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MANUFACTURING OF RUBBER BUSHING WITH NOVEL PROPERTIES FOR THE REAR FAN

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ABSTRACT

The present paper describes a good and simple method to manufacturing rubber bushing with novel properties by addition modified nano-particles (silica) at different ratio (0.2, 0.4, 0.6, 1, 1.5, 2, 2.5, 3) PPhr. rubber bush was manufactured by using two types of rubber (30% natural rubber and 70% synthetic rubber) as well as silica powder was added at (0.6 g) ratio to the master batch. They were mixed (rubber and silica) for several minutes to obtain better homogeneity. Rubber bushing has subjected to many tests which are (Tensile, Compression, Tear, Wear, Hardness, Rebound resilience, Specific gravity, and Fatigue tests) in Babel tires factory and Babylon University.

The best results were obtained from rubber bushing, the ability of bush to resist friction and fatigue and use it for a long period, as well as increase the number of cycles to a 1000 rpm after it was working for 800 rpm. Also, it was withstand high temperatures where it was up to 100 °C after working up to 60 °C. Rubber bushing that reinforcement with nano-modified silica gave better resistance to mechanical properties (tensile, compression, hardness, fatigue, tear, wear). The results of the tensile strength, elasticity modulus and tear resistance showed that addition of small quantities of modified nano silica especially at 0.6 pphr increased values up to (18.096Mpa, 7.292 and 6.86) MPa respectively.

Keywords: Elastomer, Bushes, silica, Rubber.

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1. INTRODUCTION

Bushing are one of the important machine elements used in many applications, which include rotating and vibrating component [1]. The rubber bushing is used as a vibration isolator in vehicle suspension systems in order to prevent the vibration of an engine or the tire from transferring into the guest room. The rubber bushing has been modeled as a largely deforming hyper elastic continuum and following a non-linear constitutive equation [2-4]. The heat accumulation in the rubber components is attributed to the nonlinear mechanical behavior of rubber and leads to degeneration of mechanical properties [4]. Bushing temperature are many critical parameters, such as the lubricant viscosity, load-carrying capacity, load distribution and power loss. The bushing faults can be caused by material fatigue, overheating, harsh environments, inadequate storage, contamination, corrosion, wrong handling and installation, etc. But the main cause of their failure is due to poor lubrication, which can be easily avoided by a correct maintenance plan [5]. Compared with any other metal material used in the vehicle system, rubber has a higher capacity of energy storage. Rubber bushings are expected to be strong enough to undertake a certain loading and also high damping ability to reduce the vibration and noise. However, the basic disadvantage of high damping material is the thermal effect, which leads to fatigue and shortens components' serving life. Because of the nonlinear mechanical behavior of rubber, the stress- strain curve forms elliptical loop under cycle loading, which represents the energy dissipation and results in heat built up in the rubber products [6]. The rubber bush for the suspension can be pressed into a placing, which will provide compliance between the inner and outer metals in the radial, axial, torsional and conical directions. The use of rubber bushings is often preferable to solid connections as noise and vibration are lessened. They can also eliminate the use of lubrication between two parts.

A bushing is typically composed of a hollow elastomer cylinder contained between inner and outer cylindrical steel sleeves [7]. The aim of the paper to manufacturing rubber bushing with development properties by using modified nano-silica to use in rear fan of cement factory.

2. EXPERIMENTAL

Materials used in The preparation of the master batch of rubber bushing are listed in the table (1) below:

Table 1 The composition of the master batch (recipe) of rubber bearings

Item	compounding ingredients	PPhr
1	SBR 1500	30 000
2	SMR20	70 000
3	C B S	0 500
4	Zinc oxide (activator)	4 000
5	Stearic acid (activator)	2 000
6	Anox H B	1 000
7	Antioxidant (TMQ) WAX A 111	2 000
8	Aromatic Oil	8 500
9	FEF Black	51 000
10	Sulphur	2 000
11	IPPD	1 750

