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Research Article

Rheological analysis on different oils use in tyre tread cap compound

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ABSTRACT

Rheology is principally concerned with extending the "classical" disciplines of elasticity and (Newtonian) fluid mechanics to materials whose mechanical behavior cannot be described with the classical theories. It is also concerned with establishing predictions for mechanical behavior based on the micro- or nanostructure of the material, e.g. the molecular size and architecture of polymers in solution or the particle size distribution in a solid suspension. Materials flow when subjected to a stress that is a force per area. There are different sorts of stress (e.g. shear, torsional, etc.) and materials can respond in various ways. Thus much of theoretical rheology is concerned with the forces associated and external applied loads and stresses, and the resulting internal strains. The object of this study is to investigate the relaxation time (λk) and the viscosity index (ηk) Min TQ. (lb-in) and Max's. (lb-in) of a tyre tread compound. The rheological behaviour of the sample are studied using a parallel plate rheometer and the rheological material functions .In this work three types of low PCA and one regular high PCA Petroleum oils are Rheologicaly, analyzed.These low PCA oils can act as the best alternative processing aids for rubber industry. The rheological, *properties of SSBR loaded with different LPCA & HPCA oils have been studied. in order to obtain similar properties.* [1-5].

Keywords: low PCA oils, Rheological properties, Elastomers, Shear modulus, Viscoelasticity , Fluid flow , Dynamic modulus of elasticity.

INTRODUCTION

Rubber formulations used in various tyre components previously have been designed using conventional processing oils .However, in changing to the use of the lower PCA content oils, some lose in rubber compound performance is noted. It is, there for necessary to develop new rubber compounds that provide desirable performance levels while in corpora ting the use low PCA oils[6].

COMPOUND AND MIXING

Mixing of rubber compound was carried out using a two-wing rotor laboratory Banbury mixer (Stewart Bolling, USA) in three stages (master batch remill and final batch) and the formulations are given in **Table No1.**Master batch mixing was done setting the temperature control unit (TCU) at 90°C and rotor speed at 60 rpm.. After the power integrator (PI) indicated achievement of 0.32 kWh, the master batch was dumped. The dump temperature of the master batches was found to be within 140 - 150°C. The master batches were sheeted out in a laboratory two-roll mill. Further mixing of the master batches were carried out after a maturing period of 8 hours. For final batch mixing, the TCU was kept at 60^0C and rotor speed at 30 rpm. The earlier prepared master batch was mixed with sulfur, accelerator and scorch inhibitor. The batch was dumped at a PI reading of 0.12 kWh. [6-8]

EXPERIMENTAL

The experimental characterization of a material's rheological behavior is known as rheometry , although the term rheology is frequently used synonymously with rheometry, particularly by experimentalists. Theoretical aspects of rheology are the relation of the flow/deformation behavior of material and its internal structure (e.g., the orientation and elongation of polymer molecules), and the flow/deformation behavior of materials that cannot be described by classical fluid mechanics or elasticity.Materials studied are given in Table 1. Formulation[7-10]

RESULTS AND DISCUSSIONS

The global market place is increasingly demanding safe process oils to reduce the environmental impact of tires. The replacement of classified distillate aromatic extracts by non-carcinogenic MES, TDAE, or naphthenic process oils will reduce the PAH emissions. The data show that the best results are obtained using LPCA. A comparative study has been carried out on SSBR filled with various oils (**Table No. 2** and **Table No. 3).**

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TABLE No. 1: Banbury mixer in three stages and the formulations

Ingredients	TCR	LPCA-1	LPCA-2	LPCA-3
RMA4	27	27	27	27
BR	35	35	35	35
VSL5525	52	--	--	--
SSBR-4850	--	57	57	57
N339	60	64	64	64
Reg Ar. Oil	5	--	--	--
LPCA-1	--	4	--	--
LPCA-2	--	--	4	--
LPCA-3	--	--	--	4
ZnO(WS)	2.25	2.25	2.25	2.25
St Acid	0.5	0.5	0.5	0.5
6PPD	1.9	1.9	1.9	1.9
MC Wax	2.4	2.4	2.4	2.4
MS 40	1	1	1	1
S(108)	2.2	2.2	2.2	2.2
TBBS	1.2	1.2	1.2	1.2
DCBS	0.6	0.6	0.6	0.6
PVI	0.15	0.1	0.1	0.1
Batch weight	191.2	199.15	199.15	199.15

TCR -Tread Compound Regular / LPCA- Low polycyclic Aromatic compound

TABLE No.-2: A comparative study has been carried out on SSBR filled with various oils

RHE.PROPERTIES	TCR	LPCA-1	LPCA-2	LPCA-3
RHEOMETRIC PROPERTIES @ 160^{0}C/30min (Final)				
MIN TQ. (lb-in)	2.45	2.33	2.53	2.57
MAX.TQ.(lb-in)	15.84	15.77	15.14	15.3
Final TQ.(llb-in)	14.56	14.25	13.75	13.9
tS1 (min)	4.1	3.78	3.7	3.81
tS2 (min)	5.07	4.96	4.59	4.75
tC10 (min)	4.59	4.39	4.04	4.2
tC40 (min)	5.69	5.71	5.22	5.43
tC50 (min)	5.87	5.91	5.42	5.63
tC90 (min)	7.79	9.8	7.38	7.64
Max-Min Tq.(lb-in)	13.39	13.44	12.61	12.73

TCR -Tread Compound Regular / LPCA- Low polycyclic Aromatic compound

TABLE No.-3: A comparative study has been carried out on SSBR filled with various oils

RHE.PROPERTIES	TCR	LPCA-1	LPCA-2	LPCA-3
RHEOMETRIC PROPERTIES @ 193^{0}C/2.5min				
MIN TQ. (lb-in)	0.23	0.21	0.1	0.2
MAX.TQ.(lb-in)	1.99	1.84	1.88	1.86
Final TQIlb-in)	13.61	12.46	12.93	12.68
tS1 (min)	0.49	0.48	0.47	0.47
tS2 (min)	0.66	0.63	0.63	0.63
tC10 (min)	0.5	0.49	0.49	0.49
tC40 (min)	0.83	0.79	0.8	0.8
tC50 (min)	0.88	0.84	0.85	0.85
tC90 (min)	1.19	1.15	1.17	1.17

TCR -Tread Compound Regular / LPCA- Low polycyclic Aromatic compound

CONCLUSION

Test results are intended to support the rubber and tire industries in their environmental challenge to replace the classified aromatic oils. Further extensive compounding and evaluation work will be required by using its proprietary tire formulation technology. Demand for these oils is expected to rise as car manufacturers realize that carcinogenic emissions from tires can here by be greatly reduced. It has demonstrated on a commercial scale that this challenge can be met by a change to safer alternatives such as LPCA. The production LPCA oils are already in the market.

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