DETERMINATION OF MECHANICAL PROPERTY OF SYNTHETIC RUBBER USING OPTICAL MOUSE AS A VIBRATION SENSOR

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Abstract. Synthetic rubber is an incompressible isotropic hyper-elastic material. Its mechanical property is described only by rigidity modulus at undeformed configuration which is one third of Young's modulus at the same configuration. This paper describes an indirect method to determine its rigidity modulus by measuring the frequency of oscillation of a loaded rubber string. Small super-imposed oscillation at static equilibrium stretch is measured with an optical mouse. The obtained data is processed to determine the frequency of oscillation. This process of acquiring data and processing it to obtain the desired information is known as Data Acquisition. Post processing and interpretation of the signal is done with help of MATLAB. The rigidity modulus of synthetic rubber is thus determined.

Keywords: small superimposed oscillation, rigidity modulus, hyper-elastic material, optical mouse, Fast Fourier transformation, data acquisition

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1. Introduction

Synthetic rubber is a type of artificially made polymer material commonly known as elastomer. An elastomer can undergo much more elastic deformation under stress than most materials and still return to its previous size without permanent set. Thus it is extensively used in machine and structural foundation. Its improved material properties enable it to serve as a good substitute for natural rubber. Some of the uses of synthetic rubber are as in plumbing fixtures, mechanical seal, mechanical belt, tires etc. In sheet form, it is used to make diving suit, glove, protective clothing, and radar absorbing material.

The synthetic rubber is considered to be incompressible isotropic hyperelastic material. Its mechanical property is defined through its rigidity modulus G in the reference configuration. The incompressibility condition leads the rigidity modulus as one third of the Young's modulus in such a configuration. The non linear stress-stretch relation often makes it difficult to determine the initial slope in the ground state. This work gives an indirect method to determine the rigidity modulus by measuring frequency at different steady state stretch. The method shows an effective agreement with the theory, thus determining the rigidity modulus effectively.

The experiment is conducted with an optical mouse. The optical mouse uses a tiny camera to take 1,500 pictures every second. The mouse has a small, red light-emitting diode (LED) that bounces light off that surface onto a complimentary metal-oxide semiconductor (CMOS) sensor. The CMOS sensor sends each image to a digital signal processor (DSP) for analysis. The DSP, operating at 18 MIPS (million instructions per second), is able to detect patterns in the images and see how those patterns have moved since the previous image. Based on the change in patterns over a sequence of images, the DSP determines how far the mouse has moved and sends the corresponding coordinates to the computer. The optical mouse has been demonstrated to be an optical displacement sensor beyond its use as a pointing device. It has been shown that optical mouse may be applied to measuring vibratory displacements with reasonable accuracy. Here, an experiment is done to measure low frequency mechanical oscillations using optical mouse.

The dynamic analysis of loaded rubber string was studied by Beatty and Chow[1]. They derived analytical solutions for the finite amplitude oscillations of the mass. Several important conclusions can be drawn from their work. Lawton and King[2] did an experimental investigation on rubber and tissue strip. However, authors have not come across any previous work on finding the mechanical property of rubberlike material. In the proceeding sections, formulation of the problem, brief description of the experimental procedure with observations, result and detailed discussion are given.