Development of Oil Seal from Natural Rubber Using Coconut Shell and Rice Husk as Fillers

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Abstract

The essence of this research is to determine the physicochemical properties of oil seal made from natural rubber using cocoanut shell and rice husk as fillers to determine their competitive strength with the standard carbon black. Alkaline fillers accelerate curing while acidic ones retard curing in the processing of natural rubber. Curing refer to a process that helps in the crosslinking of the different components added to the rubber after formulation and compounding. From the test result, Coconut shell and Rice husk filled seals had pH values of 7.5 and 7.1 respectively compared with the standard having a pH value of 6.5. The rate of sorption depends on the moisture content, nature of the filler and also loss on ignition of the filler.

Keywords: Carbon black, Coconut shell, Curing, Natural Rubber, Oil seal, Rice husk, Vulcanisate

1 Introduction

One of the major problems facing our society today is maintanance. This mostly affects the industrial sector. The effect of wear and tear in industrial equipment (machine parts) and in automobiles is a major challenge to the automobile, engineering, oil & gas industries and many other industries.

Oil Seals provide the best seal for dynamic, high temperature and caustic environments, and have become the most durable, dependable and robust solution to many applications in the automotive and manufacturing industries.

It is sad to know that this wonderful component of most machines especially the hydraulic press and pumping machines has lead to their abandonment due to the fact that the seal has to be imported into the country from countries like China, Italy and America at very high costs.

Fillers or extenders are the major additives used in processing natural rubber and has advent effect and influence on rubber compound. Generally, it function is to modify the physical and chemical properties of rubber Vulcanisate, improve processing and reduce cost of production [1].

However, in spite of the numerous benefits obtained from agricultural by-products such as cassava peels, maize cob, cocoanut shell, rice husk, plantain peels e.t.c., they still constitute a large source of environmental pollution that is why it was deemed necessary to incorporate them as fillers in the compounding of natural rubber for the production of the Oil Seals.

Oil seals are made from various elastomers and the most commonly used is Nitrile, Polyacrylate, and Fluorocarbon. when determining which filler is best suited for the environmental conditions in which the seal will be placed, the following properties are taken into consideration: good chemical resistance, hardness, high resistance to water and other solvents, good resistance to heat and low temperature, good resistance to ozone and weather, aging and low compression set. Organic fillers especially the fibrous type provides reinforcement at a lower density than the inorganic fillers.

Their surface treatment is to improve dispersion. Most organic fillers improve heat resistance, minimize shrinkages and reduce cost. While researches are being conducted to unveil the usefulness of some of these by-products, a lot still remain unexplored. Some residues from agricultural products such as; groundnut shell, rubber seed shell, wood flour(saw dust), sugar cane shaft, cassava peels, rice husk, corn cob, palm kernel and cocoanut shell are very useful as fillers in the processing of natural rubber [2]. In the cause of this project, Coconut shell and Rice husk have been chosen.

This research work aim at developing oil seal from natural rubber using coconut shell and rice husk.

2.1 Natural Rubber

Natural rubber was discovered during the various invasions of South American by the Spanish conquistadors in the 15th and 16th centuries. Joseph Priesley in 1770 coined the name rubber. Europeans began to experiment rubber as a water proofing agent. In the early nineteen century it was used for water proofed shoes [3]. Today it is used in making foot mats, tyres, shoe soles and oil seals.

The earlier uses of this material were quite limited. Initially the problem of NR was its sensitivity to temperature and its char consistency. In 1839-1844 Charles Goodyear improved the process called vulcanization, which modified rubber so that it resists high temperatures. It was after then that natural rubber became suitable for producing hoses, tyres, industrial bands, sheets, shoes, seals foot mats and lot more[4].

2.2 Chemistry of Natural Rubber (NR)

All rubber-like materials are polymers, which are high molecular weight compounds consisting of long chains of one or more types of molecules called monomers. Vulcanization (curing) produces chemical bonding between the loosely coiled polymeric chains, elasticity occurs because the chains can be stretched and the stress is released. NR is a polyterpene i.e. it consists of isoprene molecules linked into loosely twisted chains. The monomer units along the back bone of the carbon chains are cis arrangement and it is the spatial configuration that gives rubber its highly elastic character. In gutta-percha, which is natural polystyrene, the isoprene molecules are bonded in a trans configuration leading to a crystalline solid at room temperature. Un-vulcanized rubber is soluble in a number of organic solvents including hydrocarbons such as benzene, toluene, gasoline, and lubricating oils [5].

