Improvement of Retread Blends Composed of Natural Rubber(Nr) And Polybutadiene Rubber(Br)

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Abstract:

Tread of the tire is occasionally dislocated due to sever running on the road. Retreading is necessary in this case, and retread rubber compounds are made from a blend of NR/BR by using several additives like Activator Accelerator such as Zn salts of high molecular fatty acid (LAUREX) & homogenizing agents (Struktol-MS) produced by **Uniroyal**, Delayed Action Accelerators type Thiazoles and Sulfenamides such as (AMAX & MORFAX) produced by **Vanderbilt.**. insoluble sulfur, Pine Tar and others.

An infinite number of rubber recipes are possible in blends. The best properties of each components are selected to achieve a blend having a wide spectrum of properties (recommended for retreading compounds) which is superior to that of the individual component and also economically competitive. The effect of using different levels(0.6,0.65,0.85pphr) of accelerators such as (AMAX & MORFAX) are enhancing the phsico-mechanical properties(tensile strength, modulus,shore hardness and abrasion resistance index), and the Activators Accelerator (LAUREX & Struktol-MS) in the rubber compounds are evaluated in such away that LAUREX is more affective in recipe no.3(2.5pphr) than the same level of Struktol-MS, so that it is making use of preparing suitable retreading rubber compound

Introduction:

The retreading of tires is nearly as old as the history of tire itself. For many years, retreaded tires were often perceived to be an inferior or second class product. It is recommended to develop a retreaded tires which provides improved mileage and often the possibility of the first class substitute of a new tire**[1].** The required properties of a hot retreaded rubber compound is good **abrasion resistance**, **moderate physico-mechanical properties and improved flex and cut growth resistance[٢,3].** These compounds are generally prepared from a blend of Natural Rubber and Poly-Butadiene Rubber**.**. However dispersion of carbon black and additives posses a serious threat with this blend in normal or ordinary open mixing mill, which results in a non uniform product**[4,5,6,]**. **In present work the objective is to develop a suitable rubber composition which will give a uniform product with compromised properties leading to improved mileage for the retreading compounds.**

Experimental:

Materials used are Natural Rubber(SMR20) of 85pphr (part per hundred rubber) by weight with 15pphr of(BR) Poly-Butadiene Rubber and other ingredients which were formulated according to our experience and simulated the later studies**.** Formulations are given by tables(1&2).

Table-1, Formulations (part per hundred rubber) of Compound Used

Ingredients	RECIPE CODE Recip.No.1	Recip. No.2	Recip. No.3
SMR20	85	85	85
BR(Cis,97%)	15	15	15
Zinc Oxide	4	4	4
Stearic Acid	2	2	2
Naphthenic Oil	4	4	4
TDQ	0.5	0.5	0.5
Microcrystallene Wax	0.5	0.5	0.5
HAF Black	55	55	55
Pine Tar	2	2	2
Struktol MS Flake	2.5	--	--
LAUREX	--	--	2.5
Insoluble Sulfur	1.5	1.5	1.5
Sulfur	1.2	1.2	1.2
CBS	0.65	0.65	0.65

Table-2, Formulations (part per hundred rubber) of Compound Used.

Ingredients	RECIPE CODE Reci. No.4	Reci. No.5	Reci. No.6	Reci. No.7	Reci. No.8	Reci. No.9
SMR20	85	85	85	85	85	85
BR(Cis,97%)	15	15	15	15	15	15
Zinc Oxide	4	4	4	4	4	4
Stearic Acid	2	2	2	2	2	2
Naphthenic Oil	4	4	4	4	4	4
TDQ	0.5	0.5	0.5	0.5	0.5	0.5
Microcrystallene Wax	0.5	0.5	0.5	0.5	0.5	0.5
HAF Black	55	55	55	55	55	55
Pine Tar	2	2	2	2	2	2
LAUREX	2.5	2.5	2.5	2.5	2.5	2.5
Insoluble Sulfur	1.5	1.5	1.5	1.5	1.5	1.5
Sulfur	1.2	1.2	1.2	1.2	1.2	1.2
MORFAX	Nil	Nil	Nil	0.60	0.65	0.85
AMAX	0.60	0.65	0.85	Nil	Nil	Nil

