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B O G O T Á 2 0 2 5

Título de la conferencia

Nombre del conferenciante

XVIII Jornadas Latinoamericanas de Tecnología del Caucho

How Processing Aids Can Improve Mixing Efficiency and Solve Production Difficulties?

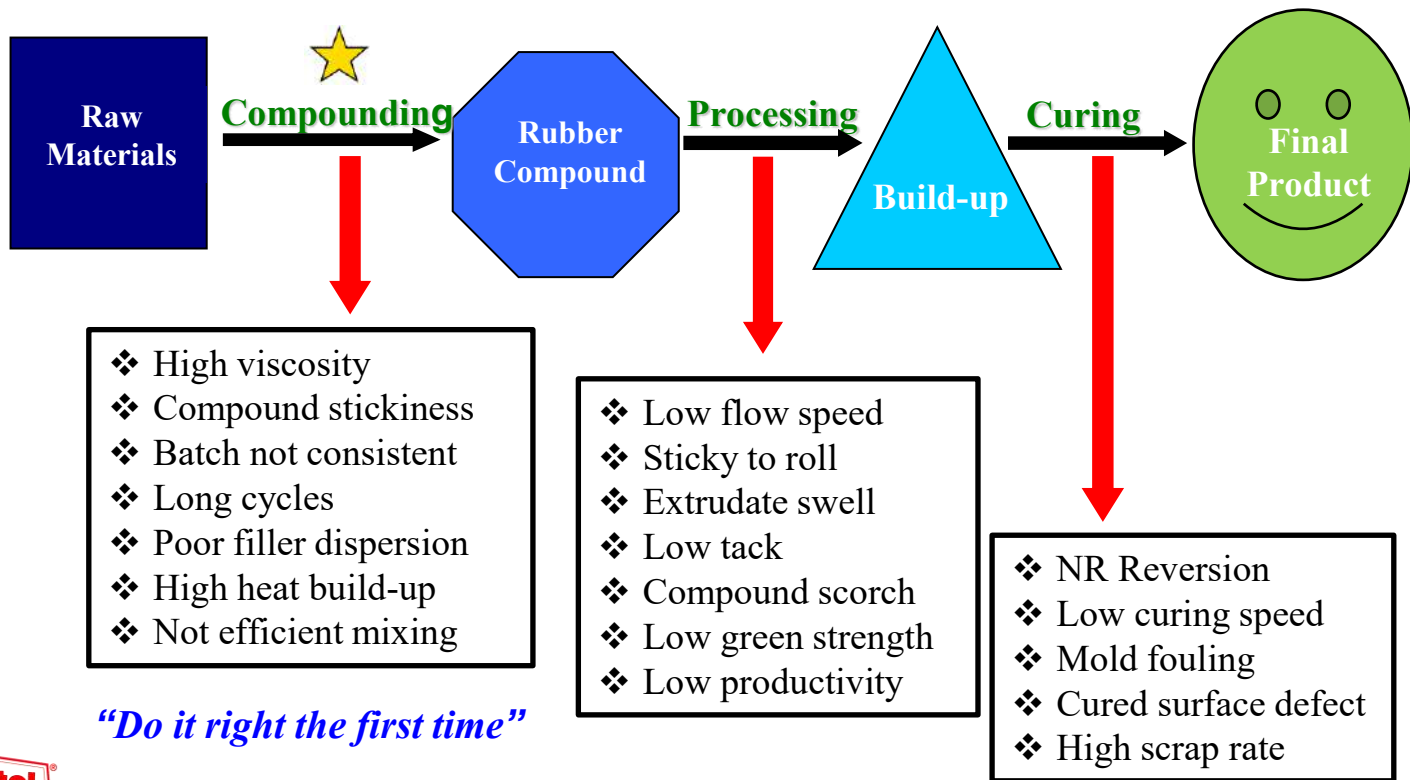
Mayu Si
Struktol Company of America

XVIII Latin American Rubber Technology Conference
11/13/2025



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BOGOTÁ 2025

Production Stages in Rubber Industry



"Do it right the first time"

