NORDIC RHEOLOGY SOCIETY

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Estimating mechanical rubber properties from moving die rheometer vulcanization curves under consideration of the rubber composition.

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Overview

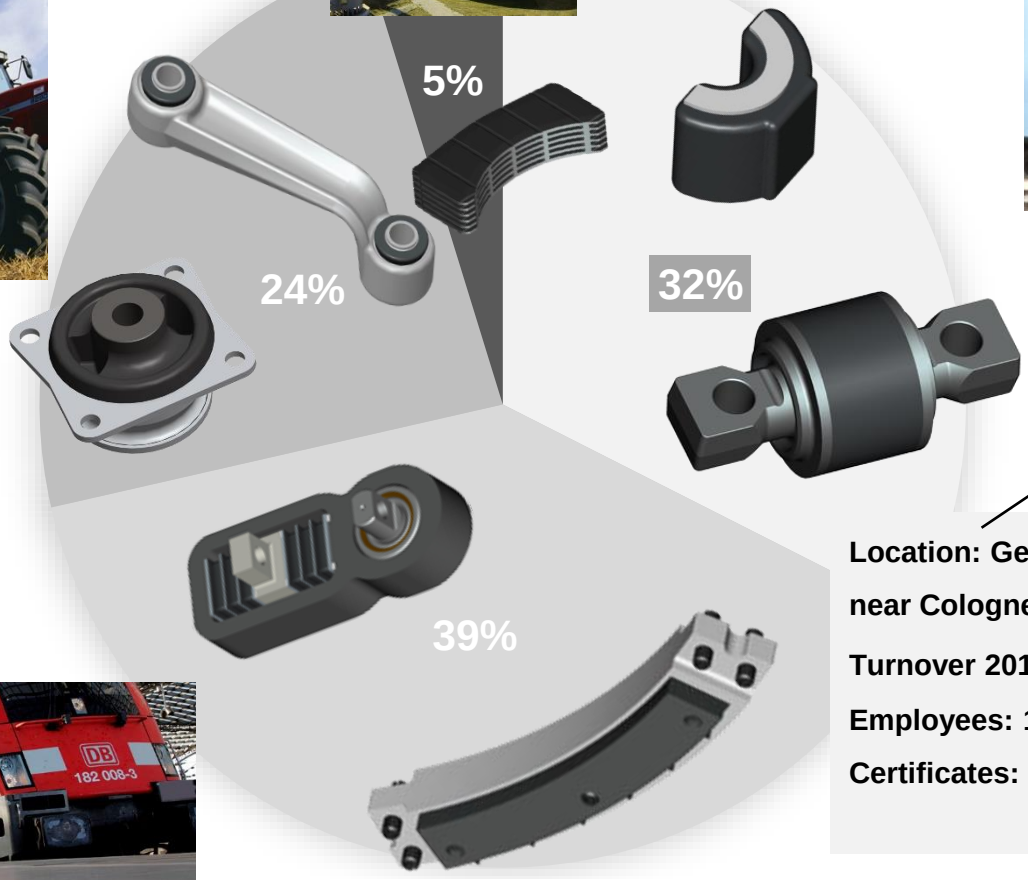
- Introduction
- Scope
- Methods & Materials
- Results
- Conclusion

BHC Gummi-Metall-Technik → **produces rubber-metal bearings and dampers for these application fields:**

