Key Engineering Materials
ISSN: 1662-9795, Vol. 851, pp 47-52

Submitted: 2020-01-23
Revised: 2020-02-21
Accepted: 2020-02-27
Online: 2020-07-03

The Effect of Addition of Waste Materials on Nitrile Butadiene Rubber to the Mechanical Properties of Roller Rubber

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Keywords: NBR, hardness, tensile strength, waste materials

Abstract. This research aims to determine the effect of adding filler material in the form of waste material on Nitrile Butadiene Rubber (NBR) in making roller rubber to improve quality in terms of hardness and tensile strength. Each rubber roller compound is made from a mixture of NBR with rice husk, recycled rubber and wood charcoal. The process of making NBR and NBR with the addition of alloys is done with two roll open mixers at a certain temperature and time accompanied by the addition of certain additives. Furthermore, the compound is pressed using Hydrosan and then cut according to the standard test to be performed. The process ends by placing the material in an environment with a certain humidity level for 24 hours. Tests carried out include the test of hardness by using Shore A Durometer and Universal testing machines to test the strength of tensile strength. The test results show that the addition of recycled rubber can increase hardness by 30% when compared to NBR without the addition of filler. While the value of tensile strength for NBR and recycled rubber alloys is much higher.

Introduction

Rubber is a hydrocarbon polymer that is contained in latex in several types of plants [1]. This rubber material comes from a tree that is a rubber tree. The rubber tree originates from the Brazilian Amazon valley with the scientific name Hevea brasiliensis [2-3]. The new rubber tree entered Asia in 1876 AD, after the British smuggled rubber seeds from Brazilia to be developed at the British Botanical Garden and its colonies including Malaysia.

Rubber is divided into two types, namely Natural Rubber and Synthetic Rubber [4]. Chemically natural rubber is a hydrocarbon compound which is a natural polymer resulting from the clumping of polyisoprene macromolecules (C_5H_8). While synthetic rubber is rubber made from raw materials derived from coal oil, oil, natural gas, and acetylene which are formed for special or certain needs. The types of synthetic rubber are NBR (Nitrile Butadiene Rubber), CR (Chloroprene Rubber) and IIR (Isobutene-Isoprene Rubber) [5].

Natural and artificial rubber is widely used in various industries, because of their superior nature. For products to be obtained from these ingredients to have the required properties, many fillings, and additives that have various properties added during the process [6]. Many literatures review has shown that various ingredients such as mica powder [7], glass fiber [8], nanoclay [9], calcium carbonate [10], carbon black [11-13] are used as fillers. The high cost of fillers has encouraged people to look for cheaper fillers. The reason for adding reinforcing fillers to rubber material in general equipment is to produce the desired commercial elastomer.

In the production of NBR rubber has a low hardness value which has good formability but has low resistance [14-16]. In NBR, several alloys can be given, namely charcoal, rice husk, and recycled rubber. Rice husk can be used on NBR type rubber by coating and adding it as their filler which is expected to increase the hardness of the NBR rubber. In addition, by changing the filler, it can reduce production costs.

The mechanical properties of the rubber material, in general, are the strength of elasticity caused by the vulcanization process in the manufacturing process so that the positions of the molecules are interlocked with each other to hold the voltage to its limit, but specifically, the nature of rubber depends on the composition of the forming needs certain uses of rubber itself [17-18].

Rubber roller is a component in a machine or cylindrical system consisting of rubber that is attached to a core or core made of metal that functions as a shaft [19]. The characteristics of roller rubber itself are determined by the type of rubber used and its use, the characteristics that need to be considered to determine quality are high coefficient of friction, quickly returning to their original shape when the shape is distorted, resistant to chemicals and protecting core rollers and shafts, preventing damage caused by scratches and vibrations, compensates for vibrations for precision machining and has many other special uses.

In this case, in addition to conventional fillers, different waste materials are used as fillers. The aim of this study is to investigate the effect of fillers on the hardness and tensile strength of rubber compounds.

