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ARTICLE

Development of NR/SBR Based Rubber Compounds with Low Hysteresis and High Durability for Transmission V-Belts Applications

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ABSTRACT

Power transmission by the belts is defined as, the transmission of power by a moving pulley to one or more driven machines through a flexible non-metallic member. There are different types of V-belts available, and Transmission Belts are one of them. Transmission V-Belt is the first invented non-metallic belts. Nowadays V-belts are used in various conditions, especially high-power transmission. These V-belts are finding their importance in many heavy industries. One of the good features of this type belt is no slippage occurs during the run. NR and SBR have used elastomers and can act as a base rubber material for this purpose. This study includes the compounding improvement for transmission V-Belts with NR and SBR rubber blends. There were so many numbers of failures in different ways during the initial research. Product failure methods and effect analysis (PFMA) have done by testing the belts multiple times and it has found that the major factors for the failure and less durability were excessive heat build-up (HBU) and poor fatigue resistance, poor crack initiation and growth, the resistance of the materials. So, initially reduction of HBU has successfully made in many steps by studying the properties of various compounds with a different type of fillers combinations, rubber combinations, curing systems variations etc. We have also improved the adhesion strength with cord and fabrics. Initially, we have taken one compound showing better properties in all aspects and have taken Belt Trial. And after some more improvement, we have found a compound showing better properties in all the cases than first trial and regular trials. By using that compound, we have developed Belts and showing better durability than earlier experiments and regular production.

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1. Introduction

In the last few decades, the popularity of rubber belts or rubber v-belts for power transmission is increasing widely in original equipment manufacturer (OEM) and also in the aftermarket. Power transmission by belts is described as the transmission of power from the prime mover to one or more driven machines by means of a flexible non-metallic member. That non-metallic member is generally a number of layers of various rubber compounds that are reinforced with cords and textiles. Basically, transmission belts shall consist of a combination of fabric, cord and elastomeric compounds, the whole being bonded together in a uniform manner and shaped in accordance with the best manufacturing practice.

As the market demand is increasing extensively, so many research and development works on belt design and compound design are also increasing. Not only the compound designing but also the tension member is important for better performance. Now a day's polyester, aramid and glass cord fibres are getting much importance for those purpose. There are so many layers in the belt (Figure 2). It is very difficult to identify the influences in the belt performance. That's why initially we have focused on rubber compound.Few major technical characteristics of the rubber compounds of the V-Belts are - (1) it should have good mechanical strength, (2) Least heat generation or heat build-up, (3) Good heat resistance, (4) Excellent resistance to flex cracking.

There are a wide variety of factors encountered in various types of belts responsible for belt life and abnormal failure. If we can increase the heat resistance or decreasing the HBU during applications, life can be improved. Another main factor is fatigue life improvement. According to Mars *et al.* [1], there are so many factors that affect the fatigue crack nucleation and growth process in rubber.

The rubber compound should have very good fatigue life as well as low heat build-up. Therefore, NR and SBR are widely used as raw rubber, for these applications. Because NR has very good mechanical strength and good tackiness and in the other hand SBR also having good mechanical strength, very good crack initiation resistant property. One of the most important points to note here is the adhesion problem between different rubber layers, between cord and rubber and between fabric and rubber layers. Especially for belts adhesion between different layers should be very good.

