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USE OF BLENDS OF GLOVE WASTE AND NATURAL RUBBER IN RUBBER PRODUCTS MANUFACTURE

W M G Seneviratne, P H Sarath Kumara and A M C Abeykoon[1]

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ABSTRACT

Substantial amount of defective examination gloves are rejected in glove manufacturing factories in Sri Lanka. These glove rejects cause severe environmental hazards. A series of experiments were therefore carried out to investigate the possibility of recycling these glove rejects and using them as a blend or a filler in the manufacture of rubber products. The results of the experiments indicate that appreciable quantity of recycled glove waste can be blended with NR to give properties comparable to that obtained from NR alone.

Key Words: Glove Waste, Glove crumbs, NR blends, Cure characteristics recycling,reclaiming, Mastication, Peptiser

INTRODUCTION

There has been a tremendous increase in the demand and the production of examination gloves especially due to the spread of the deadly disease, Acquired Immune Deficiency Syndromme (AIDS). The percentage of rejects in the production of examination gloves exceeds 5% and sometimes it reaches as high as 15%. Sri Lanka produces a substantial quantity of examination gloves which shows an upward trend in the current market position in the world. The gloves rejected due to certain production defects have created enormous problems in their disposal. So far there has been no technique developed to solve the environmental pollution problem created by these glove rejects. If these glove rejects can be recycled and used as a raw material in the production of rubber articles, it will solve the pollution problem created by them and also reduce the cost of rubber products as well.

MATERIALS AND METHODS

Pre- milled glove rejects (in crumb form), prepared by passing the glove rejects 10 times through the open two roll mill were blended in three different ways with SLR 20 grade of NR in 4 different proportions. The samples were compounded for 3 minutes in a laboratory Banbury mixer according to a standard tyre tread formula and tested for rheological and physical properties.

[1] Department of Customs. Sri Lanka

For the preparation of blends for set A, crumbs of glove waste were pre-masticated with peptiser, in the two roll mill for 5 minutes at 80 - 90°C before blending it with NR for 4 minutes on the same mill at the same temperature (blending method A). The rubber and the crumbs of glove waste were masticated together, incorporating the peptiser to the mix, for 8 minutes at 80-90 °C on the same two roll mill to obtain blends for set B (blending method B) while the crumbs and rubber were pre- masticated together, without incorporation of the peptiser, for 8 minutes at 80-90 °C on the same mill to form the blends for set C (blending method C).

The properties of the vulcanisate of the blend which was considered to give the best compromise of all the properties were compared with that of the samples prepared with different proportions of tyre buffing.

RESULTS AND DISCUSSION

The results depicted in Table 1 shows that, with increasing levels of glove crumbs, the general trend is to reduce the tensile strength, although blend A_4 has shown to retain a fairly good tensile strength while the modulus, which is an indication of the cross link density, has increased in all the three types of blends with the exception that the modulus is slightly higher in the 5 phr level and even higher than 15phr incorporation of glove crumbs. However, at the corresponding levels of glove crumb incorporation, the highest modulus and, in some cases, tensile strength have been obtained for blends of set A. This suggests that the type A blending method is more efficient and gives more compatible blends of glove wastes with NR.

There was no effect of the method of blending on resilience and hardness. Nevertheless, increasing the levels of glove crumbs in the blend, increases the hardness and reduces the resilience suggesting that glove crumbs in the blend has acted more like a semi-reinforcing filler. It is well known that addition of reinforcing filler into rubber compounds increases the hardness. Irrespective of the method of blending, compression set has increased when the level of glove crumbs was increased in the compound. This once again suggests that the glove crumbs have acted as a filler.

Results presented in table 1 also indicate that increasing the level of glove crumbs, slightly reduces the scorch time, as well as the cure time. This is attributed to the fact that increasing proportions of glove crumbs increase the accelerator/ rubber ratio in the formulation. Further evaluation of results indicate that type B blending method gives comparatively more scorchy compounds.

