URČENÍ MODULŮ PRUŽNOSTI V TAHU KORDOVÉ TEXTILIE

MODULUS OF ELASTICITY IN TENSION OF RUBBER-TEXTILE DETERMINATION

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Abstrakt

Tento článek popisuje určení modulů pružnosti v tahu kordové textilie, která se používá jako nosná výztuha pneumatických vlnovcových pružin. Takto zjištěné moduly pružnosti jsme dále použili k definování mechanických vlastnosti v FE modelu pneumatické vlnovcové pružiny.

Klíčová slova: kordová textilie, modul pružnosti, pneumatická pružina.

Abstract

The paper describes determination of modulus of elasticity of rubber-textile material which is used as brace. The obtained modulus of elasticity is further used to define mechanical properties in FE model of the air bellows spring.

Keywords: rubber-textile, modulus of elasticity, air spring.

INTRODUCTION

Air bellows springs are used in many different cases of device suspension. There are several air bellows springs producers in the world that offer vast range in shapes and sizes. However, each spring consists of three components: elastic bag, separating rings and mounting flange (Fig. 1). Primary spring operation is given by the elastic bag filled with compressed air. Dimensions of the air spring determine its applicable load. The load applied on the spring is transformed into load of the bag wall according to the bag shape. The bag wall is made of two or four layers of rubber-textile vulcanized into a rubber mixture. The rubber-textile structure embraces support fibers (texture) and binding fibers (weft). The structure is on Fig.2. The texture is made of polyamide PA 6 or viscose and the weft fibers are made of cotton.

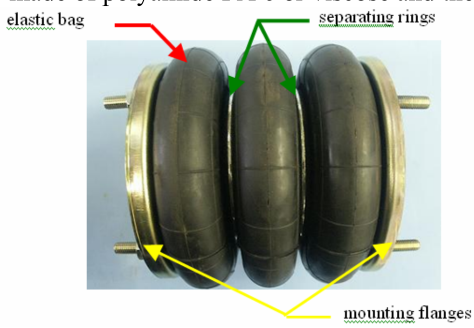

Fig.1 Components of spring

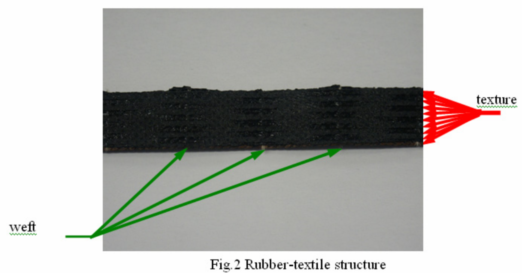

Fig.2 Rubber-textile structure

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MODULES OF ELASTICITY OF TEXTILE FIBRES

Dominant load direction of the support fibers is along the texture. The air spring load limit is given by elasticity and strength of the support fibers. Mechanical properties of textile fibers are described by initial modulus of elasticity in tension E_I and secant modulus of elasticity in tension E_S. The modules can be obtained from σ – ε diagram (Fig.3) and they are given by equations (1) and (2)

$$E_I = \left(\frac{\Delta\sigma}{\Delta\varepsilon}\right) \quad \text{for} \quad \varepsilon = 0\,, \tag{1}$$

$$E_S = \left(\frac{\Delta\sigma}{\Delta\varepsilon}\right) \quad \text{for} \quad \varepsilon = \varepsilon_0\,, \tag{2}$$

where Δσ, Δε denotes values of strain and relative deformation, respectively (see Fig.3).

The E_I modulus is defined by slope of tangent at beginning of the σ – ε diagram. The secant modulus E_S is defined by slope of line between beginning and instant point A in the σ – ε diagram. The diagram relation between strain σ and relative deformation ε is obtained from standardized test for textile fibers [1].

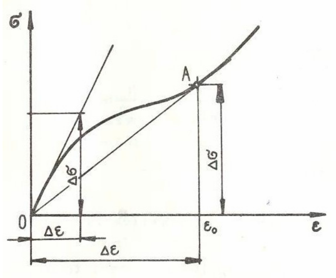

Fig.3 $\sigma - \varepsilon$ diagram

EXPERIMENT DESCRIPTION

According to the standard, initial sample length is L_0 = 200 mm and minimal deformation velocity v_0 = 100 mm/min. Sample width is given by number of fibers that can be chosen. In our case, we used a sample width of 10 texture fibers made of PA6 140 material. The fiber diameter was 0.65 millimeter.

A test stand (Fig.4) using hydraulic piston was designed and built in order to provide required test setup. The tested sample was fixed vertically between stable frame (top) and moving piston rod (bottom). The setup enabled defined sample loading and synchronous record of deformation ΔL and tension force F_t. The force sensor was fixed on top of the stable frame; the built-in position sensor inside the piston rod was used for the deformation measurement. The tested rubber-textile sample was increasingly loaded until the sample split. Complete experiment control and data record was ensured by special software running on PC.

