IMPROVEMENT OF IMPACT PROTECTION BY KORDCARBON-CPREG-200-T-3K-EP1-42-A COMPOSITE

Radek KOTTNER[1], Sandra KAŇÁKOVÁ[1], Tomasz BOŃKOWSKI[1], Ronaldo YEUNG[2], André PUKARO[2]

[1] University of West Bohemia, Univerzitní 8, Plzeň, 301 00, Czech Republic, E-mail: kottner@kme.zcu.cz, kanaksan@students.zcu.cz, tomasz@ntc.zcu.cz;

[2] University of Campinas, Cidade Universitária Zeferino Vaz - Barão Geraldo, Campinas - SP, 13083-970, Brazil, E-mail: [rndyeung, apukaro]@gmail.com;

1. Introduction

Impact protection is an important task in many modes of transport. Composites are good energy absorbers, whether used as a part of a vehicle [1, 2] or part of a human body protector [3].

Viscoelastic foams are often used to protect motorcyclists' shoulders, elbows, and knees, There are two European standards covering motorcyclists' protective clothing against mechanical impact: EN1621-1 and EN1621-2. Since testing at temperature of 40 °C is not obligatory according these standards, the producers usually test their foam protectors only at 23 ± 2 °C. However, it was found out that the foam significantly lowers its stiffness in dependency on the rising temperature, which has distinctive influence on its maximum compression and transmitted force during an impact [4].

This work is focused on the improvement of the impact protection of a foam absorber when temperature is higher than 23 °C. The improvement using a composite shell consisting of carbon fibres and epoxy resin was investigated.

2. Materials and methodology

The foam protector SAS-TEC SCL-2 [5], which meets protection level 2 of EN1621-1, was investigated. Protection level 2 means that the maximum transmitted force F in the impact test must be less than 20 kN when the central area of the protector is tested. The thickness of the central area was 11 mm.

The composite shell was attached to the outside of the foam protector. The composite shell was made of 4 layers of KORDCARBON-CPREG-200-T-3K-EP1-42-A prepreg [6]. The fabric weave of the prepreg is twill 2/2. The first, third and fourth layers (counted from the interface between the foam and the shell) had the fibres oriented identical, the second layer being rotated by 45° (Fig. 1). The proper shape was ensured by the 3D printed negative mould. The ASC autoclave was used in the curing process. The thickness of the cured shell was 1.2 mm.

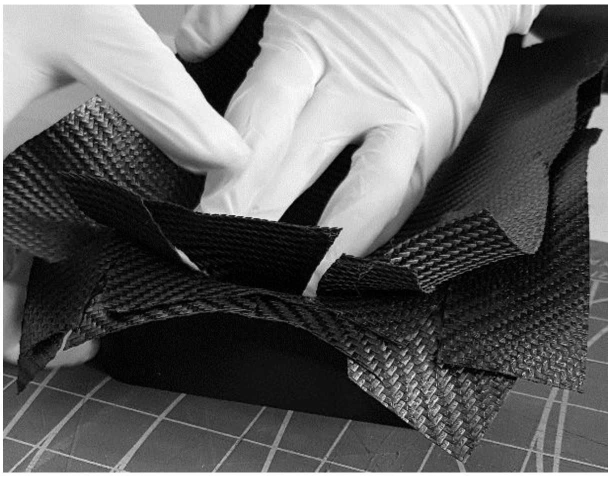

Fig. 1. Placing composite layers in mold.

Both the foam protector without the composite shell and the foam protector including the composite shell were subjected to an impact test (Fig. 2) after the protectors were one hour heated at temperature of 22, 40, and 50 °C. The impactor and the anvil corresponded to EN1621-1. The weight of the impactor with a flat steel head was 5 kg and was dropped from the height of 1 m. The diameter of the spherical anvil was 100 mm. The transmitted force F was measured by the force cell KISTLER 9351B. The impactor displacement was measured using Micro-Epsilon optoNCDT 2300-50 lasers. The impactor deceleration was measured by the accelerometer KISTLER 8742A5. The sampling frequency was 26 kHz.

