WEAR OF RUBBER PARTS

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ABSTRACT
Rubber (rubber mixture) is an indispensable material as an element for automobile because of its original characteristics such as big elongation (transformation) and ability of restoration which is unattainable by other materials. Rubber is the main raw material for production of automotive components such as tires, bushes, insulators and seals. All these products have to be safe and wear resistant. Good wear resistance is very important for tires. The article describes the testing possibilities of tires used in very hard traffic conditions (off-road tires).

Keywords: rubber, rubber mixture, wear

1. INTRODUCTION
Wear of tire treads at road surfaces is measured as abrasion resistance. Off-road behaviour of tyre treads on surfaces with sharp stones is not well characterised by abrasion resistance as the mechanism of rubber damage is here rather different. The sharp edges of stones can cut a rubber tread surfaces and gradually tear-off bigger pieces of rubber (chips or chunks).

2. EXPERIMENTAL
The test for cutting and chipping of rubber compounds which correlates with service behaviour and gives test results with reasonable speed and accuracy was described by J. R. Beatty and B. J. Miksch in RCHT, vol. 55, p. 1531. In accordance with their description we constructed rather modified apparatus. The enhanced laboratory apparatus where conditions of testing can be widely changed makes possible to measure different characteristics of chip-chunk processes.

Figure 1. Sample for chip-chunk test: a) before the test, b) after the test
Tests were carried out on cylindrical samples for Lüpke test with diameter 55 mm and thickness 13 mm. The rotating vulcanised rubber cylinders were abraded by sharp edge mounted on beam lifted and dropped on the rubber sample perimeter by pneumatic cylinder. The samples were weighed before and after test. The samples were made from compounds designated for production of motocross, motoenduro fork lifter tires and off-road tires. The evaluation of wear progress during the testing period was tested as well.

![Design of cutting and chipping tester](image)

**Figure 2. Design of cutting and chipping tester**

1 – frame, 2 – electric motor, 3 – beam, 4 – pneumatic cylinder, 5 – ceramic tool, 6 – rotating sample, 7 – control panel

![Samples wearing](image)

**Figure 3. Samples wearing during the test period**
Figure 4. Wear of samples during the test period

Figure 5. Wear of samples by various conditions

Figure 6. Comparison of all measured properties
The measured dates were statically calculated processed. For evaluation of measured dates the multiple linear regression was used. We used the linear statistical model of Chip – Chunk resistance in the form:

\[ Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2 + \beta_4 X_3 + \beta_5 X_4 + \beta_6 X_5 + \beta_7 X_6 + \varepsilon \]

where  
- \( Y \) … Weight Shortage [g]  
- \( X_i \) … measured value of properties of rubber compounds, i.e.  
- \( \beta_i \) … material constants  
  - \( X_1 \) … Tensile Strength [MPa]  
  - \( X_2 \) … Elongation [%]  
  - \( X_3 \) … Tear Strength [Nüm]  
  - \( X_4 \) … Shore Hardness [ShA]  
  - \( X_5 \) … Resilience [%]  
  - \( X_6 \) … DMA (Tensile Modulus) [MPa]  
- \( \varepsilon \) … error

By the least – square method we obtained the estimates of unknown parameters \( \beta_i \). The answered regression function takes the form:

\[ Y = 2.619273 + 0.034052 X_1 - 0.001868 X_2 + 0.000125 X_1 X_2 - 0.129815 X_3 + 0.116571 X_4 + 0.012328 X_5 + 0.000121 X_6 \]

(suitability of the model describes the determinacy index: \( R^2 = 0.850893 \)).

<table>
<thead>
<tr>
<th>Correlation matrix</th>
<th>X_1</th>
<th>X_2</th>
<th>X_3</th>
<th>X_4</th>
<th>X_5</th>
<th>X_6</th>
<th>Y</th>
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</table>

3. CONCLUSION
Presented testing method shows the possibility of evaluation of wear (chip – chunk) resistance of tire treads on the small samples. This method makes possible to compare various types of compound with a standard and follow the progress of wear during the test period. The wear of sample during the test period depends on the properties of rubber compounds and testing conditions. Significant correlation of chip-chunk resistance with usual rubber properties was found. According statistical calculation all measured data are statistical significant.

4. ACKNOWLEDGEMENT
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