



Experimental Investigation on Mechanical Properties of Indigenous Rubber Products

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Abstract: A study on the mechanical properties of different indigenous rubber sample of various companies have been conducted to have an idea of the quality of their rubber comparing with the American Society for Testing and Materials (ASTM) standard value. Two types of sample were taken for analysis: rubber sheet and bi-cycle tube. These rubber products have been procured from the local market. Tensile strength, Percentage of elongation, Hardness were obtained for both the rubber products. Then the statistical analysis was done for each of the properties. It has been observed that none of the products follow the standards.

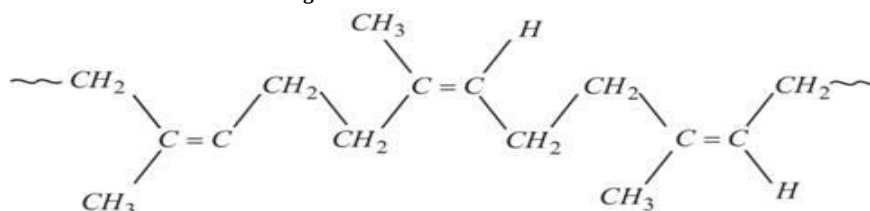
Keywords: ASTM standard; Tensile strength; Percentage of elongation; Hardness; Statistical analysis

I. Introduction

Until recently modern thinkers believed that rubber originated in 19th century Europe. The ancient Mayan people used latex to make rubber balls, hollow human figures, and as bindings used to secure axe heads to their handles and other functions. Latex [1] is the sap of various plants, most notably the rubber tree. When it is exposed to the air it hardens into a springy mass. The Mayans learned to mix the rubber sap with the juice from morning glory vines so that it became more durable and elastic, and didn't get quite as brittle. In 1791, an Englishman named Samuel Peal discovered a means of waterproofing cloth by mixing rubber with turpentine. English inventor and scientist, Joseph Priestly, got his hands on some rubber and realized it could be used to erase pencil marks on sheets of paper. Charles Goodyear, an American whose name graces the tires under millions of automobiles, is credited with the modern form of rubber. Goodyear's recipe, a process known as vulcanization, was discovered when a mixture of rubber, lead and sulfur were accidentally dropped onto a hot stove. The result was a substance that wasn't affected by weather, and which would snap back to its original form if stretched. The process was refined and the uses for rubber materials increased as well. This new rubber was resistant to water and chemical interactions and did not conduct electricity, so it was suited for a variety of products.

Natural rubber [2] is a linear polymer of an unsaturated hydrocarbon called isoprene (2-methyl butadiene). There may be as many as 11,000 to 20,000 isoprene units in a polymer chain of natural rubber.

Fig. 1. Structure of natural rubber.

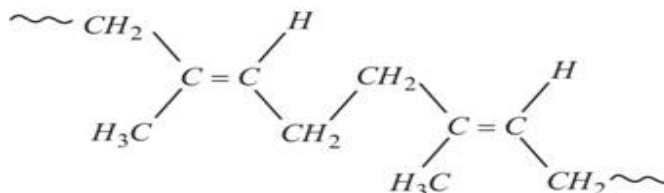


Because of its elasticity, resilience, and toughness, natural rubber (NR) is the basic constituent of many products used in the transportation, industrial, consumer, hygienic and medical sectors [3]. Of these major end-use markets for rubber, transportation is by far the largest single sector, with tires and tire products accounting alone for over 50% of NR consumption. Truck and bus tires would represent the largest single outlet for NR, followed by automobile tires. Non-tire rubber items include industrial products (for example, transmission and elevator belts, hoses and tubes, industrial lining, and bridge bearings); consumer products (like golf or football balls and other recreational and sports goods, erasers, footwear and other apparel); and articles for use in the medical and health sector (notably, condoms, catheters and surgical gloves) as well as seismic materials (for instance, over 500 and 2,500 buildings are respectively fitted with seismic rubber bearings in China and Japan).

Apart from NR, Today about three quarters of the rubber in production is a synthetic product (synthetic rubber) to obtain certain properties that are absent in natural rubber. In general, Synthetic Rubber [2] (also known as

Gutta-Percha) was obtained by the free radical polymerization of Isoprene. The rubber so formed has all trans-Configuration. As a result of this, synthetic rubber has a highly regular zig-zag chain which cannot be stretched. This accounts for non-elasticity of Synthetic Rubber.