Compounds were prepared in two stages on mixing mill(33x15 cm) at a friction ratio of 1:1.25 maintained at 70±5°C temperature. After retreading rubber compound had been properly mixed on the mill and shaped into sheets, the sheets were left for a certain time before vulcanized in clean polished molds in a vulcanizing press. Curing characteristics at 150°C were measured on Monsanto Rheometer ODR-2000 with accordance to ASTM D2084-99**.** The ODR apparatus is usually used for testing the curing characteristics of compounded rubber samples. It has a heated and seal die cavity that contains an oscillating disk. The disk moves through a small arc that exerts a shear strain on the compound as it cures. The sample changes in stiffness as the chemical process proceeds and the resultant torque on the oscillating disk is measured with strain gauges and transferred to a recording system. This can take the form of a visual display, printed record and monitored comparison with computer assistance.

Physico-mechanical testing involves measurement and evaluation of Physico-mechanical properties. Physico-mechanical properties were measured on the cured test specimens as per ASTM standard methods. These are viz., Tensile Strength, Modulus and Elongation were tested with accordance to ASTM D412-88. These tests are very important for predicting the tensile properties, the mileage of the rubber compound and low temperature performance**.** Shore Hardness was tested with accordance to ASTM D1415-89,which provides good traction and good handling characteristics for the tire tread. Abrasion resistance index with accordance to ASTM D2084-99**,** which is a measure of tread wearing. ASTM-Designation D-624 was the guide for laboratory procedures followed in determining the property of Tear Strength. One of the Standard test for cut growth is the Ross flexing machine, ASTM D1052, which is a measure of fatigue resistance.

RESULTS AND DISCUSSION:

As it was clarified the compound formulations containing various additives are presented in table-1, the formulations are based on the ratio of NR/BR,85/15 with constant loading of carbon black HAF (55pphr). The varying parameters are only the Activators Accelerator Strucktol MS flake and Zn salt of fatty acids(LAUREX).

1. EFFECT OF LAUREX & STRUCKTOL MS :

The formulation of different compounds containing Zn salt of high fatty acids(LAUREX) (Recipe-3) and (Struktol-MS), (Recipe-1) are presented. The Rheometric and Physico-mechanical properties are presented in table-3. Between strucktol MS flake and Zn salt of fatty acids(LAUREX), it is observed that (LAUREX) is better than(Struktol-MS), in processing as indicated by its safer scorch time and a slightly delayed optimum cure time (as recommended by retread rubber compound) **[7,8].**

Table-3, Rheometric and Physico-mechanical Properties

Property Tested	RECIPE CODE		
	Recip. No.1	Recip. No.2	Recip. No.3
Scorch Time(t_2),Min.	3.38	2.87	3.60
Optimum Cure Time(t_{90}),Min.	14.00	15.05	16.28
Tensile Strength(MPa)	19.5	20.0	20.3
Modulus at 300%Elong. (MPa)	8.8	9.7	10.7
Elongation at Ultimate Break(%)	500	480	490
Tear Strength N/m	61.8	28	56
Shore Hardness	59	60	59
Abrasion Resistance Index	78	112	125
Cut Growth Resistance (Initial cut upto 12mm) K Cycles	60	50	70

2. Physico-Mechanical Properties Of The Vulcanizates :

Tensile properties of the vulcanizates cured at 150°C at their optimum cure time are summarized in table-3. The over all results indicated that (LAUREX) ensures better resistance towards abrasion, while tear and cut growth are maintained at their higher values. The reason for its high tear and improved tread wear (abrasion) resistance may be due to its higher modulus and out standing tensile properties [9,10].