In the literature, there are some solutions when we

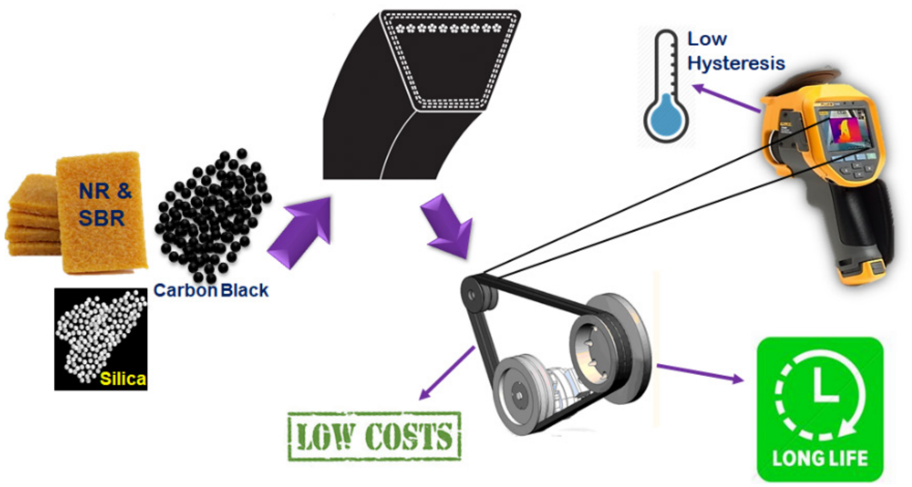


Figure 1. Power transmission

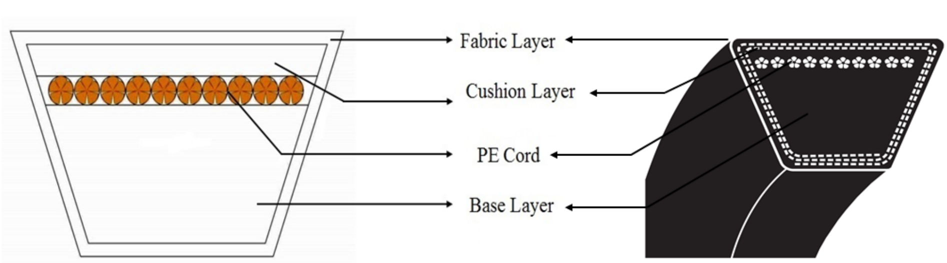


Figure 2. Cross-section of a Transmission V-Belt

looked into material studies, especially for V-belts.Among of those studies, the various mechanical properties of V Belt rubber compounds and compared with some others rubber products. In this work, we can get a brief study of NR based compound for V-belt and tyre. In another research work, the effect of temperature on fatigue life of V-ribbed serpentine belts has reported [2]. Fatigue crack growth model has proposed by them by finite element analysis. In 1996, Anil K. Bhowmick and Kamal K. Kar studied the hysteresis loss in filled rubber vulcanizates and its relationship with heat generation in Natural Rubber and SBR [3]. Sundararanman*et al.*studied the fatigue crack growth analysis of V-ribbed belts using finite element analysis in 2007 [4]. Wongwitthayakool*et al.* made a review on prediction of heat build-up behaviour on carbon black filled rubber [5]. Jun Liu *et al.*made a Numerical simulation and experimental verification of heat buildup for rubber compounds in 2015 [6]. G. Song and K. Chandrashekhara made a review on cord reinforcement properties of V-Belts with thermal effects and published some hyper-elastic models and Finite element analysis in 2005 [7]. Milan S. Banic and S. Stamenkovi predicted the heat generation behaviour of rubber due to hysteresis losses and low rubber thermal conductivity [8]. C. Rajesh and G. Unnikrishnan studied cure characteristics and mechanical properties of short nylon fibre-reinforced elastomers but with NBR [9]. In 2010 V. Le Saux and Y. Marco studied an energetic criterion for the fatigue of rubbers: an approach based on a heat build-up protocol and μ-tomography measurements [10]. A. Andriyana*et al.* studied on prediction of fatigue life improvement in natural rubber using configurationally stress in 2007 [11].

2. Experimental

2.1 Materials

Natural Rubber (ISNR Grade) which has used in all blend groups, has a Mooney Viscosity [80±5 ML(1+4) at 100ºC]. SBR (Non Staining Emulsion Grade) also used in all blend groups, has a Mooney Viscosity [55±5 ML(1+4) at 100ºC], bound styrene content 23.3%, procured from Kumho Petrochemical. Polybutadiene Rubber (PBR) used in all blend groups, has a Mooney Viscosity [45±5 ML(1+4) at 100ºC], Cis-1,4 content 96%, procured from Reliance Industries Limited. Three different types of carbon black we have used procured from PCBL, as a reinforcing filler in all the formulations. Others chemical were procured from regular sources, like Anti-oxidants, Vulcanising Accelerators (CBS, MBTS, TMTD) from NOCIL.

Table 1. Formulations of the Compounds in phr*

Ingredients	C-CB						C-RR				
	1	2	3	4	5	6	1	2	3	4	5
NR	100	0	55	55	55	55	45	40	35	35	30
SBR	0	100	45	45	45	45	55	60	60	55	55
BR	0						0	0	5	10	15
Silica	5.0						15				
HAF Black	20	20	25	25	30	30	25				
FEF Black	50	50	50	45	40	35	35				
SRF Black	15	15	15	20	20	25	20				
Resin A	3.0										
Sulphur	2.7										
CBS	2.5										
TMTD	0.2										

Table 2. Formulations of the Compounds in phr*

Ingredients	C-CS							CF		
	1	2	3	4	5	6	7	1	2	3
NR	35.0									
SBR	55.0									
BR	10.0									
Silica	15.0									
HAF Black	25.0									
FEF Black	35.0									
SRF Black	20.0									
Resin A	3.0							2.0		
Resin B	0.0							2.0		
Sulphur	3.5	2.7	3.5	2.7	2.7	2.7	2.7	2.7	2.7	2.7
CBS	2.4	0.0	0.0	2.5	2.3	1.8	1.3	1.3	1.3	1.3
MBTS	0.0	2.4	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TMTD	0.2	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2

*phr - Parts per hundred grams of rubber

2.2 Preparation of the Compounds

All the blend compounds were mixed in lab size two roll mills (Bharaj Rubber Processing Machineries, Thane, India). We have followed the following sequence for all laboratory batches (Figure 3). The milling temperature was 100ºC and time for 20 mins. Mixing for bulk batches for the final product was done in an internal mixer (Shaw K4 intermixes).

2.3 Testing Procedure

2.3.1 Vulcanizate Property Study

Rheometric behaviour of all rubber blends was performed in Ektrontek EKT2005 Rheometer, China at 160°C for 15 mins according to the method described in ASTM D5289. Mooney Scorch values (125°C at 30 mins) were determined in Mooney Viscometer (MV2000 Mooney Viscometer), Alpha Technologies, Hudson, Ohio, USA. The testing procedure was followed according to the method described in ASTM 1646.

