Numerical analysis of the work of a PUR Cellasto material buffer

Łukasz Gołębiewski[1, a)], Jarosław Mańkowski[1, b)] and Piotr Żach[3, c)]

[1]*Institute of Machine Design Fundamentals*
Faculty of Automotive and Construction Machinery Engineering
Warsaw University of Technology
Narbutta 84, 02-524 Warsaw, POLAND.

[a)]lgolebiewski@onet.pl
[b)]pzach@simr.pw.edu.pl
[c)]jaroslaw.mankowski@simr.pw.edu.pl

Abstract. The aim of the work was to perform a numerical simulation of a work of a PUR Cellasto material buffer of a passenger lift. The implementation of the task required the identification of material model coefficients. A series of tests including static tensile and compression tests were carried out. On the basis of the obtained results, coefficients were determined for selected material models based on the energy density of the form strain. Based on the identified models, the buffer work was simulated.

INTRODUCTION

Hyperelastic materials are a group of elastically deformable materials in a wide range of deformation. Their characteristic feature is the non-linear relationship between strain and stress, which means that they cannot be described by Hooke's law. For analysis of objects made of such materials using the Finite Element Method, additional tools are needed in the form of hyperelastic material models. Most often they are prepared based on expressions defining strain energy. The strain energy density function W is a dependence with a scalar value that binds strain energy density to a strain gradient. It can be described both as a function of main stresses and as a invariants of Cauchy-Green deformation tensor. Both polynomial models, including the development proposed by Ogden, as well as exponential models, dedicated to foamed structures (Hyperfoam) were considered.

IDENTIFICATION OF MODEL COEFFICIENTS

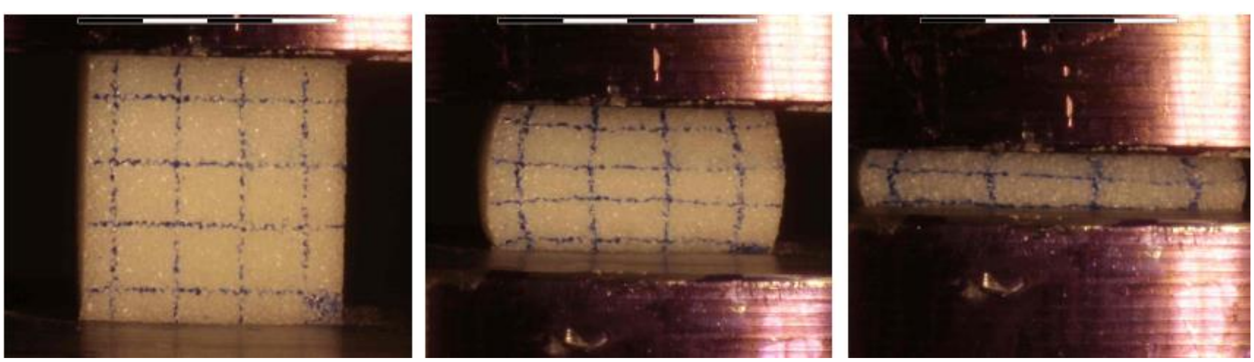
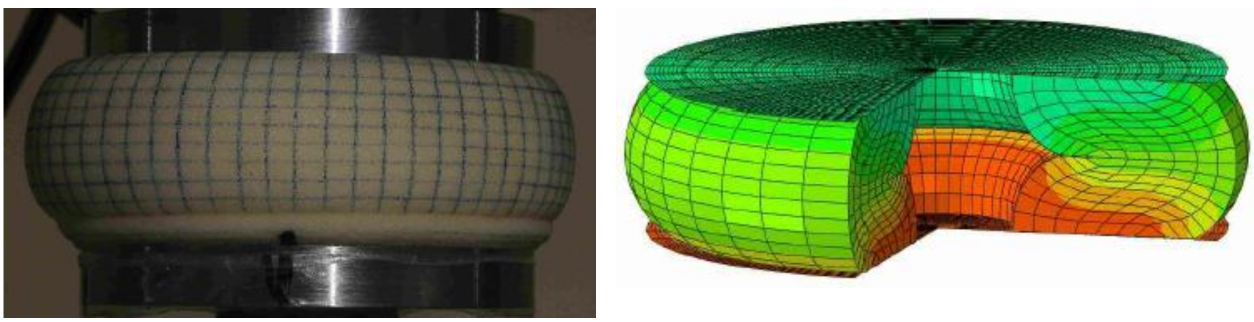


FIGURE 1. Sample of buffer material before and during the test. The maximum deflection in the photo is 16 mm.

For the purpose of identifying the material model coefficients a series of experiments was carried out. Due to the strongly non-linear and asymmetrical material characteristics, a static compression and stretching tests were performed. Samples for testing were made in accordance with the standard for foamed plastics. The influence of the load history on the properties of the tested material was checked. Buffer tests, which were used to verify numerical simulations, were also carried out. Sample of buffer material before and during the test is presented on Fig. 1.

NUMERICAL VERIFICATION

The developed numerical model of the buffer together with the prepared material model allows the reproduction of the deformation method and, to the permissible level, reflects the deflection characteristics. It allows you to indicate the most strenuous areas and reveals a particular way of changing shape. Thanks to the performed analyzes, it was shown that the axis of the buffer compression is mainly influenced by the axisymmetric hole. It causes the bumper cross-section to look visually similar to buckling, consisting in changing the compression process into the bending problem. The circumferential cuts present only increase the predisposition of the buffer to the occurrence of the above phenomenon. Comparison of the results of the buffer tests with the results of the numerical simulation is presented in Fig. 2.



(a) (b)

FIGURE 2. Comparison of the results of the buffer tests with the results of the numerical simulation

REFERENCES

1. E. M. Arruda, M. C. Boyce, "A three-dimensional constitutive model for the large stretch behavior of rubber elastic material" in *Journal of the Mechanics and Physics of Solids, Volume 41*, *Issue 2*, (1993), pp 389-412.
2. R. Jakel, "Analysis of Hyperelastic Materials with MECHANICA – Theory and Application Examples", 2nd SAXSIM | Technisches Universität Chemnitz, (2010).
3. M. W. Lewis, A. Robust, "Compressible, Hyperelastic Constitutive Model for the Mechanical Response of Foamed Rubber", TECHNISCHE MECHANIK (2016).
4. M. Schrodt, G. Benderoth, A. Kuhhorn, G. Silber, "Hyperelastic Description of Polymer Soft Foams at Finite Deformations", TECHNISCHE MECHANIK (2005).
5. R. Tobajas, E. Ibarz, L. Gracia, "A comparative study of hyperelastic constitutive models to characterize the behavior of a polymer used in automotive engines", 2nd International Electronic Conference on Materials, (2016).
6. P. Żach, *Strukturalna identyfikacja właściwości sprężysto-tłumiących materiałów hiperodkształcalnych*, (Wydawnictwo Naukowe Instytutu Technologii Eksploatacji – Państwowego Instytutu Badawczego, Radom–Warszawa, 2013).
7. J. Mańkowski, J. Lipnicki, "Digital Materials-Evaluation of the Possibilities of using Selected Hyperelastiic Models to Describe Constitutive Relations", in *International Journal of Applied Mechanics and Engineering, vol. 22, nr 3*, (2017), pp. 601-612.