Fig. 2. Structure of synthetic rubber.



There have been developed thousands of rubber manufacturers in Bangladesh which are producing rubber by local technology & technicians without following any standard. Most of them doesn't use any engineers or experts but simple illiterate technicians. So questions arises about the standard of the rubbers with respect to international standard i.e. ASTM, BS etc.

As rubber is an important engineering material, its quality must be assured. It has become important to test its mechanical properties with a view to ascertaining whether it is suitable for the require application. There must be a yearly survey on the rubber for its quality control. But unfortunately there are no such facilities for that. So, being motivated with the facts we decided to work on it to know the present condition of indigenous rubber & to play a role in improvement of its properties.

It could have been a good work if almost all the indigenous rubber products of different industries could be taken into consideration. As a preliminary step only products from two industries were taken and tested to compare their properties with international standard.

II. Theory

Following statistical parameters are used in this thesis for statistical analysis :

A. Mean

If $x_1, x_2, x_3, \dots, x_N$ represent the values of 'N' samples then the sample mean is computed from the relation [4],

$$\mu = (\sum x_i)/N$$

here, $i = 1, 2, 3, \dots, N$

B. Standard deviation

The variance can be computed as

$$\sigma_x^2 = \{(x_1 - \mu)^2 + (x_2 - \mu)^2 + \dots + (x_N - \mu)^2\}/(N-1)$$

The sample standard deviation can be written as,

$$\sigma_x = [\{\sum (x_i - \mu)^2\}/(N-1)]^{1/2}$$

C. Normal distribution curve

The most important continuous probability distribution in the entire field of statistics is the normal distribution. If 'x' is the normal random variable with mean μ & variance σ_x^2 , then the expression of the normal distribution curve is,

$$f(x) = \exp[-\frac{1}{2}\{(x-\mu)/\sigma\}^2]/\{\sigma \sqrt{2\pi}\}$$

III. Specimen preparation & test equipment

Two types of rubber specimen were used in our analysis. Specimen – A: rubber sheet and Specimen – B: bicycle tube. For each specimen 150 samples (totaling 300) were taken. The specimens were prepared by using cutting dies with the help of hydraulic press. The dimensions were maintained according to the ASTM standard [5]. The main equipment used for tensile & elongation test is rubber tensile testing machine. The machine was built in BUET by the previous alumni's. It consists of control panel box, spring balance, gripper, lead screw, 3-Ø motor (1 hp), limit switch, emergency stop switch stopper etc. Apart from that, test data's also measured in a digital machine (JT TOHSI). For hardness, testing Durometer was used.

IV. Sample calculation

Tensile Strength [6] = P/A

where, P = Applied load, in N

A = Cross sectional area, in mm^2

For Specimen-A; Sample No. 110

P = 30.41 N

A = 12.6896 mm^2

Tensile Strength = (30.41/12.6896) MPa

$$= 2.39645 \text{ MPa}$$

% of elongation [6] = [(Final length - Gauge length)/ Gauge length] x 100%

For Specimen-B; Sample No. 120

Gauge length = 25 mm

Final length = 164.9 mm

% of elongation = [(164.9 - 25)/25] x 100% = 559.6 %

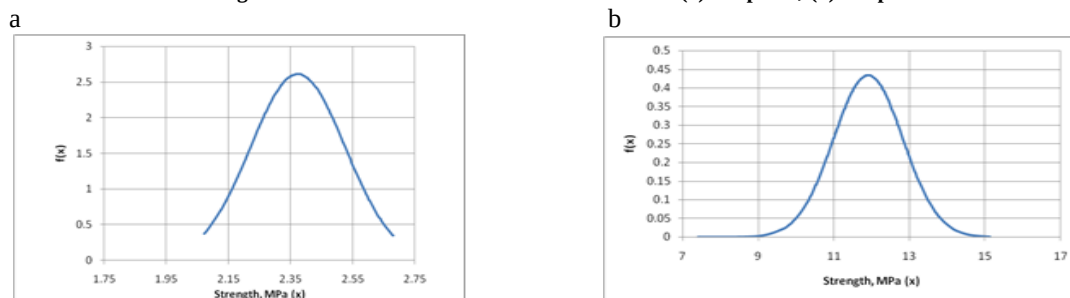
Table I. Statistical parameters obtained from experiment.

