DEVELOPMENT OF A SHEAR DEVICE FOR PRECISE SHEAR MEASUREMENTS OF RUBBER MATS

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1. Introduction

For material characterization and model parameter identification simple shear is a very important deformation state [1]. One of the best-known representatives is the cylindrical double-shear-specimen, used at the Tun Abdul Razak Research Centre (TARRC) in Hertford or – in a slightly geometrically modified version – at the "Deutsches Institut für Kautschuktechnologie e. V." (DIK e. V.) in Hannover. The design is based on a cylinder geometry which is vulcanized or glued on the front surface. An advantage is that the shear deformation can be introduced up to a high degree. The disadvantage is that vulcanization or gluing leads to shrinkage or material irritation in the measuring zone [2]. For this, a new shear device with a special fixing design is presented, which enables a uniform initiation of shear deformation for different rubber mats. Furthermore, the shear device is suitable for large shearing, tests with different rubber materials (also fibre-reinforced materials) and tests with pre-stretching [3].

2. Numerical development

The main idea is that the shear load for the rubber mat is initiated via small steel pins (d = 1.0 mm). For this, the shear deformation can be introduced uniformly for the thickness direction. Note that a form fit connection has the advantage that for the load application no high clamping force or high friction coefficient is required. In addition, the disadvantages resulting from vulcanization or gluing can be avoided. On the other hand, one disadvantage can be crack initiation. However, the functional principle shall be tested experimentally. In order to show the potential of the new pin design, a parameter study is conducted for different values of pin size and pin number. Furthermore, a local error measure is defined in such away that the error to the theoretically exact solution of simple shear is indicated. In Fig. 1 the local error (in the range of: $[0, 1]$) is presented.

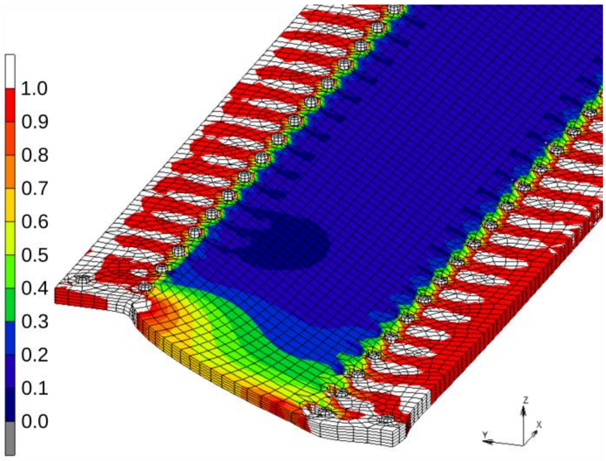

Fig. 1. Local error measure for the new shear specimen.

A nearly homogeneous deformation state in the measuring zone can be seen. Note that a dimension for the rubber mat of 10:1 (length-width-ratio) is recommended to reduce the influence of free edges (see Fig. 1).

3. Experimental setup

Next, the experimental setup for the new shear device with pins is introduced, see Fig. 2.

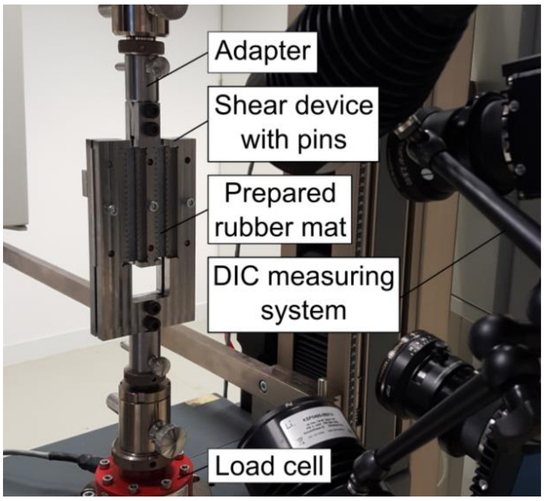

Fig. 2. Experimental setup for the new shear device.