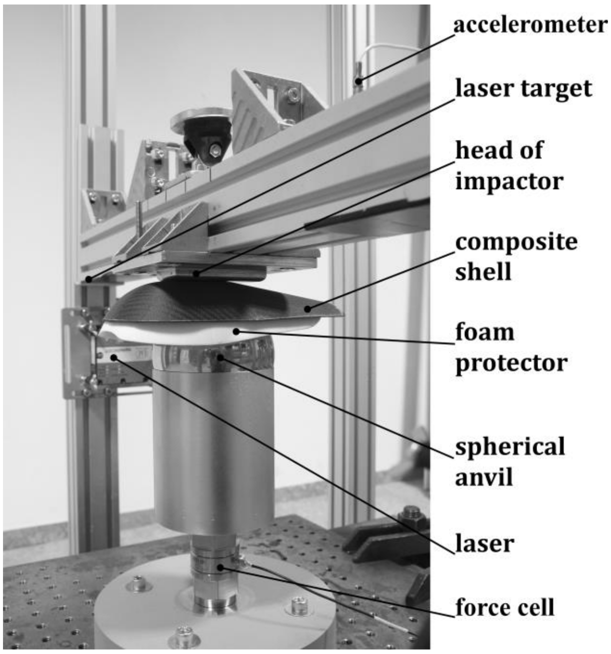

Fig. 2. Impact test.

3. Results

Fig. 3 shows the comparison of the maximum transmitted forces in the impact test. It is obvious that the values are smaller when the foam protector including the composite shell was tested. Moreover, when the protector was tested without the shell, the increase in temperature-induced force was more significant.

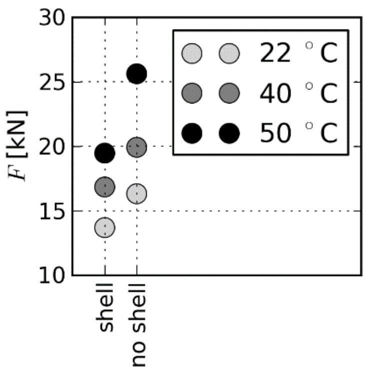

Fig. 3. Maximum transmitted forces in impact test.

The positive effect of the composite shell (reducing the maximum transmitted force) was caused by more uniform distribution of the impact force into the foam protector. When the protector was tested without the shell at a higher temperature, a foam failure occurred (a visible hole at the point of contact with the top of the spherical anvil, see Fig. 4).

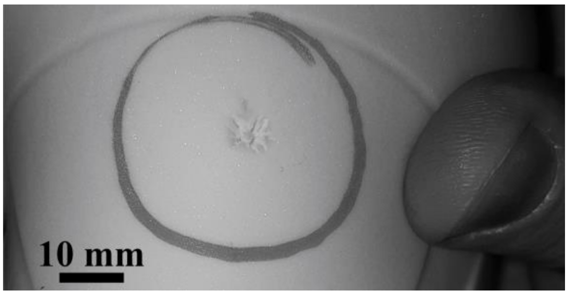

Fig. 4. Failure of foam.

4. Conclusions

The positive effect of the composite shell attached to the foam energy absorber was demonstrated. In future, obtained experimental data will be used for the validation of numerical models of the investigated foam and composite.

Acknowledgements

This publication was supported from the European Regional Development Fund-Project „Research and Development of Intelligent Components of Advanced Technologies for the Pilsen Metropolitan Area (InteCom)" (No. CZ.02.1.01/0.0/0.0/17_048/0007267) and by the internal grant project SGS-2019-002 “Biomechanical models of human body, biological tissues and biomechanical processes with application in industry and medicine”. The authors would like to thank PSí Hubík for providing foam samples.

References

[1] Muhammad Nasiruddin, S., Hambali, A., Rosidah, J., Widodo, W.S., Ahmad, M.N. A Review of Energy Absorption of Automotive Bumper Beam . *Int J Appl Eng Res*, 2017, 12(2), 238-245.

[2] Wang, T., Li, Y. Design and analysis of automotive carbon fiber composite bumper beam based on finite element analysis. *Adv Mech Eng*, 2015, 7(6), 1-12.

[3] Khosroshahi, S.F., Ghajari, M, Galvanetto, U. Assessment of the protective performance of neck braces for motorcycle riders: a finite-element study. *Int J Crashworthiness*, 2018, in press.

[4] Kaňáková, S., Kottner, R., Bońkowski, T. Influence of temperature on foam used in motorcycle protective equipment. In *Proceedings of the 57th Conference on Experimental Stress Analysis*, Luhačovice, 3-4 June, 2019; in press.

[5] *SAS-TEC body protection systems*. https://www.sas-tec.de/en/protectors/shoulder-protectors/scl-2/. Accessed May 05, 2019.

[6] *KORDCARBON*. http://www.kordcarbon.cz/produkty. Accessed May 05, 2019.