Computational Modeling of the Thorax under High Impulse Loading

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I. INTRODUCTION

It is very important to improve knowledge about the human body subjected to an explosion. For ethical reasons, blast experiments on post mortem human subjects are uncommon. Instead, computational modeling is very helpful. Numerical simulations of the dynamic behavior of the head/thorax etc. under high impulse loading allow us to better understand causes and location of injury to soft/hard tissue.

II. METHODS

In order to investigate the dynamic behavior of the human chest, numerical simulations with the explicit finite element (FE) code LS-Dyna were performed. In the simulations two FE models of a 50th percentile occupant were used: a simplified human body model developed within the THOMO project (7th Framework Programme) [1] and a FE dummy [2]. The models were subjected to the explosion of a relatively small TNT charge of mass equals to 60 grams. Additionally, the coupling between MADYMO and LS-Dyna was utilized to compare the blast response of the FE models with the behavior of the Hybrid-III 50th facet Q dummy [3].

During the research the maximum value of chest deflection and the Viscous Criterion (VC) – an injury measure that seems promising for blast testing [4] – were used as qualitative tools.

Computational Modeling

It is not possible to transfer blast loads from LS-Dyna to MADYMO in the explicit way. To compare the response of the FE models with the Hybrid-III facet dummy it was needed to prepare a test setup (shown in Fig. 1) which can be also used in the coupling procedure. A 50th percentile occupant is struck by a rigid plate (mimicking a simplified bullet-proof vest which is much stiffer than the human body) subjected to the explosion. The plate is located in front of the chest. It is assumed that at time $t_0 = 0$ the plate touches the skin of a model. The distance between the middle point of the plate and the explosive charge (in horizontal direction) is 0.5m. The blast loads are modeled using the empirical equations implemented in LS-Dyna as *LOAD_BLAST_ENHANCED.

III. RESULTS

The results show a good correlation of the maximum values of VC for the Hybrid-III 50th facet Q dummy and the FE dummy. VC for the human body model is much lower (ca. 75%). Additionally, large scatter of the maximum ribcage deflection – from 17mm (human FE model) to 34mm (FE dummy) – is observed (Table 1).

Fig. 1. FE dummy stroke by a plate

	Viscous Criterion [m/s]	Deflection [mm]
Facet dummy	1.31	25
FE dummy	1.38	34
Human FE model	0.34	17

Table 1. Viscous Criterion & ribcage deflection – max values

IV. DISCUSSION AND CONCLUSIONS

The results strongly depend on the model of the thorax used in numerical simulations. This indicates the necessity of the correlation of the results with the experimental data, if available.

It is worth noticing that based on the response of the THOMO model, causes and location of injury – e.g. ribs breakage – can be identified. This is not possible using recent computational models of crash test dummies.

V. REFERENCES

[1] THOMO project website: www.thomo.eu
[2] LSTC - LS-DYNA Finite Element Models website: models.lstc.com
[3] MADYMO Model Manual R7.3, www.tass-safe.com
[4] Bass CD et al, JOSE, 2005

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