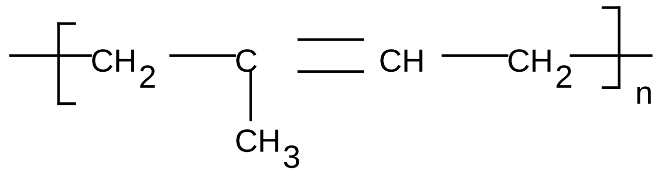

Figure 1: Natural Rubber structure

2.3 Rubber Seal

A rubber seal is a device which helps in joining systems or mechanisms together. It is a ring-shaped component that is designed to prohibit or limit the fluid leakage from a device. There are various types of seals used in various applications that have constantly moving component, such as the rotating or reciprocating shafts and cylinders that form an essential part of hydraulic and pneumatic systems including seals for windows of cars. Rubber seals are seals made from both natural and synthetic rubber.

There are many types of rubber seals used in industries for different uses. Some of the industries that make use of these rubber seals include: Medical and pharmaceutical, waste disposal, aerospace, marine, food and chemical processing, automotive, military, nuclear, pulp, paper mills and so on.

Some of the applications include pumps and valves, mechanical seals, hydraulic & pneumatics cylinder, filter, actuators, motors, engine, lubricating System etc.

Oil Seal: This is a very common type of seal. It is used to retain oil and other lubricants in rotary applications and prevent leaks. Many of these seals function with a flexible lip that rubs against the shaft or housing to prevent leakage by providing a tight seal.

One of the most important components of an oil seal is the elastomer material being used. When determining what elastomer is best suited for the environmental conditions in which the seal will be placed, the following properties are important to consider:

- Good chemical resistance

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- Good elasticity
- High resistance to water
- Good resistance to heat and low temperature
- Good resistance to ozone and weather aging
- Low compression set

These are particulate materials which are added to rubber mix to modify the physical nature and to some extent, the chemical properties. They also improve the processing characteristics and reduce cost [6].

2.4 Problem Statement

Nigeria is blessed with natural rubber but most of the oil seals being used in Nigeria are imported. In addition, majority of the machines that employ oil seals tend to remain idle when their oil seals develop problems this result to difficulty getting a replacement since the seals are not locally produced. Another problem this work seeks to address is the environmental pollution caused by rice husk and cocoanut shell which can be utilized as fillers to the natural rubber based seals.

3.1 Methods and Results

3.1.1 Coconut Shell Procrssing

50 g of the CNS is collected from the cocoanut processing industry, washed and allowed to dry either by air drying or use of mechanical dryers. The sizes of the shells were then reduced by harmer mill machine to coarse sizes. The pieces were then sent to an electrical powder milling machine to get a fine particle size. The powder is then sieved using a mesh size of (7 μ m) to obtain a finer powder of known particle size [7].

3.1.2 Rice Husk Processing

50g of RH is collected from a rice mill industry. It is washed and dried by either air drying or the use of mechanical dryers. The husk is then fed into an electrical powered milling machine to a fine powder. A mesh of size (7 μ m) was used to sieve the powder to a finer particle size [7].

3.1.3 Compounding

Mixing of rubber compound involves the incorporation and uniform dispersion of weighed ingredients into the rubber. The two roll mill machine was used to carry out the mixing. The rubber was thoroughly masticated to reduce its viscosity and enhance its flow. After three minutes of mastication, the rubber began to form a band round the roll of the mill. Mastication continued until a band was formed in between the top of the rolls and the compounding additives were added in the order listed below.

The zinc oxide and stearic acid were added first and allowed to mix for about two minutes, and then mercapto benzothiazole, mercapto benzothiazole disulphate, tetramethyl disulphate and trimethyl quinoline were added at two minutes intervals. 25pp/100 of the fillers was added and allowed to mix for two minutes before the remaining portions were added to allow proper mixing. The compound mix was then sheeted out from the rolls and stored in a clean plate for about two hours for stress relaxation.

3.1.4 Curing

The curing of the compounded rubber was carried out in a hot hydraulic press machine with electrically heated platterns. A mold of specified shape (45*5*3mm) was used to prepare test pieces. The mold was preheated for five minutes to a temperature of 150± 20°C. It was then removed from the machine and lubricated with silicon oil before the compound mix was loaded into the mold and placed in between the platterns of the hot press machine at a pressure of 10kN. This procedure was repeated for the three samples at an interval of 10minutes.