Rubber bushing was prepared from the materials listed in the table (1). Two types of rubber were used in different percentages (70% of Styrene Butadiene Synthetic Rubber and 30% Natural Rubber). After mixing the ingredients together, the batch was obtained appropriate .After the vulcanization process, silica powder (particle size (65-85)nm ,purity 100%,density 0.2817 g/cm^3) was added as a reinforcement materials to the master batch at different ratio (0.2, 0.4, 0.6, 1, 1.5, 2, 2.5, 3) pphr. The tests were carried out to finding the best rate of filler that can be added to the rubber batch to give suitable results for the manufactured bushing.

3. RESULTS AND DISCUSSION

3.1. Mechanical Properties

Fig. (1) shows high tensile strength with the addition of small quantity of modified nano silica, it was concluded that an increase of the tensile strength. As, the concentration of modified nano-silica increase, tensile strength decrease. Such behaviour can explain that in the case of small quantities, particles will fill the spaces between rubber chains, thus will give a rigid structure with better tensile strength (18.096Mpa). While in high quantities of modified nano silica will happen aggregate in rubber matrix. These aggregate will lead to the formation of defects where the start cracking and thus weaken the tensile strength to the (9.299). This result agrees with references [8-11].

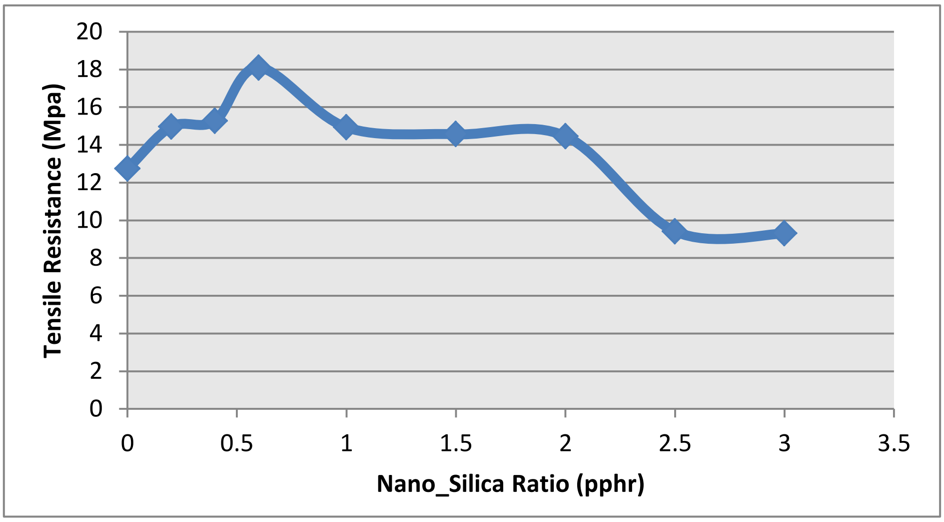

Figure 1 Effect of small and large quantities of modified nano silica on tensile strength of recipe

