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Influence of elevated temperature on motorcyclist protective equipment

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1. Introduction

Motorcycle transportation is becoming more popular nowadays and therefore it is really important to use a qualitative protective equipment. Simulations of the protective equipment such as [2] and [3] are becoming a common matter and their main purpose is to improve the protector and its designing process. Unfortunately, many aspects influence the ability to absorb energy during the accident. One of the key aspect is the temperature.

Joint protectors should satisfy requirements of the standard EN 1621-1. However, the higher temperatures are common matter in the motorcycle transportation, the part of this standard concerning a temperature influence is optional [1].

This work deals with a different mechanical response of commercially available joint protectors exposed to a variety of temperatures during an impact test. These temperatures were selected to reflect obligatory 23 ± 2 °C and optional 40 ± 2 °C according the standard, and moreover 50 ± 2 °C. The temperature influence proved to be an important factor that marginally affected ability of protectors to absorb energy. Since in addition to transmitted forces, displacements of an impactor were measured during the compression of the protectors, the measured data will be used to model the protectors.

2. Experiment

An impact test was chosen to demonstrate the influence of elevated temperature on the motorcyclist protective equipment.

A serie of impact tests was realized to obtain source data. A drop tower was designed to reflect the geometry of the standard test [1]. An impactor with flat steel head weighted 5 kg. The impactor was released from 1 m height over a spherical anvil.

The maximal transmitted forces and the impactor displacements were measured. The experiment was carried out for three temperatures, namely 23 ± 2 °C, optional 40 ± 2 °C, and above standard 50 ± 2 °C. The protectors were left in the respective temperature for one hour prior the testing. The impact tests were carried out within 30 s after taking out the protector from a heating chamber, which meets the requirements of the standard.

Three types of joint protectors were examined, see Fig. 1: (a) SAS-TEC SCL-2, (b) perforated BETAC, and (c) compound BETAC protector. Both, SAS-TEC SCL-2 and perforated BETAC, consist of one type of a different energy absorbing foam. The compound BETAC protector has complicated structure and consists of two main firmly connected layers. The bottom layer is made of a softer foam. The upper layer is made of a denser foam, similar to the materials of previous protectors. Both SAS-TEC SCL-2 and compound BETAC are protectors with protection level 2, therefore, the maximal transmitted force during the standard test cannot overcome 20 kN. The perforated BETAC is level 1 protector, its limit for maximal transmitted force is 35 kN.

The chosen protectors are commercially available and were recommended for the research by czech manufacturer of motorcycle clothing PSÍ Hubík.

Fig. 1. Joint protectors: (a) SAS-TEC SCL-2, (b) BETAC with perforations, (c) compound BETAC

The obtained data are displayed in Fig. 2. The temperature has a negative influence on both the maximal compressions and the maximal transmitted forces. The transmitted force increases its value with increasing temperature.

The perforated BETAC protector satisfies the level 1 protection requirements for all three temperatures. This protector satisfies level 2 protection limit for 23 °C.

The SAS-TEC SCL-2 meets the requirements of the level 2 protection limit, however, its response is on the verge of the level 2 protection limit for 40 °C. The level 2 limit is overcome in case of 50 °C.

The compound BETAC protector satisfies this limit for all measured temperatures. Its compressions reach significantly lesser values for 23 °C and 40 °C than SAS-TEC SCL-2.