3. Effect Of (Amax & Morfax) In Nr/Br Compounds:

Recipes formulations containing Accelerators such as AMAX(N-Oxydiethylene benzothiazole-2 Sulfenaminde) and MORFAX(4-Morpholinyl-2 benzothiazole disulfide) are illustrated in table-2. Rheometric properties clearly indicated by means of the recipe(4,5,6,7,8,9), where AMAX vulcanizates in recipe (4,5,6) provide a good balance properties like cut growth, tear and abrasion resistance, but as soon as the level of AMAX increased from 0.60pphr to 0.85pphr, cut growth resistance is decreased. This may be due to the high modulus in compound(recipe 5&6) [11,12,13]. MORFAX containing vulcanizates in recipe (7,8,9) also gives a longer optimum cure time but inferior tensile properties than AMAX. The other properties like tread wear resistant, tear strength etc., is also inferior to that of AMAX based compound. Table- 4 and graphs(1,2,3,4,5,6,7)had been showed all the phyico-mechanical properties on attached appendix.

4. Other Observation:

The data represented in this paper is based on compounds containing LAUREX, Pin Tar, insoluble sulfur in NR/BR blends. LAUREX is very easy to handle and is completely stable in storage. It is also reduces viscosity than ZnO alone and expected to be consumed less power during mixing and calendaring the recipe. It doesn't bloom on extruded products (for retread) up to certain percentage. Pin Tar provides tack and excellent flex to the vulcanizates. Improved filler dispersion of carbon black in blends is achieved by the additives which are subsequently confirmed by tensile studies of vulcanizates as well rheometric studies of the compound.

Coclusions:

Use of the accelerator AMAX in place of the accelerator MORFAX considerably improved tear resistance, abrasion resistance, tensile strength and modulus of the vulcanizates.

The level of AMAX is extremely important in order to have a good balance of properties on NR/BR blends. Use of increased accelerator level (AMAX) i.e. 0.85pphr adversely affects the cut growth resistance.

Use of Activators Accelerator Zn salt of high fatty acid LAUREX is found to be best choice in order to achieve a delayed optimum cure time, good tear resistance and outstanding abrasion resistance properties.

(LAUREX) is better in processing, safer in scorch time and slightly delayed optimum cure time which fitted the recommendation of retreading compounds or vulcanizates.

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Appendix

Table-4, Rheometric and Physico-mechanical Properties

Property Tested	RECIPE CODE					
	Reci. No.4	Reci. No.5	Reci. No.6	Reci. No.7	Reci. No.8	Reci. No.9
Scorch Time(t_2),Min.	5.50	5.55	5.04	5.90	5.54	5.66
Optimum Cure Time(t_{90}),Min.	15.80	14.70	12.90	20.15	19.24	17.38
Tensile Strength(MPa)	21.0	21.7	22.4	18.6	19.8	20.6
Modulus at 300%Elong. (MPa)	11.4	12.2	13.2	10.5	11.0	11.4
Elongation at Ultimate Break(%)	470	460	450	450	440	430
Tear Strength N/m	74.5	75.5	75.5	57.8	56.9	59.8
Shore Hardness	60	61	64	59	60	60
Abrasion Resistance Index	158	158	175	122	145	155
Cut Growth Resistance (Initial cut upto 12mm) K Cycles	55	58	40	50	46	46

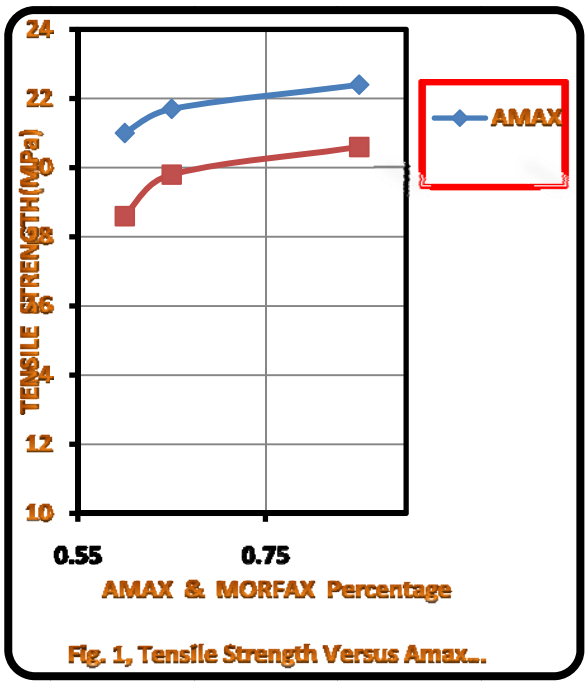

Fig. 1, Tensile Strength Versus Amax...