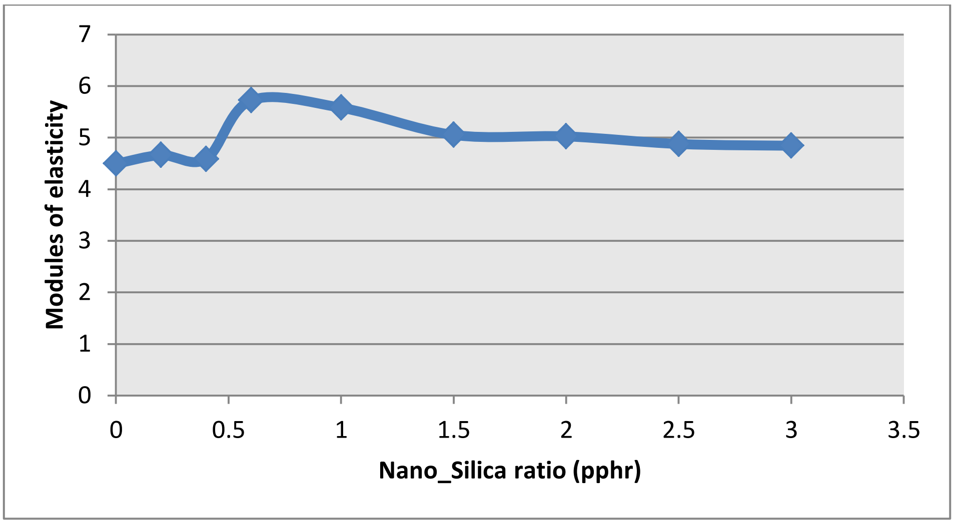

Figure 2 Effect of small and large quantities of modified nano silica on modules of elastic recipe

Figure (2) shows an increasing in the modulus of elasticity with small amounts of modified nano silica. Due to the fineness of particles makes it easy to distribute between rubber chains, so increase the modulus of elasticity. But when an increase in quantities modified nano-silica, decreases the modulus of elasticity, this is due to non-homogeneous distribution leads to the agglomeration of particles between the chains. Then weaken the cross-linking and thus generated cracks, so decreases the modulus of elasticity, which agrees with researches [8] [9].

Figure (3) shows effect of addition quantities of modified nano silica on fatigue of recipe. This property represents the material resistant to cracking development. At small amounts of modified nano-silica, as shown in figure (3) Silica behaves as a filler and gives a resistance to crack growth. As the amount of silica increases agglomerate will take place and inhomogeneous distribution makes stress in recipe which discreet cracking as in figure (3).

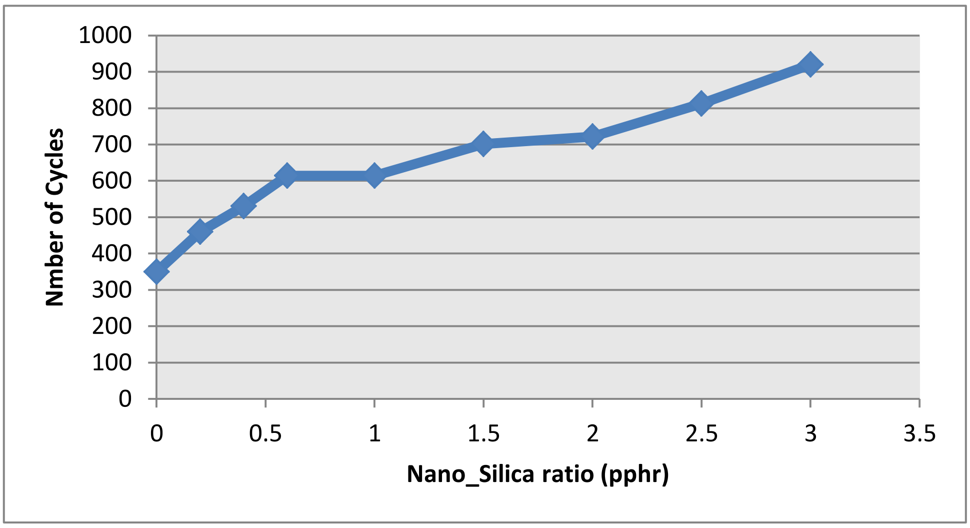

Figure 3 Effect of addition quantities of modified nano silica on fatigue of recipe

In general, Figure (4) shows increasing in the rebound resilience. At 0.2 pphr of modified nano silica show jumps in the values due to silica acts as a filler to fill the spaces and dose not absorb the energy. Then it begins to decrease while nano particles percent increase. As figures(4) at 3 pphr of nano silica rebound resilience increase due to beginning of particles agglomerate and make pressure in structure of rubber matrix which enhances cracks growth and decrease hardness property. After that agglomerate will take place and form excess material work on absorb the applied energy and dissipate as a heat, thus decreases resilience force. The rebound resilience related to the hardness and specific gravity characteristics.

