THE EFFECT OF ADDING NANO-ZINC OXIDE PARTICLES ON MECHANICAL PROPERTIES OF RUBBER COMPOSITE

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ABSTRACT

The aim of this research is to produce an improved rubber valve by adding reinforced nanoparticles (zinc oxide) used to increase the protection of the rubber valve against tearing and wear and to improve the flexibility and service life of the valve. Zinc oxide nanoparticles were used as fillers in different percentages of phr (0.2, 0.6, 0.8, 1 , 1.2) to rubber pastry consisting of (100 % butyl rubber and 5 % neoprene rubber). In order to ensure that the nanoparticle (zinc oxide) added to the rubber affects the mechanical properties of the rubber, the following tests were carried out (tensile strength, hardness, elongation, wear, elasticity, density). The results showed that when a small amount of nano-zinc oxide is added, the mechanical properties of the rubber dough are significantly improved, increasing the product's lifespan by five times its original lifespan. The results (tensile strength, hardness , wear, fatigue) when zinc oxide was added (0.2, 0.6, 0.8, 1 , 1.2) showed that the best percentages added were (0.6) as in the following tests. (12.26 Mpa , 49 shore A, 817.5 % , 0.04 % g , 35,000 no. of cycle , 3.14 Mpa) .

Keywords— butyle Rubber;Zinc Oxide Nano powder;Tensile Test ;Hardness Test;Fatigue test .

INTRODUCTION

Rubber has played a major role in modern civilization, Because of its desirable requirements such as flexibility, light weight and other requirements. There are different types of rubber such as natural rubber (NR), synthetic rubber (SBR),(BR) and others. Rubber comes as a base material in overlapping products (composite materials) where raw rubber is blended with other additives that are essential for making the rubber product appropriate for the implementation for which it was produced. It should be observed that the requirements for rubber products are extremely dependent on the method of vulcanization or (entanglement)[1]. It is a method in which compounds move from elevated solubility and plasticity to an insoluble flexible state with enhanced mechanical characteristics and resistance to modifications in temperature and to the impact of solvents and other requirements. Other materials are added to the rubber in the vulcanization method in order to enhance some of its characteristics in order to promote its production or decrease costs. One of the most significant additives in rubber vulcanization is zinc oxide, citric acid, accelerators and carbon dioxide [2]. If nano scale zinc oxide minutes is used to activate the rubber dough and, due to its big surface area, the quantity of zinc oxide responds almost entirely and stays a negligible excess which can be ignored and heavily linked to the polymeric network. For this reason, a negligible quantity of unreacted matter is anticipated to be filtered and deposited in such a way that its minimal toxic effect on the surroundings and organisms can be ignored The purpose of this paper is improved mechanical properties of the rubber spout and boost the operating life of the spout, thereby lowering the costs of the repeated replacement of the rubber spout due to fast failure [3-6].

MATERIALS USED

A. Zinc Oxide Nano Powder

Zinc oxide is fine particles size (10–30nm) .This type of nanoparticles is supplied from (Sky Spring Nanomaterials, Inc.2935 Westhollow Dr., Houston, TX 77082 .USA).Table 1 shows the specifications of (ZnO) nanoparticles by manufacture.

Table 1. the specification of ZnO nanoparticles

Specification	Results
ZnO %	99+
Specific surface area	>60 m^2/g
Particles size	10-30 nm
Density (g/cm^3)	5.606
Color	White
Morphology	Nearly spherical

B. Rubber Compound

The materials used in this work are: The rubber batch materials are Polysar Butyl Rubber (100% of butyl rubber) blend with (ZnO) nano particles.

Table 2. The Composition of the Master Batch (Recipe) of Rubber Spout

Item	Compounding Ingredients	pphr					
1	Butyl rubber IIR	100.00	100.00	100.00	100.00	100.00	100.00
2	Neoprene CR	5.00	5.00	5.00	5.00	5.00	5.00
3	Traditional ZnO	5.00	…….	…….	…….	…….	…….
4	Nano ZnO	…….	0.2	0.6	0.8	1.00	1.2
5	Vulkaresen	10.00	10.00	10.00	10.00	10.00	10.00
6	Castor oil	5.00	5.00	5.00	5.00	5.00	5.00
7	HAF Black	60.00	60.00	60.00	60.00	60.00	60.00
Total		185.00	180.2		180.8	181.00	181.2