Materials and Method

The raw material is in the form of synthetic rubber and checks are carried out in the form of examining synthetic rubber and its composition. The process of making a rubber compound is fully carried out with an open mill type 2 cylinder mill which is used to soften raw materials (raw or synthetic rubber) and mix them with carbon (other chemicals) homogeneously.

NBR (Nitrile Butadiene Rubber) rubber is purchased directly from Japan and rice husks, recycled rubber, and charcoal are purchased from local products. The NBR manufacturing process is carried out with an two-roll open mixer, which has been cleaned. Furthermore, synthetic rubber (NBR) is milled before being ground until plastic for 1-3 minutes. Then mixed with chemicals namely ZnO and stearic acid, then cut each side up to three times for 2-3 minutes. Then MBT, TMQ, IPPD and CBS are added until the milling achieves uniform / homogeneous results. NBR rubber is formed at 80˚C and 60 rpm for 10 minutes

Then, rice husk, recycled rubber, and charcoal are added with a percentage of 10% Wt. into NBR rubber compounds. After being mixed, the mixture is left to stand for 24 hours. The mixture is then mixed in a two-roll open mixer at 80˚C and at 40 rpm for 5 minutes, followed by additives such as softener, activator, vulcanization, and sulfur, and stirring is continued for 3 minutes.

Rubber compounds are cut into small pieces, placed in a 180x180x6 mm mold that can be compressed with a press (Hydrosan) to 160ºC at 5 minutes under a pressure of 16 MPa and the compound is vulcanized under the same conditions. All tests were carried out after the compounds were cut into standard dimensions according to the relevant test standards and stored in an environment that had a 50% relative humidity at 28 ± 2 ºC for 24 hours. Measurements of vulcanized hardness were carried out using Shore A Durometer. Tensile strength tested using Universal Testing Machine.

Results and Discussions

The process of making compounds includes 5 functions, namely mastication or destruction of rubber so that the viscosity or molecular weight drops, mixing with other chemical compounds, incorporation or coating of chemical compound filler in rubber where the rubber will undergo large deformation which will wrap the filler, dispersion where the filler has bandaged rubber is crushed again into smaller particles and distribution and plasticization to increase mixed homogeneity.

The mixing process takes place between two rotors which rotate in the opposite direction. The two axes of the rotor are parallel, and each rotor has a different tangential speed. The distance between the surface (nip) of the rotor is regulated by a screw regulator.

As a result of the difference in tangential speed and narrowing of the nip, the rubber compound experiences shear forces, and the shear forces break the bonds (chains) of the rubber molecules. With the breakdown of the rubber, molecule chain allows carbon and other chemicals to be mixed with rubber.

From the Quality Control setelah proses pembuatan NBR selesai, carried out the data obtained from the hardness test of NBR rubber at various different temperatures and then illustrated in Figure 1 below.

