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# Manufacturing of High-Load Engine Mounts From Rubber Composites (Natural Rubber and Carbon Black) with Novel Properties

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**ABSTRACT** This paper explains the successful and simple process of generating a rubber mount with novel properties by incorporating carbon black particles type ISAF 220 at different ratios ([46, 56, 66, 76 , 86] [pphr]). Rubber mounting was made using 100 % natural rubber and carbon powder that was applied to the master batch ratio (60 g). To achieve greater homogeneity, rubber and carbon were combined for several minutes. The rubber mount has been subjected to several tests at Babylon tires factory and Babylon University (tensile, elongation, modulus, compression, hardness, rebound resilience, specific gravity and fatigue tests). The best results were obtained from the rubber mount, as it had the ability to resist fatigue and could be used for a long period of time. It could also increase the number of cycles to 900 rpm. The rubber mount that was reinforced with carbon had a better resistance to the mechanical properties (tensile, hardness, fatigue and resilience). The results of the tensile strength, hardness, fatigue and resilience tests showed that additional quantities of carbon at 66 pphr increased the values by up to 18.95 Mpa, 64 Mpa, 600 Mpa and 55.5 Mpa, respectively.

## 1. INTRODUCTION

Engine mounts are constructed from rubber and steel. The metal part attaches to the motor on one side and the frame on the other. In the meantime, the rubber has enough stability to ensure that the shaking engine does not cause the vehicle to rock. The number of engine mounts varies between the truck and car [1].

The mount's movements come from the following two distinct points: 1. the engine noises to be extracted are usually in the range of 30Hz–200 Hz, with amplitudes that are typically less than 0.3 mm; 2. the frame, which is influenced by disturbances of the ground surface through the suspension mechanism. Usually, these frequencies are in the one Hz to 30 Hz range and have an amplitude greater than 0.3 mm. The optimal dynamic stiffness for mounting an engine is shown in the figure below.



High damping for shock excitation is required for low frequencies to prevent engine bounce and to provide driving stability [1].

Natural rubber is produced from plants and is known as a chemical compound of polymerA with large molecules of the same kind, which are formed from many smaller molecules. Some polymers spontaneously occur, and others are manufactured in laboratories and factories.

A polymer is a chemical compound that is composed of many smaller molecules of the same kind with large molecules.

Rubber's properties include high strength and the potential to stretch several times without cracking. Natural rubber compounds are highly versatile, strong and resistant to many corrosive substances [2].

Carbon black is a substance that is formed by the incomplete combustion of heavy petroleum products, such as Fluid catalytic cracking tar, coal tar or cracking tar with ethylene. Carbon black is a type of paracrystalline carbon with a high ratio of surface-area-to-volume, which is lower than activated carbon. It is dissimilar to soot due to its significantly higher surface-area-to-volume ratio and significantly lower polycyclic aromatic hydrocarbon (PAH) content (negligible and non-bioavailable). However, carbon black is commonly used for diesel oxidation studies as a model compound for diesel soot. [3] Additionally, it is used mostly as a protective filler for tires and other rubber goods, as well as a dye additive in fibres, paints and inks [4]. Among the previous studies in this field are the following: In Al-Kawas's [5] study, the natural rubber type NR (SMR5) and neoprene rubber (CR) with different loading levels of carbon black (35, 45, 55, 60, and 65 pphr) were used separately.

The tensile, compressive, shear, stiffness and ultraviolet light effect tests were planned to obtain the best properties with carbon black reinforced NR (60 pphr) and carbon black reinforced CR (70 pphr).

## 2. Materials and Method

### 2.1 Used Materials

The material that was used in this research was natural rubber (100 pphr), and the materials that were used to prepare the rubber recipe were the activator (zinc oxide), sulfur, (CBS), anox (HB), (IPPD), antiozone (WAX A 111), activator (stearic acid), aromatic oil and carbon black. These were imported by the Diwaniyah tire company.