TESTS FOR FILLERS MATERIALS

A.Tensile Test

For the purpose of preparing a sample for the above tests, a slice of each recipe with a dimension of 150 * 150 * 2.5mm is prepared from a mould containing two sections 150 * 150 * 2.5mm Mounted on base

395 * 160 * 10 mm and covered with a lid with the same dimensions as the base for regular thickness. After the sample has been prepared, the test shall be carried out in accordance with ASTM D412-88 by the Monsanto T10 Tensometer, which is shown in the" Fig.1, " by using special jaws to holding the tensile sample, which is movable at speed 500 mm per minute

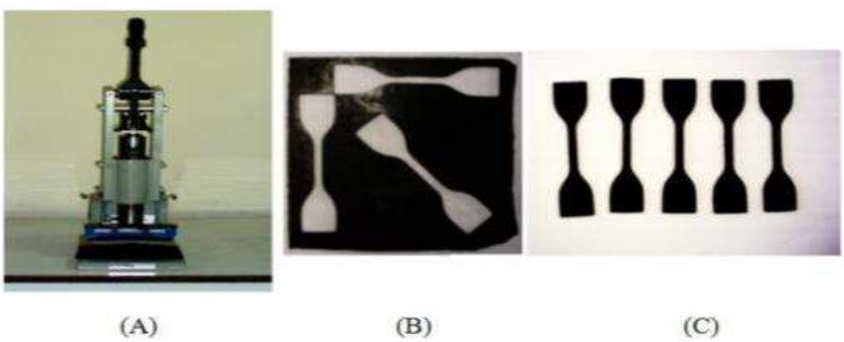

Fig. 1. (A) Hand Press, (B) Slice after Cutting, (C) Dumbbell Specimen.

B. Hardness Test

Preparation of the sample for the purpose of testing the hardness, where the use of a template containing three parts of the bottom of the base and the top part is considered as a cover with dimensions 150 * 150 * 10 mm, the middle part is a dimension of 200 * 180 * 6.5. Contains 9 circles open where are placed The samples are enclosed and sealed by the upper part and placed in a hydraulic press for vulcanization at pressure 500 PSI and temperature 160ºC for 30min. The samples are taken off from the mould and left for 24hr for cooling before test as shown in "Fig.2, ". International Hardness Testing one of the most important measurements of solid ball penetration in a rubber sample is in certain conditions where the test is performed according to ASTM-2240 standard using (Shore A) endurance scale, where the hardness gauge is used directly through the needle surface to measure the rigidity. Each sample has(5) readings to verify the accuracy of the test [7].

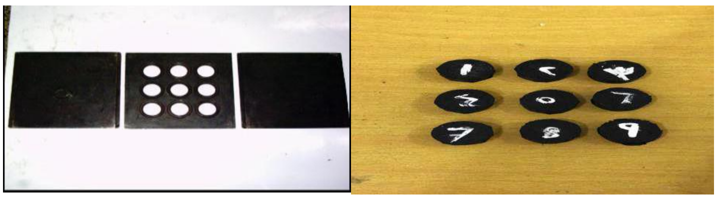

Fig. 2. (A) Hand Press, (B) Slice after Cutting, (C) Dumbbell Specimen.

C. Fatigue Test

For preparation flexibility test samples with dimensions contain half circular middle notch with a radius of 2.5mm the mould consists of three parts, the middle part with a dimension of 282*222*6mm contains on 6 empty spaces with (153*62mm) dimension a circular middle notch with a radius of 2.5mm divided the part and the 6 vacant . The first part is fixed on a base with a dimension of 282*222*10mm and covered with a cover for regulation thickness. Have circular middle shoulder divided the cover in the manner that the shoulder enters in the middle notch in the first base in order to create homogenous notch without cracking to facilities the process of cracking creation in the samples during the continuity of the test as shown in "Fig.3". The test was performed on the Dumb-bull sample according to the ASTM-4484 specification of the static capacitance test and the capacitor variable

Fig. 3. Sample of Fatigue Test.