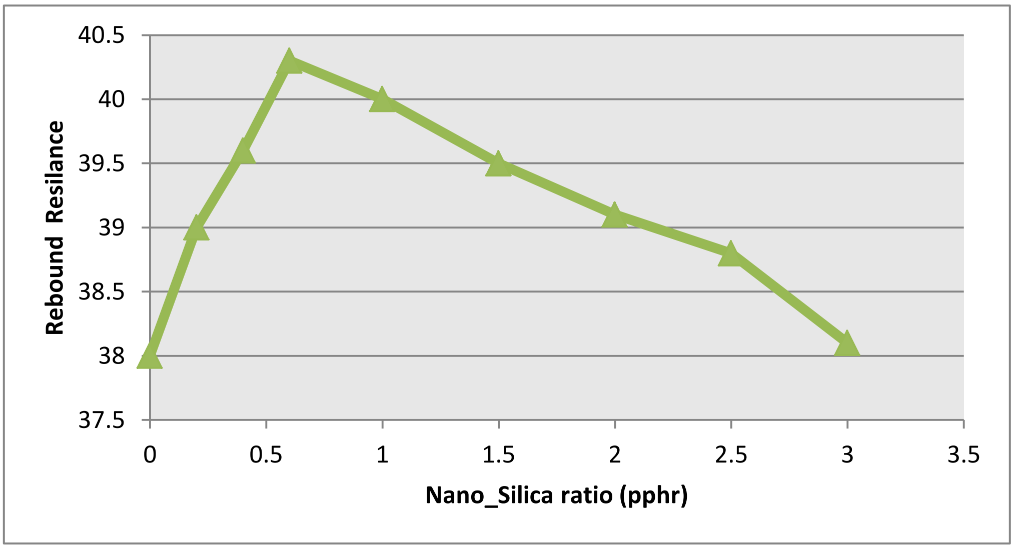

Figure 4 Effect of addition quantities of modified nano silica on rebound resilience of recipe

Figure (5), When adding the silica nano particles which has the particle size (75-85Nm) to the rubber in different proportions (0.2, 0.4, 0.6, 1, 1.5, 2, 2.5, 3) pphr to the recipe of rubber, note an increase in the hardness values, because the particles of silica have a surface area of active and irregular which increases entanglements between them and the rubber chains when contact with the rubber, which increases resistance to penetrate the outer body of compound, as a result of increased surface tension.

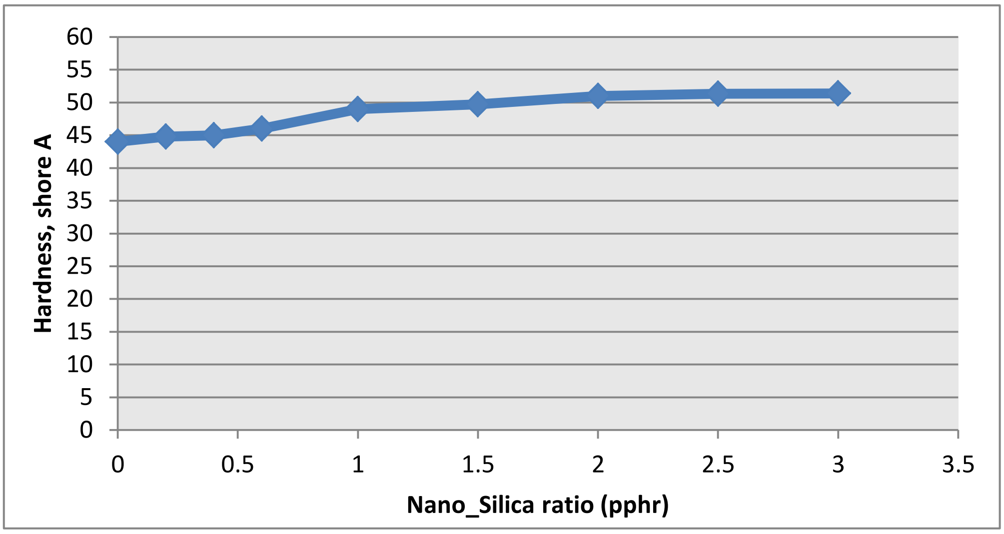

Figure 5 Effect of addition quantities of modified nano silica on hardness of recipe