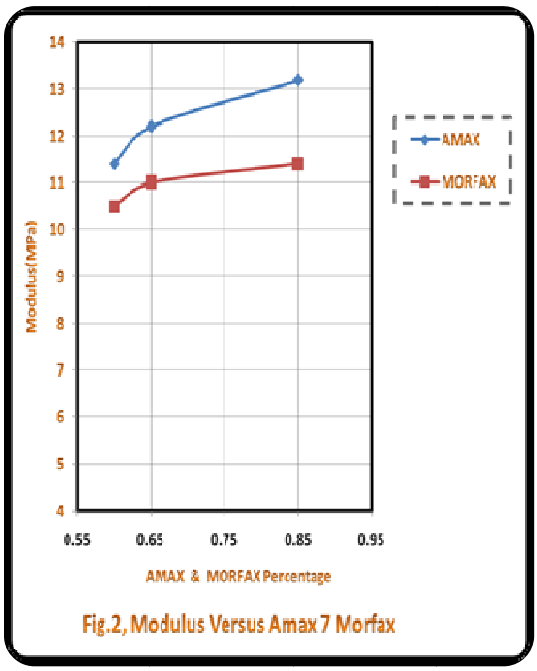

Fig.2, Modulus Versus Amax 7 Morfax

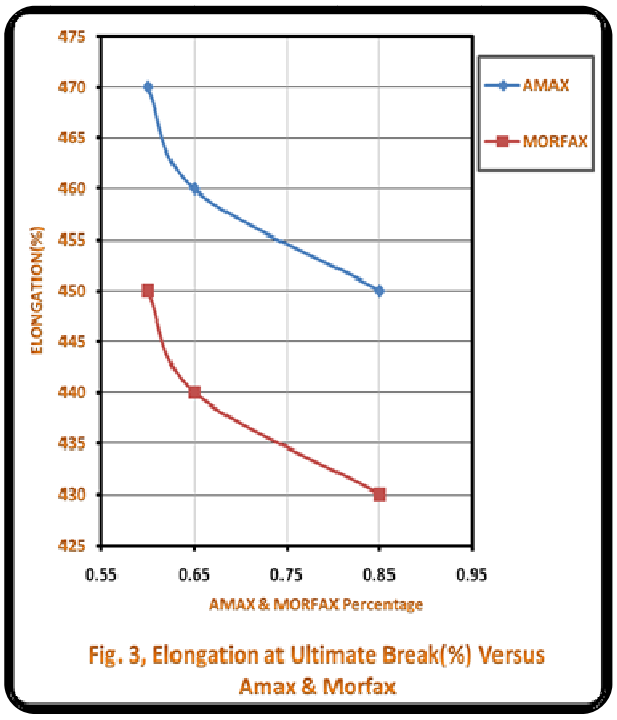

Fig. 3, Elongation at Ultimate Break(%) Versus Amax & Morfax

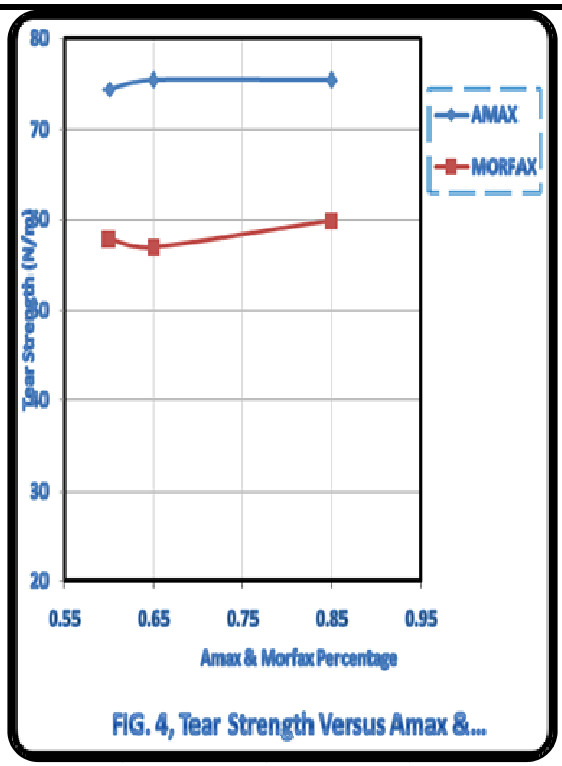

FIG. 4, Tear Strength Versus Amax &...

