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THOR DUMMY PROTOTYPE ABDOMEN FINITE ELEMENT MODEL DEVELOPMENT

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Introduction

Frontal crashes are the most common car accidents [1] and the abdomen is one of the body regions to suffer the most fatal injuries [2]. However, there is no current requirement for the abdomen protection in frontal collisions and crash test dummy abdomen biofidelity still needs to be improved. The aim of this study was to validate the Finite Element (FE) model of a prototype abdomen equipped with Abdominal Pressure Twin Sensors® (APTS) for the THOR dummy [3,4].

Methods

The abdomen of the THOR FE model Version 2.1 released by UVA and NHTSA/USDOT in January 2015 [5] was modified in order to model the prototype abdomen as described in [4]. The model of the APTS sensors was inserted in the front foam part of the abdomen model. The APTS fluid was modelled using solid elements and an equation of state linking pressure in the material and volume. Seatbelt pull tests performed on the dummy abdomen prototype by NHTSA's Vehicle Research & Test Center (VRTC) were reproduced in simulation under LS-DYNA R4. These tests were adapted from [6] where a seatbelt was routed around the dummy abdomen and was pulled toward its back with a 3 m/s velocity, the dummy back being unrestrained. A 4-parameter viscoelastic material model was used for the foam blocks of the abdomen in order to find a set of parameters that matches closer the test data under different conditions. Seatbelt retraction tests at 3.0, 3.6, 3.9 m/s and rigid impactor tests at 3.0 m/s and 6.1 m/s were used.

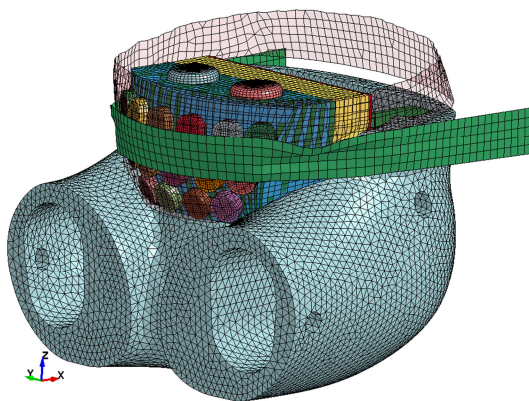


Figure 1: FE model of the THOR dummy prototype abdomen under seatbelt pull condition.

Results

The pressure-penetration and force-penetration responses of the abdomen FE model under 3.0 and 3.9 m/s seatbelt pull conditions is compared to the test data in Figure 2. The model pressure peaks match the test data whereas the force and penetration values are overestimated.

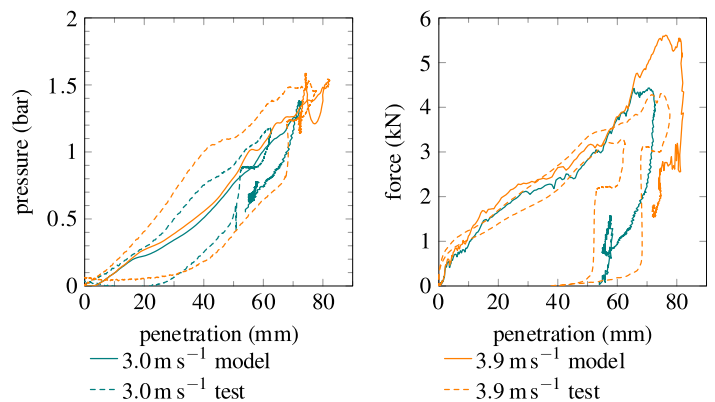


Figure 2: Pressure-penetration and force-penetration responses of the abdomen model.

Discussion

Although the model stiffness is similar to test data, the penetration and the force peaks are 20% overestimated. This could be due to the difficulty of reproducing the exact test condition: the belt displacement was imposed in the simulation whereas in the test protocol the pressure of the device pulling the belt was controlled. Next steps would be to tune the FE model parameters to guide biofidelity improvements of the prototype and correlate pressure measurements with the injuries seen on Post Mortem Human Subjects under the same loading conditions.

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