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The effect of carbon black filler on mechanical properties of EPDM rubber component

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ABSTRACT

Ethylene Propylene Diene Monomer (EPDM) rubber emerges as a dominant elastomer for major engineering applications such as automotive (sealing, bushing, serpentine belts), construction (roofing, dilatation joints) and electric/electronic (insulators). Due to friction between the EPDM bushing and the mating surfaces, it loses material resulting in noiseand failure. Fillers like Carbon black enhance the mechanical properties such as the abrasion resistance or the fatigue life and thermal properties of rubber.The pin-on-disk tribometer serves for the investigation of friction and wear processes under sliding conditions and measures tribological quantities, such as coefficient of friction, friction force, and wear volume between two surfaces in contact. It can be operated for solid friction without lubrication and for boundary lubrication with liquid lubricants.By using different % of Carbon black in EPDM, we may find the most effective composition to reduce specific wear rate of bushings.

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I. INTRODUCTION

Rubber and rubber like materials are generally called elastomers. Rubber has excellent properties that make it an excellent choice for tire industries, rubber has high mechanical strength and can be compounded to have excellent elasticity, good abrasion resistance, low relative cost, good dynamic mechanical properties, Rubber parts are widely used in different application fields such as automotive (sealing, bushing), construction (roofing, dilatation joints) and electric/electronic (insulators).Movement can be realized only and merely by the friction, but during a motion, friction permanently causes different kinds of losses (energy dissipation, mass loss, movement loss).Therefore, friction is the process where positive and negative effects manifest both. In a certain situation, a large friction force is required, but in other situation small friction force is required.

Ethylene Propylene Diene Monomer (EPDM) rubber is widely used in automobiles They are subjected to wear and tear due to pressure, vibration, friction and exposure to extreme conditions of atmosphere. Though EPDM has outstanding heat, ozone, weather resistance ability and resistance to any polar substance as well as steam is also very good, still some realistic tribological data are yet to be developed. This is particularly true for any indigenous development of EPDM.

To avoid wear of EPDM, it must have higher wear resistance properties. Experimental results reveal that the hardness of EPDM rubber has significant effect on the flow behaviour and wear characteristics. The hardness, again, depends on the proportion of carbon black (CB) content.

Thus it can be stated that the flow behaviour can be governed by controlling the CB concentration in the EPDM rubber.[1,2]As filler plays important role in obtaining mechanical properties, by varying percentage of filler material (Carbon black) we can achieve required results. Fillers like Carbon black enhance the mechanical properties such as the abrasion resistance or the fatigue life and thermal properties of rubber.The pin-on-disk tribometer serves for the investigation of friction and wear processes under sliding conditions and measures tribological quantities, such as coefficient of friction, friction force, and wear volume between two surfaces in contact. It can be operated for solid friction without lubrication and for boundary lubrication with liquid lubricants.

II. LITERATURE REVIEW

Karger-Kocsis, Mousa, Major,[1] studied dry friction and sliding wear of ethylene/propylene/diene rubbers (EPDM) against steel as a function of the carbon black (CB) content using various testing configurations, such as pin(steel)-on-plate(rubber) (POP) and ring(steel)-on-plate(rubber) (ROP). The EPDM rubbers were characterized using tensile, compression tests and dynamic-mechanical thermal analysis (DMTA). The coefficient of frictions (COF) and specific wear rates of the EPDMs were determined. They found that with increasing CB content the specific wear rate was reduced. A similar tendency was found for the COF in ROP tests. Both COF and wear rates of the EPDM mixes strongly depended on the test configurations. The wear mechanisms were concluded by inspecting the worn surfaces in scanning electron microscopy (SEM) and discussed. Albeit several rubber characteristics follow the same trend as the COF and wear rate, at least for this EPDM formulation, further investigations are needed to deduce eventual correlations between themFelhos and Kocsis [2] studied friction and sliding wear behaviors of peroxide-cured ethylene/propylene/diene rubbers (EPDM) against steel counterparts under dry conditions. The carbon black (CB; N347 type) content of the EPDM rubbers was varied between 0 and 60 parts per hundred parts rubber (phr). For their tribotesting, different test configurations, viz. pin(steel)-on-plate(rubber) (POP)and roller(steel)-on-plate(rubber) (ROP), were used and their oscillation wear behavior (fretting) studied, too. The EPDM rubbers were characterized using dynamic-mechanical thermal analysis (DMTA), hardness, tensile and tear tests. The coefficient of friction (COF), volume loss and specific wear rate of the EPDM rubbers were determined. It was found that with increasing CB content all above characteristics were reduced. They found that COF and wear parameters strongly depended on the related test configuration. They concluded wear mechanisms by inspecting the worn surfaces in scanning electron microscope (SEM).