Agenda

- ❖ One-stage mixing
- ❖ High BR based compound processing

One-Stage Mixing Study

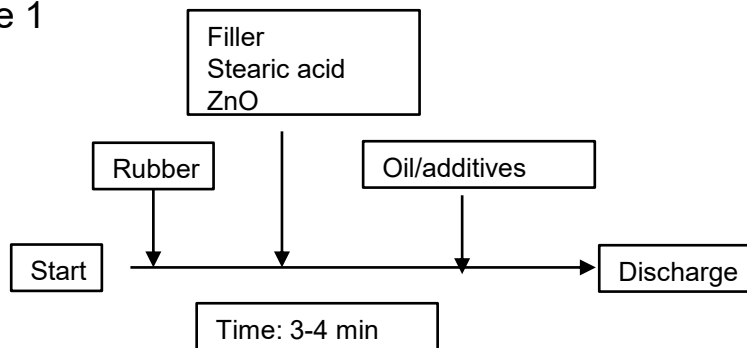
With Struktol ZB 47



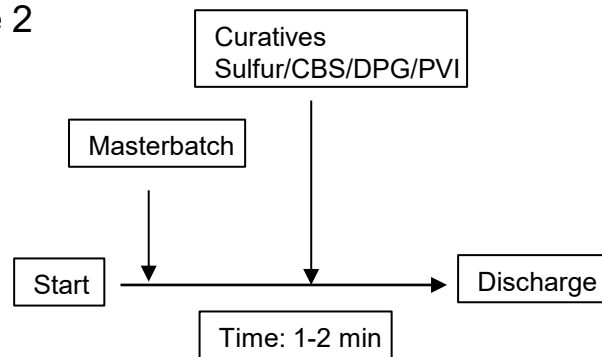
Mixing Stage Reduction: A Sustainable Approach

Traditional multi-stage mixing is often necessary for uniform dispersion of ingredients and compound viscosity control, including masterbatch and curative stages.

Stage 1



Stage 2



Mixing stage reduction is the process of consolidating or eliminating mixing steps

- ❖ Reduced production costs
- ❖ Increased throughput and efficiency
- ❖ Lower logistics costs

Steps inside the Mixing Process

- ❖ Mastication/blending
- ❖ Wetting/incorporation of ingredients
- ❖ Dispersion of ingredients
- ❖ Distribution of ingredients
- ❖ Homogenization
- ❖ Thermo-mechanical reactions; melting, fluxing, bond breaking/forming
- ❖ Evacuation of volatile

Polymers

Co-polymers

Miscible
Homogeneous

Polymer Blends
Heterogeneous

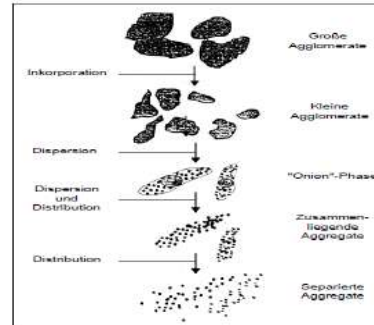
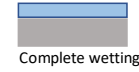
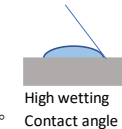
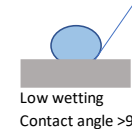
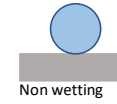
Immiscible