Rheographs (Fig.1,2,3 & 4) obtained for the compound formulations which appear in table 1, show that they are more close to a plateau type cure except for the blend B_1 and C_3 (Fig.3 & 4). Therefore it is clear that blending of NR with glove crumbs gives reasonably reversion resistant mixes, when compounded according to the chosen tyre tread formulation in this study. It has been found that improved processability and enhanced ageing and abrasion resistance could be obtained in the presence of MBTS/ZDC activated by 3.5 pphr stearic acid in the tread formulation (W.S.E Fernando *et al.* 1984). The rheographs (Fig. 5) obtained for D,E,F,G and H blends (Table 2) prepared according to the blending method A and compounded with this accelerator/activator combination and the results in Table 3 confirm this. Of these compounds, blend F shows the best scorch safety. Apart from the accelerator/ activator system, the only change that has been made in this compound as against compound A_4 is the peptiser level which is 0.12 phr. It is reasonable to justify that glove crumbs peptised with this particular level of peptiser are more compatible with NR so that accelerator/ rubber ratio becomes lower than that of other blends thereby increasing the scorch time of blend F.

The effect of the incorporation of tyre buffing was also investigated in this study for comparison. Preparation of the compounds incorporating tyre buffing was also done in the same way as the compound F was prepared. Vulcanisates of all these three samples show poor tensile strength and abrasion resistance compared to that of sample F (Table 4). The scorch safety of these compounds also is very much less compared to the compound F (Fig. 6).

Table 1. *Cure & physical properties of blends of set A,B and C.*

	C_{NR}	A_1	A_2	A_3	A_4	B_1	B_2	B_3	B_4	C_1	C_2	C_3	C_4
SLR 20	100	95	90	85	80	95	90	85	80	95	90	85	80
Glove crumbs	-	5	10	15	20	5	10	15	20	5	10	15	20
Structol A82'	-	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	-	-	-	-
Black N-330	45	45	45	45	45	45	45	45	45	45	45	45	45
Dutrex R	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5
ZnO	4	4	4	4	4	4	4	4	4	4	4	4	4
Stearic Acid	2	2	2	2	2	2	2	2	2	2	2	2	2
IPPD	1	1	1	1	1	1	1	1	1	1	1	1	1
Sulphur	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2	2.2
Santocure MOR''	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Modulus @ 100% elongation (MPa)	2.9	3.4	2.8	3.2	3.6	3.1	2.7	2.8	3.1	3.3	2.7	3.1	3.2
Compression set (%)	9.6	9.6	10.9	11.2	9.9	9.7	10.8	11.5	11.2	9.5	12.5	12.9	16.5
t_5 min	4.5	4.8	4.0	4.0	3.4	5.0	3.7	3.6	3.6	4.7	4.6	4.5	3.6
t_{95} min	12.8	12.3	12.0	8.5	8.3	13.5	9.3	9.0	8.5	13.3	12.5	9.8	9.5
Tensile strength (MPa)	30.7	30.0	27.0	25.4	27.8	29.9	28.1	26.4	24.2	28.9	27.0	25.4	25.8
Elongation @ break (%)	550	540	530	480	510	500	530	450	460	550	580	500	520
Hardness (IRHD)	56	58	59	66	63	58	57	63	65	57	57	58	63
Resilience (%)	60	55	55	50	51	56	59	52	51	56	59	54	51
Abrasion loss (mm^3/500 rev)	10.5	21.7	24.0	47.9	16.9	18.3	22.0	64.2	68.4	24.8	32.5	55.4	78.8
After ageing @ 70°C for 72 hours in													
Modulus (MPa)	3.9	4.1	3.7	4.6	3.9	3.3	3.3	4.3	4.1	3.7	3.6	3.7	3.9
Tensile strength (MPa)	29.9	29.1	26.0	24.9	25	29	26.9	24.6	20.3	28.1	26.1	21.9	20.8

Table 2. *Variation of cure properties on peptiser level*

Ingredient	D	E	F	G	H
NR (SLR 20)	80	80	80	80	80
Glove Crumbs	20	20	200	20	20
Structol A 82	0.03	0.06	0.12	0.18	0.24
Black N-330	45	45	45	45	45
Dutrex R	7.5	7.5	7.5	7.5	7.5
Zno	4	4	4	4	4
Stearic Acid	3.5	3.5	3.5	3.5	3.5
IPPD	1	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5	2.5
MBTS	1	1	1	1	1
ZDC	0.2	0.2	0.2	0.2	0.2
Cure properties					
Compound Viscosity					
[ML (1+4) @ 100°C]	37	39	36	-	-
t_5 min	3.6	3.7	4.2	3.3	3.8
t_{95} min	6.25	6	6.5	6.25	6.75