D. Dry Sliding Wear Test

The sliding test was conducted in the pin-on-disk wear device. Under dry (unlubricated) circumstances, wear samples were screened. The size of the pin specimen (5 cm long, 6 mm in diameter). For all tests, the counter face was made of steel carbide with 0.1 μm roughness, 57HRc hardness and 35 mm diameter. The experiments were conducted under environmental circumstances.

RESULTS AND DISCUSSION

A. Tensile

"Fig.4," shows high tensile strength by adding small amounts of modified Nano zinc oxide , an increase in tensile strength was calculated). The tensile strength decreases as the concentration of modified zinc oxide Nano particles increases. Such behavior can explain that particles will fill the spaces between rubber chains in the case of small quantities, thus giving better tensile strength to a rigid structure (12.26 MPa). While aggregate in rubber matrix will occur in elevated amounts of altered ZnO Nano particles. This aggregate will result in the creation of defects where the beginning cracks and thus weaken the tensile strength to the (9.695MPa). This is agrees with [8],[9] .

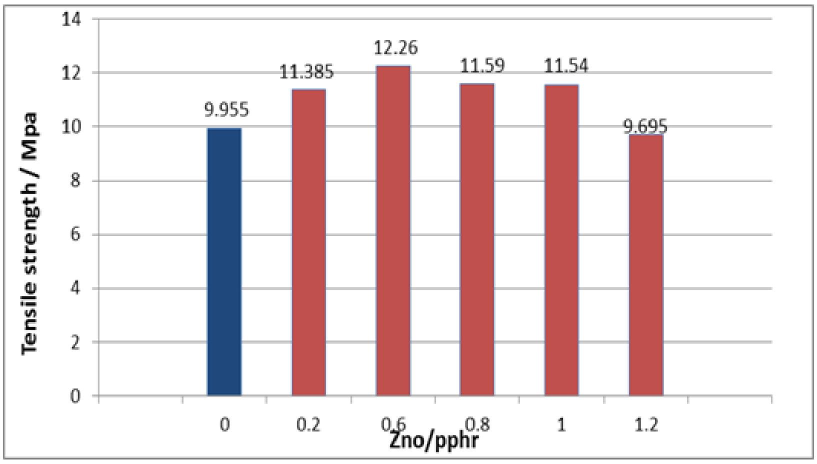

Fig. 4.Effect of Small and Large Quantities of Modified Nano-Zinc on the Tensile Strength of the Rubber Compound

B. Hardness

"Fig,5" when zinc nanoparticles are added to rubber at distinct proportions (0.2, 0.6, 0.8, 1.0, 1.2) pphr, a slight reduction in butyl rubber hardness values is noted when the proportion of nano zinc oxide added is increased. Which may have been the outcome of zno being partly devulcanized by the accelerator. The method of devulcanization produced gases that could have acted as a foaming agent; this is in line with studies [10-13].

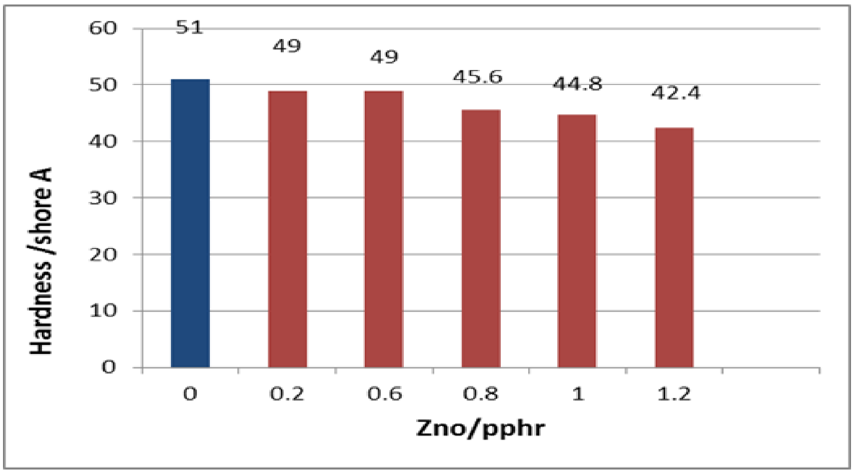

Fig. 5. Effect of the Addition Quantities of Modified Nano Zinc on the Hardness of the Rubber Compound

C. Fatigue

This property is a material that is resistant to cracking development. Zinc oxide nano particles acts as a filler at tiny quantities of altered nano zinc oxide as shown in "Fig.6" and provides resistance to crack growth. As the quantity of nano-particles rises agglomerate will occur and inhomogenous distribution will create stress in the recipe which discreet cracking as [14-16].