Stamenkovic et al [3]studied theoretical and experimental studies of friction the rubber and theother materials. For this purpose the studied footwear-floor friction. In that sense measurement of static friction coefficient between footwear sole and floorsamples was performed. For that purpose they designed measuring device for static frictionestimation. Measuring results show that staticfriction coefficient is stochastic andunpredictable.Hamzah and Al-Abadi [4] studied the effect of carbon black type on the mechanical properties of rubbery material characterization. To do this, they performed different tests on filled rubber with three different kinds of carbon black N326, N375, and N660. All tests were performed at room temperature. The tests include rheometer tests, hardness tests, tensile tests, specific gravity tests, compression tests, relaxation test, and cyclic loading tests. Tensile tests were done with different strain rate, relaxation tests done under different mean strain. The results shows that the hardness for the blend with carbon black N375 is more than that in blend with carbon black N326 which in turn more than hardness in blends with carbon black N660. Higher hysteresis would be expected during cyclic strain. That exactly occurred for blend with carbon black N375 because it had higher filler network.

Li,Zhang and Chen [5] investigate the cure kinetics of EPDM filled with conductive carbon black and other rubber grade black. Mechanical experimental results demonstrate that the composite with conductive carbon black, comparing with other blacks, has the highest hardness, tensile strength at break, tensile modulus at 300% and permanent set. The EPDM/N472 composite shows the significantly higher volumeresistivity than other samples. Martınez [6] studied tribological properties and surface characteristics of ethylene–propylene-diene elastomers were studied as a function of carbon black (CB) content. The surface analysis was performed inside and outside the wear track by X-ray photoelectron spectroscopy (XPS) in order to evaluate possible compositional changes produced by rubbing. Carbon black content had only a small influence on the surface chemistry of the unworn surfaces. They found however, on the surfaces subjected to friction, the oxygen concentration decreased with increasing CB content. Neither the surface analysis by XPS nor the wettability tests revealed important thermal degradation of the polymer in these friction tests.

III.PROBLEM BACKGROUND

EPDM rubber bush are used in textile industrial weaving machines. As bush slides over shaft with high speed and causes wear and thus failure. Although bush is very cheap but the production loss due to machine stoppage is very large. So the objective of this project is to finding most effective composition of EPDM bush which will enhance the working life of existing bushes by reducing specific wear.

IV.METHODOLOGY

A. Preparation of raw rubber

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.Sulpher 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 banding on mill. Then curing agents and accelerator were added. Curing was done for cycle time 30 minutes at temperature 90°C.

TABLE I
COMPOUND FORMULATION

Ingradient/ phr	Samples			
	A	B	C	D
EPDM	100	100	100	100
Zinc Oxide	5	5	5	5
Stearic Acid	2	2	2	2
6 PPD	1.5	1.5	1.5	1.5
Carbon Fef N550	70	30	20	10
Carbon HAF N330	30	50	80	90
Silica	0	10	15	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

B. Mechanical characterization (tensile strength and %elongation)

The dumb-bell shaped specimens were punched out from a molded sheet by using ASTM Die C. The tests were done by means of a universal tensile testing machine (Hounsfield H10KS) under ambient condition (25 ± 2 _C), following the ASTM D 412-07 and ASTM D 624-07. Tensile strength, and elongation at break (%) were measured at room temperature. The initial length of the specimens was 25 mm and the speed of the jaw separation was 500 mm min_1. Five samples were tested for each set of conditions, at the same elongation rate. The relative error was below 5%. The hardness was measured by Shore A hardness tester.(ZWICK Germany)

TABLE II
TENSILE STRENGTH AND % ELONGATION

Sample	A	B	C	D
Tensile Strength in Mpa	12.5	13.8	14.3	15.7
% elongation	535	501	465	382

C. Hardness and density

The Shore A hardness of the rubbers was determined according to the ISO 868 standard. The hardness was measured by Shore A hardness tester. (ZWICK Germany).For the density determination the Archimedes principle (buoyancy method) was adopted using methanol.

TABLE III
HARDNESS

Sample	A	B	C	D
Hardness in Shore A	60	65	70	85

D. Heat Air Aging

Air aging test was conducted at 100degree temperature for 70 hours at laboratory. The test was carried in Veekay make oven VK1 300 x300 x300 mm. Following results were found. This test was carried out as per standard procedureASTM D573 - 04(2010)

Results shows the increase in percentage elongation and hardness while decrease in tensile strength.

TABLE IV
HEAT AIR AGING RESULTS

Sample	A	B	C	D
Tensile Strength in Mpa	10	11.3	12.5	13.4
% elongation	563	516	496	400
Hardness in Shore A	65	75	80	90

E. Wear Testing Procedure

Abrasive wear study will be done on a pin-on-disc machine, by sliding a cylindrical specimen of the material to be tested (EPDM) against disc in a dry condition. The specimens will be of 10 mm diameter and 30 mm height. Applied loads will be divided into process variables such as: various loads (10, 25, 50, & 75 N), velocities (1,2,3,4m/s), divided into process variables such as: various loads (10, 25, 50, & 75 N), and times 5 min intervals for 1 hour and the material variables such as: carbon black content or concentration 30,50,80,90 phr.

V. CONCLUSION

This work was devoted to study the dry friction and sliding wear of EPDM rubbers containing various amounts of carbon black (CB). The results allow us to draw the following conclusions: with increasing CB content, the hardness and tensile strength of EPDM increases and at the same time % elongation decreases. Yet to be determining the wear resistance, abrasion resistance, so on that basic we will be able to conclude the suitable composition for EPDMbush.

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