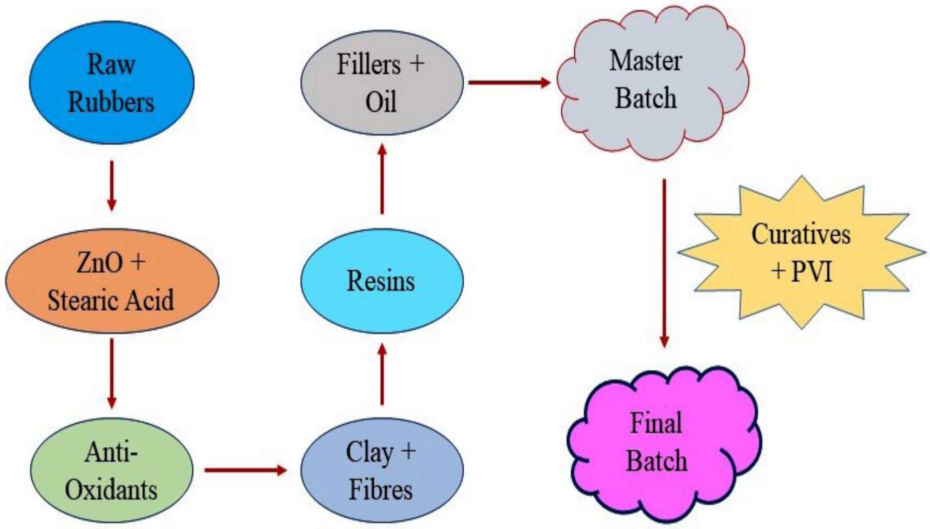


Figure 3. Scheme of preparation of blend compounds

2.3.2 Preparation of Samples and Mechanical Properties Study

The compounds were formed in sheets and were moulded in compression moulding machine (Santosh Industries, India) at 160°C for 15 minutes at 1000 psi pressure according to their respective curing time as per the ASTM standards. The hardness of each sample was measured by IRHD Durometer (Wallace Cogenix Hardness Tester) as per ASTM D 1415 test method. Average of three observations has taken. To study the different type of physical properties of the samples like Tensile strength, Elongation at break and Modulus, we have cut the Dumbbell sample according to ASTM D-412 from 2.5 ± 0.5 mm sheath and and same for Tear Strength according to ASTM D-624 and tested in Universal Testing Machine (Instron 3366). All the samples were aged in an aging oven (70°C for 70 hrs) and tested after that.

2.3.3 Heat Build-up (HBU) Measurement

Heat Buildup of the samples was tested as per ASTM D-623 in Goodrich Flexometer, operated under constant frequency 30 Hz, stress 2 kPa and stroke 1800 cycles/min.

2.3.4 Fatigue Property Study

To determine the dynamic properties of the rubber sample DeMattia Fatigue test are widely followed in industries. Respective samples were prepared by compression moulding and tested according to ASTM D-813 specifications by using DeMattiaFlexometer. Usually, the length of propagation of the crack was measured for every 30 min. An average of three samples was taken for the account.

2.3.5 Characterizations of the Samples

DMA was done in Metravib DMA-50 to measure the tanδ (loss factor) of the rubber compounds in temperature sweep at a constant frequency 1 Hz in tension mode having 2 mm thickness, 5 mm width and 25 mm length of the samples.

Thermal stability of the compounds was characterized by Thermal Gravimetric Analyser (Shimadzu TGA-50) at a temperature range of ambient temperature to +650ºC at N_2 atmosphere at 10 K/min heating rate.

3. Results and Discussions

3.1 Compound Series: 1

The following Table 3 shows the mechanical properties of the samples before and after aging. If tensile strength is the only concern, then CCB02 (100% SBR) would be the best one. But, 100 % SBR compound will be more costly than regular compound, that's why we are not considering that compound for the next step. And, according to our application, all mechanical properties are highly considered; in that case, CCB04 is the best compound.

In the other hand we can see that, Compression Set% also least for the compound CCB04 than other compounds. We have considered this compound for the reference compound in the next trials.

3.2 Compound Series: 2

In this trial, we have taken the Carbon Black percentages of the compound CCB04, NR and SBR blend compound (HAF: FEF: SRF = 25:45:20) which

Table 3. Mechanical properties of the compounds before and after aging

Sample Name	Condition	T.S. in MPa	Retention of TS in %	E B %	Modulus in MPa			Hardness (IRHD)
					50%	100%	200%	
C-CB01	Initial	12.4	**92**	262	2.7	4.9	9.9	80
	Aging	11.4		194	3.5	6.5	11.5	80
C-CB02	Initial	14.8	**100**	242	3.1	6.0	12.9	81
	Aging	14.8		187	4.0	7.9	-	84
C-CB03	Initial	13.8	**99**	254	3.1	5.7	11.8	82
	Aging	13.6		182	4.2	8.0	-	83
C-CB04	Initial	14	**97**	273	2.6	5.1	11.0	80
	Aging	13.6		197	3.6	7.1	8.6	81
C-CB05	Initial	13.5	**93**	240	3.0	5.8	12.3	81
	Aging	12.6		156	4.2	8.3	-	84
C-CB06	Initial	13.3	**96**	237	3.0	5.6	11.8	84
	Aging	12.8		169	4.1	7.8	-	83