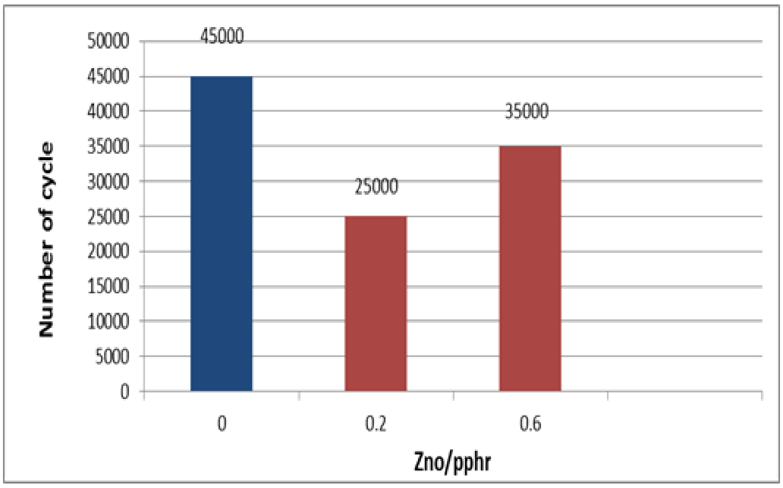

Fig. 6.The Effect of ZnO Nano Particles Weight Percentage on Fatigue Resistance of Nano Composites

D. Wear Strength

Vulcanized rubber goods are not as sticky as natural rubber and do not harden or excessively soften in cold weather, except at high temperatures, and return to shape after deformation instead of remaining deformed, it is very resistant to skimming. In other words, because the rate of vulcanization and entanglement in rubber increases the abrasion resistance of the vulcanized rubber material. In addition to its triggering function in vulcanization, zinc oxide increases skimming resistance as a filler [17],[18] .It has been found that with zinc oxide nanoparticles, the physical properties of rubber pastries have significantly improved, especially abrasion resistance [19],[]. This is why we find increased resistance to abrasion of the rubber dough (Zno/0.6 pphr) compared with traditional dough (Zno/pphr); this rise was due to the entanglement strength of the dough, as well as the role of zinc oxide in the reinforcement as a filler.

NOVATEUR PUBLICATIONS
JournalNX- A Multidisciplinary Peer Reviewed Journal
ISSN No: 2581 - 4230
VOLUME 8, ISSUE 6, June-2022

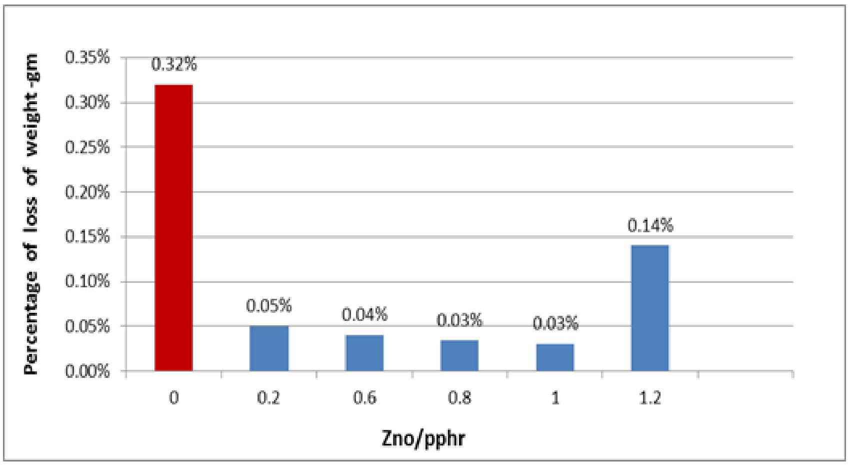

Fig. 7. Effect of Quantities of Nano Zinc Oxide on Wear Strength

CONCLUSIONS

The best fillers percentage that can deliver the best results is (0.6). Adding small quantities of nano-fillers to rubber improves mechanical and physical properties, but by adding a large amount of fillers, aggregates of material result in weakening the properties in particular.

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