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

DETERMINATION OF DIFFERENCE BETWEEN SIMILAR POLYMER MODELS SIMULATING THE BEHAVIOUR OF BIOLOGICAL TISSUES

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1. Introduction

Biological tissue can be characterized by time – dependent behaviour [1]. During the stress analysed material deforms and after removing load factor it return to initial state [2]. Generated curve is called hysteresis and is characteristic for viscoelastic nature of biological tissues [3]. This behaviour can be observe by cameras and analysed by image processing algorithms like digital image correlation or optical flow [4].

2. Materials and methods

Studied were made in a special design system. The stand consists of two high-speed cameras and their setup, a stationary part (camera stand), a robotic arm, and a microcontroller with sensors. All parameters included in the equipment were selected according to the literature and to the expected measurement possibilities. In Fig. 1 was presented camera configuration.

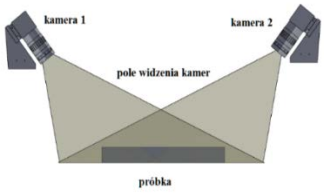

Fig. 1. Camera configuration in designed system.

The measuring system was designed to deflect the sample at central region and analyse the changes occurring on its surface during mechanical stress (Fig. 2).

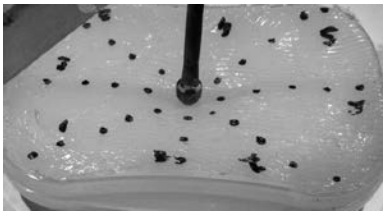

Fig. 2. Analysed sample during the measurement

Then, on the basis of the tracked points, the surface of the analysed sample was reconstructed (3D). It allows to determine the real displacement (in all dimensions) and create the displacement-force curve. The area of the resulting hysteresis is a measure of the energy absorbed by the material during mechanical stress, and its decomposition may suggest potential local rigidities.

Comparison of silicone layer (thickness 15 mm) (SL) and silicone layer (thickness 15 mm) with 1 mm NBR rubber elements (SL+NBR) (Fig. 3) was investigate in this study.

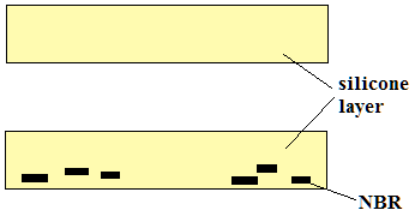

Fig. 3. Visualization of studied samples.

3. Results

After measurements the changes of points position on the surface were analysed by optical flow algorithm. This data let to determinate X, Y and Z coordinates of marks and generate displacement-force curve (Fig. 4.).

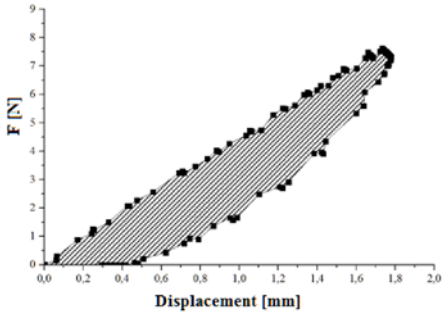

Fig. 4. Visualization of studied samples

Presented relationship let to determine the energy absorbed by the material during mechanical stress as the hysteresis area. Obtained results are presented in Tab. 1.

Tab. 1. Example of average results for a several points for analysed sample

	r [mm]	A [N*mm]	SD [N*mm]	CV [%]
SL	10	2,76	0,54	19,65
	17	1,46	0,18	12,44
	24	0,87	0,26	29,49
	31	0,71	0,1	13,37
	38	0,7	0,06	9,03
SL+NBR	10	3,07	0,28	9,2
	17	1,09	0,17	15,52
	24	0,76	0,08	9,93
	31	0,76	0,04	5,38
	38	0,54	0,07	11,05

Legend: A – hysteresis area, r – distance from centre of the sample, SD – standard deviation CV - coefficient of variation

Average hysteresis area allow to determine distribution map of energy absorbed by analyse sample. Example of obtained maps are presented in Fig. 5. and Fig. 6..

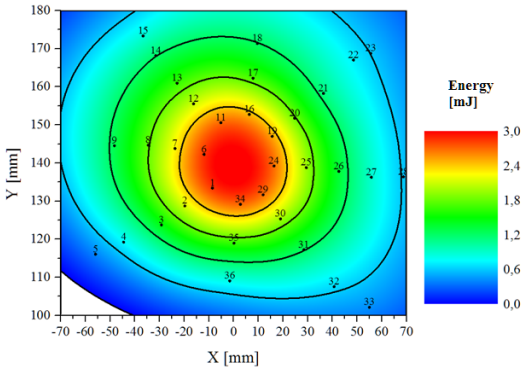

Fig. 5. Distribution map of absorbed energy by SL

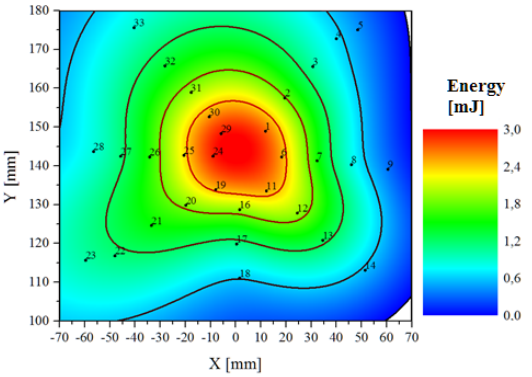

Fig. 6. Distribution map of absorbed energy by SL+NBR

Analysis of Fig. 6 let to successful determine region with NBR components.

4. Conclusion and summary

Presented measurements system and experimental method show that it is possible to analyse the continuity of the structure on the basis of the surface observation under the influence of mechanical force.

The presented method is cheaper ,faster and the results obtained are easily interpretable.

Further studies are needed to fully understand proposed method.

References

[1] M. Meyers, P. Chen, A. Lin, and Y. Seki, “Biological materials: structure and mechanical properties,” Prog. Mater. Sci., 2008.

[2] A. Natali, P. Pavan, E. Carniel, P. Dario, and I. Izzo, “Characterization of soft tissue mechanics with aging,” IEEE Eng. Med. Biol. Mag., 27, 2008, pp. 15–22..

[3] Y.-C. Fung, Biomechanics : Mechanical Properties of Living Tissues. Springer New York, 1993.

[4] J. N. Reddy, An introduction to continuum mechanics : with applications. Cambridge University Press, 2008.