COMPUTATIONAL MECHANICS 2022
37th conference with international participation
Srní
November 7 - 9, 2022

Finite element model of interaction of human body and seat with variable stiffness

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1. Introduction

Prolonged sitting is a source of discomfort. We consider the option of changing seat cushion stiffness as the next level of seat customization, which can potentially increase sitting comfort. Modification of the cushion stiffness results in the change of distribution of contact pressure between the human body and the seat. To assess the effects of various seat designs on the contact pressure distribution, we decided to build a finite element model.

2. FEM model

To create the FEM model of the seat (see Fig. 1), we used the 3D scanning of the real seat to get the geometric data of the cushion since we could not get the original CAD data. In order to create a volume finite element mesh of the seat cushion, we first generated the surface tria-quad shell mesh with the target element size of 5 mm. To generate volume mesh, we used the "HEXA POLY" function of the ANSA pre-processor. Which creates hexahedral mesh inside the volume and polyhedral mesh closer to the surface – see Fig.3.We kept the surface shell mesh in the model for the latter definition of the cushion-human contact and surface pressure recovery. To simplify the model, we did not model the backrest. Thus, we applied a boundary condition to a human body model instead.

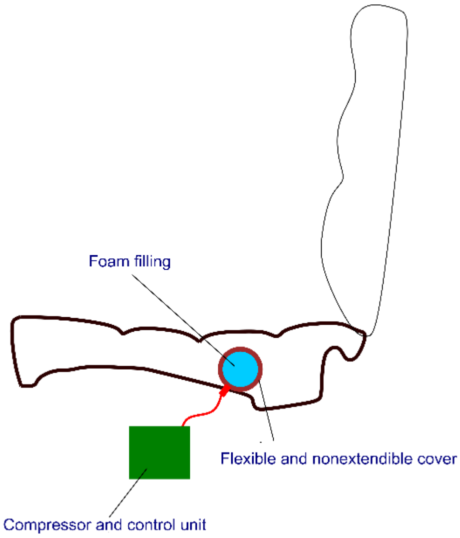

Fig. 1. automotive seat with variable stiffness

Fig. 2. TOYOTA AM50 5.03 occupant model

To identify the material model parameters of the cushion polyurethane foam, we provided laboratory measurements with the foam specimens sized 100x100x50 mm. We exposed the specimen to compressive loading up to relative deformation of 60%. We chose MSC.Marc built-in material model of type "foam," which is a modification of the Ogden model for compressible materials – for the details, see [1].

Next, we implemented the model of the pneumatic element according to the patent [2] (closely described in [3]) into the seat FEM model. The used model of the human body is based on the THUMS human body model AM50 by TOYOTA [4] (see Fig. 2). The THUMS model was initially intended for vehicle collision simulations, but its FEM mesh is coarse enough to keep the model simple and fine enough to maintain its fidelity. Moreover, it is modeled in the sitting position. To shorten the computational time, we used only part of the body, and the rest we replaced with boundary conditions.

3. Conclusion

We simulated the model without applying internal pressure to the pneumatic element – such a case we consider as it was the seat simulation without a pneumatic element. Although we collected experimental data on the pressure distributions of several volunteers seated in the real seat, a comparison of simulated human-seat contact pressure distribution to the experiments is yet to be done.

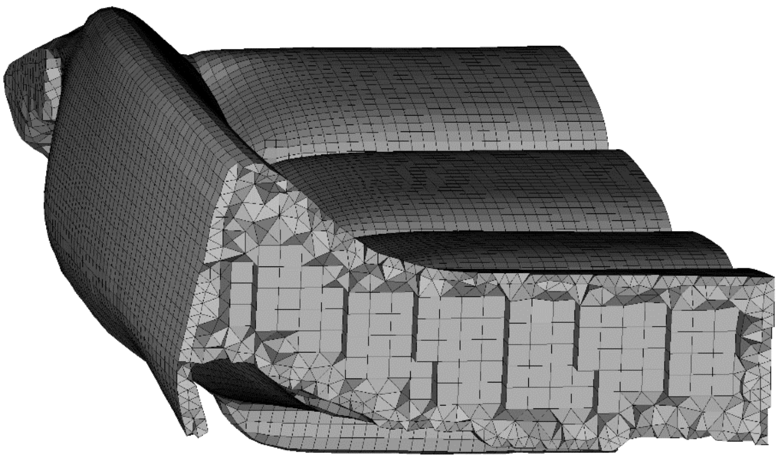

Fig. 3. volume mesh of the seat cushion with hexahedral elements insideand polyhedral close to the surface

Acknowledgements

This work was supported by project European Smarter Seats for Global Innovation in the Automotive Sector (ESSGIAS, no. LTE 120004). The project is co-funded by Czech Ministry of Education, Youth and Sports within the INTER-EUREKA (LTE) INTER-EXCELLENCE programme, supported by EURIPIDES[2] programme and monitored by AENEAS.

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