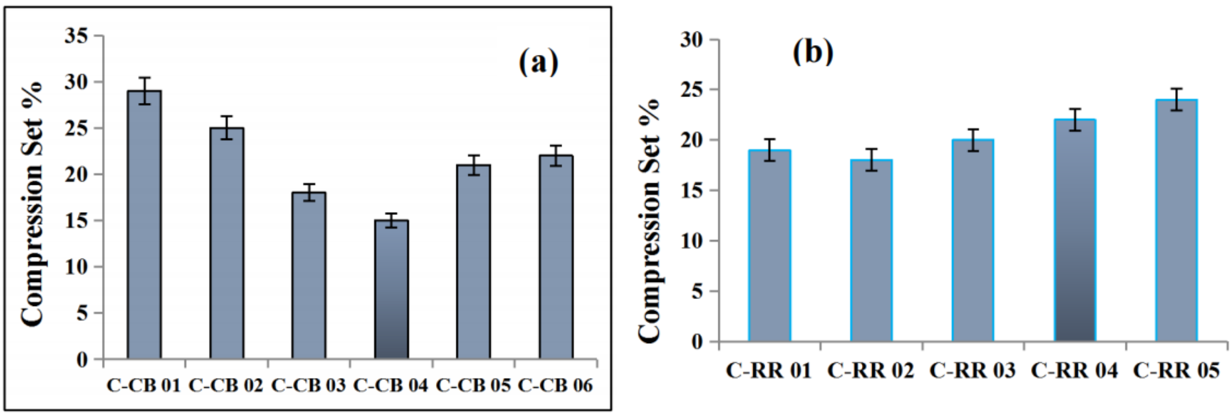


Figure 4. Compression Set % of the Compounds (a) and (b)

shows very good physical properties. We had replaced some amount of carbon black by Silica to improve the mechanical properties and also NR by Polybutadiene (BR) rubber to reduce Heat Buildup. From the Table 4, we can see that compound CRR04 is showing very good mechanical properties as well as Hardness also. In the case of compression set%, it is good for other compounds (Figure 4b). As mechanical properties are prime concern that's why compound CRR04 we have taken for reference compound in the next step.

3.3 Compound Series: 3

3.3.1 Compound Series: 3.a

In this trial, we have taken the Raw Rubber percentages of the compound CRR04 of NR-SBR-BR blend compound with the filler combination of HAF: FEF: SRF = 25:35:20 of earlier best combination (CCB04). Here, for two compounds CCS01 and CCS02, we have used the CV System and for C-CS03 and C-CS04 SEV System. For the first two compounds we have used CBS and TMTD combination and for the second two compounds, we have used MBTS and TMTD combination.

We can see that CCS01 and CCS04 showing good tensile strength and hardness but Elongation at Break is very less than CCS04 for CCS01. And also, we can see that Compression Set % is also higher for CCS01. That's why we are not considering that compound CCS01. For further confirmation, we have studied the Heat Build-up study which is discussed later.

Table 4. Mechanicalproperties of the compounds before and after aging

Sample Name	Condition	TS in MPa	Retention of TS in %	E B %	Modulus in MPa			Hardness (IRHD)
					50%	100%	200%	
C-RR01	Initial	14.7	101	269	2.7	5.2	11.5	82
	Aging	14.8		216	3.5	6.6	14.0	81
C-RR02	Initial	12.8	119	209	3.1	5.8	11.6	83
	Aging	15.2		225	3.6	6.8	14.0	80
C- RR03	Initial	14.7	97	213	3.3	6.3	13.2	82
	Aging	14.3		188	3.7	7.7	15.0	83
C-RR04	Initial	14.7	98	217	3.5	6.8	13.9	83
	Aging	14.4		160	4.1	8.2	-	83
C-RR05	Initial	14.5	97	239	3.0	5.8	12.4	82
	Aging	14.1		178	4.1	8.1	-	82

Table 5. Mechanicalproperties of the compounds before and after aging

Sample Name	Condition	TSin MPa	Retention of TS in %	E B %	Modulus in MPa			Hardness (IRHD)
					50%	100%	200%	
C-CS01	Initial	14.5	100	173	4.3	8.6	0.0	88
	Aging	14.4		145	5.0	10.1	0.0	87
C-CS02	Initial	14.9	94	216	3.5	6.8	14.1	86
	Aging	14.0		173	4.0	7.6	0.0	85
C-CS03	Initial	12.5	100	152	4.0	7.9	0.0	84
	Aging	12.7		143	4.0	8.4	0.0	82
C-CS04	Initial	14.0	103	246	3.1	5.8	12.4	86
	Aging	14.5		214	3.5	6.8	13.8	86

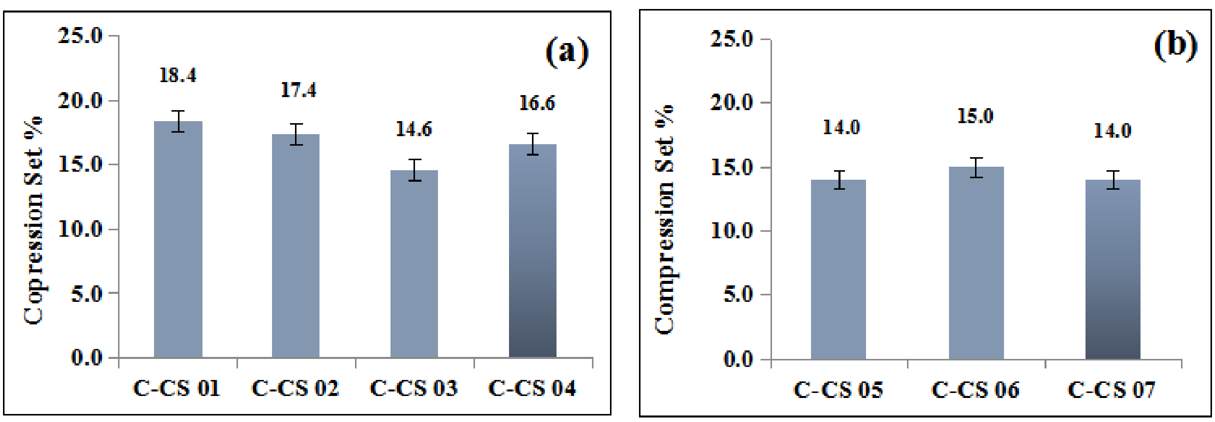


Figure 5. Compression Set % of the Compounds (a) and (b)

