STUDIES ON EFFECT OF OVERCURING AND AUEING ON THE PROPERTIES OF PETREAD COMPOUNDS

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ABSTRACT

During retreading, the outer surface of the tread is overcured due to extended heating time, to vulcanise the inner layer or to cure the bonding gum, depending upon the method used for retreading. The tread again undergoes thermal ageing during service , due to high heat developed because of flexing and braking effects. This paper describes the effect of overcuring and ageing , done under laboratory conditions , on the properties of retread compounds based on NR, NR /BR ,NR /SBR and SBR /BR blends and attempts to explain the difference in service performance of the compounds under different severity conditions. It was observed that the SBR/BR blend showed better retention in properties while the 100 % NR based compound had higher physical properties and lower heat buildup , after overcuring and ageing. This observation provides an explanation for the better performance of the SBR /BR based retreads under low severity conditions, where thermal ageing is important and that of the NR based compounds under medium / high severity conditions, in which case high inherent sterngth and low heat build up are more important.

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INTRODUCTION

Unlike in many other countries, retreading industry in India is all the more important due to various reasons such as higher price of new tyres, lower retreading charges and fast wearing of the tread portion of the tyre. Both conventional and precured processes are used to retread tyres of common sizes. Performance of retreads depends on many factors such as average load on tyres, speeed of the vehicle, road and vehicle condition, besides environmental factors and driving habits. Research work in the field of conventional retreads were mostly aimed at developing compounds having better shelf life, tackiness and improved mileage (Chakravarthy and Pandit,1973 :).With the advent of precured retreading process, factors such as tackiness and shelf life of the compound and heat buildup of the vulcanizate assumed less importance due to the specific nature of the process. In this case, other parameters such as mileage, wet skid resistance and fuel economy became prominent aspects for compound design (Loh et.al, 1988 :). Whichever be the method adopted for the process, the retread compound undergoes a very long heating cycle during the process of retreading, either to cure the bonding gum (for precured process) or the tread and cushion gum (conventional process). Vulcanised tread undergoes further exposure to temperature due to heat developed during service. Earlier work showed that network structure of the tread undergoes changes during service of the tyre (Russell, 1969; Cunneen and Russell, 1969:). It has been shown that improved performance of the tread compounds could be achieved through network structure modification brought about by the use of a higher dosage of stearic acid (Barnard et.al. 1985; Baker and Wallace,1986;Gelling and Newell,1992:). Attempts to decrease the overall effect of heating cycle by reducing the vulcanisation time have also been reported (Kuriakose et al 1983; Kuriakose,1993:).The present paper describes the effect of overcuring and ageing , done under laboratory conditions, on the physical properties of retread compounds based on natural rubber(NR), polybutadiene rubber (BR) and styrene butadiene rubber (SBR).

EXPERIMENTAL

Compounds baesd on NR,NR/BR,NR/SBR and SBR/BR were prepared on a two roll 30 x 75 cm mixing mill.Formulations of the compounds used are given in Table 1. Cure characteristics of the compounds at 150 ^{o}C were evaluated using a Monsanto Rheometer (Model R 100).Time to attain 90% of the maximum torque was taken as the optimum cure time (t90). Standard test specimens for evaluating the physical properties as per the relevent ASTM/DIN specifications were prepared by moulding the compounds at 150 ^{o}C for their respective optimum cure times in a steam heated hydraulic press.Overcured test samples were prepared by giving 20 minutes additional curing, (t90 + 20) at 150 ^{o}C. Ageing of the test specimens was conducted by placing the samples in an air circulated oven, set at 70 ^{o}C, for 4,8,12 and 16 days.

Table 1. Formulations of compounds

Ingredients	NR(A)	NR/BR(B)	NR/SBR(C)	SBR/BR(D)
Natural rubber(ISNR 5CV)	100	65	65	--
Polybutadiene rubber (Cisamer 1220)	--	35	--	35
Styrene butadiene rubber (Synaprene 1502)	--	--	35	65
Zinc oxide (white seal)	4.0	4.0	4.0	4.0
Stearic acid	2.0	2.0	2.0	2.0
Benzothiazyl-2-sulphene morpholide	0.8	0.8	0.8	0.8
2,2,4-Trimethyl 1,2- dihydro-quinoline (polymerised)	1.0	1.0	1.0	1.0
N-(1,3 dimethylbutyl)-N′phenyl p-phenelene diamine	1.0	1.0	1.0	1.0
ISAF black (N 220)	50	50	50	50
Naphthenic oil	8.0	8.0	8.0	8.0
Sulphur	2.2	2.2	2.2	2.2

RESULTS AND DISCUSSION

Optimum cure time of the compounds and the technological properties of the optimum cured and 20 minutes overcured vulcanisates, before and after ageing at 70 ^{o}C for 16 days, are given in Table 2. Compounds based on 100 % NR and blend of NR and BR have comparable cure times while compounds from NR /SBR and SBR /BR blends showed much longer cure times, due to the slow curing nature of SBR. Tensile strengths of the optimum cured vulcanisates were in the order