Figure (6) showed , In each percent addition of silica nano modified ,silica acts as a filler as mentioned before, so increase the weight of unit volume, result increasing the specific gravity as figure (6)

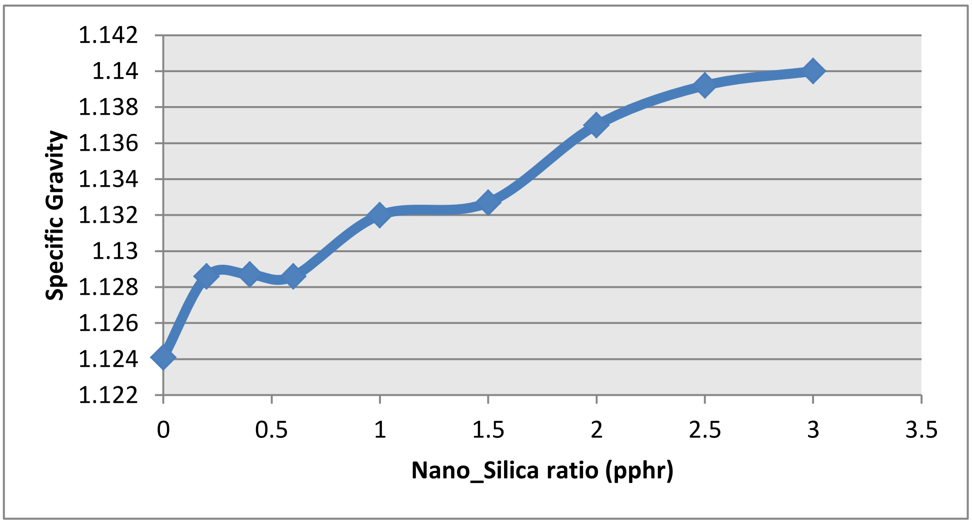

Figure 6 Effect of Addition Quantities of Modified Nano Silica on Recipe Specific Gravity

Tear resistance shows the resistance of material to growth of any cut when it is under tension. This property is related to the tensile property. So that, tear resistance increase with small quantities of modified nano silica, as shown in figures (7). For the same reason as previously mentioned in the case of tensile property that the particles will fill the spaces between rubber chains and increase the mechanical bond between them. This lead to better tear resistance .In case of increasing the quantity of modified nano-silica for 3pphr, tear resistance decreases to 4.07 MPa of silica as shown in figure (7). The tear resistance decreases due to irregular distribution of (nano silica particles) in rubber matrix and aggregate between chains as mentioned in the case of tensile property. This agree with research [12].