### 2.2 Preparation Method

Mixing was done in a two-roll mill. The kneading and mixing operations were conducted on this machine as per ASTM D 15. The shape of the mixing machine and the manufactured samples, both mechanical or physical, are as follows:



**Figure 1.** Mixing machine.



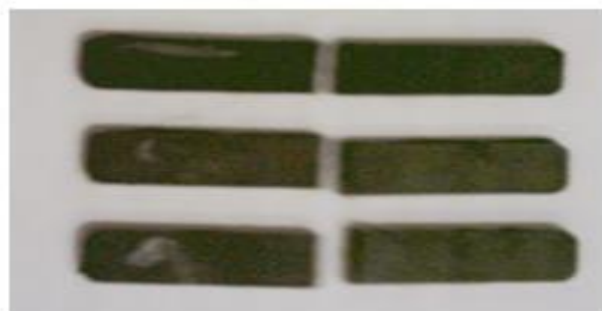
**Figure 2.** Vulcanisation test.



**Figure 3.** Tensile, hardness and resilience specimen.



**Figure 4.** Compression specimen.



**Figure 5.** Flexibility specimen.

### 3. Results and Discussion

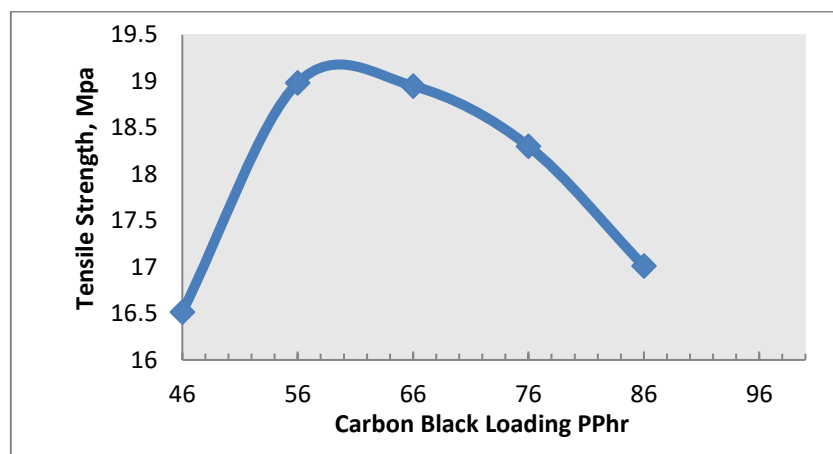
#### 3.1 Mechanical Properties

Figure (6) shows high tensile strength due to the wide surface area and black carbon winding with a high degree of carbon black in the rubber recipes.

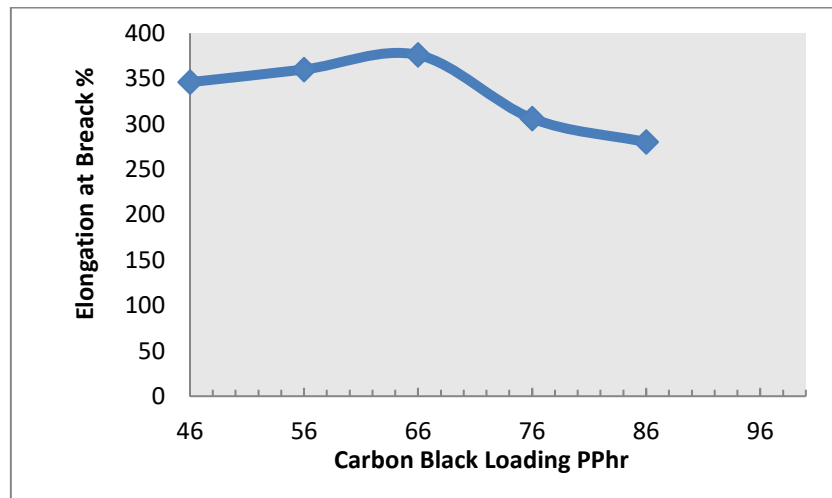
Strong interlacing systems improve the mechanical properties of the new compound as they come into contact with rubber (NR) and make the composite material resistant to tensile strength and drag. This resistance persists with the rise in carbon black but at higher loading ratios (56 pphr and above). The tensile resistance starts to decrease due to the increased fragility of the rubber material, which is compatible with the findings of other researchers [5,6].