Table 3. *Physical properties and ageing properties of blend F*

Property	Unaged	Aged for 72 hours @ 70°C
Modulus @ 100% elongation (MPa)	3.20	3.4
Tensile strength (Mpa)	26.58	24.46
Elongation at break (%)	500	440
Hardness (IRHD)	66	-
Resilience (%)	50	-
Abrasion loss (mm^3/500 rev.)	12.3	-
Compression set (%)	10.5	-

Table 4. *Formulation and effect of incorporation of tyre buffing on cure & physical properties*

Ingredient	F	P	Q	R
NR (SLR 20)	80	95	90	80
Glove Crumbs	20	-	-	-
Black N-330	45	45	45	45
Tyre buffing	-	5	10	20
Structol A 82	0.12	0.12	0.12	0.12
Dutrex R	7.5	7.5	7.5	7.5
Zno	4	4	4	4
Stearic Acid	3.5	3.5	3.5	3.5
IPPD	1	1	1	1
Sulphur	2.5	2.5	2.5	2.5
MBTS	1	1	1	1
ZDC	0.2	0.2	0.2	0.2
Cure & Physical Properties				
t_5 min.	4.2	2.6	2.5	2.5
t_{90} min.	6.5	9.5	12.5	11.5
Tensile strength (MPa)	26.6	20.6	19.4	17.5
Hardness (IRHD)	66	56	59	64
Resilience (%)	50	56	53	51
Abrasion loss (mm^3/500 rev.)	12.3	22.3	27.5	37
Compression set (%)	10.5	9.5	35.4	37