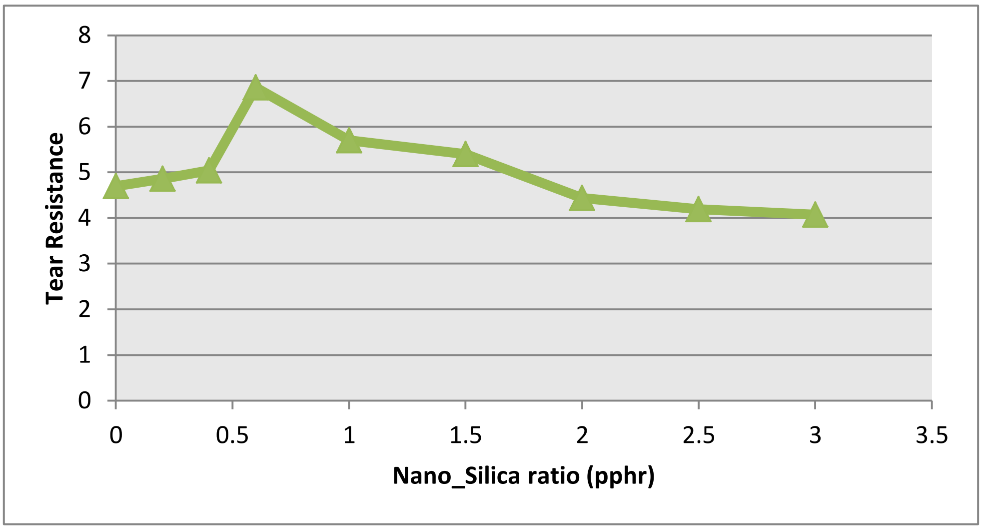

Figure 7 Effect of addition quantities of modified nano silica on tear resistance of recipe

Figure (8) of rubber wear shows that the addition of small amounts of nano-particles (modified nano-silica) ,at 0.2 pphr ,the weight loss of rubber increase due to nano particles as a fillers which do not contact with abrasion load. Then begins to decrease. But, the weight loss of rubber begins to decrease due to nano particles will be restrict weight loss because of the homogeneous distribution of nano-particles through rubber chains leads to good links with each of the chains and thus increasing the abrasion resistance.

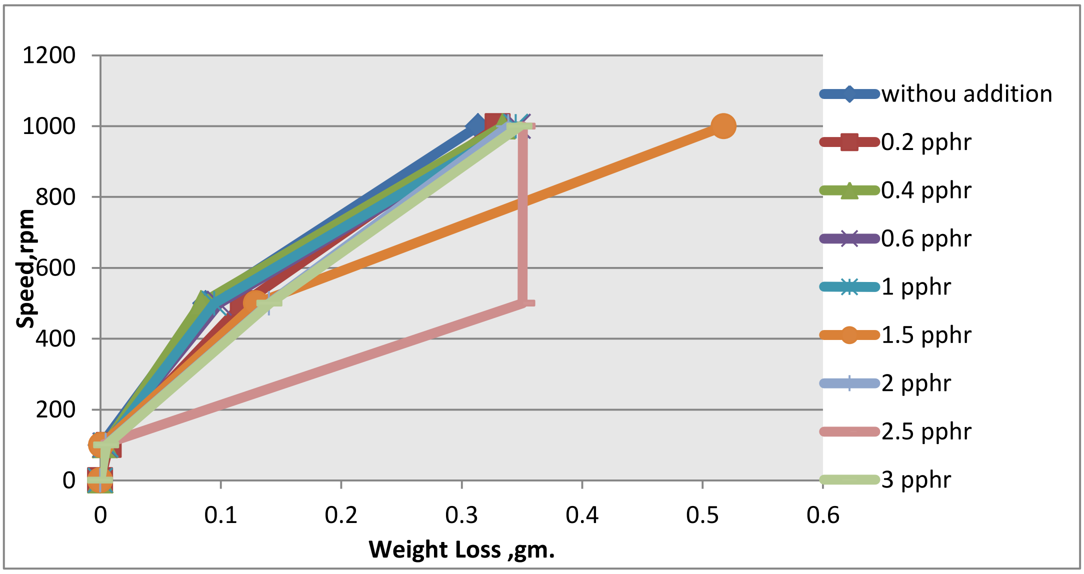

Figure 8 Effect of addition quantities of modified nano silica on wear resistance of recipe

3.2. Vulcanization properties (viscosity, torque, scorch time, cure time)

Modified Nano-silica at any percent addition increases the solidity of the elastic recipe, thus reflects an increment on both torque and viscosity. As shown in figure (9),(10).the appearance of nano-alumina leads to restricting the movement of rubber chains and thus increasing these properties.

