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Numerical and Experimental Investigations of the Deployment Behaviour of a Knee Airbag featuring Real Gas Flow Phenomena

Modern cars count up to ten airbags used to optimise the crash worthiness which drastically increases the development efforts of a car safety system. Therefore simulation is seen as the future tool to support the crash engineers, as described in /1/. But there still exists known limitations of the simulation methodology which narrows its application range. Especially the numerical performance of a deploying airbag suffers from inaccurate or missing input data. The capabilities and qualities of current crash codes were recently assessed in e.g. /2/ and /3/.

The present paper carries on the approach first published in /4/. The study aims at establishing a numerically and experimentally based methodology to cover the whole simulation process of airbag modules, from the provision of folded airbag simulation models at the right time to quality assured simulation results of airbag deployment processes.

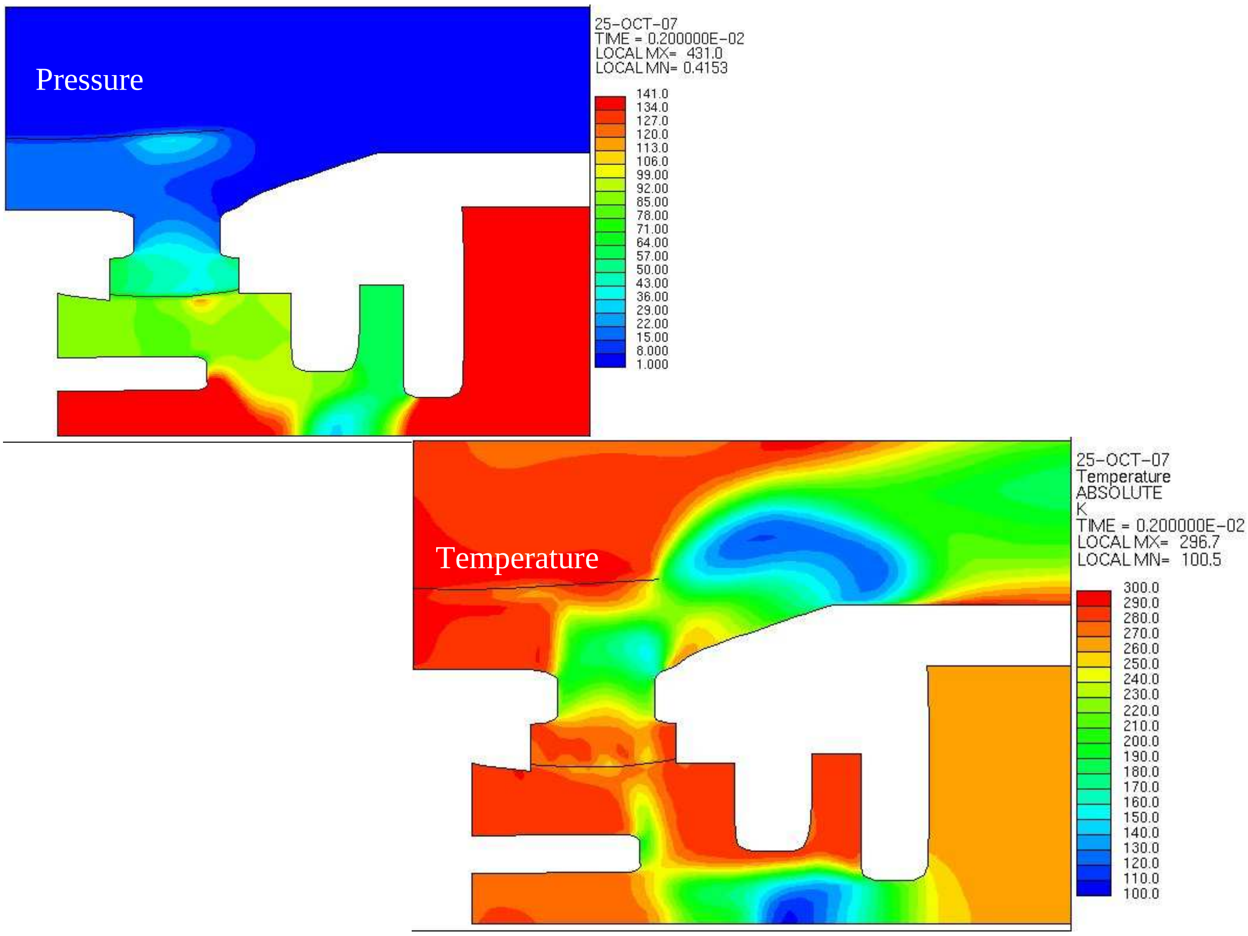

Figure 1: Instantaneous static pressure and temperature distribution in a cross section passing the burst membrane and the plenum chamber

The paper first addresses the simulation of flow phenomena occurring in a gas generator filled with pure Helium at high pressure. The applied CFD method comprises the simulation of real

gas effects which will be explained in detail. Figure 1 shows an instantaneous static pressure distribution in a cross section passing the burst membrane and the plenum chamber after 2 ms: The storage pressure is already reduced to about 431 bar. Thereby the gas is cooled down, although the Joule-Thomson real gas effect counterworks the temperature effects from an adiabatic expansion, as shown in the lower part of figure 1.
The method can be upgraded to also cover real gas effects of multi component gas mixtures.

Next the transfer of these detailed CFD results to a crash code is demonstrated: This procedure, described in /5/, allows for accurate results without paying the penalty of exploding turn around times. The differences between conventional and new simulation results will be worked out in relation to experimental results. Figure 2 shows the results of conventionally performed PAMCRASH simulations reflected to an experiment.