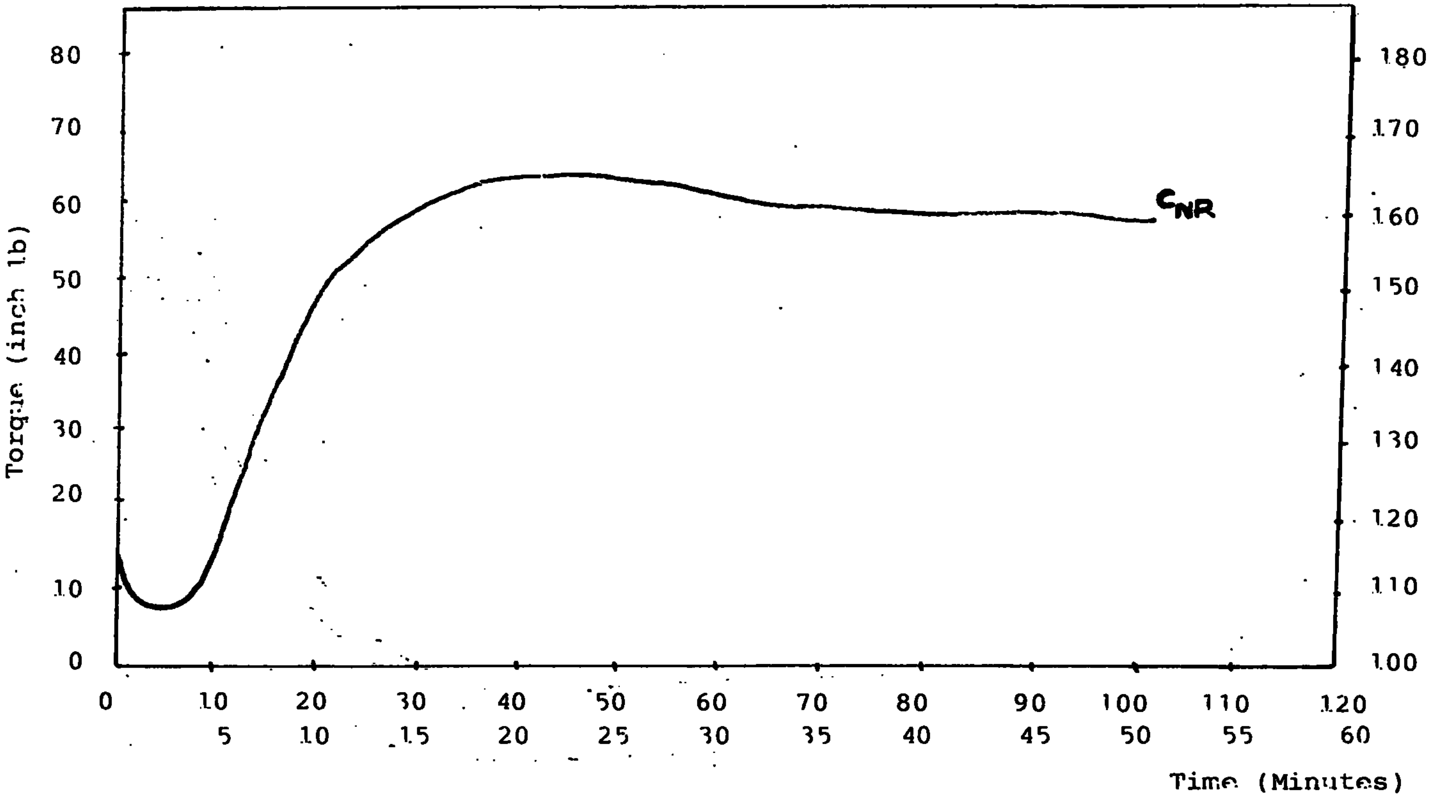

Fig. 1. Monsanto rheograph of C_{NR} compounds
Chart motor - 60, Range sel 100, Temp. 140 C