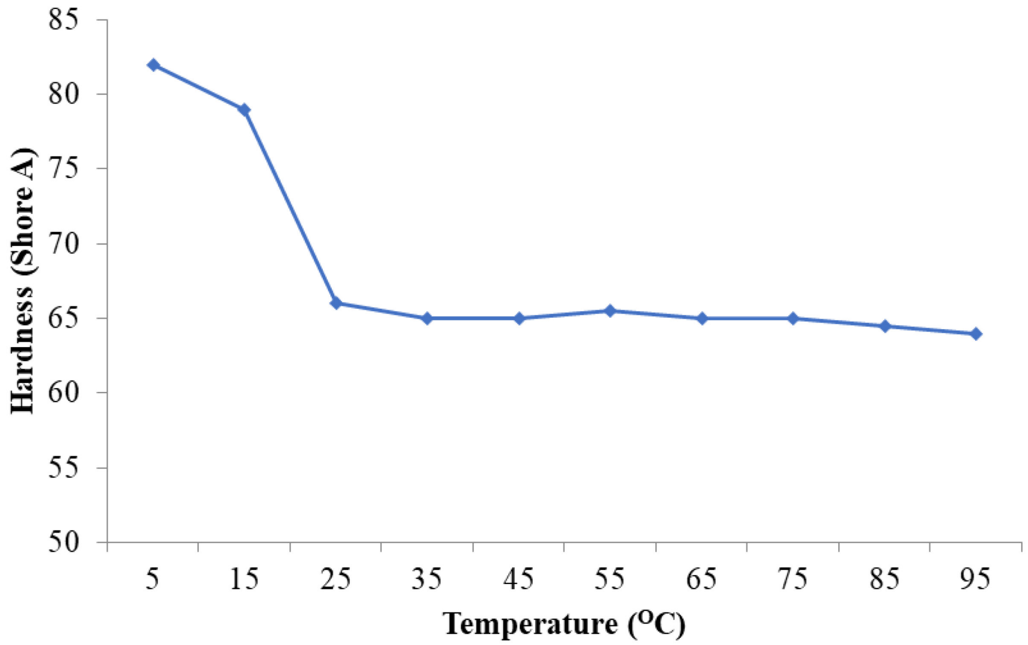

Figure 1. Temperature Resistance Test Results for NBR

From the above data, it can be seen that the higher the ambient temperature, the lower the hardness of NBR rubber. This is caused by the density of particles stretching with increasing temperature, causing softening of the material and decreasing the hardness of compound of NBR.

In the data above there are some differences in the data that the company has with the data taken. This happens because the material tested has an uneven difference in hardness as a result of the heating carried out

Meanwhile, from the hardness test, the hardness data obtained from the manufacture of NBR (Nitrile Butadiene Rubber) rubber with various fillers can be seen in Figure 2.

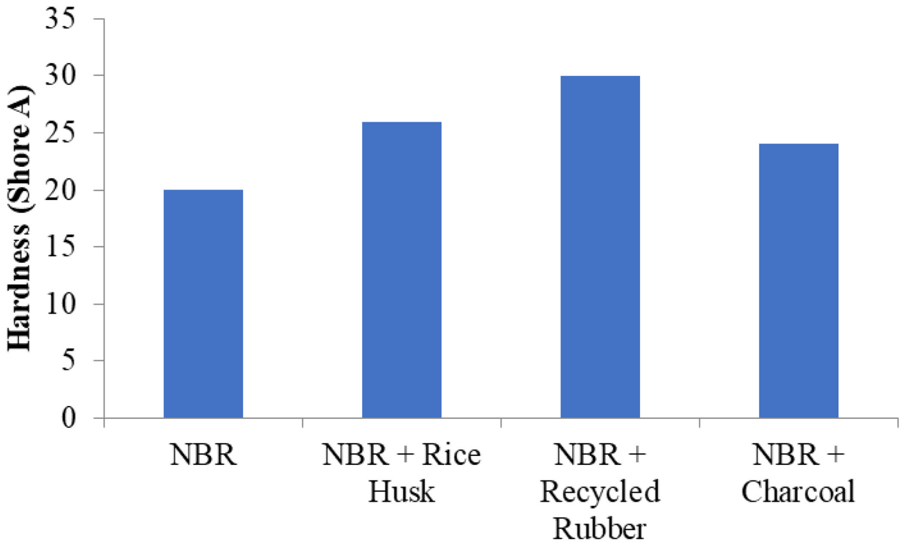

Figure 2. Hardness number of NBR with various fillers

From the data above it can be seen that each alloy gives a different effect. The alloy is a reinforcement of the NBR as its main material. Each filler has different characteristics, rice husk and charcoal only slightly changes the value of hardness because it still has properties similar to NBR rubber but already has impurities. For the alloy of NBR rubber with rice husk, the highest hardness is 26 Shore A. This material in terms of price is cheaper because it is waste material. However, the display has a rougher surface compared to other materials. Whereas the use of charcoal as an alloy of NBR rubber has a lower hardness compared to the alloy of NBR and rice husk which is equal to 24 Shore A. But the appearance that is owned is the same as the alloy of NBR and rice husk. So from that, the best as a filler is recycled rubber which has succeeded in increasing hardness with the value of hardness is 30 Shore A and reducing production costs. Increasing hardness is caused by the presence of an optimum amount of reinforcing filler, which will increase the hardness, wherein the strengthening effect of the filler is determined by particle size, surface condition, shape, grain fineness and even distribution.