Compatibilisation
Alloys



liquid = polymer

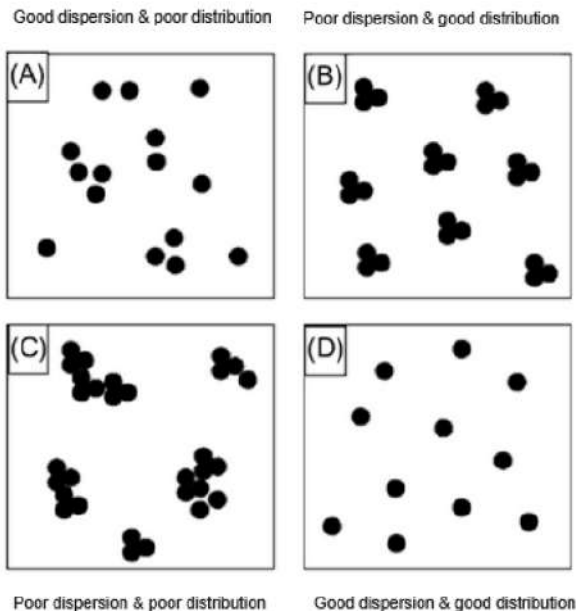


Mixing Stage Reduction Challenge

A short mixing time due to mixing stage reduction causes:

- ❖ Poor filler dispersion/distribution
- ❖ Potential scorch issue
- ❖ High compound viscosity
- ❖ Compound physical properties deterioration

Dispersion vs. Distribution



Model Premium Compound Initial Trial

SBR 1502	15.00
Buna CB 24	35.00
SIR 20	50.00
N220	55.00
Sundex 790TN	7.00
ZnO	4.00
Stearic acid	2.00
Akrowax 5084	2.00
TMQ	2.00
6PPD	3.00
PVI	0.25
Sulfur	1.25
DPG	0.32
CBS	1.00

One-stage mixing spec

Rotor speed = 80 rpm

0 sec.: add all rubber or 40 MS

30 sec. reduce rotor speed to 60 rpm, add remaining ingredients except curatives

After reaching 95 C, ram up, sweep, add curatives

Discharge at 115 C

Total mixing time is around **130** sec, much shorter than two-stage mixing, 1st stage: 220 sec plus 2nd stage 70 sec

Big challenge is temp arise so quickly, not enough time for filler dispersion before possible compound scorch

One-stage vs. Two-stage

	Control	40 MS
SBR 1502	15.00	15.00
Buna CB 24	35.00	35.00
SIR 20	50.00	50.00
N220	55.00	55.00
Sundex 790TN	10.00	7.00
ZnO	4.00	4.00
Stearic acid	2.00	2.00
Akrowax 5084	2.00	2.00
TMQ	2.00	2.00
6PPD	3.00	3.00
40 MS		5.00
PVI		0.25
Sulfur		1.25
DPG		0.32
CBS		1.00
PVI	0.25	
Sulfur	1.25	
DPG	0.32	
CBS	1.00	
Total	180.82	182.82

	Control	40 MS
Tensile strength (MPa)	24.0	21.3
Elongation (%)	664	670
100% Modulus (MPa)	1.9	1.9
200% Modulus (MPa)	4.3	3.8
300% Modulus (MPa)	7.9	6.6
Hardness (Shore A)	64	65
Die C Tear (N/mm)	117.9	97.5
DIN (mm3)	110	133
ML (1+4) @100 C	53	69
Mooney scorch (125 C)		
Minimum torque	41.8	55.2
T5	46.47	38.12
MDR (150 C/30 min)		
ML	2.59	3.02
MH	16.38	17.10
MH-ML	13.78	14.09
Ts1	8.67	6.84
Ts2	9.72	7.90
T10	9.23	7.44
T50	11.42	9.54
T90	16.27	13.58

struktol



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Different Approaches

The loss of tensile strength and abrasion resistance could come from poor CB dispersion due to short time mixing

- ❖ Introduce Struktol additive, ZB 47, help CB dispersion and improve mixing efficiency
- ❖ Increase discharge temp? scorch concern
- ❖ Reduce/increase rotor speed?



Curative Addition Sequence?