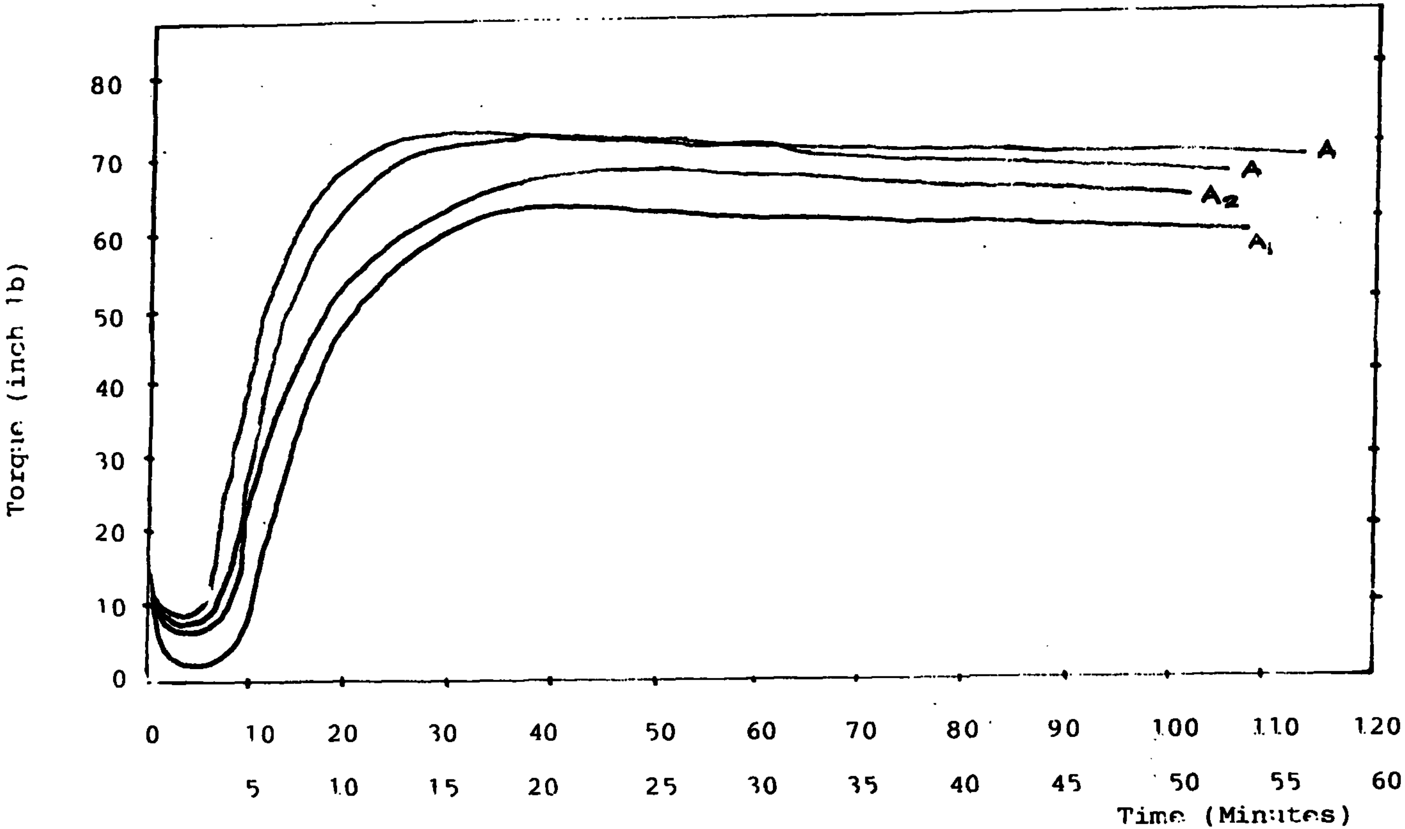

Fig. 2. Monsanto rheographs of set A compounds
Chart motor - 60, Range sel. 100, Temp. 140 C