Table 2. Properties of compounds / vulcanisates

Properties			Compound No. A (NR)	B (NR/BR)	C (NR/SBR)	D (SBR/BR)
Optimum cure time at 150 C(minutes)			12.50	13.75	18.50	27.50
Tensile strength (MPa)	OPC	Unaged	24.2	23.2	23.8	19.3
		Aged	23.0	21.2	20.9	17.5
	ORC	Unaged	22.4	21.3	23.2	19.4
		Aged	20.6	18.5	18.9	17.0
Tear strength (kN/m)	OPC	Unaged	86.2	83.5	76.4	74.8
		Aged	79.9	76.8	68.6	69.4
	ORC	Unaged	70.5	70.2	78.1	70.3
		Aged	63.2	66.0	64.3	61.9
Hardness (Shore A)	OPC	Unaged	55.0	57.0	59.0	60.0
		Aged	62.0	62.0	66.0	69.0
	ORC	Unaged	56.0	56.0	60.0	62.0
		Aged	60.0	62.0	65.0	70.0
Rebound Resilience (%)	OPC	Unaged	49.0	50.0	47.0	48.0
		Aged	47.5	49.0	46.0	50.0
	ORC	Unaged	46.0	49.0	44.0	52.0
		Aged	43.0	47.5	42.0	50.0
Compression set (%)	OPC	Unaged	39.0	29.0	31.5	33.0
		Aged	19.0	15.5	14.0	11.0
	ORC	Unaged	34.0	27.0	23.5	24.0
		Aged	17.5	15.0	13.0	10.5
Heat build up (ΔT, °C)	OPC	Unaged	39.3	47.8	45.5	48.5
		Aged	34.0	42.8	39.7	42.6
	ORC	Unaged	45.5	46.8	43.4	46.8
		Aged	40.8	42.9	42.6	43.3
Tan δ	OPC	Unaged	0.266	0.250	0.267	0.316
		Aged	0.212	0.221	0.234	0.239
	ORC	Unaged	0.297	0.276	0.293	0.319
		Aged	0.261	0.248	0.281	0.236

OPC -Samples cured for optimum cure time
ORC -Samples overcured for 20 minutes
Aged -Samples aged for 16 days at 70°C

> C > B > D. After ageing for 16 days at 70^{o}C also almost the same order of strength was noticed. For the overcured samples, the initial tensile strength was in the order C >A >B >D . But after ageing for 16 days, vulcanisate A showed maximum value and D had the minimum . The reduction in tensile strength on overcuring and ageing was considerable for compound A,B and C compared to D. This is due to the poor ageing resistance of NR compared to SBR and BR. The combined effects of better oxidation resistance of SBR and self curing nature of BR might have resulted in higher retention in tensile strength of the SBR / BR based compound. In the case of tear strength also, the 100% NR based compound showed higher initial value for the optimum cured vulcanisate , but on overcuring and ageing, this sample showed considerable drop in tear strength. Among the four compounds, the SBR / BR based vulcanisate showed higher hardness. On ageing , as well as on overcuring and ageing, all the four vulcanisates showed an increase in hardness, which was highest in the case of SBR /BR based vulcanisates. This indicated continued crosslinking of the SBR /BR blend under such conditions. In NR based compounds the increase in hardness was less since crosslinking, crosslink modification and chain scission reactions take place simultaneously. This is further evident from the rebound resilience values, which always decreased on ageing, as well as on overcuring and ageing, for the NR based compounds.In the case of SBR /BR compound, there was a small increase in resilience values on ageing as well as on overcuring. This indicated that in NR based compounds, a certain extent of crosslink breakage / crosslink rearrangement / chain scission had taken place, while in SBR /BR compound, further crosslink formation predominated.

The 100% NR based compound showed maximum compression set before and after aging. The overcured and aged samples also showed the same trend. The SBR / BR blend had the lowest set after ageing, which further confirmed the continued crosslinking of this blend. Heat buildup was lower for the 100 % NR based compound before and after ageing. NR/BR and SBR /BR based compounds showed higher heat buildup than NR and NR/SBR based compounds. On overcuring as well as on overcuring and ageing, the heat buildup of 100 % NR compound increased considerably. This is because during overcuring main chain scission, which produces lower molecular weight fractions, predominated over crosslink formation. The tanδ value, which is the ratio of loss modulus to storage modulus, was initially high for compound D, but on ageing as well as on overcuring and ageing, tanδ value of this compound decreased considerably. This may be due to either a decrease in loss modulus or an increase in storage modulus resulting from continued crosslinking of the base polymers.

The change in abrasion loss of the four vulcanisates during ageing of the optimum cured and overcured samples is shown in Figure 1. The NR /BR and SBR /BR blends showed minimum abrasion loss, while the 100 % NR compound showed the maximum value. The NR /SBR blend had abrasion loss in between the above. In all the cases after 8 days ageing, the abrasion loss increased considerably. The effect of overcuring and ageing in reducing the abrasion resistance was higher in NR /SBR blend. Overcuring and ageing had the lowest effect on abrasion loss of NR /BR and SBR /BR blends.