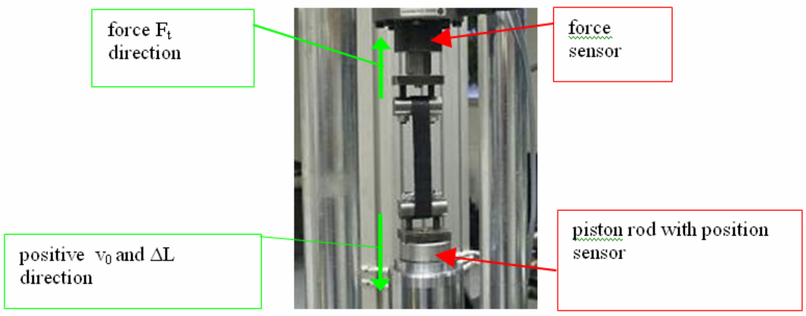

Fig.4 Test setup

The measurement result was F_t – ΔL relation (Fig.5) which we transformed to σ – ε correlation (Graph 3). The transformation is given by equations (3) and (4), where S_0 is initial fiber cross-section area and L_0 is initial sample length.

$$\sigma = \frac{F_t}{S_o}, \tag{3}$$

$$\varepsilon = \frac{\Delta L}{L_o}. \tag{4}$$

MEASURED AND TRANSFORMED DEPENDENCIES

The equations (1) and (2) imply that E_I value is constant and the E_S value varies according to relative deformation ε (Fig.6).

Initial modulus of elasticity in tension E_I

$$E_I = \left(\frac{\Delta\sigma}{\Delta\varepsilon}\right)_{\varepsilon=0} = \frac{70-24}{0.026-0.009} = \frac{46}{0.017} = 2700\ MPa\ .$$

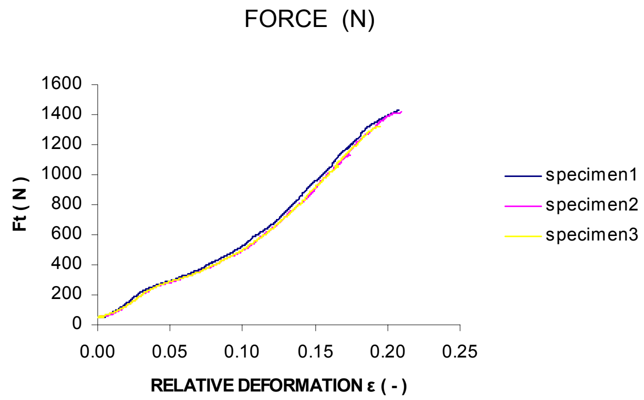

Fig.5 $F_t - \Delta L$ relation

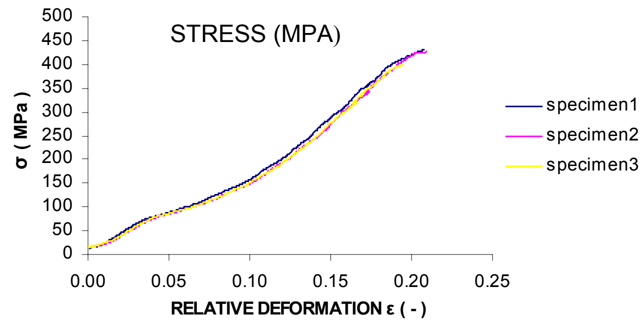

Fig.6 $\sigma - \varepsilon$ relation

Secant modulus E_S:

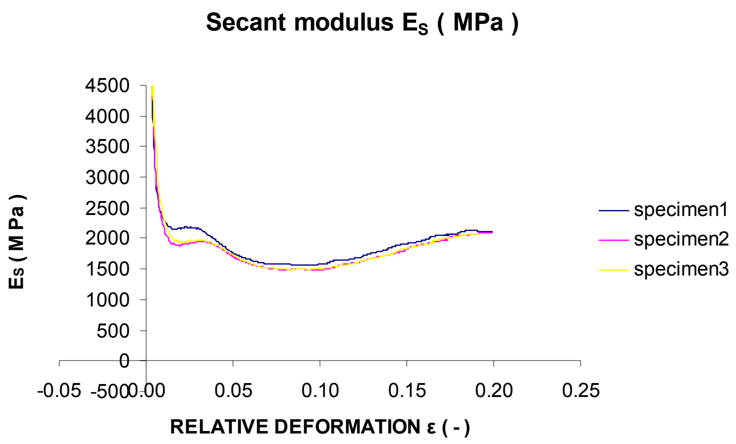

Fig.7 $E_S - \varepsilon$ relation

RESULTS

At this stage, only the force development in dependence on the sample deformation was evaluated in order to get the above relations. 22 samples were tested in total but only 12 split as expected (Fig.8). The rest split close to the fix point (Fig.9). Only three representative samples are presented here for better orientation. The experiment proved expected nonlinear characteristic of strain in relation to the deformation of polyamide rubber-textile sample. The results correspond to information given by the producer.

Fig.8 Expected split

Fig.9 Split close to the fix point

Precise values for a particular rubber-textile material that complement the material specification offered by its producer were obtained. The obtained experimental values of the modules will be applied on FE model of an air spring based on this material.

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