INSTYTUT INŻYNIERII MATERIAŁÓW POLIMEROWYCH I BARWNIKÓW

GROUND TYRE RUBBER (GTR) AND ITS APPLICATION TO RUBBER MIXES

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IMPiB Seminar 19th November 2013, Piastów, POLAND

Recycling, Valorisation of rubber waste

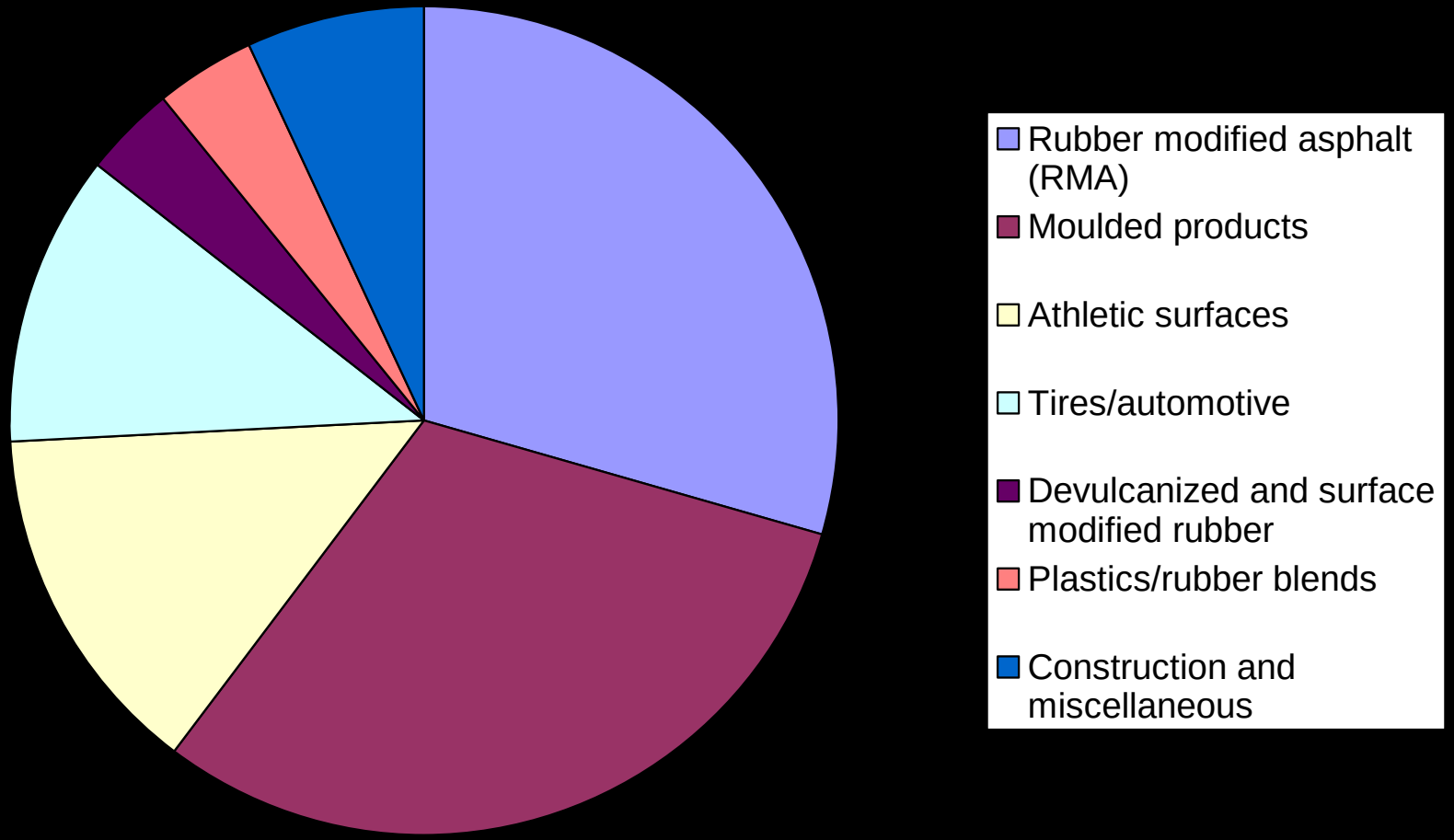
1. W. Parasiewicz, L. Pyskło, J. Magryta: *Handbook - Recycling of waste car tyres*, IPGum „STOMIL”, Piastów 2005.

2. Grant No R0802903: *Mixes and composites containing waste tyre rubber devulcanized in twin-screw extruder. Properties and applicability*, 2008-2011

3. Grant POIG (Eco-Capital): *Studies on pyrolysis of waste car tyres and valorization of its products,* 2010-11.

Applications for recycled tire rubber

Source: Recycling Research Institute 2012



Direct binding of NGR by rubber

NR binded composites

NR	7.7 wt.%
NGR	92.3 wt.%
H, °Sh A (ISO 48)	53 - 54
TS, MPa (ISO 37)	3.5
E_b, %	169

CR binded composites

CR	7.7 wt.%
NGR	92.3 wt.%
H, °Sh A (ISO 48)	54
TS, MPa (ISO 37)	2.5
E_b, %	140

Compression set and stress relaxation !