Figure (7) shows the rate of elongation declining as the percentage of carbon black rises. This is because raising the carbon black reduces the amount of rubber base material covering the carbon black minutes, which improves the fragility and hardening of the rubber compound. This decreases the elongation when cutting. This finding follows the findings of other researchers [7,5].

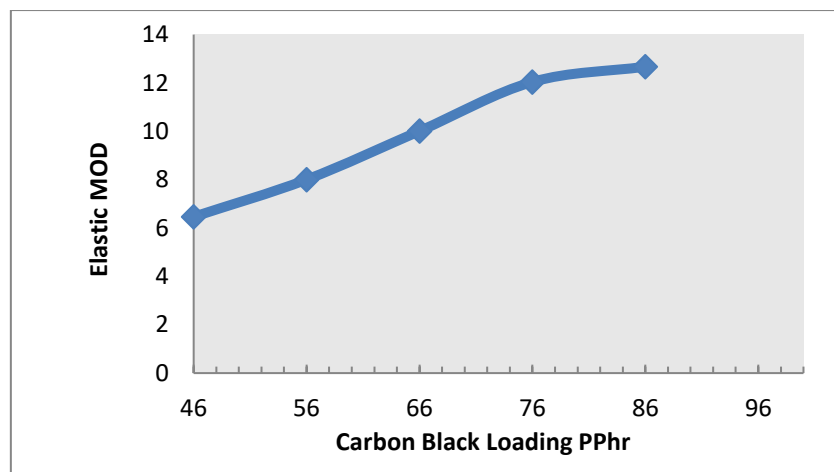
The elastic modulus seen in Figure 8 increases as carbon black rises for the same reasons as above to increase tensile resistance. This finding correlates with the findings of other researchers [7,5].



**Figure 6.** Effect of CB (pphr) on the tensile strength of NR matrix composite.

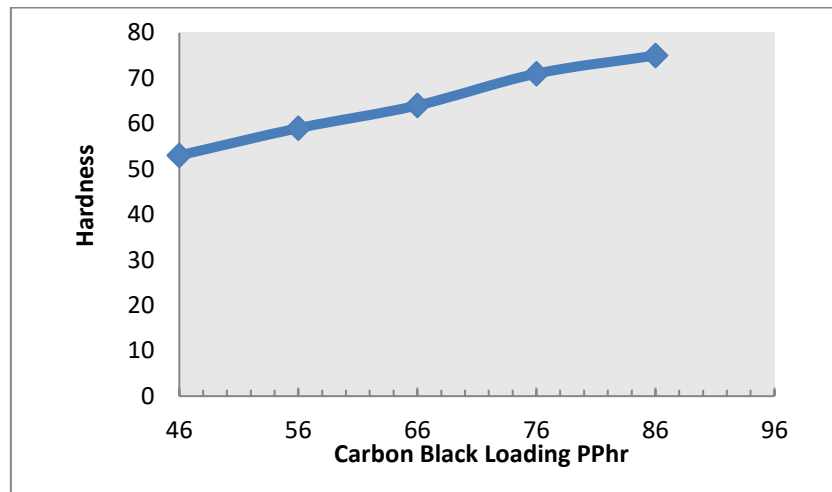


**Figure 7.** Effect of CB (pphr) on the elongation of the NR matrix composite.



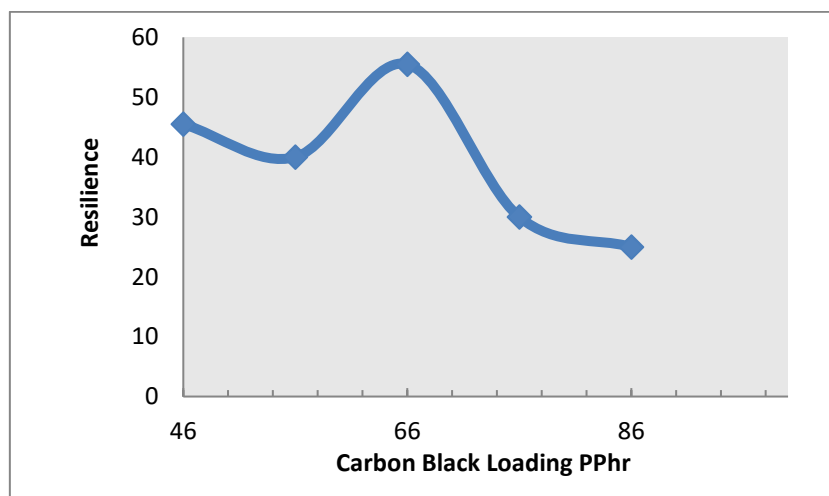
**Figure 8.** Effect of CB (pphr) on the elastic modulus of the NR matrix composite.