- ❖ Later addition: believe to be safe to control scorch, but leave a short time for curatives to be mixed well
- ❖ Early addition: worry about compound scorch, but better for curatives dispersion, more homogenous

If the compound is scorch safe, early addition should be a better way to go, easy to run in production

Introduce Struktol ZB 47

	Control (two-stage)	One-stage	ZB 47
SBR 1502	15.00	15.00	15.00
Buna CB 24	35.00	35.00	35.00
SIR 20	50.00	50.00	50.00
N220	55.00	55.00	55.00
Sundex 790TN	10.00	10.00	10.00
ZnO	4.00	4.00	4.00
Stearic acid	2.00	2.00	2.00
Akrowax 5084	2.00	2.00	2.00
TMQ	2.00	2.00	2.00
6PPD	3.00	3.00	3.00
ZB 47			2.00
PVI		0.25	0.25
Sulfur		1.25	1.25
DPG		0.32	0.32
CBS		1.00	1.00
PVI	0.25		
Sulfur	1.25		
DPG	0.32		
CBS	1.00		
Total	180.82	180.82	182.82

One-stage mixing spec

Rotor speed = 80 rpm

0 sec.: add all rubber

30 sec. reduce rotor speed to 60 rpm

add remaining ingredients

75 sec, ram up, sweep

105 sec, ram up, sweep

Discharge at 115 C

	One-stage	ZB 47
Mixing time (sec)	145	158
Batch temp (C)	134	134



Compound Data/ZB 47 Benefit

	Control (two-stage)	One-stage	ZB 47
Tensile strength (MPa)	22.9	22.5	22.8
Elongation (%)	711	646	641
100% Modulus (MPa)	1.8	2.0	2.1
200% Modulus (MPa)	3.7	4.5	4.5
300% Modulus (MPa)	6.8	7.8	7.8
Hardness (Shore A)	55	62	56
Die C Tear (N/mm)	112.5	82.2	79.9
Rubber window Tear (N/mm)	252.0	242.6	228.8
DIN (mm3)	117	125	117
ML (1+4) @100 C	53	82	78
Mooney scorch (125 C)			
Minimum torque	38.6	61.3	58.8
T5	40.87	31.08	34.11
MDR (150 C/30 min)			
ML	2.51	3.59	3.85
MH	15.98	17.00	16.49
MH-ML	13.47	13.41	12.64
Ts1	8.18	6.07	7.41
Ts2	9.07	7.08	8.26
T10	8.62	6.55	7.71
T50	10.65	8.66	9.95
T90	14.8	12.61	14.19

ZB 47 Contributes

- ❖ Improve CB dispersion, achieve better compound abrasion resistance.
- ❖ Reduce compound Mooney viscosity, help production processing
- ❖ Improve compound scorch, boost production safety

Compound Slab Picture



Two-stage Control



One-stage w/ZB 47

Further Study with Rotor Speed/Discharge Temperature

	ZB 47
SBR 1502	15.00
Buna CB 24	35.00
SIR 20	50.00
N220	55.00
Sundex 790TN	8.00
ZnO	4.00
Stearic acid	2.00
Akrowax 5084	2.00
TMQ	2.00
6PPD	3.00
ZB 47	2.00
PVI	0.25
Sulfur	1.25
DPG	0.32
CBS	1.00
Total	180.82

One-stage mixing spec

Rotor speed = 80 rpm

0 sec.: add all rubber

30 sec. reduce rotor speed to **variable** rpm

add remaining ingredients

75 sec, ram up, sweep

105 sec, ram up, sweep

Discharge at **variable** temperature

Rotor Speed Effect

Rotor Speed (rpm)	50	60	70
Tensile strength (MPa)	22.6	22.9	21.3
Elongation (%)	706	682	633
100% Modulus (MPa)	2	1.9	2.1
200% Modulus (MPa)	4	4	4.3
300% Modulus (MPa)	6.9	7.1	7.5
Hardness (Shore A)	57	58	58
Die C Tear (N/mm)	85.8	79.4	81.3
DIN (mm3)	113	113	111
ML (1+4) @100 C	72	75	76
Mooney scorch (125 C)			
Minimum torque	56.2	58.3	57
T5	34.63	34.4	32.6
MDR (150 C/30 min)			
ML	3.51	3.76	3.69
MH	16.78	16.64	17.14
MH-ML	13.28	12.88	13.45
Ts1	7.67	7.38	7.08
Ts2	8.0	8.25	8.02
T10	8.07	7.71	7.48
T50	10.42	9.97	9.69
T90	15.18	14.52	14.87