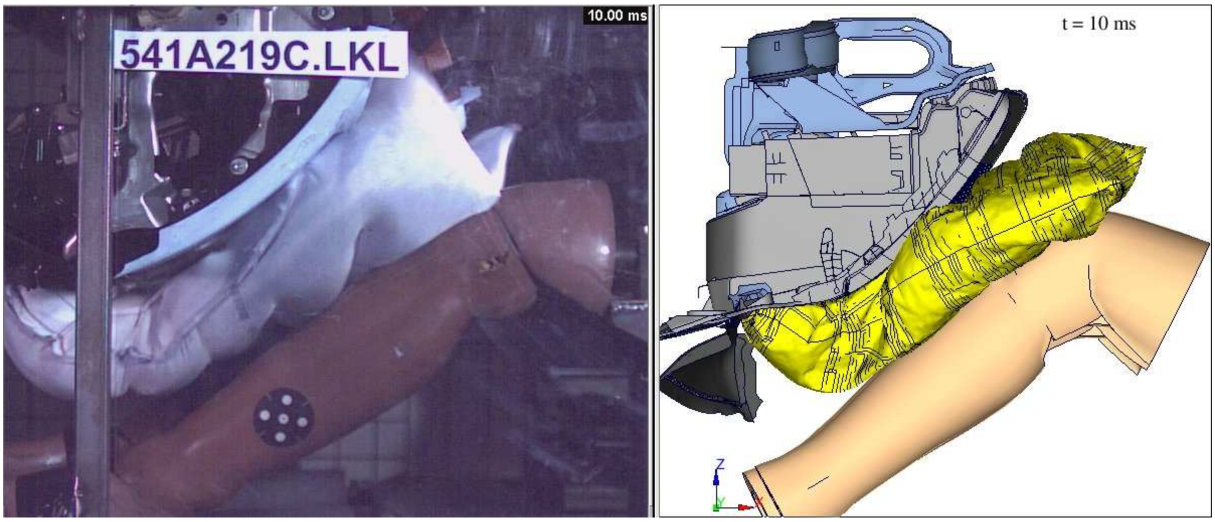

Figure 2: Intermediate deployment state of a knee airbag
rhs: Simulated result using conventional PAMCRASH Uniform Pressure method
lhs: Experimental result

The last part of the paper focuses on technical aspects of the product development process mainly the improvement of the numerical folding process of airbags. A folded airbag simulation model is obviously the ultimate prerequisite to perform deployment simulations. The concept of AUDI to improve and speed up a numerical folding process will be described. Figure 3 shows an intermediate state of a folded airbag. The major goal is to achieve a model which on the one hand exhibits a low level of internal energy at the beginning of the deployment simulation and on the other hand starts from the flat membrane layout.

As soon as a reliable and fast folding method will be established, the whole development process chain can be covered thus allowing to better support crash engineers in their work. In fairness it should be noted that there still exists gaps as e.g. the temperature dependant modelling of the instrument panel opening behaviour.
But also the experimental methods used to evaluate simulation input data or to validate individual numerical methods have to be further developed.

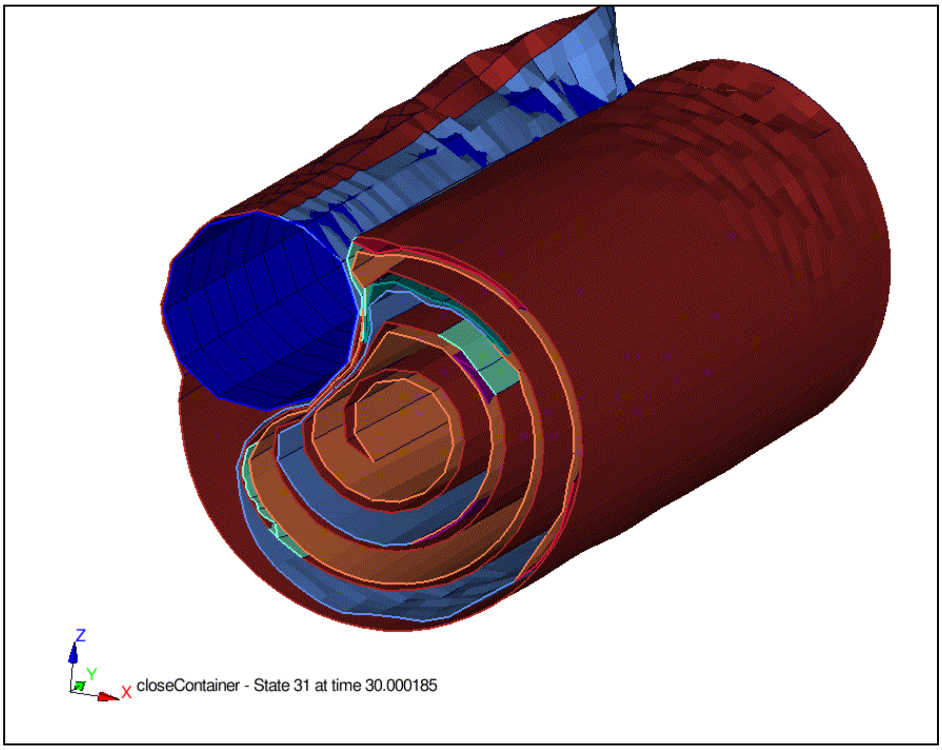

Figure 3: Intermediate state of an airbag folding process

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Literature:

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