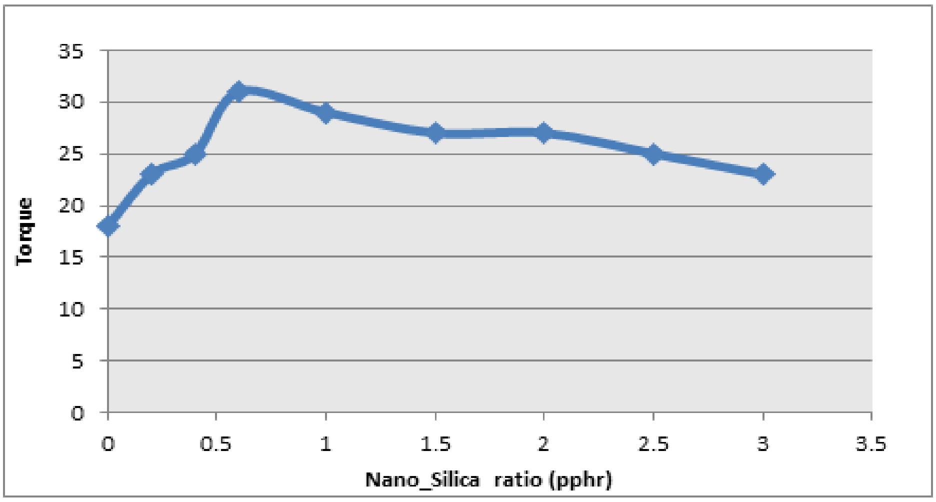

Figure 9 Effect of addition quantities of modified nano silica on torque of rubber composite

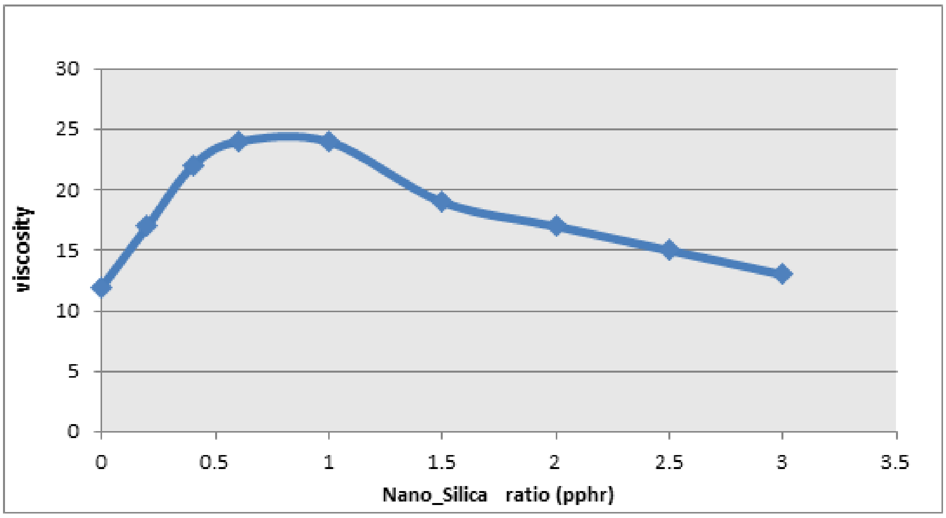

Figure 10 Effect of addition quantities of modified nano silica on viscosity of rubber composite

