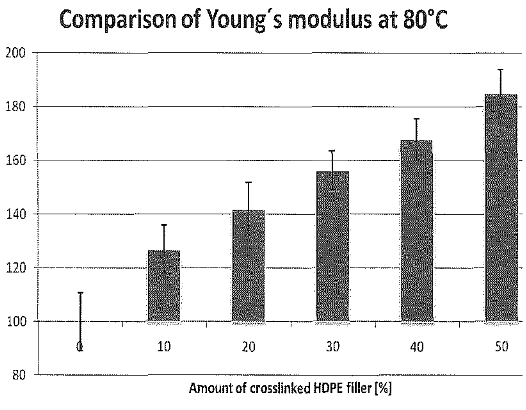

Fig. 3. **Comparison of modulus of elasticity for mixtures of virgin LDPE and crosslinked HDPE at 80 °C**

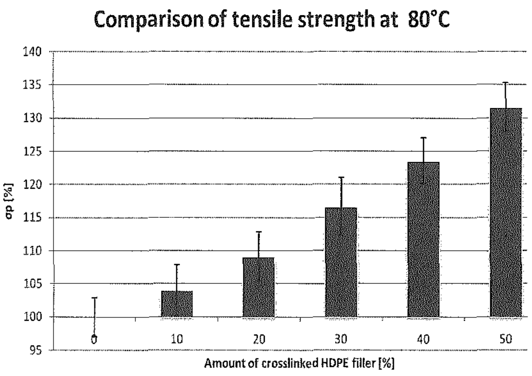

Fig. 4. **Comparison of tensile strength for mixtures of virgin LDPE and crosslinked HDPE at 80 °C**

Opposite to this, higher amount of filler comes a increase tensile strength and modulus of elasticity.

Another good result is the possibility of mixture LDPE and HDPE which are in normal state miscible with difficulties.

These results are significant for both the engineering practice, where product price can be reduced by the filler addition with increase in their properties, furthermore thus contribute to a possibility of recycling the radiation crosslinked products and also consequently for the consumer.

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CL-10
THE TESTING OF HYPERELASTIC PROPERTIES OF THE RUBBER MATERIALS

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Abstract

The aim of our work is to set up nonlinear material parameters of elastomers for numerical simulation of these materials. For this purpose, it is necessary to test material in three different modes: uniaxial tension, equibiaxial tension and pure shear. The equibiaxial elastomer characterization is the object of this paper. A bubble inflation technique was used for this characterization. We use data from this test and from uniaxial test to create the FEM models of elastomer.

Introduction

Thanks their special properties we can find the elastomers in almost all areas of human doings (let us remember their sealing and damping properties)[1,2]. A need of exact description of the highly nonlinear mechanics of this material arises still more often.

Our aim is to set up nonlinear material parameters of elastomers for numerical simulations. The measuring the engineering constants for nonlinear material models is demanding more special equipment than the measuring the constants for previously used linear material models. For accurate evaluation of hyperelastic material constants we need to test material in all deformation modes that will occur during simulation. Usually three basic deformation modes are tested: uniaxial tension, equibiaxial tension and pure shear[3,4]. The uniaxial tension is easy to perform on standard testing machines[5]. But the special equipments are necessary for next two deformation modes.

One of the suitable methods for equibiaxial characterization of elastomers is the bubble inflation technique in which an elastomer is inflated to the shape of bubble[6].

Experimental

A uniform circular specimen of elastomer is clamped at the rim and inflated using compressed air to one side. The specimen is deformed to the shape of bubble. The inflation of the specimen results in a biaxial stretching near the pole of the bubble and the planar tension near the rim.

Thanks to the spherical symmetry we can consider equibiaxial stress at the pole of the bubble. The thickness of specimen is small and the ratio between the thickness of the inflated membrane t and the curvature radius r is small enough, then the thin shell assumption allows us to neglect the radial stress in the specimen. With consideration of material incompressibility we can express the thickness of inflated

$$t = \frac{t_0}{\lambda_{\theta\theta}^2}$$

specimen as:
where t_0 is the initial thickness of specimen (unloaded state). Further we have to measure the stretch $\lambda_{\theta\theta}$ at the pole of inflated material. Generally stretch λ is the ratio between the

$$\lambda = \frac{l}{l_0}$$

current length l and the initial length l_0:

We can use some of optical method for measurement of stretch $\lambda_{\theta\theta}$ and curvature radius r (camera, video camera, laser etc.).

Finally we can compute the hoop stress $\sigma_{\theta\theta}$ on the pole

$$\sigma_{\theta\theta} = \frac{p r \lambda_{\theta\theta}^2}{2 t_0}$$

of the inflated specimen as ref.[6]:
The specimen of 2 mm thin elastomer is fixed between two rings with inner diameter 40 mm. Rings are clamped in a support.

Next function of the support is distribution of the compressed air to one side of the specimen. The current value of applied pressure is recorded using a pressure sensor. The inflation of the specimen is recorded using a high resolution CCD video camera. A computer is used to control the pressure.

The white strips were drawn in the central area of specimen for stretch measurement. It is important to measure elongation and curvature radius only in the area near to pole (between the strips) of inflated specimen and not on entire bubble contour because only on the pole the equibiaxial state of stress occurs.

The common SBR compound for tire manufacturing was tested. The material was loaded until failure. We obtained values of stretch ratios $\lambda_{\theta\theta}$ and curvature radii r from image analysis of video record.

Results

The equibiaxial stress-strain diagram of tested material is shown in Fig. 1. Also the uniaxial stress data are presented in this diagram for comparison. We can see generally known fact[3], when equibiaxial stress values are 1.5-2 times greater

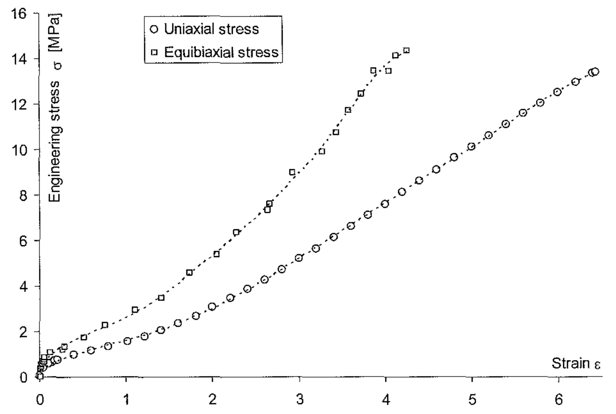

Fig. 1. **Stress-strain diagram of tested material**

than uniaxial.

The FEM model of specimen inflation (based on 5-terms Mooney-Rivlin hyperelastic model) was created and compared with experiment.

Conclusions

It is not possible to predict biaxial behaviour of elastomer from uniaxial data only. When both uniaxial and biaxial data are used, the material models closely follow both uniaxial and biaxial experimental data[6]. The bubble inflation technique is very suitable method for the equibiaxial tension test of elastomers and for the accurate description of hyperelastic behaviour of material.

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