3.3.2 Compound Series: 3.b

After studying the curing system variation batches, we fixed the Rubber, Filler and Curing System combination of compound C-CS04, because this compound meeting our required properties and also showing the least amount of Heat Buildup. Next trial, we have tried to observe the effect of the accelerator in different amounts. That's why we have taken three different amounts of CBS and by keeping the Sulfur and TMTD amount the same.

Table 6. Mechanical Properties of the compounds before and after Aging

Sample Name	Condition	TS in MPa	Retention of TS (%)	E B %	Modulus in MPa			Hardness (IRHD)
					50%	100%	200%	
C-CS05	Initial	13.1	**92**	209	3.4	6.0	11.8	85
	Aging	12.0		200	3.4	7.0	0.0	82
C-CS06	Initial	13.4	**94**	218	3.3	5.8	12.0	86
	Aging	12.6		210	4.0	7.5	0.0	85
C-CS07	Initial	13.8	**94**	264	3.0	5.1	10.8	87
	Aging	13.1		250	3.7	6.9	0.0	84

3.4 Compound Series: 4

In this trial, we have tried to increase the adhesion strength than regular compound and decreasing the Heat Buildup. We have optimized two different approaches - a) Using two different types of accelerator and variation in amount, i.e. Conventional and Semi-efficient, b) after optimization of the system (CV or SEV) we have tried to study the effect of the amount of accelerator with a constant amount of Sulphur and TMTD.

We have seen that SEV system with CBS+TMTD combination presenting least heat build-up and for next trials CCS07 is presenting least Heat Buildup than other compounds. That's why we have taken the curing system of the CCS07 for final trial batches.

Here we have taken two different of Resins to increase the adhesion strength between the compound and fabric and compound and cord. Previously we have used only one resin. And another variation we have made in these trials, we have varied the amount of Silica for increasing the strength and decreasing the Heat Buildup and we have decreased the total Carbon black amount from 80 to 75 PHR.

From the Table 7, we can see that CF01 and CF02 compounds are showing good Tensile Strength but CF03 showing less. As a reason may be, higher filler agglomeration presents in CF03 compound because of a higher amount of Silica. And it easily visible that, as

Table 7. Mechanical Properties of the compounds before and after Aging

Sample Name	Condition	TSin MPa	Retention of TS in %	E B %	Modulus in MPa			Hardness (IRHD)
					50%	100%	200%	
CF01	Initial	14.4	87	285	2.7	4.8	10.6	82
	Aging	12.5		188	3.6	7.1	-	82
CF02	Initial	14.7	88	277	2.9	5.3	11.3	83
	Aging	12.9		168	3.9	7.6	-	83
CF03	Initial	13.2	94	263	2.9	5.1	10.6	85
	Aging	12.4		176	3.9	7.3	-	86

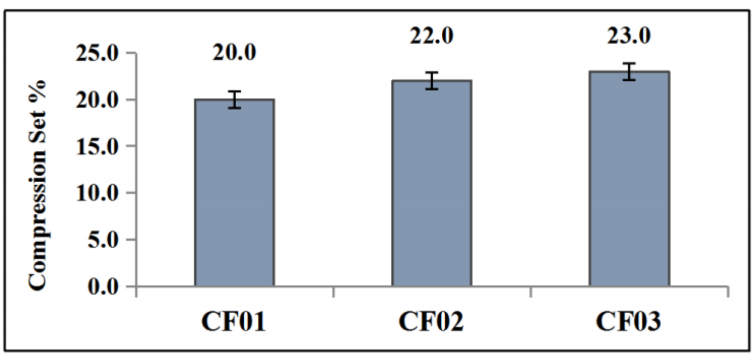


Figure 6. Compression Set % of the Compounds

the amount of Silica increased, Elongation at Break also decreased.

In the other hand Modulus (50%, 100%, and 200%) and Hardness (IRHD) is not varied significantly with respect to the other properties.

After studying the above three compounds we can observe that with the respect of Mechanical properties CF01 compound is showing the best properties. And if see Compression Set % and Abrasion Resistance, that also best for CF01 compound. And the other properties like Heat Build-up and Fatigue resistance, have discussed later.

3.5 Heat Build Up Results

We have studied Heat Build-up (ΔT in ºC) thoroughly for all the compounds results are as follows.

