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VISUALIZATION OF TIRE TREAD BEHAVIOUR AT WEAR PROCESS

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Abstract: *Wear of off-road tires is a very complicated matter and presents a big problem for end users. Sharp edges of stones and grits, including terrain irregularities, chip off (tear) small parts of tire tread compound, which can cause tire destruction. Two tire tread compounds of different hardness used for the production of tires for construction machinery were selected for the laboratory tests. The wear process was recorded by high-speed camera system Olympus i – 2. The type of wear of individual tire tread compounds was monitored with respect to the manner of tearing and size of the torn particles. In this article the difference in the behaviour of soft and hard compounds during the laboratory test of wear of off-road tire tread compounds is described.*

Key words: *wear, rubber, mechanical properties, behaviour, tire*

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

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.

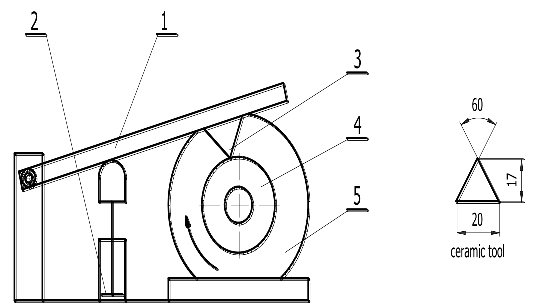

Fig. 1. Design of testing equipment:1 – Arm, 2 – Pneumatic cylinder, 3 – Ceramic tool, 4 – Rubber sample, 5 – Electric motor

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.

Properties of the tested samples were examined using the optical method, in this case the high-speed camera system “ Olympus i-SPEED 2“. The camera system was used in order to visualize the behaviour of the tested sample at the drop of the ceramic tool (Fig. 3,4).). The deformation of the sample at the drop of the ceramic tool was monitored. At the same time we monitored the occurrence of first cracks at the drop of the ceramic tool on an undamaged surface of the sample which resulted in avalanche wear and destruction of the sample (Fig. 3).

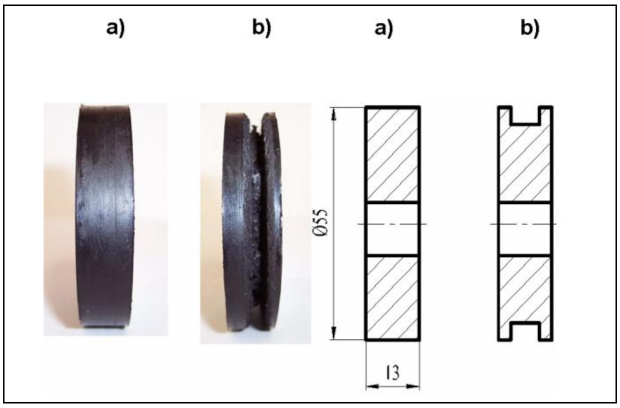

Fig. 2. Testing sample for fast wear test a) before the test, b) after the test

High-sped camera system enables to better understand the problem and gives a more detailed insight into the process of tire wear. It enables both to visualize the course of the deformations and quantify the ongoing processes (values of compression of the sample, penetration of the tool in the sample, size of the falling particles, speed of their fall, etc.).

3. RESULTS AND DISCUSSION

Results of Olympus i-SPEED 2 Basic software, which were taken by the high-speed camera system “Olympus i-SPEED 2“ were processed and graphically evaluated. In Fig. 4 it is possible to see to what depth in the tested rubber sample of soft compound the tool managed to penetrate. Fig. 4 shows penetration in hard compound sample (there is an obvious progress/result for the hard compound sample). Values of the depth of the penetration do not grow linearly with the number of drops made but depend on the variable force caused by the falling tool and by possible previous damage of the tested surface (Fig. 3, 4).

A very interesting observation is the different depth of the penetration of the ceramic tool in soft and hard compounds. For soft compound tested there is an obvious significant elastic deformation. On the other hand in Fig. 4 we can see a much smaller depth of the ceramic tool in the hard compound tested (white compound). The different depths of the penetration of the ceramic tool (in other words rough terrain) in the tire tread compound (Fig. 4) have a considerable effect on wear and are closely linked to the mechanical properties of the tread compound.

Variability of the drops of the tool corresponds with the penetration of sharp edges of stones and terrain roughness in the tire tread. The depth of the tool penetration is evidence of its different force effect at every drop just like in the real conditions of driving in rough surfaces.

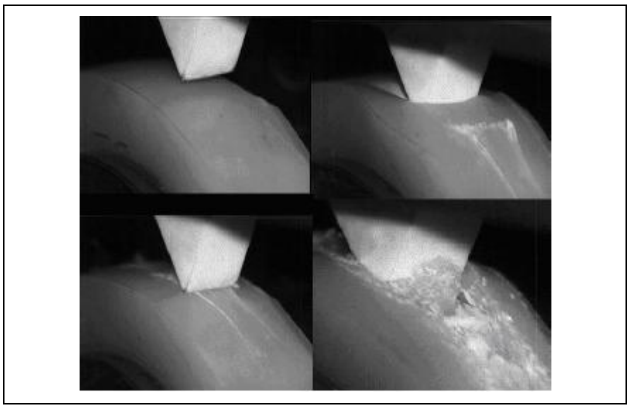

Fig. 3. Ceramic tool during the drop on the testing sample

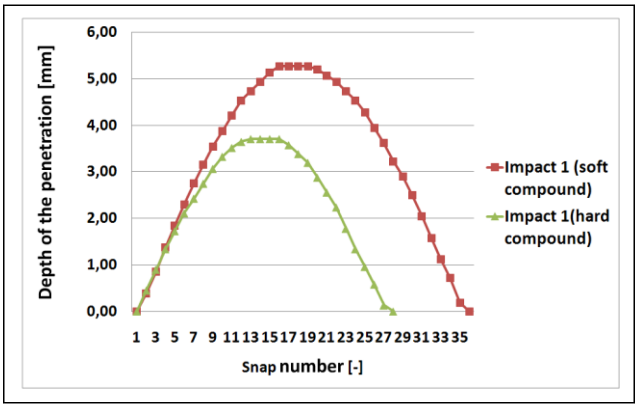

Fig. 4. Depth of penetration of ceramic tool after dropping on the testing sample

4. CONCLUSION

The article evaluates behaviour of tire tread compounds for off-road tires under high stress. High-speed camera system Olympus i - speed 2 was used with the aim to better understand the process of wear in this type of tire tread compounds or, in other words, tires used in rough terrain conditions. The drop of the ceramic tool on the surface of the testing sample made from hard and soft tire tread compound was recorded with the camera.

The previously found correlations between mechanical properties and wear show that there is a certain relationship between hardness and complex dynamic module. Low values of hardness and dynamic module are characteristic for tire tread compounds which show low values of wear. Compounds with high values of hardness and dynamic module showed the opposite – a large extent of wear.

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