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# Protective helmet behavior under dynamic load

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The article deals with the analysis of the foam part of the protective helmet under dynamic load. Protective helmets are tested by drop tests to meet technical standards [2]. During them, the helmet is subjected to impact by a heavy rigid punch while being mounted on the head model. The standards specify the minimum value of energy that a helmet must absorb, while not exceeding the maximum permissible force transferred to the helmet user's head. For possibility to improve these helmet properties by changing its geometry [1], a drop test simulation model is being created. The result of the drop test simulation of the helmet foam part is then compared with the measured stiffness characteristics.

The drop test is simulated using explicit FEM analysis in Ansys software (Fig. 1). For simulation purposes, a compression test of the foam samples is performed. Foam properties are represented by porosity-crushable foam material model in the simulation.

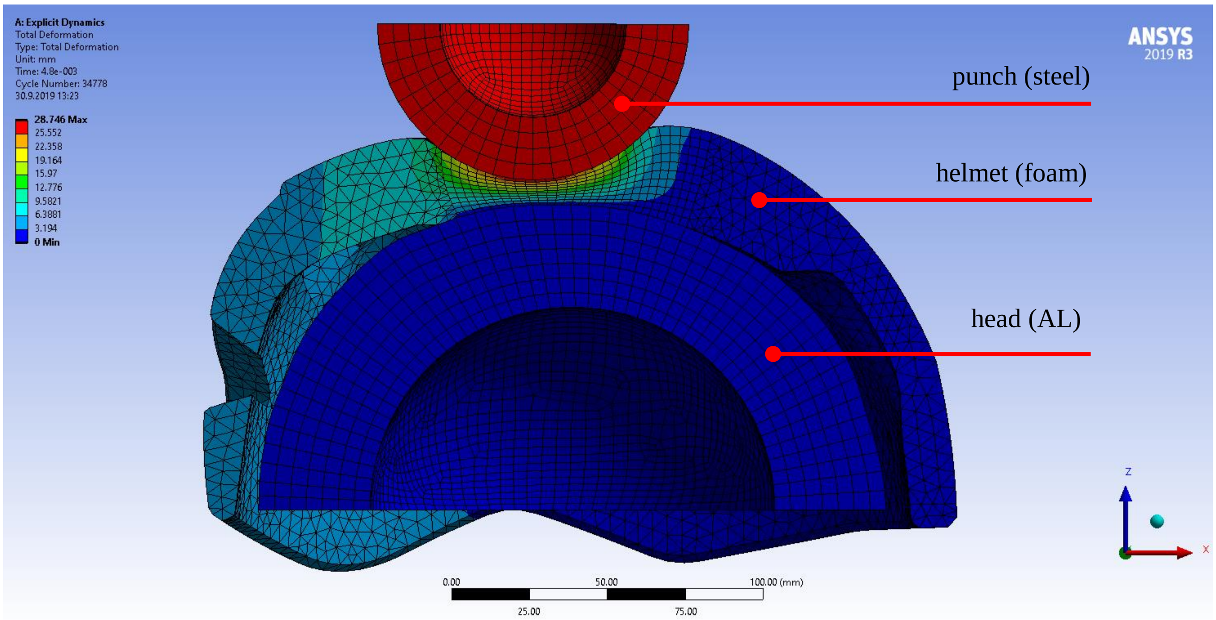


Fig. 1. Explicit FEM analysis of a drop test

Real drop tests are performed on a test machine that is commonly used by a helmet manufacturer. As standard, the test machine is equipped with a strain gauge force sensor placed in the base, on which the head model with the tested helmet is attached. In some cases, the obtained record of force did not match the assumptions because of the unexpected waves. Therefore, the testing machine is supplemented with other sensors (Fig. 2) - dynamometer consisting of piezoelectric force sensors (ForceZ), acceleration sensors (AccFront, AccBack) and laser distance sensors (DispL, DispR). The aim is to obtain independent signals of the force [3]. In addition, two high-speed cameras are used to monitor the stability of the punch and helmet movement during impact.

By evaluating the measured data considering the dynamic properties of all used sensors, it is possible to explain the differences in the results obtained by different methods of force measurement. The cause of the unexpected waves in the force record obtained by a strain gauge force sensor is the low natural frequency of the sensor and the attached masses. Similarly, the results from a plate dynamometer with piezoelectric force sensors are negatively affected too, because it lies on the oscillating force sensor.

The most accurate method for obtaining a force curve in a drop test is to use an acceleration sensors (AccFront, AccBack) verified by displacement signals (DispL, DispR). The resulting acceleration is then converted to the force by applying Newton's law of force.

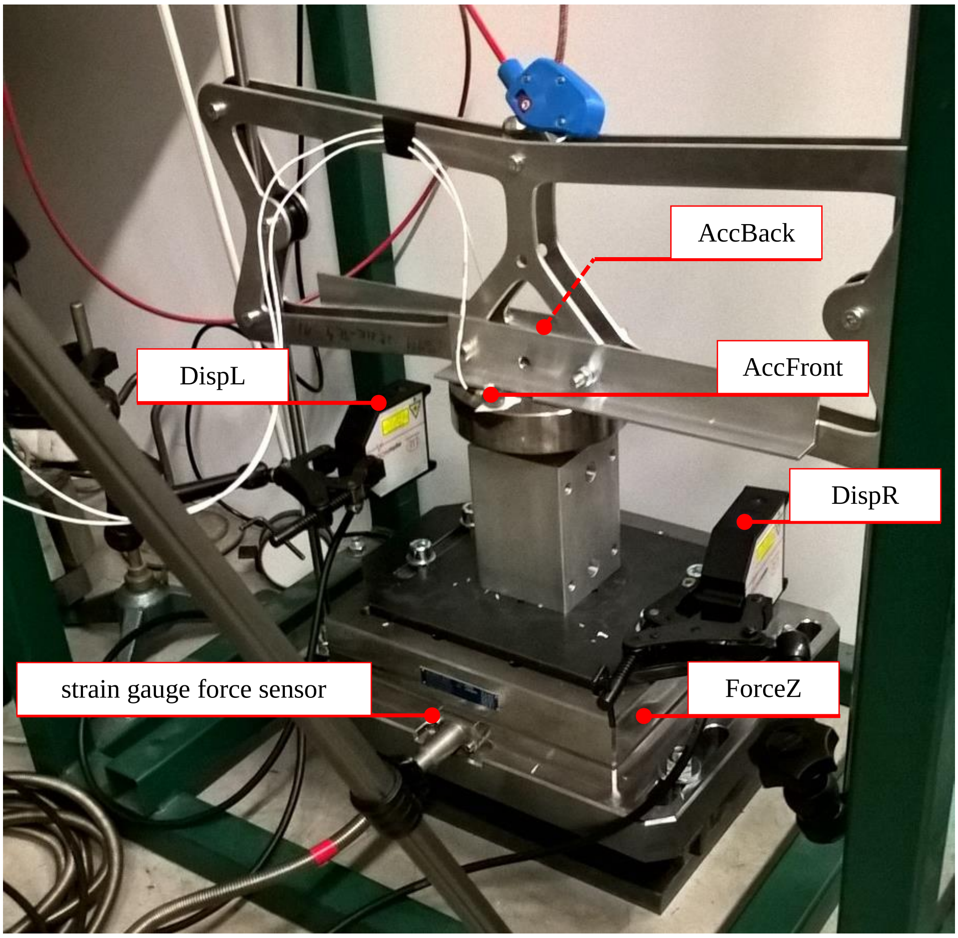


Fig. 2. Drop tower with all used sensors

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