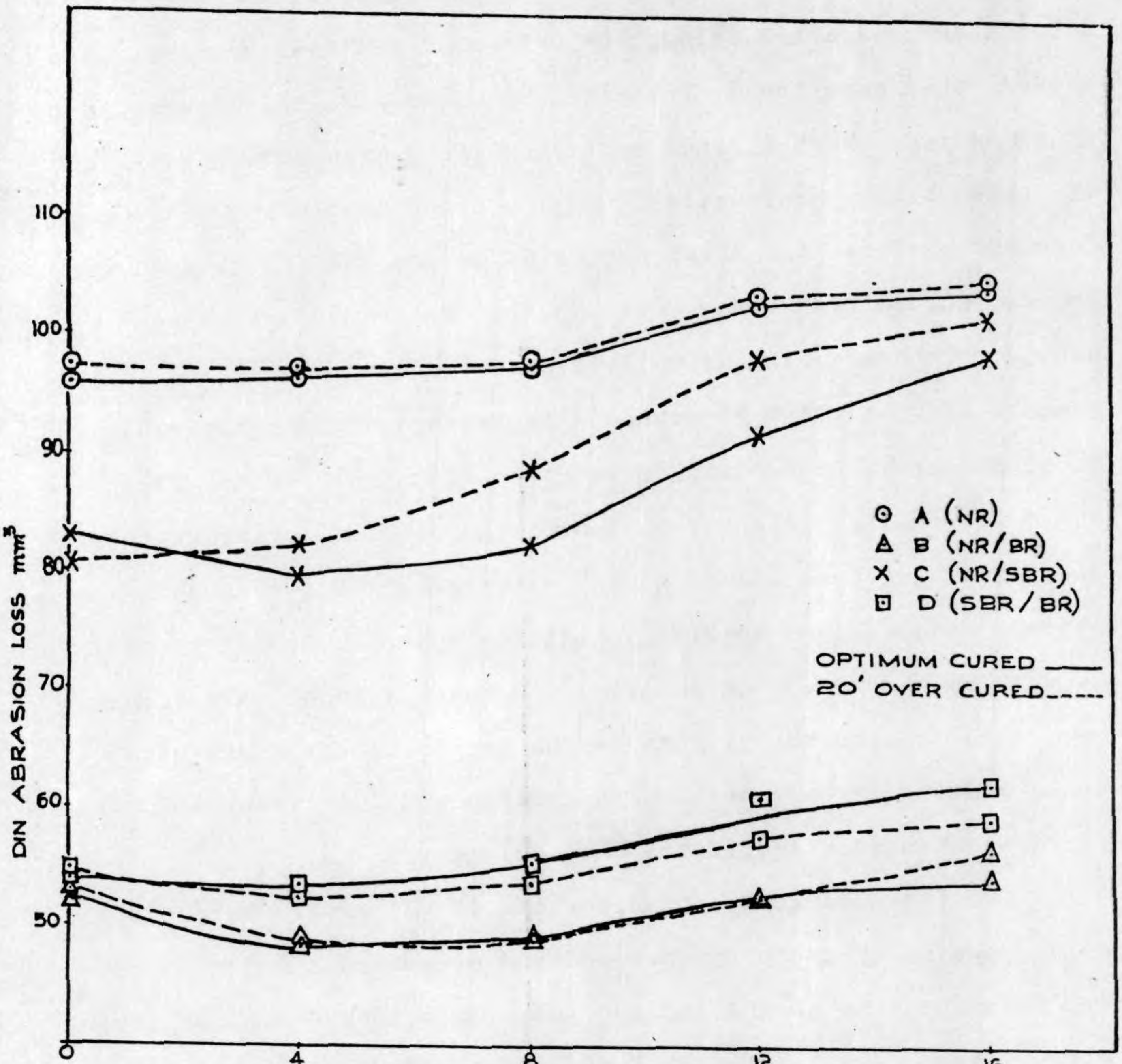

FIGURE 1. EFFECT OF OVERCURING AND AGEING ON DIN ABRASION LOSS

CONCLUSIONS

The present study revealed that overcuring and ageing affect the properties of NR, NR /BR, NR /SBR and SBR /BR based compounds in different ways. The change in properties, especially the abrasion loss, was minimum for the SBR /BR and NR /BR blends. Even though the 100 % NR based compound showed higher drop in properties on overcuring and ageing, it still had higher tensile and tear strength values and lower heat buildup, compared to SBR /BR blend. These observations provided a basic explanation for the service performance of retread compounds based on NR ,NR /BR, NR /SBR and SBR /BR blends, under varying severity conditions. Under low severity conditions where degradation resistance is more important than inherent strength, the SBR /BR compound performed better due to its thermal ageing resistance. Under high severity conditions NR and NR /BR blends performed better due to the inherent strength and low heat buildup characteristics.

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