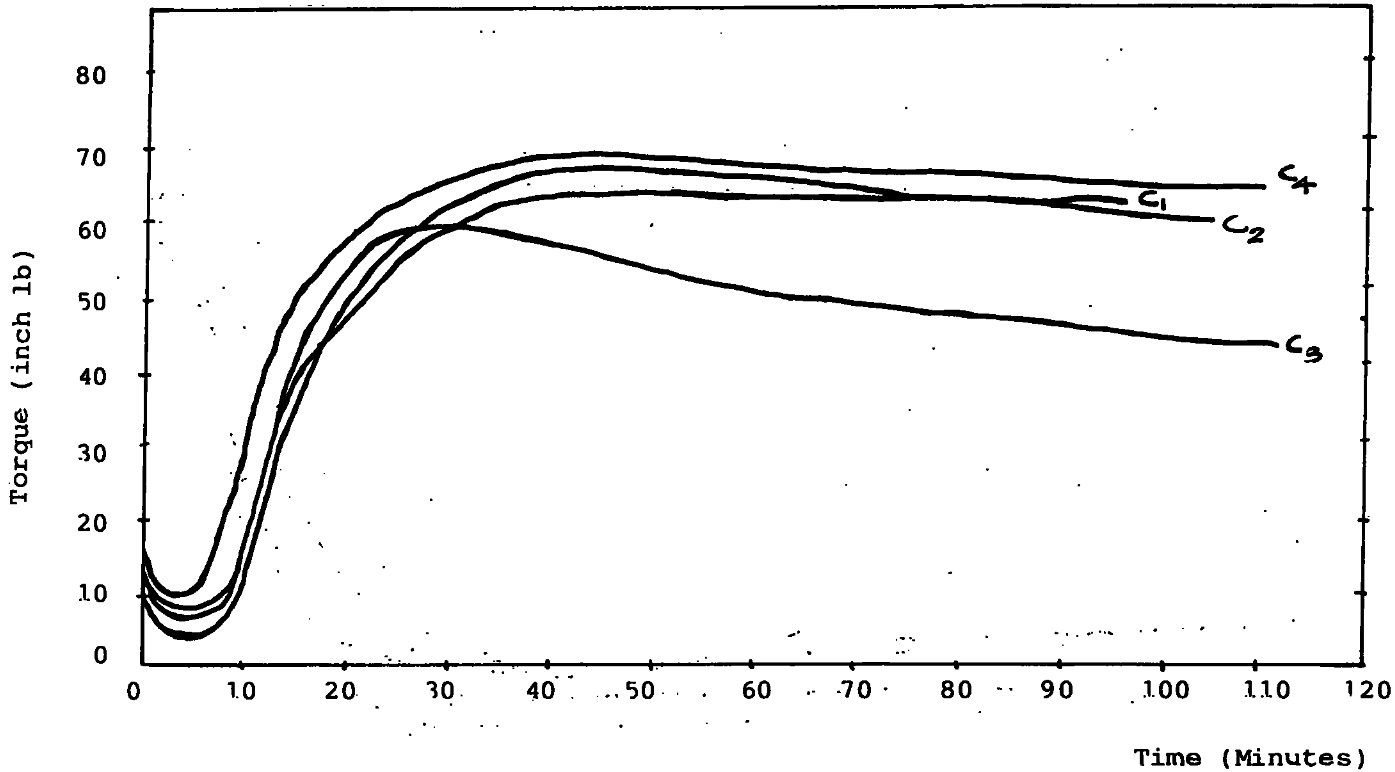

Fig. 4. Monsanto rheographs of set C compounds
Chart motor - 60, Range sel 100, Temp. 140° C