The same discharge temp: 125 C

Rotor speed (rpm)	50	60	70
Mixing time (sec)	241	175	138
Batch temp (C)	134	142	143

Increase rotor speed

- ❖ No big effect on physical properties
- ❖ Compound scorcher

Discharge Temperature Effect

Discharge temp	115 C	125 C
Tensile strength (MPa)	21.0	22.9
Elongation (%)	648	682
100% Modulus (MPa)	2	1.9
200% Modulus (MPa)	4.1	4
300% Modulus (MPa)	6.9	7.1
Hardness (Shore A)	58	58
Die C Tear (N/mm)	76.14	76.9
DIN (mm3)	122	113
ML (1+4) @100 C	79	75
Mooney scorch (125 C)		
Minimum torque	57.3	56.3
T5	35.77	34.4
MDR (150 C/30 min)		
ML	3.96	3.76
MH	17.03	16.64
MH-ML	13.07	12.88
Ts1	7.7	7.38
Ts2	8.53	8.25
T10	8.03	7.71
T50	10.29	9.97
T90	14.89	14.52

The same rotor speed: 60 rpm

Discharge Temp (C)	115	125
Mixing time (sec)	147	175
Batch temp (C)	133	142

Increase Discharge Temperature

- ❖ Better physical properties
- ❖ Lower viscosity
- ❖ Compound scorcher

One-stage Mixing Factory Trial



Summary

- ❖ Struktol ZB 47: great benefit to one-stage mixing, make it possible to run in production
- ❖ Recommend early addition of curatives, dependent on curing system
- ❖ Higher discharge temp contributes better compound physical properties

High BR Based Compound Processing

With Koresin



Abrasion Resistance Compound Needed



Conveyor Belt



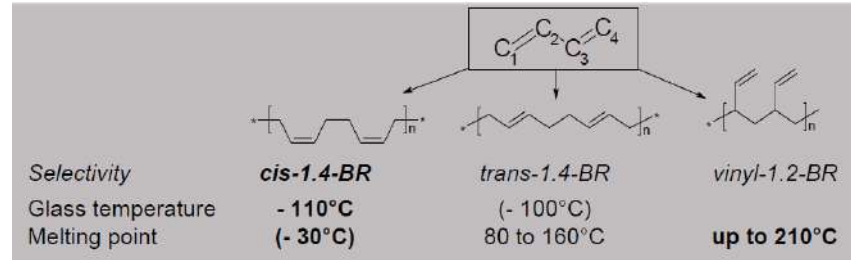
Mill liner

Key Factors: rubber and filler

- ❖ NR: high tensile and tear strength, low heat buildup
- ❖ **BR: excellent abrasion resistance, too high-level causing bagging issue**
- ❖ SBR: better crack initiation and good processing