Tensile strength is the amount of load needed to stretch the pieces of the NBR test to break, which is expressed by the amount of load given divided by the area of the cross-section of the test pieces before stretching. The value of the breaking stress indicates the elasticity of the rubber [6]. The effect of filler addition on the manufacture of NBR rubber on tensile strength can be seen in Figure 3.

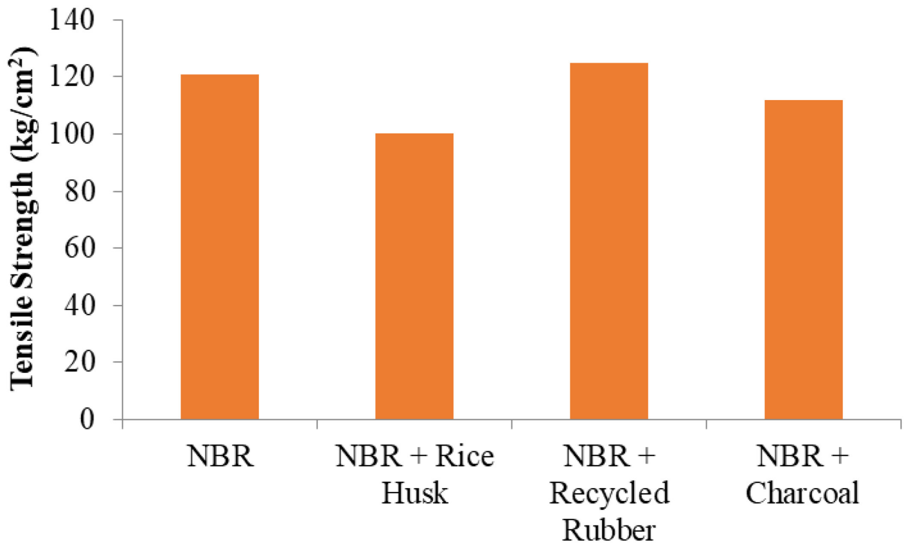

Figure 3. Tensile strength of NBR with various fillers

From Figure 3, it can be seen that the value of tensile strength on the NBR added by recycled rubber has the highest breakdown value when compared to NBR with the addition of recycled rubber. This is related to the value of the hardness obtained from the results of the previous hardness test, the hardness of NBR added by recycled rubber has the highest value. The high value of this tensile strength indicates that this material is more toughness. There is a tendency that the use of recycled rubber results in higher UTS values. This is due to the ability of the butadiene group to react with the active group on the NBR rubber molecule to form new cross-bonds between molecules that have the effect of increasing UTS. The tensile testing process will break some of the existing polymer bonds, resulting in the rubber becoming stronger so that the UTS become high after the tensile testing process is complete [20].

Conclusions

From the research that has been done, it can be concluded that NBR has changed its mechanical properties when mixed with other materials, either in the form of rice husks, recycled rubber or charcoal. The results show that the higher the ambient temperature, the higher the NBR hardness. This is caused by the density of particles that enlarges with increasing temperature, causing softening of the material and reducing the hardness. however the addition of filler can increase the hardness and tensile strength. The highest value for hardness and ultimate tensile strength was obtained by NBR with the addition of recycled rubber of 30 Shore A and 125 N / cm^2. This is due to recycled rubber distribution and particle size and surface conditions can provide a reinforcing effect.

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