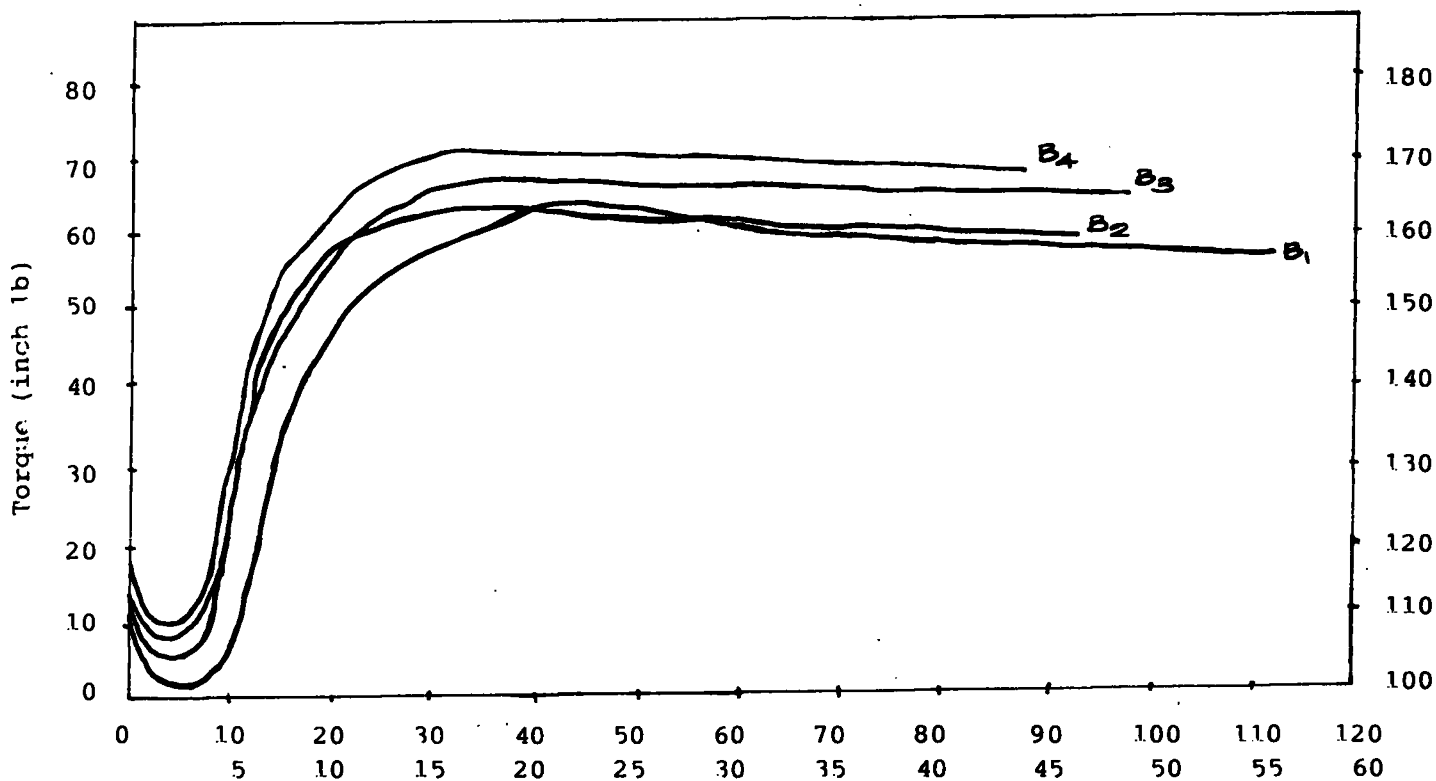

Fig. 3. Monsanto rheograph of set B compounds
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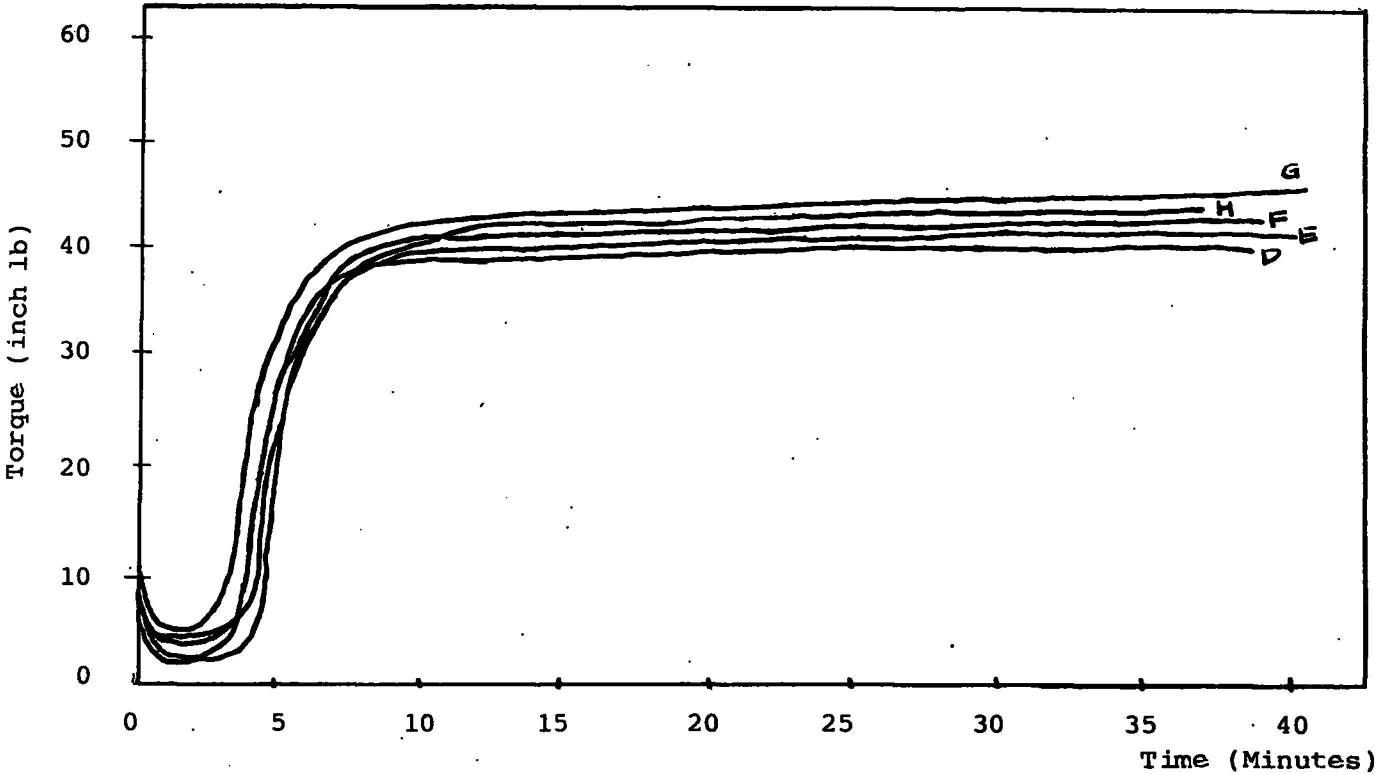