Table 8. Compound Series #1 (C-CB)

	0 Min	5 Min	10 Min	15 Min	20 Min	25 Min
C-CB 01	52	19	23	24	25	25
C-CB 02	52	21	24	25	26	26
C-CB 03	52	19	23	24	25	26
C-CB 04	52	18	22	23	23	**24**
C-CB 05	52	21	26	26	27	27
C-CB 06	52	21	26	27	27	27

Table 9. Compound Series #2 (C-RR)

	0 Min	5 Min	10 Min	15 Min	20 Min	25 Min
C-RR 01	52	15	21	21	22	24
C-RR 02	52	16	20	21	22	24
C-RR 03	52	19	23	25	25	25
C-RR 04	52	17	21	22	22	**22**
C-RR 05	52	21	24	24	24	24

Table 10. Compound Series #3 (C-CS)

	0 Min	5 Min	10 Min	15 Min	20 Min	25 Min
C-CS 01	52	19	22	24	24	24
C-CS 02	52	19	23	24	24	24
C-CS 03	52	19	23	24	24	24
C-CS 04	52	19	21	22	22	**22**
C-CS 05	52	19	22	23	24	24
C-CS 06	52	19	22	24	24	24
C-CS 07	52	18	19	19	21	**22**

Table 11. Compound Series #4 (CF)

	0 Min	5 Min	10 Min	15 Min	20 Min	25 Min
CF 01	52	19	20	20	22	**22**
CF 02	52	19	21	23	24	24
CF 03	52	19	23	24	24	25

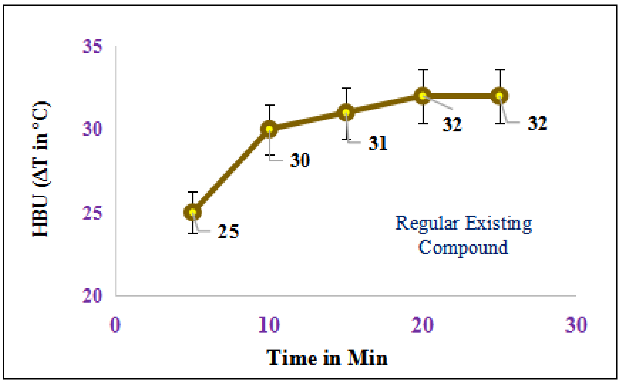


Figure 7. Heat Buildup of Regular Existing CompoundHeat Buildup decrease in percentage (%) than Regular Existing Compounds.

Table 12. Decreasing of HBUin % (ΔT at 25 min)

C-CB01	22	*C-RR01*	25	*C-CS01*	25	*C-CF01*	**31.3**
C-CB02	19	*C- RR02*	25	*C-CS02*	25	*C-CF02*	25
C-CB03	19	*C-RR03*	22	*C-CS03*	25	*C-CF03*	22
C-CB04	**25**	*C-RR04*	**31**	*C-CS04*	**31.3**	-	-
C-CB05	16	*C-RR05*	25	*C-CS05*	25	-	-
C-CB06	16	-	-	*C-CS06*	25	-	-
-	-	-	-	*C-CS07*	**31.3**	-	-

3.6 Adhesion Test Results

3.6.1 Fabric Adhesion Strength (180º Pell Test) [ASTM D3330]

Table 13. Fabric Adhesion Test Results

	Regular Compound	CF01	CF02	CF03
Strength in Lbf/in	11.21	17.12	14.80	19.27
Change in % w.r.t Regular Compound		**53**	**32**	**72**

3.6.2 Cord Adhesion Strength

Table 14. Cord Adhesion Test Results

	Regular Compound	CF01	CF02	CF03
Strength in kgf	4.37	5.76	3.42	4.39
Change in % w.r.t Regular Compound		**32**	**-22**	**0**

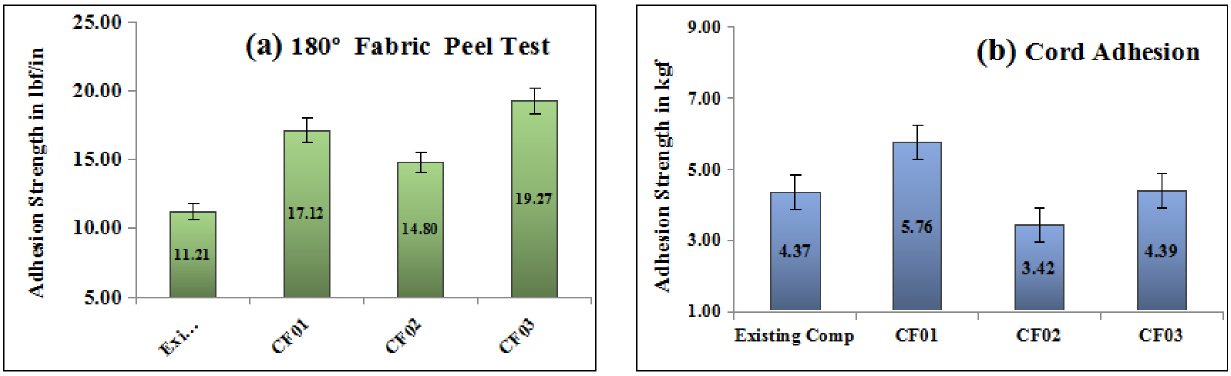


Figure 8. Adhesion Strength Comparisons of the Compounds (a) Fabric and (b) Cord

3.7 DeMattia Results

The DeMattia Fatigue Test results are as follows.

From the DeMattia Fatigue Study, we can see that the Regular Compound showing Fatigue Life of about 190 Kilocycles and from the first trial batch Compound C-CB04 showing highest Life of about 263 Kilocycles. In the next trials, we can see that life is improved than earlier batches and it has achieved up to 272 Kilocycles. After final trials, we can see that the maximum Fatigue life we have achieved 270 to 272 Kilocycles and whereas Regular Compound life is 190 Kilocycles. That means we have increased the Fatigue life up to 40% than Regular Compound.