The cured pieces were brought out from the mold and allowed to cool to room temperature before analysis.

3.1.5 Sorption Test

Sorption test of vulcanisate was determined by putting the rubber seal of known weight in various solvent at room temperature at an interval of 5 - 180min. The rubber vulcanisate was then removed and weighed. The difference between the initial weight and final weight (ΔW) was recorded as the sorption rate [8].

Table 1:

Sorption rate result for Carbon Black (CB) filler

Time (min)	Toluene, (g)	Benzene, (g)	Xylene, (g)	Hydraulic Oil (g)	Petrol, (g)	Kerosene, (g)
5	0.2	0.2	0.1	0	0	0.1
15	0.3	0.3	0.2	0	0.1	0.1
30	0.4	0.4	0.4	0	0.2	0.1
50	0.5	0.5	0.5	0	0.3	0.2
75	0.6	0.6	0.6	0	0.3	0.2
105	0.7	0.7	0.7	0	0.4	0.2
120	0.9	0.7	0.8	0	0.5	0.3
140	0.9	0.8	0.9	0	0.5	0.3
160	1	0.8	0.9	0	0.6	0.3
180	1.1	0.9	0.9	1	0.6	0.3

Table 2:

Sorption rate result for Coconut Shell (CNS) filler

Time (min)	Toluene (g)	Benzene (g)	Xylene (g)	Hydraulic Oil (g)	Petrol (g)	Kerosene (g)
5	0.1	0.1	0.1	0	0	0
15	0.2	0.2	0.3	0	0.1	0.1
30	0.3	0.3	0.4	0	0.2	0.1
50	0.4	0.4	0.5	0	0.3	0.2
75	0.5	0.5	0.7	0	0.4	0.2
105	0.6	0.6	0.8	0	0.4	0.2
120	0.7	0.7	0.9	0	0.5	0.3
140	0.9	0.8	1	0	0.6	0.3
160	1	0.8	1	0	0.7	0.3
180	1.1	0.9	1.2	0	0.7	0.3

Table 3:

Sorption rate result for Rice Husk (RH) filler

Time (min)	Toluene (g)	Benzene (g)	Xylene (g)	Hydraulic Oil (g)	Petrol (g)	Kerosene (g)
5	0.1	0.1	0.2	0	0.1	0
15	0.3	0.2	0.3	0	0.2	0.1
30	0.4	0.3	0.4	0	0.3	0.1
50	0.5	0.5	0.5	0	0.4	0.2
75	0.7	0.6	0.6	0	0.5	0.2
105	0.8	0.7	0.7	0	0.5	0.2
120	0.9	0.8	0.8	0	0.6	0.3
140	1	0.9	0.9	0	0.7	0.3
160	1	1	1	0	0.8	0.3
180	1.1	1.1	1	0	0.8	0.3

From Tables 1, 2, and 3, it was observed that the difference in the sorption rate at 180 min between the standard (carbon black) and the samples (cocoanut shell and rice husk) was 0.1g in hydraulic oil.

- In toluene, hydraulic oil and kerosene at 180min, the sorption rate was the same in both the standard and the samples.
- In benzene at 180min, the sorption rate in the standard and CNS remained the same but in RH there was a difference of 0.2g.
- In xylene at 180min, the sorption rate in the standard and RH remained the same but in CNS there was a difference of 0.2g.
- There was a slight variation in the sorption rate of the standard and both samples in petrol at 180min. Coconut shell varied by 0.1g while rice husk by 0.2g.

The slight differences in the sorption rate between the standard and the samples in some of the solvents could be attributed to the moisture content. The presence of water affects inter-

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particle bonding and filler-polymer interaction. Coconut shell and Rice husk are not carbonized hence will have a greater Moisture Content than Carbon black.

4. Conclusion

(a). It can be deduced from the results that the seal filled with Coconut shell competed favourably with the standard Carbon Black than that filled with Rice Husk hence can be used in its stead.

(b). comparatively, coconut shell and rice husk filled seals were observed to be more effective in the presence of hydraulic oil than the standard which was filled with carbon black.

(c). however, in the presence of benzene and petrol, seals filled with carbon black and coconut shell showed favourable sortion property than those filled with rice husk, where as in xylene solvent it is more favourable to use seals filled with rice husk and carbon black than that filled with coconut shell.

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