IJARSCT
ISSN (Online) 2581-9429
International Journal of Advanced Research in Science, Communication and Technology (IJARSCT)
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
Impact Factor: 7.53
Volume 4, Issue 7, April 2024

Analysis of Carbon Black Proportion on Durability and Wear Behavior of EPDM Rubber

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Abstract: *This study aims at understanding the effect of carbon black on mechanical properties of EPDM rubber. For this we select combination of carbon blacks N330 and N550 with standard curing procedure to minimize the wear rate and maximize durability. The EPDM rubbers were characterized using hardness, tensile, wear and durability tests. The coefficient of friction (COF), volume loss and wear rate of the EPDM rubbers were determined. It was found that with increasing CB content all above characteristics were reduced. Result shows that by using optimum combination of carbon black we can enhance wear performance and durability of EPDM rubber.*

Keywords: EPDM rubber, Carbon black, Durability, Wear rate

I. INTRODUCTION

Ethylene-propylene rubber continues to be one of the most widely used and fastest growing synthetic rubber having both specialty and general purpose applications. Polymerization and catalyst technologies in use today provide the ability to design polymers to meet specific and demanding application and processing needs.

Filler reinforcement of rubbers has been an area of interest to the rubber industry for more than a century. Reinforcing fillers include carbon blacks, silica and resins, which increase the strength of vulcanized rubber more than tenfold. Filling carbon blacks in elastomers and plastics also reduces the cost of the end product and modifies the electrical and optical properties of the polymer matrix. Reinforcement of rubber by carbon blacks has been intensively studied Carbon black is used as a reinforcement to increase the structural and thermal properties of rubber. When a rubber component filled with carbon black is under loading, the rubber matrix around carbon black is strained more than the rest.

Typical rubber compounds used to manufacture industrial products contain up to eight classes of chemical additives including curing agents, accelerators, activators, processing aids, and antidegradants.

Thus, researchers try to explain the improved performance of rubber from the microscopic view, relating the observation of cure kinetics and mechanical properties with the interactions between elastomers and carbon blacks. The entanglement of rubber molecules on the carbon black surface is supposed to play an important role for rubber attachment on carbon blacks. Therefore, it is important to figure out the characteristics and effects of carbon black in order to understand the material behavior of rubber

II. MATERIAL AND METHODS

The compounding formulations for the EPDM blend with its various ingredients were mixed in a two roll mill at a friction ratio of 1:2 following standard mixing sequence. Compounding formulations based on changing of the Carbon FEF N550, Carbon HAF N330, and Silica contents are shown in Table 1. Two types of carbon blacks N550 and N330 used. Sulphur was added as curing agent. Accelerators like MBTS, TMTD, ZDBC were based on 100 phr of rubber and the samples have the code name A, B, C, D. 6 PPD was used as crack resistance additive.

Vulcanized slabs were prepared by compression molding. Warm up of rubber done by passing it through mill. It gives good bonding on mill.

Then curing agents and accelerator were added.

Curing was done for cycle time 30 minutes at temperature 90°C.

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The material is compressed in the press for approximately 10 minutes. The molding operation has been carried out as per IS: 3400 1977 specification. The extra projection of materials, if any, has been trimmed by scissor after molding to give the specimen proper shape. The dimension, specific gravity and shore hardness values of all the samples have been measured accordingly using appropriate measuring tools and instruments for the respective parameters.

Table 1: Composition of EPDM Rubber

Ingredient/ phr	A	B	C	D
EPDM	100	100	100	100
Zinc Oxide	5	5	5	5
Stearic Acid	2	2	2	2
Stearic Acid 6 PPD	1.5	1.5	1.5	1.5
Carbon FEF N550	70	00	30	40
Carbon HAF N330	00	70	60	70
Silica	20	20	20	20
Oil	70	70	70	70
Processing Aid	2	2	2	2
Resin	3	3	3	3
Sulphur	1.2	1.2	1.2	1.2
MBTS	2	2	2	2
TMTD	0.5	0.5	0.5	0.5
ZDBC	2	2	2	2

The samples have been prepared for the wear test as per the requirement of the sample older of multi tribo tester 'TR-25'. 20mm × 20mm × 6mm mild steel blocks have been prepared following various machining operations. Blocks of 20mm × 20mm × 2mm EPDM rubber have been cut from the larger sheets of EPDM. The smaller sheets have been pasted on the top of the mild steel blocks using Fevistick adhesive. Thus, samples of size 20mm × 20mm × 8mm have been prepared to be accommodated in the holder of the multi tribo tester. The substrate of each sample is 6mm thick mild steel and the abrading surface is a 2m thick EPDM rubber.

Test Conditions for Wear test: The abrasive wear is a complex function of load and speed. Hence these two variables were considered for the study of wear behaviour. Wear test were performed using Plate-on-Roller Wear and Friction monitor. Testing conditions were used as follows,

Normal Load, FN:- 25N

Sliding speed, N=50,75,100,125,150 rpm

Test Duration, T=900 seconds. Hardness of specimens was measured by using Shore A method. Tensile tests were carried out on UTM machine .Durability test was carried out on Durability Test rig with the help of actual manufactured component.

