evaluating total work needed for wear (i.e. creating a groove on the testing sample) only by the energy of the drop would be biased. After the first testing of the experiment equipment, it was clear that the results in a given series of measurements would be comparable if the experiments ran under the same conditions. The construction of the main body with a key fitting the groove on the shaft and clamping basement with teeth prevent skidding of the testing sample while running and the control system of the testing machine will secure constant conditions for testing.

3. RESULTS AND DISCUSSION

During the process of wear the real contact area between the surface of the rubber test sample and the sharp edges of stones and of terrain irregularities is very small. When the test sample is rotating (in rotational movement), tension arises in this area. When the ceramic tool drops on the circumference of the test sample, the tool is pushing the surface layer of the rubber and tensile strengths arise behind the head of the deformation alongside the groove (Figure 3). If the tensile strength exceeds the mechanical strength of the rubber material, a part of rubber is torn away, either completely or partly. Tension and deformation in the area of the drop of the ceramic tool decrease and the same phenomenon can repeat a bit further away. The ceramic tool therefore machines the surface of the rubber test sample (it mills it). The way by which the individual parts are torn away is similar to the way of tearing during the tear strength test. It can then be assumed that the factors influencing the process of wear are the deformation energy needed to cause the tear and the size of the ceramic tool (in real life the sharp edges of stones and terrain irregularities), which is determining for the size of deformed microareas and particles which are torn away. The phenomenon during which the rubber particle is torn away can be seen as elementary tensile test in which the speed of tearing is much bigger than the speed of the movement of the test sample. Resistance to wear is closely linked to the deformation energy needed for tearing the given rubber particle away.

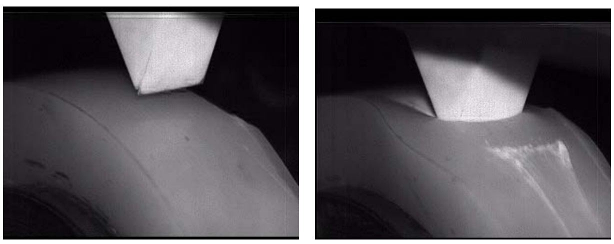

Fig. 3. Ceramic tool during the drop on the testing sample

When investigating properties of the testing samples, high-speed video camera system Olympus i-SPEED 2 was used. The camera system was intended to visualize the behavior of the tested sample during the ceramic tool drop (Figure 3 and Figure 4).

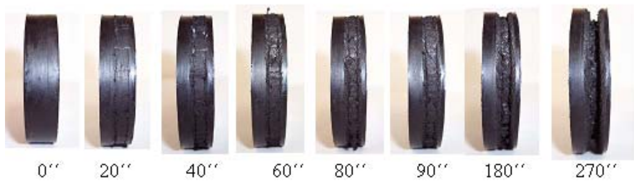

Fig.4. Wear of tested samples in time (0 – 270)s

4. CONCLUSION

The presented test method shows the possibility of the evaluation of wear (chip – chunk) resistance of tire treads on small samples. This method makes possible to compare various types of compound with a standard and to observe the wear progress during the test period. The wear of the sample during the test period depends on the properties of rubber compounds and on test conditions.

The evaluation of the wear test using a high-speed video camera system Olympus i-SPEED 2 enables very detailed analysis of the wear process of heavily strained rubber parts, tire treads in particular. The visualisation of the ceramic tool drop on the testing samples can determine the path of tool penetration, as well as its speed. Simultaneously, the deformation of the testing sample can be observed. The path and speed ratio can determine the moment when the surface is damaged and first rips created.

5. ACKNOWLEDGEMENTS

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