Agriculture

General Industry

Truck & Trailer



Railway

Location: Germany, Meckenheim, near Cologne

Turnover 2017: 26 Mio€

Employees: 135

Certificates: IATF 16949, ISO 9001, ISO 14001, ISO 50001, OHSAS 18001

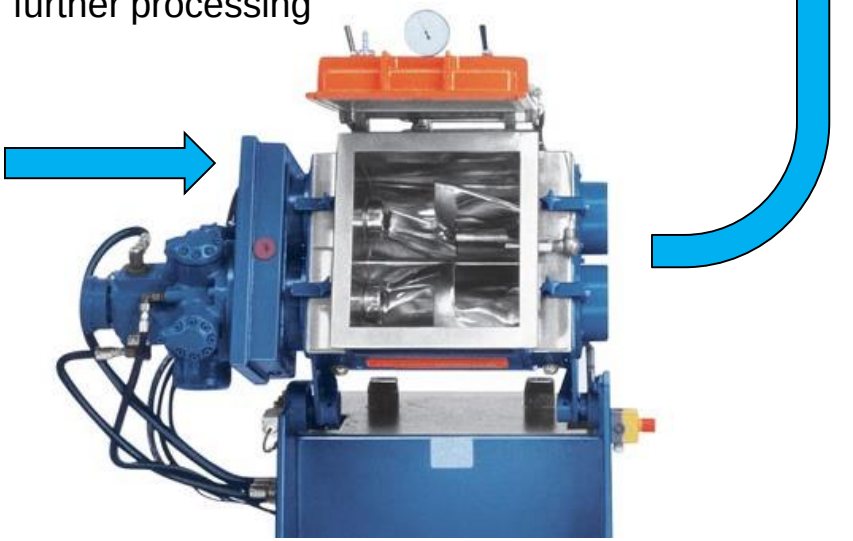
Introduction

BHC → Incoming rubber compounds

- Processing of approx. 400t p.a. of NR-, NR/BR-, NR/SBR- & NBR-compounds
- 108 BHC own recipes und specifications
- 4 compound suppliers & development partners

Rubber compounds are complex mixtures of rubbers, carbon black, oils, waxes, fillers, sulphur, accelerators, inhibitors, stabilizers, etc.

After homogeneous mixing the unvulcanised rubber compound is provided as stripes for further processing



BHC → Incoming rubber quality inspection

Moving Die Rheometer (Curemeter)

Every incoming rubber batch:

- Moving Die Rheometer (Curemeter):

  storage torque and loss angle prior to,

  during and after vulcanization

  → flowability during processing

  → dyn. mech. properties after vulcanization

Shore A hardness

Rebound resilience

Sporadically testing of further properties:

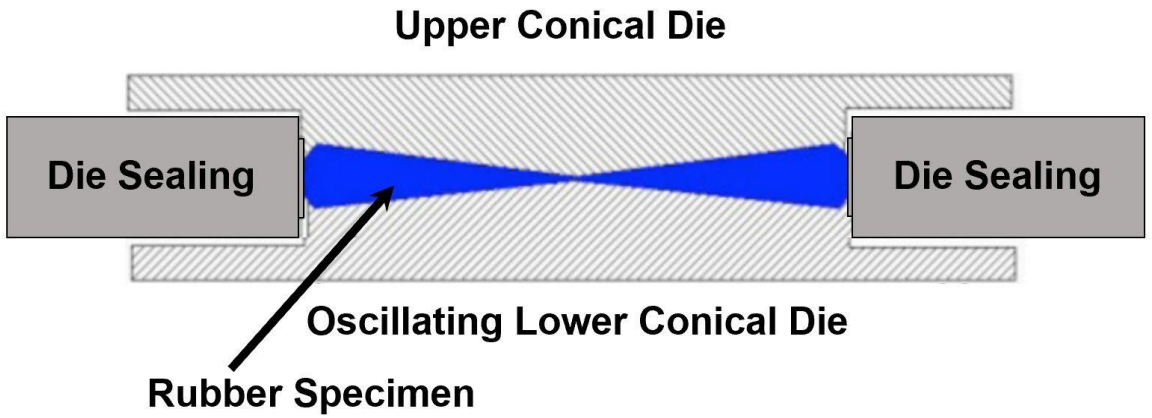
- Shore A hardness
- Rebound resilience
- Others, e.g. tensile, abrasion, etc.