TS < 1.6 MPa

F. Qadrini et al., J. Mat. Eng. Innov. (2009)

Aplication of NGR in standard SBR mixes

NGR series

Components \ Rubber mix	NGR-0	NGR-10	NGR-15	NGR-20	NGR-20A (new RP)
KER 1500	100.0	90.0	85.0	80.0	80.0
Stearic acid	2.0	2.0	2.0	2.0	2.0
ZnO	3.0	3.0	3.0	3.0	3.0
CB N-550	60.0	60.0	60.0	60.0	60.0
Oil AN-68	10.0	10.0	10.0	10.0	10.0
TMQ	1.0	1.0	1.0	1.0	1.0
IPPD	0.7	0.7	0.7	0.7	0.7
Thiuram	0.2	0.2	0.2	0.2	0.2
CBS	1.2	1.2	1.2	1.2	1.2
Sulphur	1.8	1.8	1.8	1.8	1.8
NGR	-	20.0	30.0	40.0	40.0
Σ	**179.9**	**189.9**	**194.9**	**199.9**	**199.9**

Vulcametric parameters (ISO 3417, Monsanto 160°C×30 min)

Parameter \ Mix	NGR-0	NGR-10	NGR-15	NGR-20	NGR-20A (new RP)
ts_2	3’9”	2’19”	1’54”	1’48”	1’49”
t_{90}	7’42”	5’26”	5’03”	5’14”	6’02”
ML, dNM	10.2	10.5	20.8	27.2	39.7
MH, dNm	41.3	39.5	80.9	86.4	98.2

Mechanical properties of rubber vulcanizates

Parameter \ Sample	NGR-0	NGR-10	NGR-15	NGR-20	NGR-20A (new RP)
H, °Sh A (ISO 48)	60	64	66	68	66
TS, MPa (ISO 37)	15.2	13.6	12.5	12.7	14.2
E_b, %	475	306	265	260	297
TES, N/mm (ISO 34-1)	44.4	41.3	37.5	35.9	38.2

Compression set and stress relaxation !

Vulcametric parameters and mechanical properties of original NGR composites

		Reference	10 wt% powder	20 wt% powder	30 wt% powder
Cure characteristics, MDR2000E, 160℃, 15 min, 0.5 arc					
ts2	[min]	2.76	2.03	1.71	1.60
t5	[min]	2.57	1.92	1.61	1.51
t50	[min]	3.36	2.39	2.02	1.92
t90	[min]	5.35	3.27	2.86	2.79
ML	[Nm]	0.25	0.26	0.28	0.31
MH	[Nm]	2.48	2.37	2.37	2.36
Hardness, 10 mm test piece, IRHD			**Vulcanized for 2xt_{90} at 160℃**		
Hardness	[°, SN]	72	72	74	74
Tensile properties			**Vulcanized for t_{90} at 160℃**		
Tensile strength at max	[MPa]	19.3	18.8	18.5	17.5
Elongation at break	[%]	234	241	241	227
Modulus 25%	[MPa]	1.9	2.0	2.0	2.0
Modulus 50%	[MPa]	3.6	3.6	3.5	3.5
Modulus 100%	[MPa]	8.1	7.6	7.4	7.3
Modulus 200%	[MPa]	17.3	16.1	15.8	15.6
Tear strength. crescent+nick			**Vulcanized for t_{90} at 160℃**		
Max force	[N]	70	74	71	70
Tear strength	[kN/m]	37	37	37	38

Aplication of NGR in tyre tread mixes

MB series

Components \ Rubber mix	MB-0	MB-1	MB-2
KER 1500	240.0	200.0	200.0
SKD	150.0	125.0	125.0
RSS-1 (masticated)	210.0	175.0	50.0
Stearic acid	12.0	10.0	10.0
ZnO	18.0	15.0	20.0
CB N-330	360.0	300.0	310.0
Processing oil	72.0	60.0	80.0
Cumarone resin	18.0	15.0	15.0
KN resin	18.0	15.0	15.0
IPPD	4.2	3.5	3.5
TMQ	6.0	5.0	5.0
NGR	-	190.0	190.0
CBS	7.2	6.0	6.0
Thiuram	1.2	1.0	-
Sulphur	13.2	11.0	12.0
Σ	**1129.8**	**1131.5**	**1041.5**