3.8 DMA Results

From the Figure 20, we can see that tan δ value is

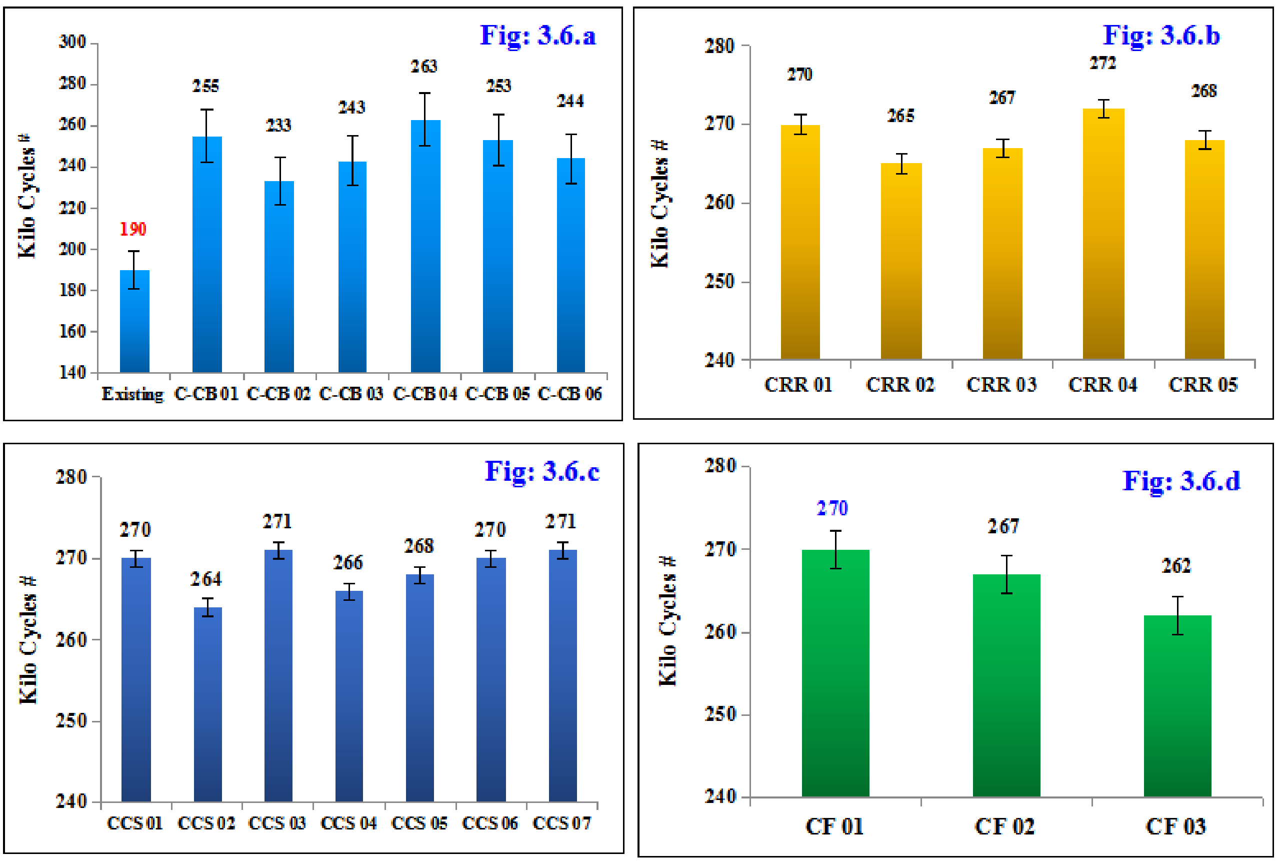
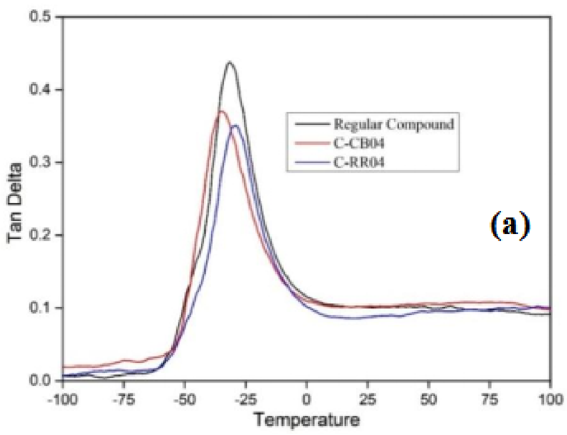


Figure 9. DeMattia Fatigue-Life of Compounds



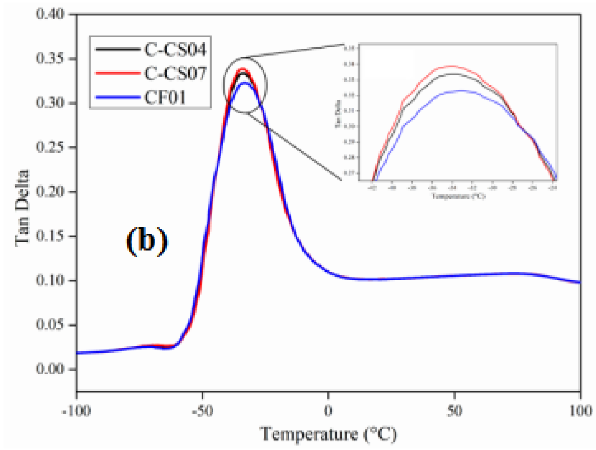


Figure 20. DMA Study of New compounds and Regular compounds

shifting downwards from Regular Compound > C-CB04 > C-RR04 and for Figure 20 we can see the same trend, C-CS04 > C-CS07 > CF01. That means Tanδ value decreasing and as the Tanδ value will be less Heat Buildup also will be less, which is in confirmation with the Heat Buildup data discussed earlier. In the above table, we have calculated the change tan δ with respect to Regular compound in percentage and we have decreased the tan δ value up to 14% to 24% less than Regular Compound.