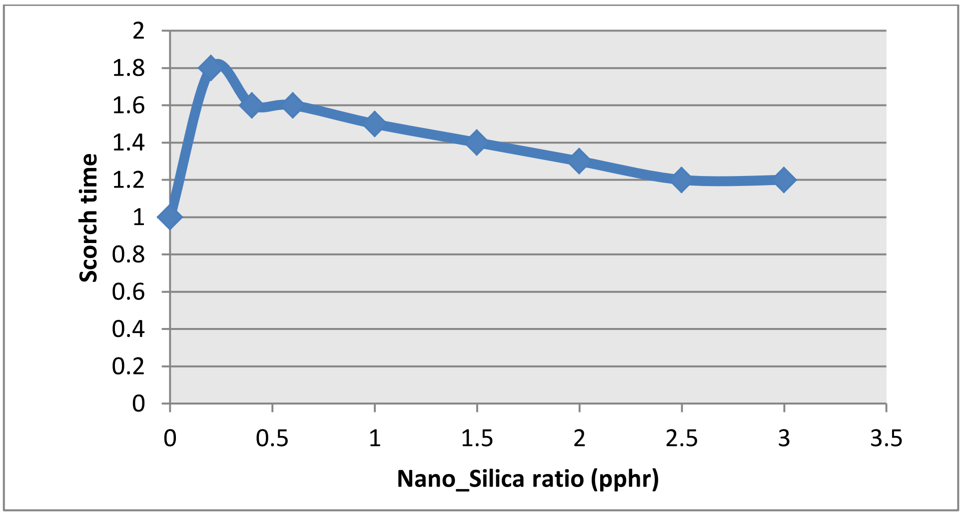

Figure 11 Effect of addition quantities of modified nano silica on scorch time of rubber composite

For scorch and cure times, modified nano silica at low percent appears an increment in both of these properties as figures (11 &12). This is due to the fact that silica makes as a coat on rubber molecule which allows the reaction with sulfur slightly and there is no extra effect on these times as nano silica increase.

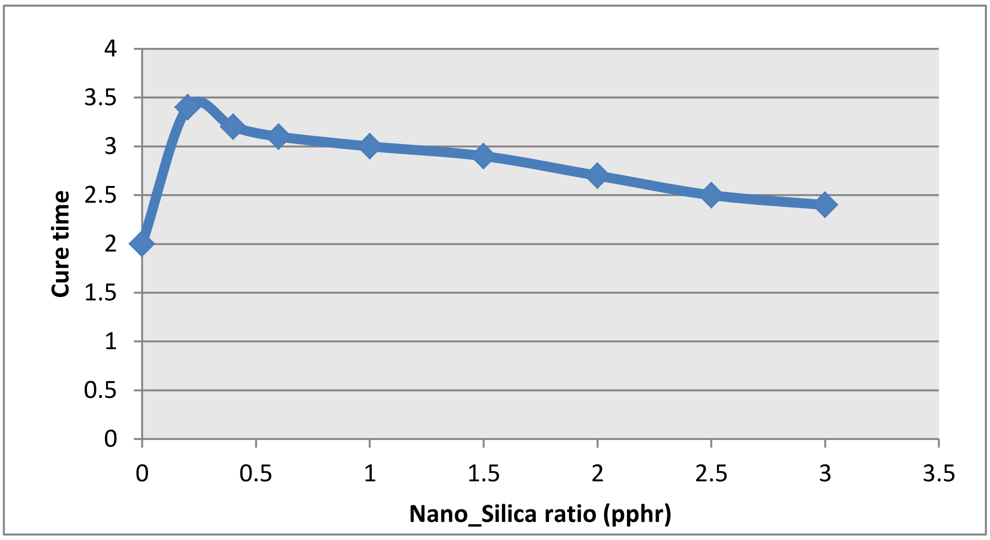

Figure 12 Effect of addition quantities of modified nano silica on cure time of rubber composite.

Figure 13 Show the rubber bushing product Manufactured

4. COCLUSIONS

- The best percentage of fillers that can give the best results is 0.6.
- The addition of nano-silica to the rubber in small quantities improve mechanical and physical properties, especially tensile strength, elongation, tear and wear. However, when adding a large quantities of fillers lead to aggregates of material that weakens the properties in general.
- The problems of the bush which are (heat, friction, and wear) improved by adding fillers where it can be operated at high temperatures at 1000 cycles per minute without friction or any defect.

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