Numerical parameter describing the resistance against Chip & Cut behaviour of rubber

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Outline

• Introduction
• Theoretical background
• Lab testing equipment
• Experimental
• Conclusion
Introduction

Source: www.youtube.com/watch?v=bTnE66fjrI&t=4s
Introduction

**TIRE FIELD TEST**

- Long time analyses
- High distance duration
- Limited no. of analysed tires
- Tread geometry specific effect

**LAB TEST**

- Short time analyses
- Low no. of rotating cycles
- Unlimited no. of analysed specimens
- Pure rubber matrix investigation

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What is the correlation between Chip&Cut behaviour of tire tread at the field test and rubber matrix based on tire tread compound at lab test?
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Theoretical background

SLIPPING

ROLLING

$\omega \neq 0 \text{ rad/s}$

$V = 0 \text{ m/s}$

$\omega \neq 0 \text{ rad/s}$

$V \neq 0 \text{ m/s}$
Theoretical background

Crack closing: the interfacial binding energy $2\gamma_0$ is partly converted into elastic energy and partly dissipated in the rubber:

$$2\gamma_{\text{close}}^{\text{eff}} = 2\gamma_0 - \left( \frac{P}{V} \right)$$

Crack opening: the flow of elastic energy into the crack consists of the fracture energy plus viscoelastic energy dissipation:

$$2\gamma_{\text{open}}^{\text{eff}} = 2\gamma_0 + \left( \frac{P}{V} \right)$$

where the energy dissipation per unit time is:

$$P = \int d^3x \dot{\varepsilon}_{ij} \sigma_{ij}$$

Most energy is dissipated in the crack opening mechanism:

$$\gamma_{\text{close}}^{\text{eff}} \ll \gamma_0 \ll \gamma_{\text{open}}^{\text{eff}}$$

Theoretical background

Source: H. Liang et al., Wear 266, 2009
Theoretical background

TIRE FIELD TEST

The resulting tire tread surface is the main criterion for evaluation of the rubber resistance against chip&cut!
From the surface topology
The P-Parameter [N/cycle] based on friction force describing the resistance against Chip&Cut mechanism has been determined!
What exactly is describing the P-Parameter?
The lower the P-Parameter is, the higher the rubber resistance against Chip&Cut!
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Lab testing equipment

**TIRE FIELD TEST**

**REAL LOAD ON 4WD TIRE**
Outer diameter: up to 1.000 mm
Load on tire: up to 1.000 kg = 10.000 N

**LOAD ON TEST SPECIMEN**
Outer diameter: 50 mm
Load on tire: up to 50 kg = 500 N

**LAB TEST**

DOWN SCALED
Factor cca, 20

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Parameters:
- Dynamical loading (≤ 10Hz)
- Pulse width (≥ 20ms)
- Rotation velocity (≤1500min⁻¹)
- 2-axis loading cell (Fₓ, Fᵧ)
- Changable direction of rotation
- Cyclic or permanent abrasion
- Normal force variation during analysis
Lab testing equipment

$D_1 = 55 \text{ mm}$

$D_2 = 26 \text{ mm}$

$T = 13 \text{ mm}$
Lab testing equipment

SLIPPING

ROLLING

\[ \omega \neq 0 \text{ rad/s} \]

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Lab testing equipment

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Lab testing equipment
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## Experimental

### Ingredients

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### Roration speed

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Experimental

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![Graph showing parameter P vs. cycles]

Parameter P [N/cycles] vs. Cycles [-]

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## Experimental

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*Images showing different samples labeled 2, 3, and 4.*
### Experimental

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Bar chart showing the parameter P [N/cycles] for compounds NR and SBR, with different conditions (Cond1, Cond2, Cond3, Cond4).
## Experimental

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**NR**

**SBR**
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Conclusion

- Sufficient Data Base for statistical Evaluation
- Very quick Test Results in Laboratory (few days comp. to several weeks)
- Material ranking by reliable measured values rather than by qualitatively misleading estimations

- Faster „time to market“
- Decisions are much more secured
- Saves money
Many thanks for your kind attention!