34th Danubia-Adria Symposium on Advances in Experimental Mechanics
University of Trieste, Italy, 2017

DEVELOPMENT OF A NEW SPECIMEN SETUP FOR HIGH PRECISION UNIAXIAL TENSION-COMPRESSION TESTS OF RUBBER

Lars Kanzenbach[1], Christoph Naumann[2], Martin Stockmann[1], Jörn Ihlemann[1]

[1] Chemnitz University of Technology, Professorship of Solid Mechanics, Reichenhainer Str. 70, 09126 Chemnitz, Germany. E-mail: lars.kanzenbach@mb.tu-chemnitz.de

[2] Freudenberg & Co. KG, Höhnerweg 2-4, 69469 Weinheim, Germany

1. Introduction

This contribution deals with the development of a new specimen setup, which enables high precision uniaxial tension-compression tests of technical rubber materials. Due to a specific design of the mounting geometry, a nearly homogeneous deformation field can be achieved. Consequently, phenomenological effects of rubbers, like hysteresis, permanent set, softening, Mullins- and Payne-effect, can be investigated up to a compression strain of -50 % [2].

2. Functional principle

The mounting geometry of the standard dumbbell [1] leads to an abrupt contact between mounting and test specimen, which results in an inhomogeneous deformation field. To improve the homogeneity of the deformation field and to avoid buckling, the mounting geometry is modified using the algorithm shown in Fig. 1. Using dynamic FE-simulations, the eigenfrequency course can be identified. This course enables the estimation of the buckling risk. The main idea for designing the mounting geometry is to prescribe a special eigenfrequency course and to calculate the corresponding mounting geometry. This approach leads to an gradual contact between the specimen and mounting with a homogeneous deformation field.

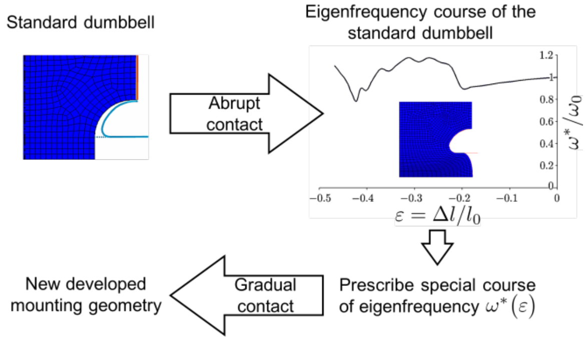

Fig. 1. Algorithm for the identification of the mounting geometry.

3. Experimental setup

The identified specimen setup (test specimen and mounting geometry) is manufactured and tested. The experimental setup and the corresponding measuring device are presented in Fig. 2.

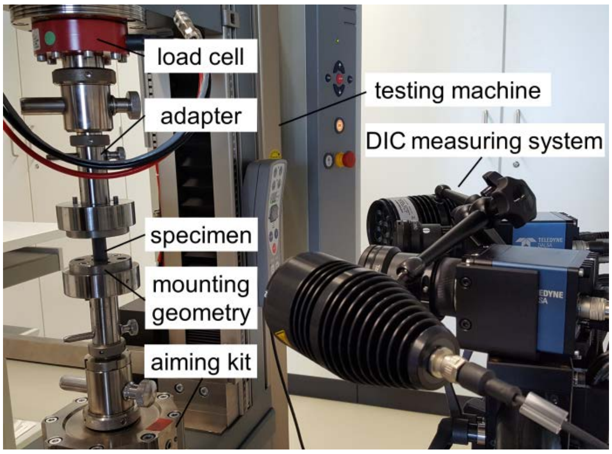

Fig. 2. Experimental setup for the new test specimen with measuring device.

The tests were performed with a ZWICK/Roell testing machine. The force is measured with a load cell and the displacement field was measured and evaluated with a Digital Image Correlation (DIC) measuring system. Note, that arbitrary test sequences can be considered using the external target value control [3].

To avoid axial and angular offset of the specimen from the testing machine, an aiming kit was applied.

4. Experiments and Results

Within this contribution, filled EPDM has been characterized using the developed experimental setup. The deformation field at the highest achievable compression is given in Fig. 3. Note, that even for such high compression no buckling occurs and the strain field is nearly homogeneous.

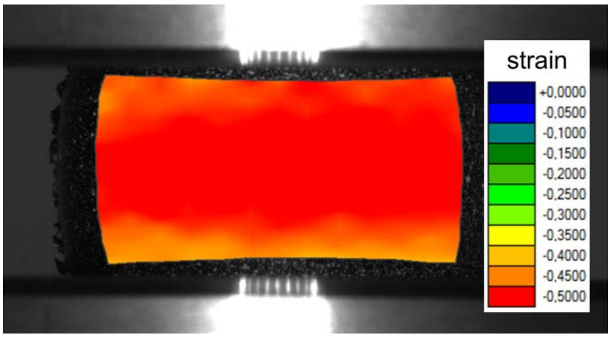

Fig. 3. Homogeneous deformation field in compression for the new test specimen.