Test Conditions for Durability test: As per requirements of customer for final product and parameters as per standard ASTM D813 specimens were prepared and tested. Test conditions were as follows. Temperature 30±10°C.Stroke length 11mm and Frequency 1-3 Hz

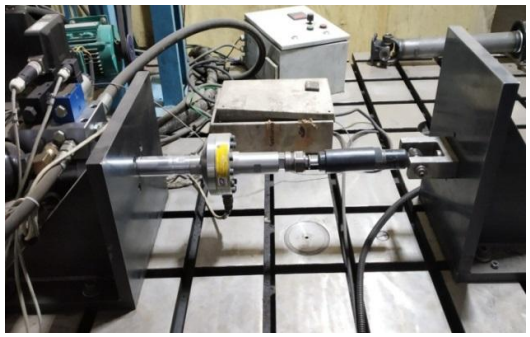

Fig. 1 Experimental set up- Durability Test for component side

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Durability test for material was carried out on Flex Testing Machine as shown in figure No. .Machine was Presto India make. Rubber samples were cut as per ASTM D813standard and were tested for life. A crack propagation and total failure of component was observed. Total number of cycles was set 3,00,000 with frequency of 1-3 Hz.

Fig. 2 Experimental set up- Durability Test for material

III. RESULT AND DISCUSSIONS

Three types of EPDM rubber have been selected for the wear test based on the proportions of carbon black as filler material. Sample A is with carbon black N550 and sample B is with carbon black N330.Samples C& D are with composition of both N330 and N550 Hardness of the material depends on the carbon black content (parts per hundred). The Shore A hardness of the rubbers was determined according to the ISO 868 standard. The hardness was measured by Shore A hardness tester. (BSE, India).Hardness tester with probe 1.25 mm, truncated cone type. Measuring time was 3 seconds and minimum sheet thickness of specimen was kept 6mm.Fig.3 shows the obtained results.

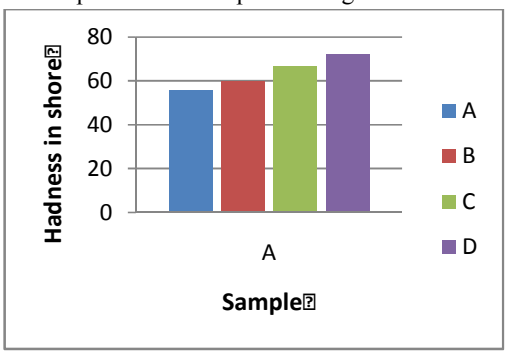

Fig. 3 Hardness testing

The results obtained from Wear test are given in fig.4. The result shows samples had an increase in wears resistance as compared to conventional single carbon black composition.

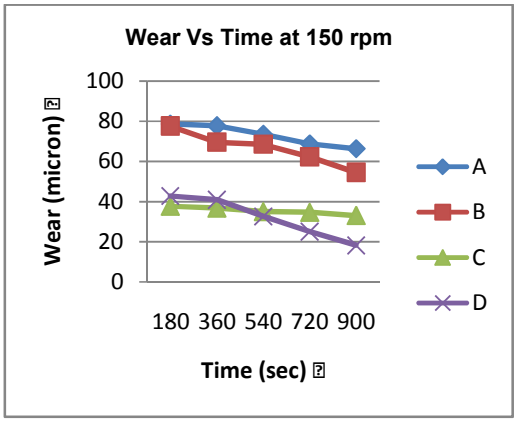

Fig. 4 Wear Vs Time at 150 rpm

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Graph shows wear behaviour of EPDM rubber samples at 150 rpm. In all the cases initial wear is very high for both the rubbers and the wear reduces gradually as the time proceeds. Sample C and D shows better performance. Durability test was conducted for both material and component on durability tester. Material test was performed after batch preparation and component test was carried out after finishing process, on actual manufactured component. Both test shows increase in durability with increase in carbon black percentage. As customer requirement was 3, 00,000 cycles life so we stopped test at specified cycles.

Samples	Life (No. of Cycles)		Hardness in Shore A	Carbon black Composition	
	Material	Component		N550	N330
A	209365	210245	56	70	0
B	280540	278640	60	0	70
C	284074	279030	67	30	60
D	300000	300000	72	40	70

Table 2: Durability test Results

IV. CONCLUSION

It is needless to mention that it is very difficult to harmonize the experimental conditions with real life applications and it is also very difficult to arrive at an unique conclusion in case of a viscoelastic material like rubber. In spite of the limitations as mentioned, the following conclusions have been drawn:

1. Hardness of the rubber has been increased with increasing carbon black (N330) content (pph) as per customer requirement;
2. Coefficient of friction decreases with increase in hardness;
3. Carbon black N550 plays important role in curing kinematics in combination with N330
4. As per requirement by customer Durability and Wear resistance of EPDM rubber has been improved by the addition of carbon black with proper composition;

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