→ 6 mm testing plate has to be manufactured (~ 20 min + 10 min for additional measurements)

BHC → Incoming rubber quality inspection

- Moving Die Rheometer (Curemeter)

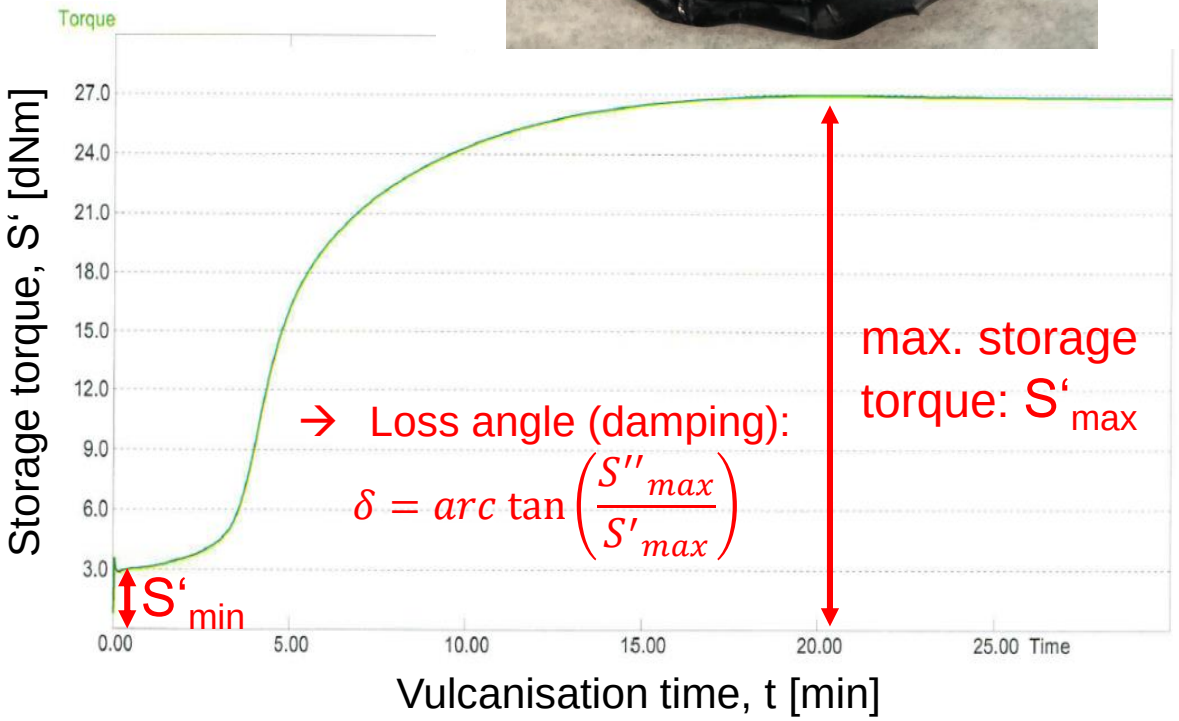
Vulcanisation at:
- 170°C
- Oszillation
  0.5°/1.67Hz



BHC → Incoming rubber quality inspection

- Moving Die Rheometer (Curemeter)

Vulcanisation at:
- 170°C
- Oszillation
  0.5°/1.67Hz



Evaluated rubber types with incoming quality inspection:

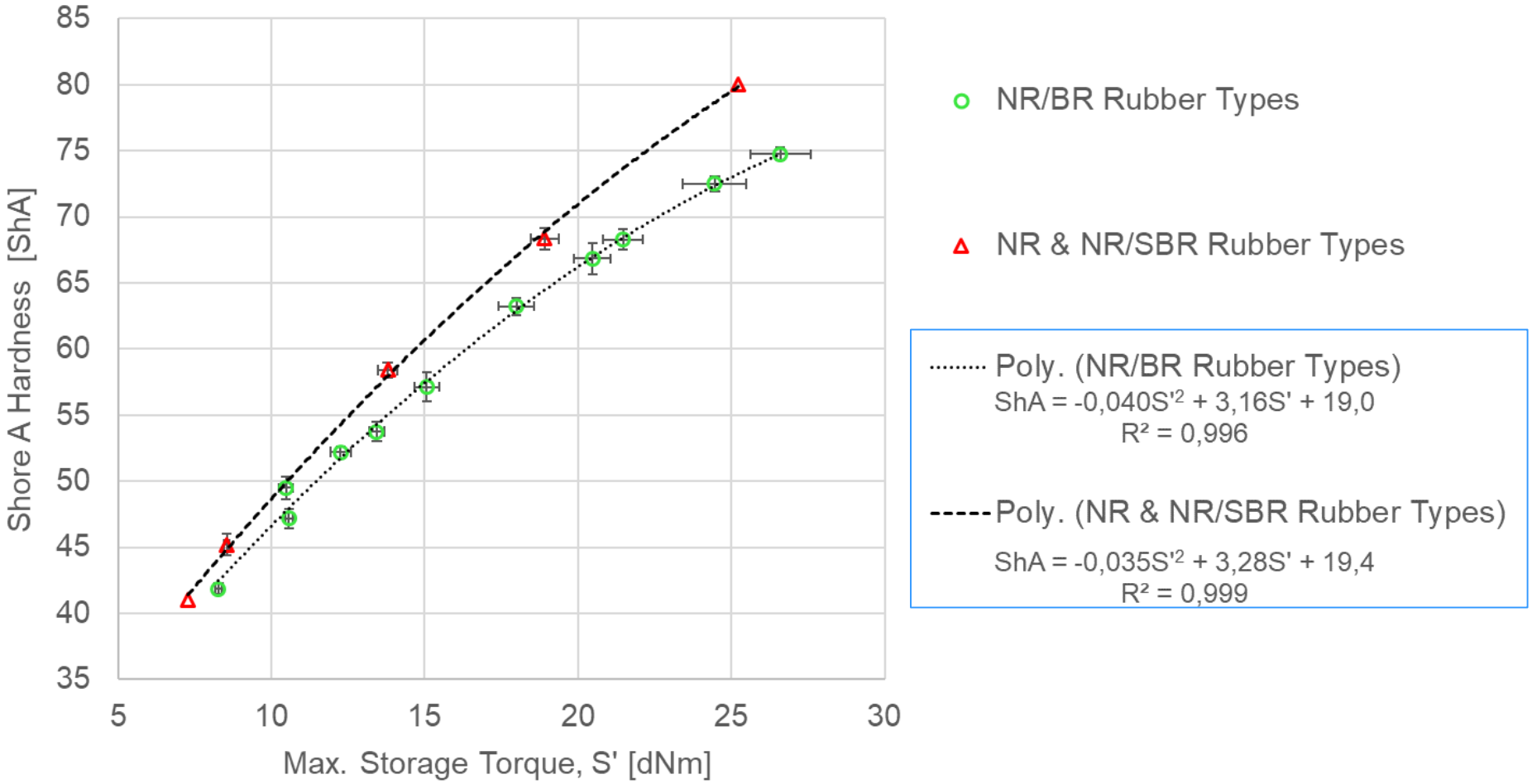
(all tested with moving die rheometer)

No.	Name	Polymer type: NR: natural rubber, BR: butadiene rubber, SBR: styrene butadiene rubber	Mean Shore A Hardness Acc. to 3.1 report of rubber supplier (No. of tested batches)
1.	41-NRSBR	NR, SBR	41.0 (1)
2.	42-NRBR	NR, BR	41.8 (4)
3.	45-NR	NR	45.2 (7)
4.	47-NRBR	NR, BR	47.2 (7)
5.	50-NRBR	NR, BR	49.5 (6)
6.	52-NRBR	NR, BR	52.2 (4)
7.	53-NR	NR	52.5 (2)
8.	54-NRBR	NR, BR	53.8 (7)
9.	57-NRBR	NR, BR	57.1 (7)
10.	58-NRSBR	NR, SBR	58.4 (5)
11.	63-NRBR	NR, BR	63.2 (7)
12.	67-NRBR	NR, BR	66.8 (6)
13.	68-NRBR	NR, BR	68.3 (7)
14.	68-NRSBR	NR, SBR	68.3 (6)
15.	73-NRBR	NR, BR	72.5 (4)
16.	75-NRBR	NR, BR	74.8 (3)
17.	80-NRSBR	NR, SBR	80.0 (1)

Results

Evaluated rubber types with incoming quality inspection:

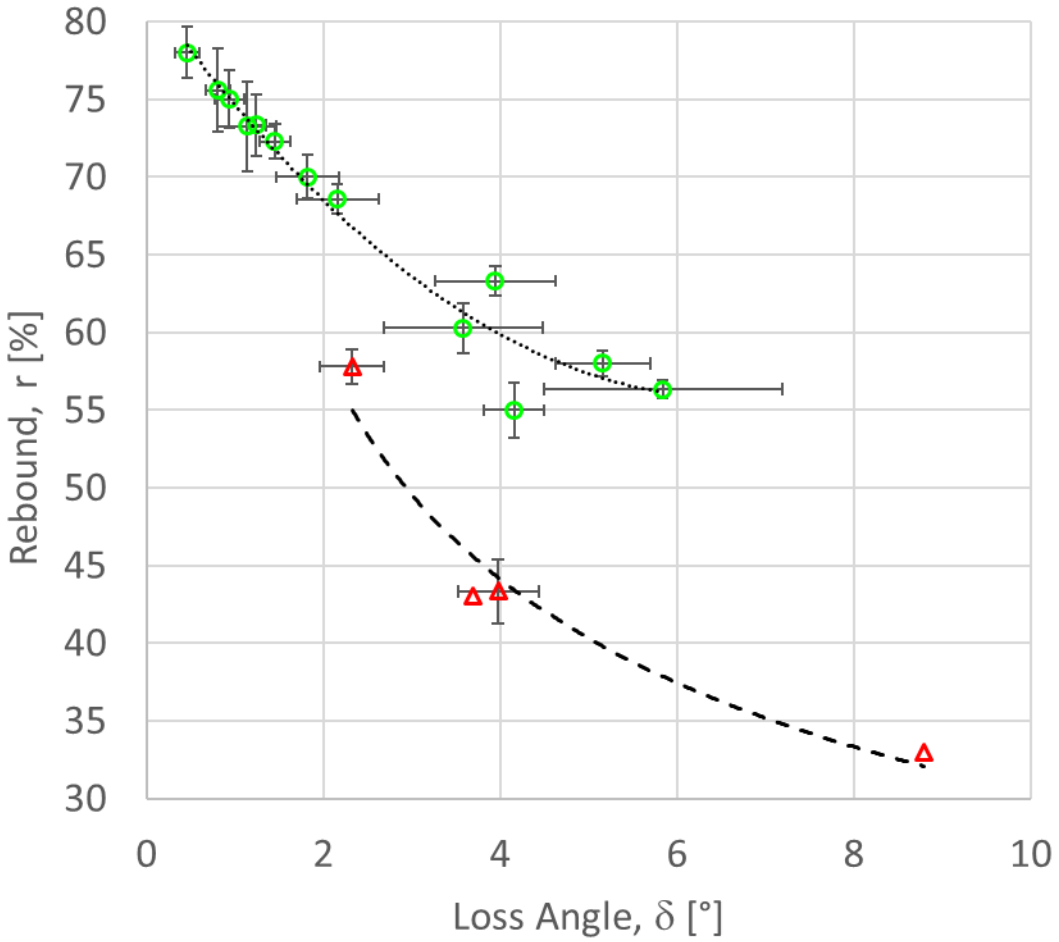
Correlation of shore A hardness from suppliers 3.1 test report with max. storage torque



Results

Evaluated rubber types with incoming quality inspection:

Correlation of rebound resilience from suppliers 3.1 test report with max. loss angle



NR and NR/BR Rubber Types

NR/SBR Rubber Types

Poly. (NR and NR/BR Rubber Types)
$r = 0.598\ \delta^2 - 7.90\ \delta + 81.9$
$R^2 = 0.956$

Pot. (NR/SBR Rubber Types)
$r = 77.3\ \delta^{-0.405}$
$R^2 = 0.955$

Conclusion

- Moving die rheometer measurements for incoming goods quality inspection can be used to calculate shore A hardness and rebound resilience