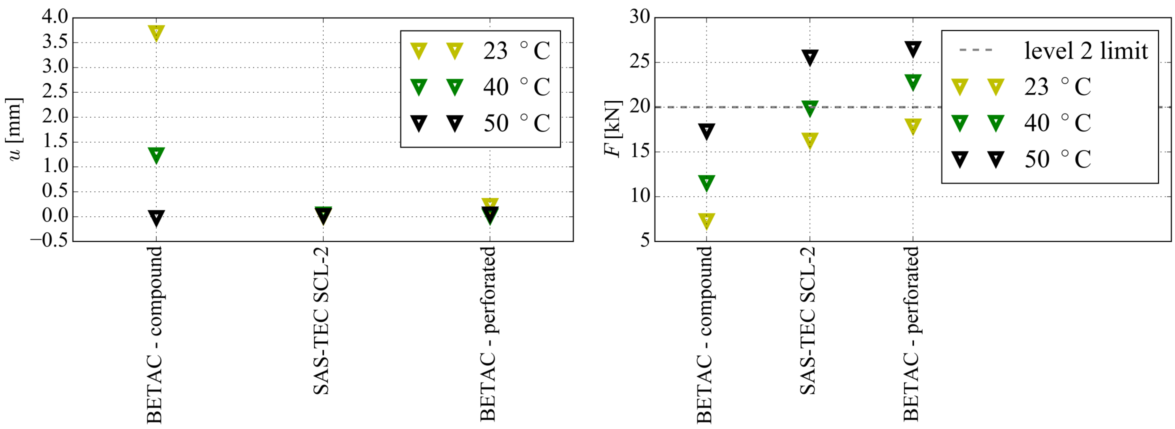

Fig. 2. Obtained data: (a) maximal compressions, (b) maximal transmitted forces

3. Simulation

The simulation of the carried out test was created in ABAQUS software. The model uses the symmetry of the geometry, boundary conditions and load, therefore, only the half of the problem was simulated (see Fig. 3). The impactor head and the anvil were simulated using shell elements. The geometry of the SAS-TEC SCL-2 protector was created in Rhinoceros software. The protector consisted of 5151 solid elements. The impactor displacement and the transmitted force were evaluated.

This simulation will be further used for a calibration of a material model previously researched in [4] and [5]. The simulation will be also extend with the compound BETAC protector geometry and its material models identification.

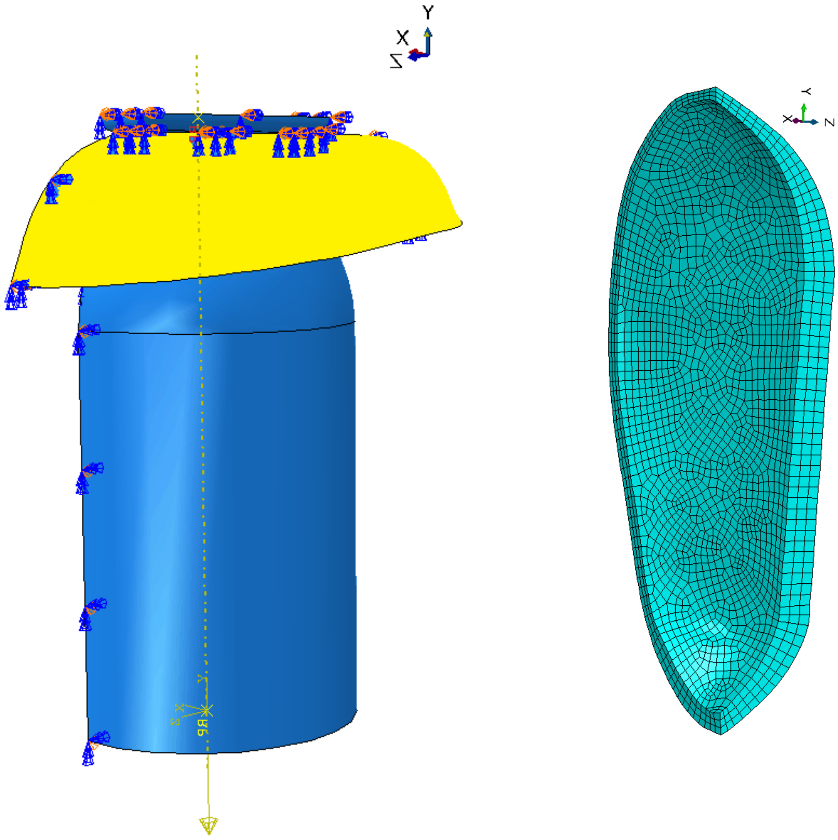

Fig. 3. Simulation: (a) assembly, (b) protector mesh

4. Conclusions

Elevated temperature has a negative influence on the foam protectors. The values of the maximal transferred forces are rising with increasing temperature. Omitting the optional part of the standard [1] can favour the protector and grade it as the level 2. The SAS-TEC SCL-2 and the perforated BETAC reach comparable values of the maximal transmitted forces and the maximal compressions, despite their different protection levels. The compound BETAC protector was the best of the tested protectors.

The simulation of the experiment will be further used for the identification of material model parameters of the compound BETAC protector and the calibration of SAS-TEC SCL-2 material model.

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