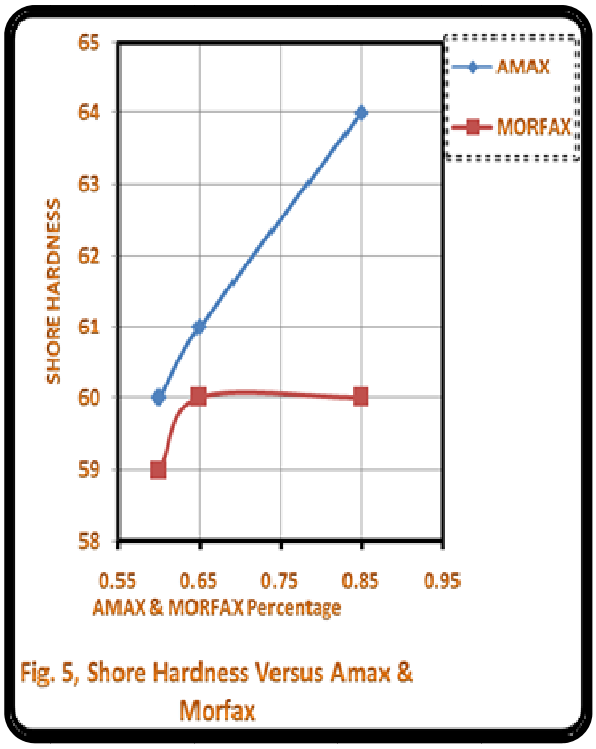

Fig. 5, Shore Hardness Versus Amax & Morfax

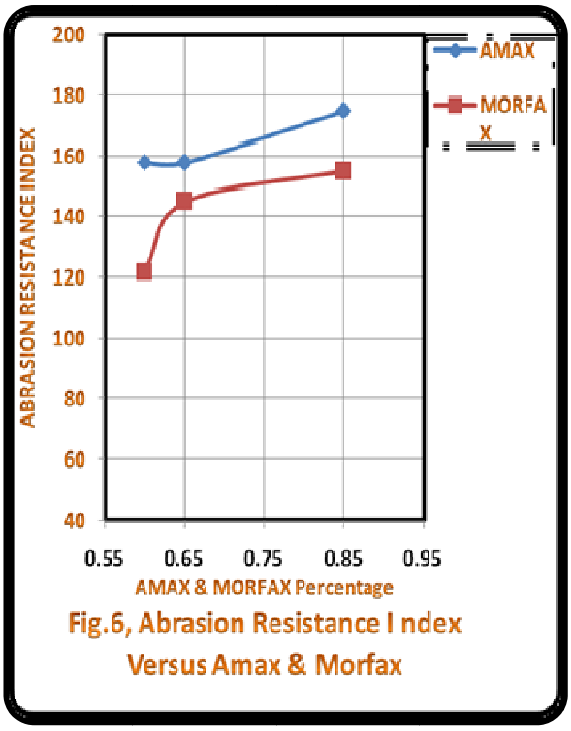

Fig.6, Abrasion Resistance I ndex Versus Amax & Morfax

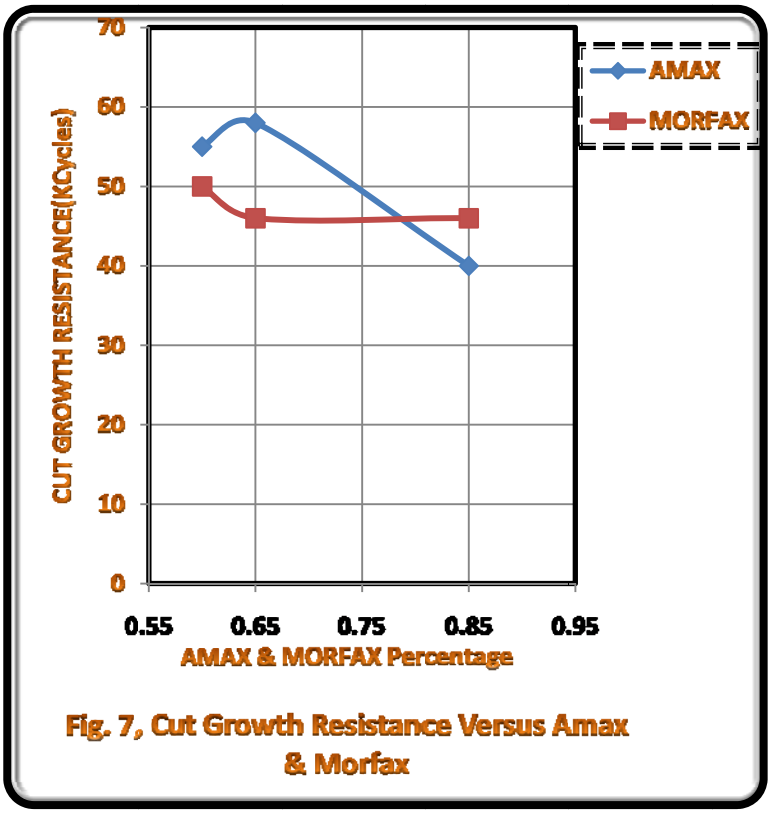

Fig. 7, Cut Growth Resistance Versus Amax & Morfax

الخـلاصـــة:

بين حين واخر تظهر مشكلة انخلاع الجزء الملامس للارض (المداس) عن جسم الاطار الرئيسي بسبب ظروف الخدمة القاسية على الطريق.وحتى تتم اعادته للخدمة لابد من اعادة اكساء الاطار retread من جديد.

عادة ما تستخدم عجينة المطاط الطبيعيNR مع عجينة مطاط البيوتداينBR في اعادة أكساء الجزء الملامس للأرض للإطار بعد تعرضه للانخلاع وتستخدم ايضا العديد من المواد الكيمياوية المضافة مثل منشطات المعجلات كأملاح الخارصين ذات الأحماض الشحمية عالية الوزن الجزيئي مثل الـ (LAUREX) وعوامل المجانسة مثل الـ (Struktol-MS) والمنتجين من قبل شركة Uniroyal للكيمياويات. وتستخدم أيضا المعجلات ذات التأثير المؤجل وهي من أنواع الثايزولات والسولفين