Fig. 5. Monsanto rheographs of D, E, F, G and H samples
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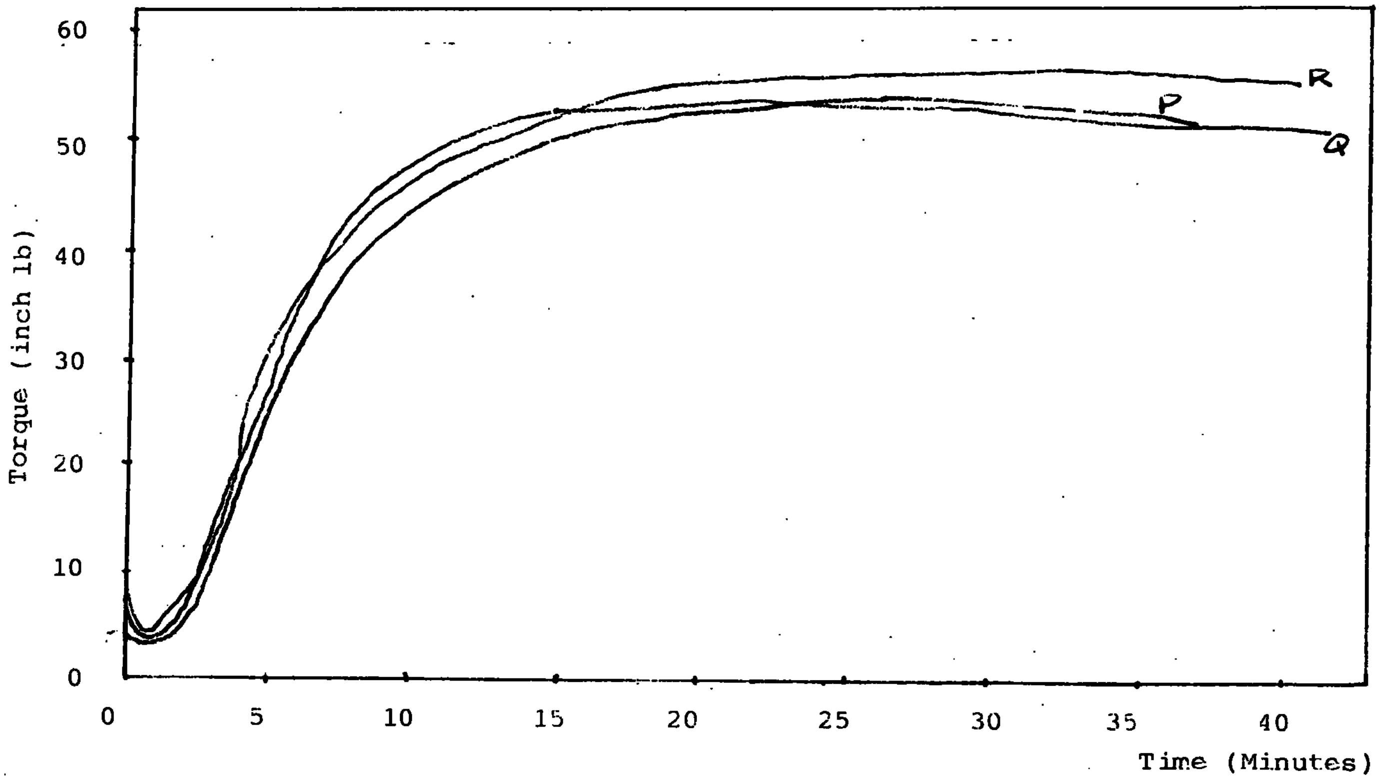

Fig. 6. Monsanto rheographs of P, Q and R samples
Chart motor - 60, Range sel. 100, Temp. 140 C

CONCLUSION

Rejected examination glove waste can be reclaimed by milling them in a two roll mill which is a much less complicated procedure than reclaiming of other rubber products such as tyres, since these gloves do not contain materials like steel bead wires and reinforcing or non - reinforcing fillers except in very negligible quantities. Mastication of glove waste with peptiser prior to blending them with NR gives more compatible blends of glove waste with NR. The glove crumbs can be blended with NR upto 20 phr level.

Improved processability, enhanced ageing and abrasion resistance of the vulcanisates of the blends of glove crumbs with NR could be obtained with the modified curing system with MBTS/ZDC accelerator combination activated by 3.5 pphr of stearic acid.

As no black fillers are added in the manufacture of examination gloves, the glove crumbs blended with NR could also be used in the manufacture of some coloured rubber products.

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