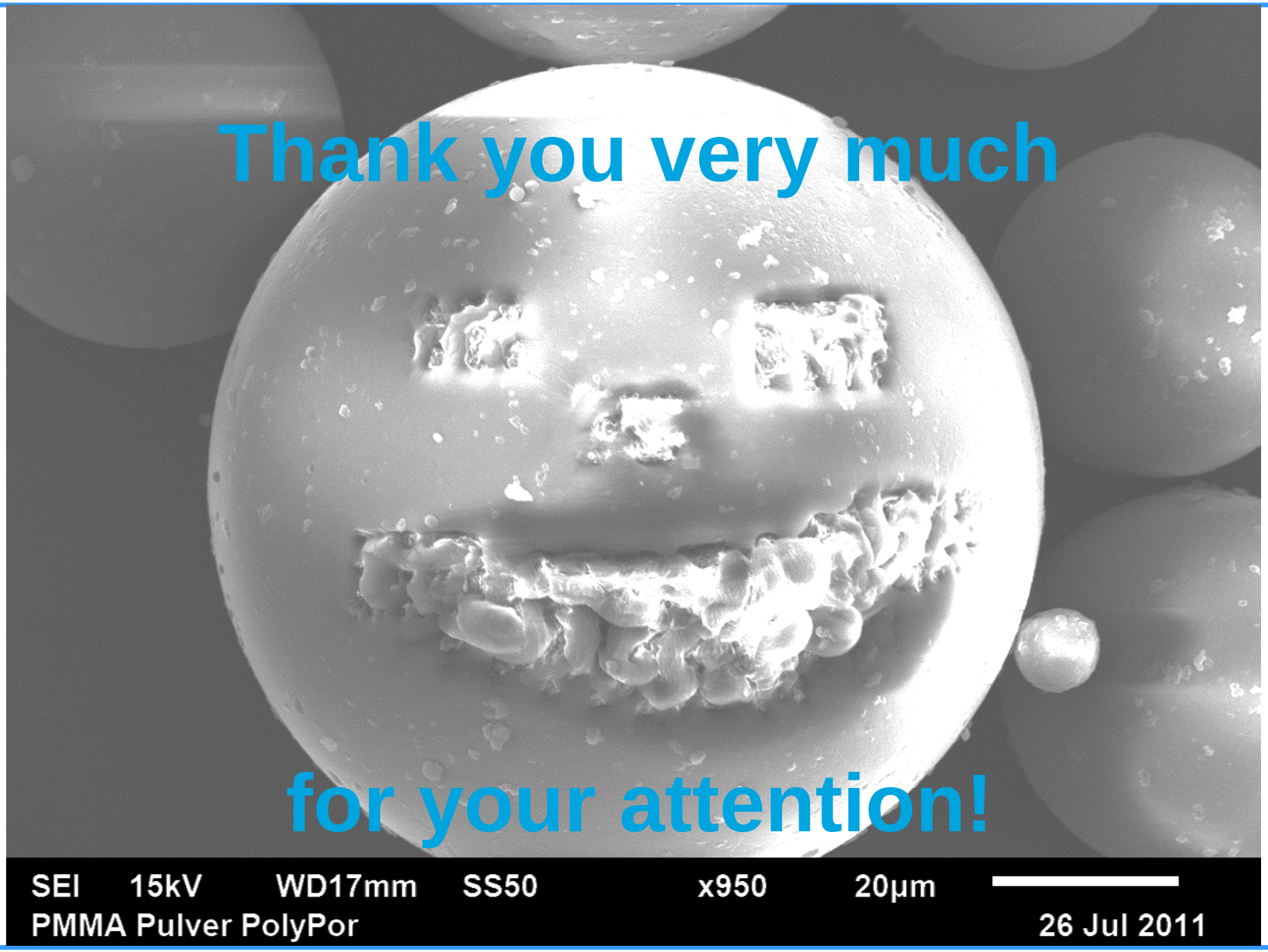
- For shore A hardness the prediction error is <5%

- For rebound resilience the prediction error is <10%
  → Scattering increases with higher filler contents resp. higher loss angles

Benefits:

- Easy comparison with 3.1 test report data from the rubber compound supplier

- Prediction of changes of the mechanical properties of cured rubber batches with respect to longer storage time (ageing) prior to curing.
  → shelf-life


Thank you very much
for your attention!
SEI 15kV WD17mm SS50 x950 20µm
PMMA Pulver PolyPor
26 Jul 2011