When applying the carbon black form N-220, which has a granular size of 350 microns to the natural rubber with different loading ratios (pphr [46, 56, 66, 76, 86]), there is an increase in the hardness values. This is because the carbon black granules have an active and winding surface, which increases the tangles or bonds between them and the rubber chains when they come into contact with the rubber. This increases the resistance to the external body penetration of the compound due to the increased surface tension, as seen in Figure (9) [8,6,5].



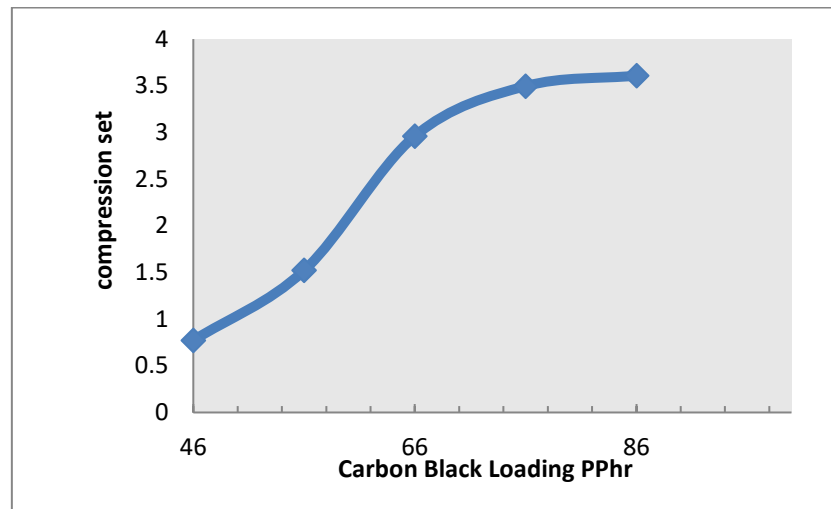
**Figure 9.** Effect of CB (pphr) on the hardness of the NR matrix composite.

Figure 10 shows a decline in the rebound values. This is due to the increased strength of the compound rubber material with the rise in the percentage of carbon black, which gives the rubber material a greater ability to absorb kinetic energy and transform it into thermal energy and less propensity to return it. This finding correlates with previous research [5].



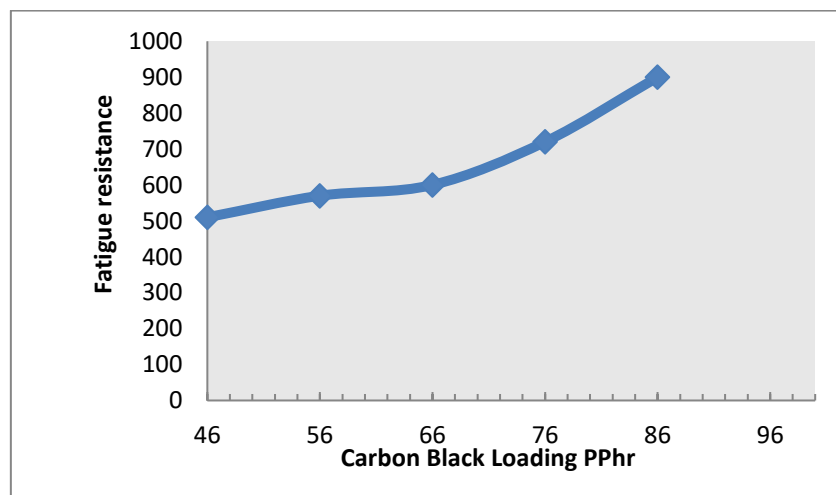
**Figure 10.** Effect of CB (pphr) on the resilience of the NR matrix composite.