Properties	Statistical Parameters	Sample-A	Sample-B
Tensile Strength	Mean, μ (MPa)	2.37	11.91
	Standard deviation, σ_x (MPa)	0.15	0.92
% of elongation	Mean, μ (%)	80.98	547.78
	Standard deviation, σ_x (%)	14.66	23.03
Hardness	Mean, μ	82.15	50.31
	Standard deviation, σ_x	1.71	0.89

V. Result analysis

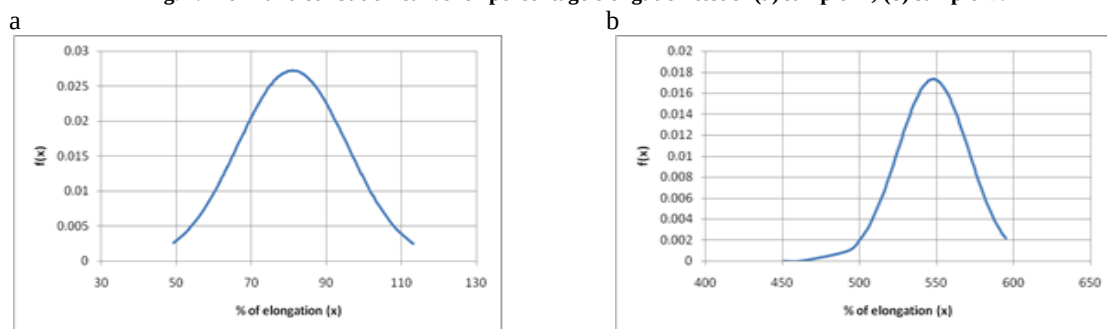
The mean value of tensile strength obtained from test for specimen – A and specimen – B is 2.37 MPa and 11.91 MPa respectively. While according to ASTM standard [5] the minimum value of tensile strength should be 15.5 MPa.

Fig. 3. Normal distribution curve for tensile test of (a) sample-A; (b) sample-B.



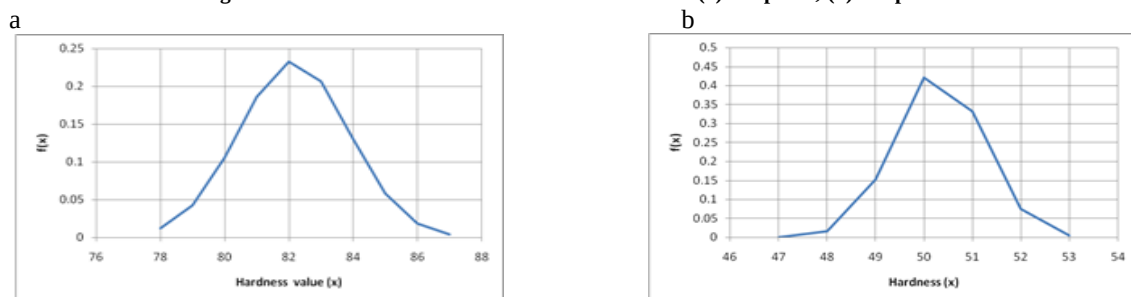
The mean value of percentage of elongation obtained, 80.98% for specimen – A and 547.78% for specimen – B while the ASTM standard is 350%. [7].

Fig. 4. Normal distribution curve for percentage elongation test of (a) sample-A; (b) sample-B.



For vulcanized rubber products the acceptable range of hardness (Shore-A) number is 60 ± 5 [8]. But from experiment, it was found that the mean value of hardness of specimen – A is 82.15 & for specimen – B, it is 50.31.

Fig. 5. Normal distribution curve for hardness test of (a) sample-A; (b) sample-B.



VI. Discussion

The rubber products were produced locally & sold in the market without test. The manufacturers are not following any standard; as a matter of fact the people of this country are purchasing rubber products of non-standard mechanical properties. More integrated prediction can be made if the effect of temperature on the various properties of natural rubber can be studied along with other mechanical properties of rubber e.g. ash content, compression set, shear modulus can be determined.

VII. References

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