Stretched Solutions for the Rubber Industry

Rheological Measurement & Control in the Rubber Factory

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Alpha Technologies
Complete Supplier

• Integrated Product Portfolio
  – Instruments
  – Software
  – Installation and Training
  – Application Support and Training
  – Parts Supply
  – Local Service and Calibration
Product Range

- Mooney
- VS Mooney
- ODR
- MDR / P
- P-MDR
- Software

- Minitester
- RPA
- PPA
- T2000
- CPMP
Product Positioning

Functionality

Price

ODR  VSM  MDR  PMDR  PPA  PPA Options  RPA

Price:

$30k  $40k  $50k  $60k  $70k  $80k  $90k  $100k  $110k  $120k

Mini Tester

The First Name in Testing Solutions
Products

- Mooney
- VS Mooney
- ODR
- MDR / P
- P-MDR
- Software

- Minitester
- RPA
- PPA
- T2000
- CPMP

The First Name in Testing Solutions
MDR / P

Upper Die Oscillating

Excentric Motor

Torque Transducer

Heating

Upper Die

Rubber

Sample

Lower Die Oscillating

Upper Sealplate

Lower Sealplate

Upper Sealplate

Lower Sealplate

The First Name in Testing Solutions
Products

- Mooney
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- Minitester
- RPA
- PPA
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- CPMP
The RPA2000 is Four Instruments in One

- RAW POLYMER TESTER
  - Viscosity
  - MW Distribution
  - Branching
  - Gel Content
  - Ageing

- PROCESSABILITY TESTER
  - Mill / Extrusion Behaviour
  - Die Swell
  - Mould Flow
  - Process Viscosity
  - Filler Dispersion

- ADVANCED CUREMETER
  - Process Scorch
  - Cure Rate
  - Cure Time
  - Reversion
  - Non-isothermal Cure Testing

- DYNAMIC MECHANICAL TESTER
  - Modulus
  - Elasticity
  - Viscoelastic Properties
  - Heat Build-up
  - Damping

The First Name in Testing Solutions
A Family of Products based on RPA Technology

• 3 discrete models
  – **PPA Polymer** - Analysis & control of raw polymer and rubber masterbatches
  – **PPA Processability** - Meaningfull assessment of compound processability
  – **PPA Post cure** - Measurement of dynamic properties of cured compounds

a MDR + Much More ...
Mooney Values = the industry STANDARD for manufacture and receipt of raw polymers

But Not enough, because:

- Mooney is insensitive to the key factors determining elastic behaviour
- Polymers with equal Mooney viscosity from different sources can have significantly different performance
- The earlier in the production process that variability can be detected the lower the cost of correction
Polymer Branching

Linear - PP
Dentrit - LDPE
Star - Sol SBR
Special - H form
Ultra Branched
SCB - HDPE

SCB = C < 6  LCB = C > Me (288)

"High performance EPDM polymers based on a new technology of controlled long chain branching", H.J.H. Beelen, paper at IRC'97, Nurnberg.
Polymer polydispersity

G' & G'' (kPa)

(-) MWD
(+, -) MW
(+, -) MWD

Frequency (Rad/s)
PPA PROCESSABILITY

• Analysis and control of
  – Masterbatches and final mixed compounds.
  – Filler effects, dispersion, carbon blacks and silica.
  – Mill handling, flow and die swell.
RPA2000 Compound Mixing Study
Silica ‘Green’ Tyre

Increasing reaction
SiO₂ > Silane

increased silane degradation

G' (KPa)

Strain (% SSA)

100°C, 0.1 Hz
Uncured

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Extrusion correlation
Semi-industrial environment Compound number <65

Tread compound
Formulation: Identical
Industrial “Orbitread” extruder
Very slow production conditions
Extrusion correlation

Full industrial environment normal process conditions
Linear Model Input relevance
Extrusion correlation

Full industrial environment normal process conditions
Linear Model Best Solution
Injection moulding correlation

EPDM white compound

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<tr>
<th>RPA DATA</th>
<th>EPDM L</th>
<th>EPDM N</th>
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<tr>
<td></td>
<td>0.03 Hz</td>
<td>0.03 Hz</td>
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<tr>
<td>Real dynamic $\eta'$</td>
<td>100</td>
<td>124</td>
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<tr>
<td>(Pa.s)</td>
<td>710</td>
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<td>Complex dynamic $\eta^*$ (Pa.s)</td>
<td>133</td>
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<tr>
<th>INJECTION DATA</th>
<th>Lengt (cm)</th>
<th>Press (bar)</th>
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<td>2% of max speed</td>
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<tr>
<td>3%</td>
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<td>5%</td>
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<td>25%</td>
<td>87.6</td>
<td>1971</td>
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</table>

Rectangular cross-section

Channel length : 100 cm

Injection gate
Pressure transducer (path Interval between transducer : 10 cm)
PPA POST CURE

- Measurements of cured dynamic characteristics
  - Data relating to key performance properties - eg. Damping, HBU, Rolling resistance, Dynamic stiffness, Hardness, Resilience and Tensile modulus
  - No prior cured sample preparation, fast results
RPA20000
Combined Uncured & Cured Test

Frequency
- Strain sweep: 1 Hz, 1.67 Hz
- Temperature: 100° C, 170° C
- Time: 0 Mins., 60 Mins.

Variable temperature cure
- Strain sweep: 1%, 200%, 7%
- Temperature: 1% 1%, 50%, 40%
- Time: 0 Mins., 60 Mins.

Cured visco-elastic properties
- Frequency: 10 Hz
- Strain sweep: 1%, 50%, 1%
- Temperature: 40° C
- Time: 60 Mins.

Automated RPA enables fully automatic testing

The First Name in Testing Solutions
Cured Anti-Vibration Compound
RPA Correlation with Product Quality Test

Cured $G''(10\%/10\text{Hz})$ vs Resonant Frequency

$R^2 = 0.9697$

\[ \begin{array}{c|c|c}
\text{Resonant Frequency Hz} & 950 & 1010 \\
\hline
\text{G'' kPa} & A & C \\
\end{array} \]
Pathfinder concept
Dual user interface

Instrument PC

Workbench

Control Room

SQL database

Control Room
Remote access
Workbench: Test result graphics from RPA or PPA
Curve overtracing