The compression range increases with the increasing carbon black, which is attributed to the rise in the entanglement density (the same reasons for the increase in the tensile strength, as described above), the decrease of the movement of rubber strings and the increase of the rigidity of the compound rubber. These entanglements limit the portability of the processing of compound rubber [9,10].



**Figure 11.** Effect of CB (pphr) on the compression set of the NR matrix composite.

This property represents the materials that are resistant to crack growth. In small proportions, carbon, as shown in Figure 12, has a low resistance to crack growth. A higher number of particles increases fatigue resistance, and the introduction of fillers possessing uniform geometries effectively reduce the crack propagation rates. This is due to the structures of the filler network, especially at high tearing energies [11].

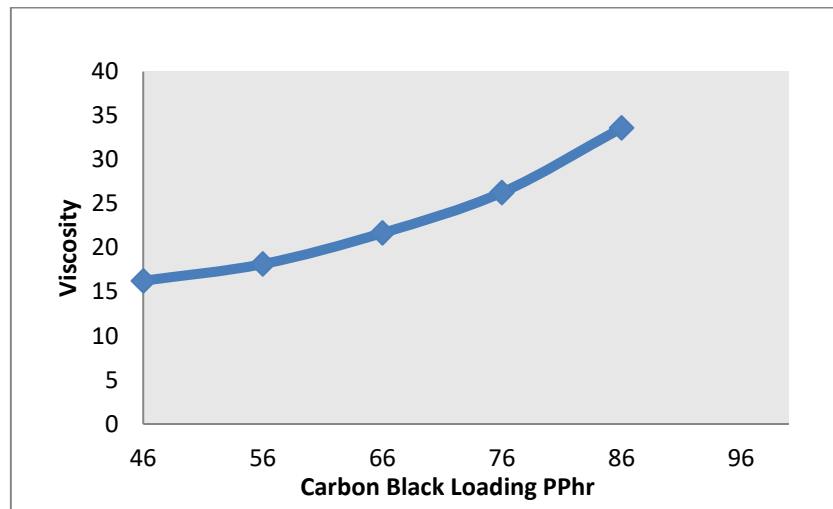


**Figure 12.** Effect of CB (pphr) on the fatigue resistance of the NR matrix composite.

### 3.2. Physical Properties

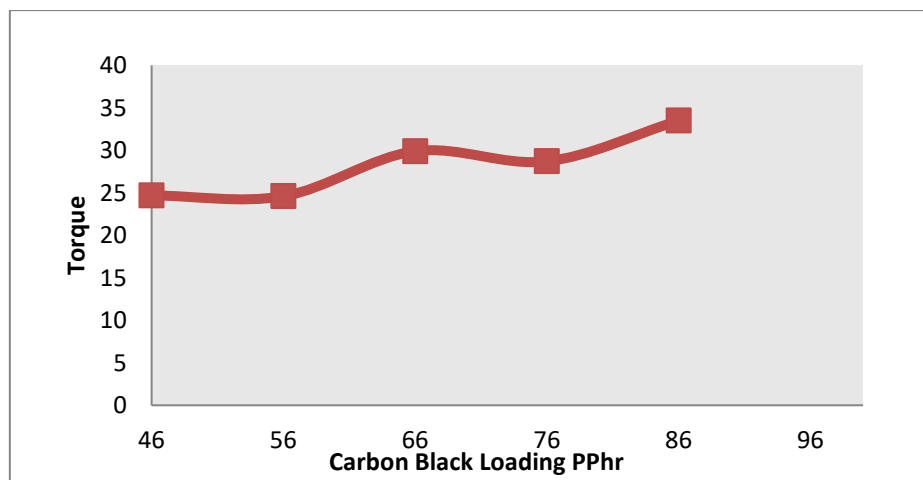
Figure 8 indicates an improvement in the viscosity values, which is an indicator of the elasticity of the rubber component and its ability to produce the rubber compound content with an increase in carbon black due to an increase in the interconnections and a decrease in the freedom of mobility of the rubber chains. This refers to the stability between the carbon granules and rubber chains.