BR Structure Effect on Abrasion Resistance

BR Structure

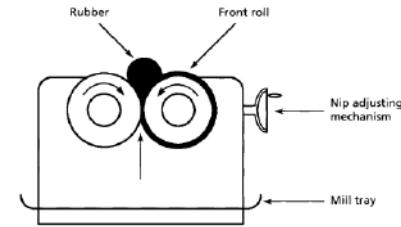
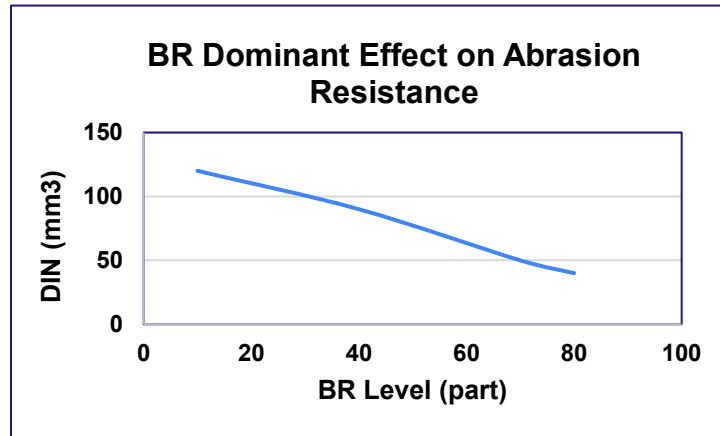


- ❖ With very low Tg (-106 °C), good chain flexibility, high resilience and less heat buildup under dynamic deformation, BR provides excellent abrasion resistance. Need to increase BR to certain high level without sacrificing processing
- ❖ Neodymium catalyzed BR have the highest cis-1,4 content, >97%, and even lower Tg (-109 °C), providing better abrasion resistance: such as Buna CB24

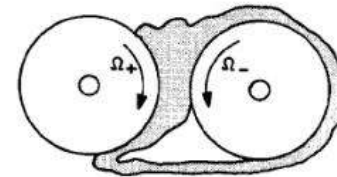
Catalyst	Cis 1,4 (%)	Trans 1,4 (%)	Vinyl 1,2 (%)	Tg (°C)
Nd	>97	2	<1	-109
Co	96	2	2	-107
Ti	92	4	4	-105
Li	38	52	10	-93

High BR: Performance Up/Processing Down

High BR contributes significant abrasion resistance improvement, but creates bagging issue during milling and calendering



Normal Operation

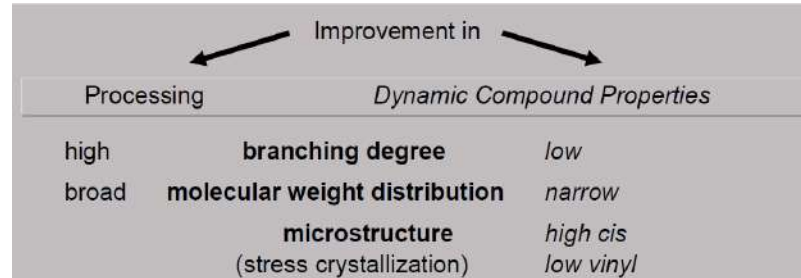


Mill Bagging

Mill Bagging: Further Discussion

Rubber type related: internal tack of the rubber is critical, BR, NBR and EPDM

Rubber structure impact: high molecular weight and narrow molecular weight distribution



Approach:

- ❖ Powdered milk to help create a temporary sticky surface
- ❖ Mixing time and temperature
- ❖ Mill nip distance and surface temperature, roll friction ratio
- ❖ **Tackifier resin**

Koresin: A Super Tackifier

A “Super Tackifier”

- Increased initial tack
- Extended **long-term** tack

❖ High tack

❖ Long-term tackiness ⇒ prefabrication, stocking time

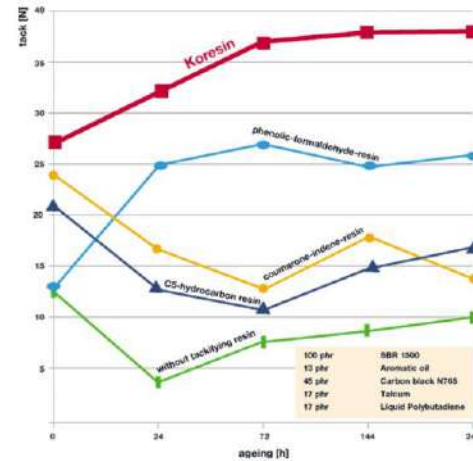
❖ Low heat build up ⇒ tire dynamics

❖ Unmeasurable effect on vulcanization and on scorch time ⇒ processing reliability