The shearing device can first be divided into a lower and an upper apparatus. The lower part consists of a front and a rear U-profile, which is responsible for the rigid fixation of the rubber mat. The upper part consists of a front and a rear I-profile, which represents the movable fixation on the traverse. The prepared rubber mat is connected to the shearing device via steel pins only. The force was measured by means of a 20 kN load cell and strains were determined using 3D DIC system GOM ARAMIS 4M. A special feature is the vertical test setup of the 3D DIC system. On the one hand, this results in a larger available measuring field and, on the other hand, in a better illumination of the measuring area compared to a horizontal orientation of the DIC system.

4. Experiments and Results

In the following, a double-sided shear test is conducted with the new shear device. In Fig. 3 the “stress-shear value” diagram can be seen for filled EPDM.

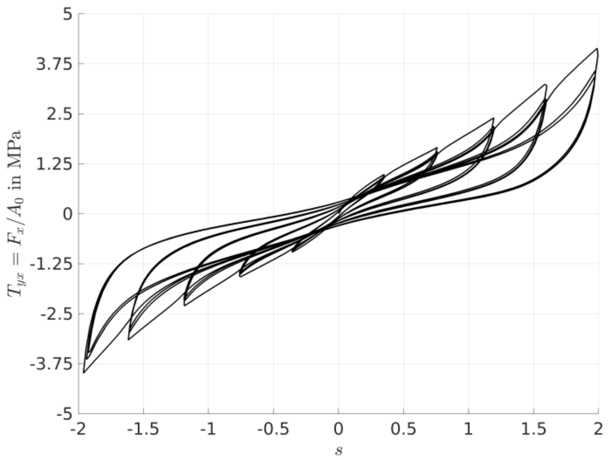

Fig. 3. Double-sided shear test with the new shear specimen.

For this, a nearly point-symmetrical stress-strain curve occurs. The shear value s was calculated via [3]:

$$s = \tan(\varphi)\,. \tag{1}$$

The value φ describes the shear angle. Furthermore, it can be seen in Fig. 4 that in the middle section of the measuring zone a nearly homogeneous deformation field occurs. Only at the edges where the pins are located, inhomogeneities can be detected. With these first results, the functional principle can be confirmed.

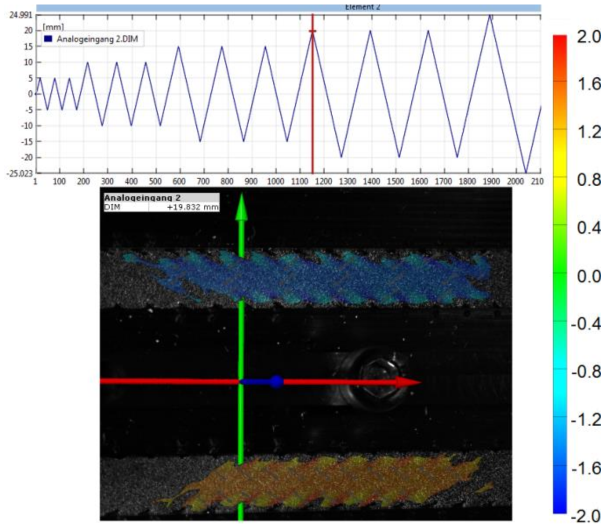

Fig. 4. Presentation of the shear value s for the new shear specimen (evaluation with DIC).

5. Conclusions

In this contribution a new shear specimen is presented, which enables precise shear measurements for large shear values. As pointed out, the special pin design enables a uniform initiation of shear deformation for different rubber thicknesses. The nearly homogeneous deformation field (in the middle section of the shear specimen) is measured and evaluated with a DIC system. Finally, the new shear specimen can be used for the phenomenological investigation of typical rubber properties. A particular focus is on the investigation of anisotropic characteristics.

In further investigations, the new pin design shall be used for the analysis of fibre-reinforced materials.

Acknowledgements

The authors gratefully acknowledge the financial support from Vibracoustic GmbH & Co. KG and Freudenberg Technology Innovation SE & Co. KG.

References

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