**Figure 13.** Effect of CB (pphr) on the viscosity of the NR composite.

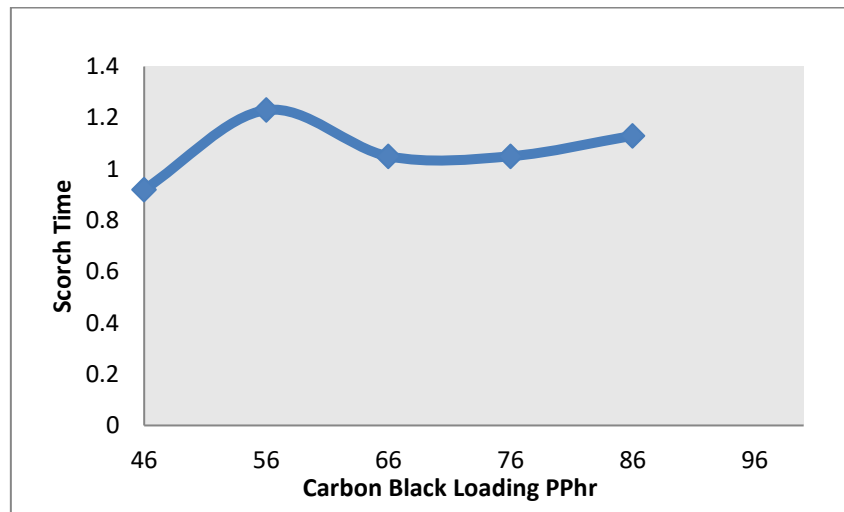
Figure 14 indicates a steady rise in torque with an increase in carbon black for the same reasons as the increase in viscosity. These findings are compatible with previous research [5].



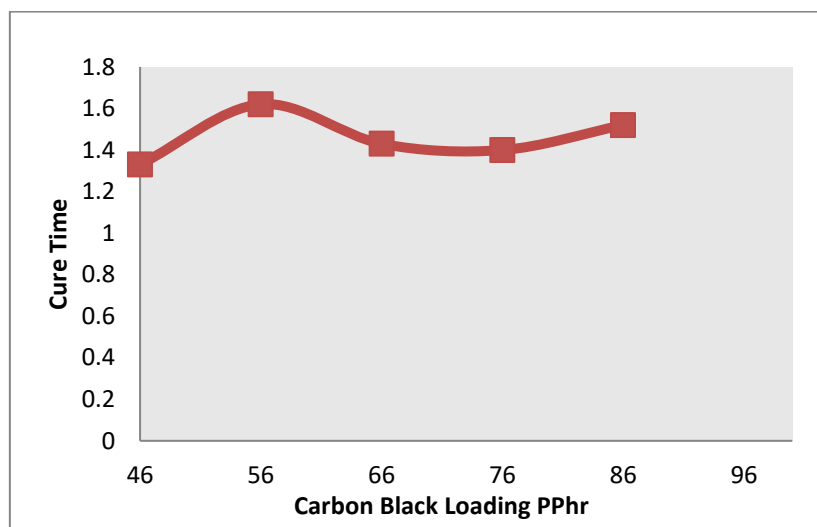
**Figure 14.** Effect of CB (pphr) on the max. torque of the NR composite.

Figure 15 shows a decrease in the combustion time with an increase in carbon black. The increase in the surface area of the carbon particulate matter is due to meandering in the carbon surface. This means that carbon black acts to provide the required heat to complete the vulcanisation process of the internal structures of the rubber formula due to its contact with the interconnections.

The cure time in Fig. 16 declines as the amount of carbon black in the rubber mixture increases as carbon black joins the networking connections and thereby contributes to early maturation [5].



**Figure 15.** Effect of CB (pphr) on the scorch time of the NR composite.



**Figure 16.** Effect of CB (pphr) on the cure time of the NR composite.



**Figure 17.** The rubber mount product, as manufactured.

#### 4. CONCLUSIONS

The problems of the mount, which are hardness, fatigue and resilience, were improved by adding fillers where it can be operated at a high load at 900 cycles per minute without any defects. The addition of carbon to the rubber improved the mechanical and physical properties, especially tensile strength, elongation, hardness, fatigue and resilience. However, adding large quantities of fillers led to aggregates of material, which weakened the properties. The best percentage of fillers for the best result is 66 pphr.

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