Fig. 4 shows the corresponding stress-strain curves for two different specimens.

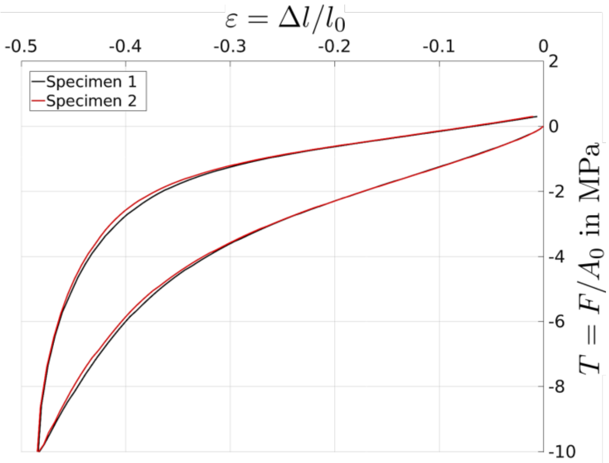

Fig. 4. Stress-strain diagram for the compression test.

As shown in Fig. 5 and Fig. 6, the new specimen setup can also be utilized for multi-hysteresis tests as well as cyclic tension-compression tests. The results illustrated in Fig. 6 are required to characterize the Payne-effect.

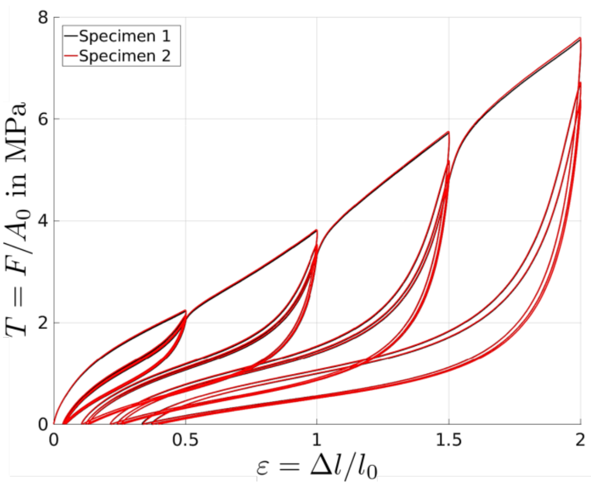

Fig. 5. Multi-hysteresis test.

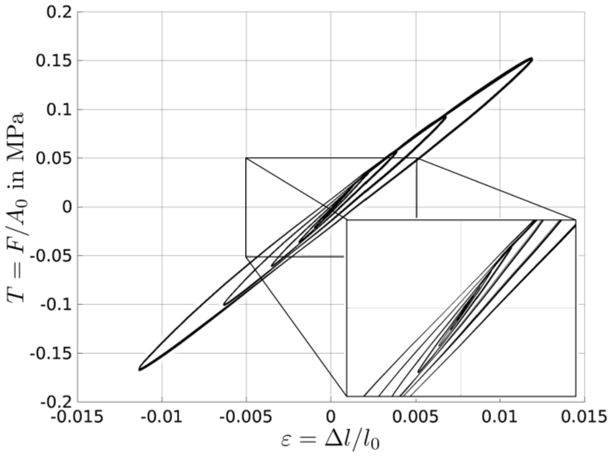

Fig. 6. Cyclic tension-compression test.

It should be mentioned, that different types of specimens are no longer required for this experimental investigation. Furthermore, the new specimen setup can be used for the identification of material model parameters.

5. Conclusion

The developed specimen setup has a large range of applications and enables new possibilities in the field of material research. For example, the phenomenological effect of technical rubber materials, like Payne- und Mullins-effect, softening, permanent set, relaxation and recovery, can be characterized.

Acknowledgements

Financial support from Vibracoustic GmbH and Freudenberg & Co. KG is gratefully acknowledged.

References

[1] Alshuth, T., Hohl, C., & Ihlemann, J. (2007). Vergleichende Messungen und Simulationen annähernd homogener Belastungsverteilungen. *PAMM*, *7*(1), 53-54.

[2] Kanzenbach, L., Naumann, C., & Ihlemann, J. (2016). Specimen design for high precision tension-compression tests. *PAMM*, *16*(1), 207-208.

[3] Kanzenbach, L., Stockmann, M., & Ihlemann, J. (2016). Extension of the Testing Machine Control for High-precision Uniaxial Tension Measurements. *Materials Today: Proceedings*, *3*(4), 993-996.