❖ Good extrudability, smooth surface

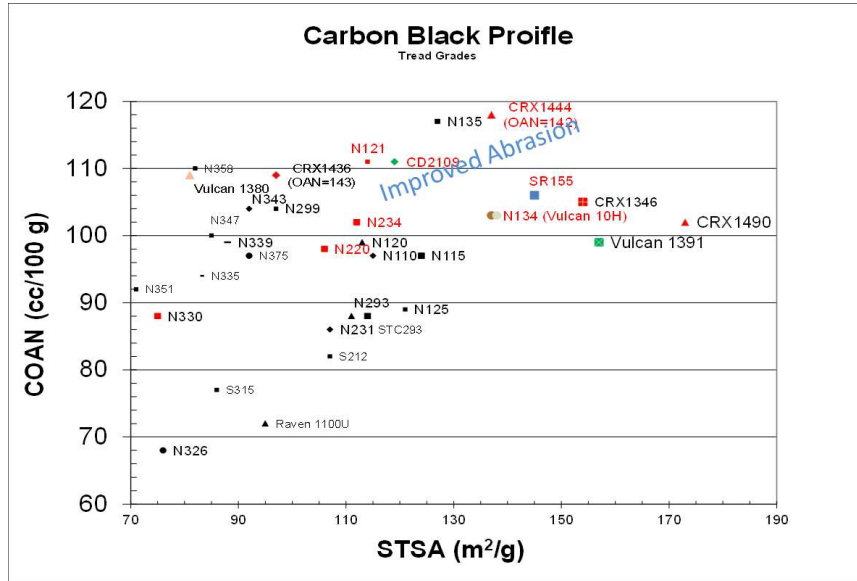
❖ Excellent dispersion of carbon black

❖ Physical characteristics of the vulcanized rubber remain nearly unchanged



Filler: Carbon Black Dominate

Carbon black parameters for highly abrasion resistant compound



- Small particle size/high specific surface area
- High structure
 - Narrow particle/aggregate size distribution
 - Strong polymer-filler interaction
 - Good carbon black dispersion
- Optimal carbon black loading
 - Polymer system dependent
 - Filler distribution, oil loading, crosslinking

Further High BR Level?

SIR 20	30/20
Buna CB 24	70/80
N234	45.00
Aromatic oil	3.00
ZnO	3.00
Stearic acid	2.00
6PPD	3.00
TMQ	2.00
Wax	1.00
Sulfur	1.25
CBS	1.25
PVI	0.20
Total	161.70

BR level	70 BR	80 BR
Physical properties		
Tensile strength (MPa)	23.4	21.1
Elongation (%)	605	607
100% Modulus (MPa)	2	1.8
200% Modulus (MPa)	4.3	3.5
300% Modulus (MPa)	8.2	6.7
Hardness (shore A)	58	62
DIN abrasion (mm ³)	42	40
ML (1+4)	74	76



Bagging Issue Resolved: Koresin

NR/BR (20/80)	Control	w/ 5 parts Koresin
Physical properties		
Tensile strength (MPa)	21.3	20.6
Elongation (%)	614	654
100% Modulus (MPa)	1.7	1.6
200% Modulus (MPa)	3.4	3.1
300% Modulus (MPa)	6.8	6.1
Hardness (shore A)	59	57
DIN abrasion (mm ³)	40	38
ML (1+4)	75	73
Milling	Baggy	Good

Mill Bagging Improvement



BR/NR: 80/20 Control



BR/NR: 80/20 with 5 parts Koresin

Tested @10N/10Sec	Control	5 parts Koresin
Tack (N)	2.73	10.93

Koresin: Optimize Processing and Performance

- ❖ Koresin, as a super tackifier, solves high BR caused bagging issue to enable high BR approach, not sacrificing abrasion resistance
- ❖ Koresin can ensure high abrasion compound practically run in production



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Gracias / Thank you