Table 15. DMA Test Results Summary

Samples	Tan δ_{max}	Temperature	Change of Tan δ_{max} w.r.t. Regular Compound
Regular Compound	0.438	-31.68	-
C-CB 04	0.375	-34.84	14 %
C-RR 04	0.351	-29.04	20 %
C-CS 04	0.336	-33.78	23 %
C-CS 07	0.330	-34.14	24 %
CF 01	0.331	-33.25	24 %

3.9 Comparison: Regular and New Trials Bulk Batch Compound

Table 16. Comparisons of Different Properties

Parameters	Regular	New trial - I	New trial - II
Tear Strength in N/mm	54.69	58.84	61.9
Heat Buildup at 25 min	84	76	74
DeMattia Fatigue inKilo Cycles	190	258	270

3.10 TGA Results: Bulk Batch Compounds

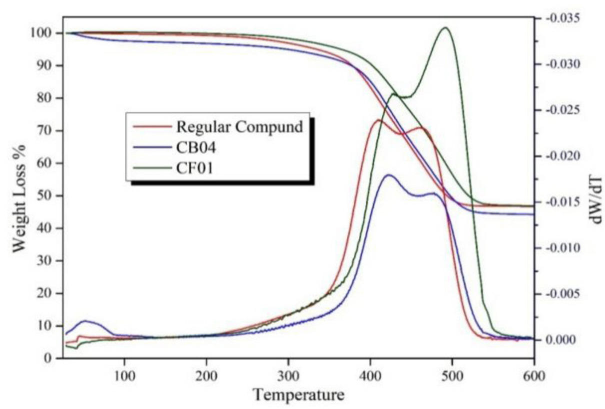


Figure 21. TGA Study of New compound and Regular compound

Table 17. TGA Results Summary

Compounds	Degradation Temperature	Change of Temperature w.r.t. Regular Compound
Regular	409°C and 464°C	-
New Trial - I (CB04)	425°C and 477°C	4 % and 3 %
New Trial - I (CF01)	439°C and 492°C	7 % and 6 %

From the above Figure 21 and Table we can see that we have got two degradation temperatures for all three compounds at a different temperature. We have also calculated the improvement or change in degradation temperature for New Trial compounds, and it is showing almost 6-7 % improvement.

3.11 Belt Physical Properties

From the below table, it is observed that our New Trials are showing good single cord adhesion strength than regular belts. Elongation at 160 Kgf, is also less than regular belts. The Breaking strength of the belt per each cord is higher for our new trial than the regular belts.

Table 18. Belt Properties

	Regular Sample	New Trial 1	New Trial 2
Cord Adhesion	9.7	13.4	15.6
Improvement %	-	**38**	**61**
Jacket Adhesion	8.5	9.2	10.3
Improvement %	-	**8**	**21**
Breaking Strength	800	840	860
Improvement %	-	**5**	**8**

3.12 Durability Test at Test RIG

Table 19. Belt Durability

Type of Belts	Run without Crack in Hours	Run up to Failure in Hours	Durability Improvement in %	
Reg. Production	230	340	-	-
New Trial - I	283	**400**	**~23**	**~18**
New Trial - II	295	**415**	**~28**	**~22**

3.13 Belt Temperature Study at Test RIG

We have studied the belt temperature by Infrared Thermal Imager (FLUKE Ti480 PRO IR Camera) at a different time interval in same conditions, during running.

Figure 22. Belt Temperature Study by IR Thermal Imager

Table 20. Belt Temperature Generation

Type of Belts	Heat Generation at Side Portion
Regular Production	89ºC
New Trial - I	82ºC
New Trial - II	78ºC

4. Conclusions

We have done Heat Build-up study of all compounds with various fillers ratios, different rubber compositions, the effects of Curing Systems. The amount of reduction in HBU of C-CB04, C-RR04, C-CS04, C-CS07andCF01 compounds are 25%, 31%, 31.3%, 31.3% and 31.3% less, respectively than the Regular production compound. Finally, we tried to improve the adhesion strength between Compounds to Cord and Compound to Fabric. Fabric Adhesion improved 32-53 % than Regular Compounds. From the DMA study we can observe the Tanδ value of CF01 < C-CS07 < C-CS04 < C-RR04 < C-CB04 < Regular compound and this data trend is matching with the Heat build-up data trend. From the TGA study we can see that CF01 and C-CB04 are showing higher degradation temperature than a Regular compound. The developed New Trial-I and New Trial-II belts are providing 38% and 61% more cord adhesion strength and 5% and 8% more breaking strength, respectively than Regular compound belts. The New Trial-I and New Trial-II belts are giving nearly 60-70 hours more life than previous trials. We have measured the Belts Temperature during running condition and it is showing less temperature generation for New Trial Belts.

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