امايد مثل الـ (AMAX & MORFAX) والمنتجين من قبل شركة Vanderbilt لتكنولوجيا المطاط والإطار. كما تستخدم الكبريت غير الذائبinsoluble sulfur والى ما هناك من المواد الإضافية الأخرى اللازمة لعجينة المطاط الخاص باعادة اكساء الإطار المخلوع.

يمكن الحصول على عدد كبير من العجنات المطاطية حسب تغيير نسب الخلطات، وقد تم اختيار العجنات او الخلطات التي تزودنا بأفضل طيف من الخواص الملائمة لمطاط اعادة الاكساء وذات جدوى اقتصادية. تمت دراسة تأثير المعجلات (AMAX & MORFAX) المذكورة في أعلاه بعد استخدامها بنسب مختلفة (0.6,0.65,0.85pphr) وتحليلها بما يفيد في تحسين الخواص الفيزيوميكانيكية مثل(قوة الشد، ومعامل المرونة، وصلادة شور، ودليل مقاومة الحك). كما اظهر البحث ان استخدام محفزات المعجلات (LAUREX & Struktol-MS) قد بين ان الـ LAUREX في العجنة الثالثة وبدرجة التحميل (2.5pphr) اكثرفعالية من الـ Struktol-MSبنفس درجة التحميل مما يساعد في تحضير مركب مطاطي يلبي استخدامات إعادة أكساء الجزء الملامس للارضretread للإطار.