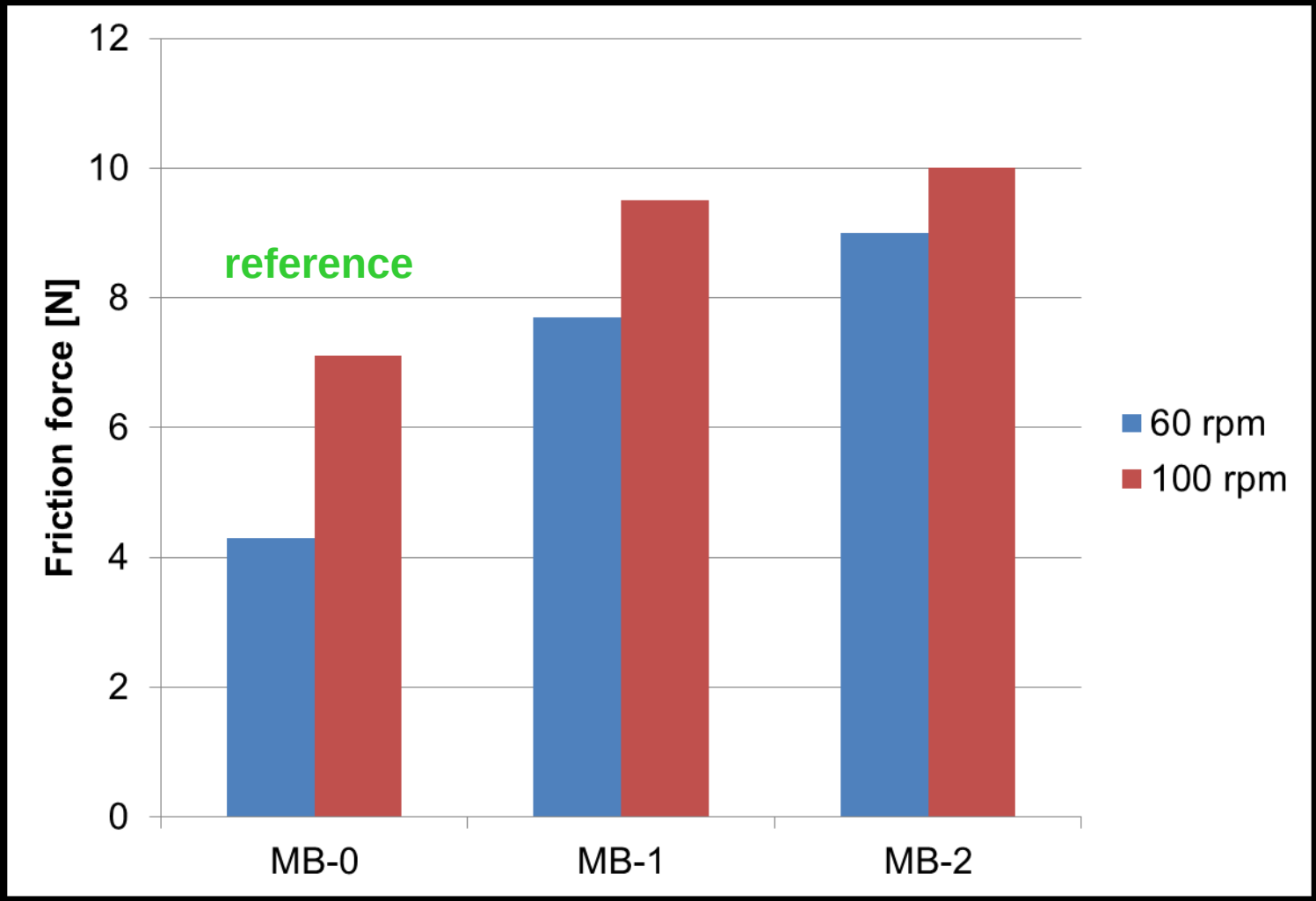
Vulcametric parameters (ISO 3417, Monsanto 160°C×30 min)

Properties \ Rubber mix	MB-0	MB-1	MB-2
M min., dNm	10.5	15.2	17.7
M max., dNm	60.7	65.9	73.7
ΔM, dNm	50.2	50.7	56.0
ts_2, s	170	129	142
t_{90}, s	255	250	353

Mechanical properties and ageing resistance of rubber vulcanizates

Parameter \ Sample	MB-0	MB-1	MB-2
H, °Sh A	65	67	73
TS, MPa	19.8	14.2	12.5
E_b, %	454	353	240
Thermal ageing resistance, 70 °C x 168 hrs: - ΔTS, % - ΔE_b, % - ΔH, °Sh	 +1 -18 +7	 +4 -15 +6	 +7 -23 +8
TES, kN/m	42.7	41.5	32.0
Permanent set (70°C $\times$ 70h), %	25.7	28.4	29.1
Abrasion, mm^3	107	96	124
Density, g/cm^3	1.13	1.14	1.18

Tribological properties



PICTURES OF WARSAW