MODEL IMPROVEMENT DURING SEAT PROJECT

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ABSTRACT

To help predict the behaviour of a seat assembly when performing a seat belt anchorage pull test (according to regulation ECE R14/05 and directive 76/115/EEC) a FE-model has been built and improved in several steps. To increase the accuracy of the simulation (quasi static), a number of modifications were made to the initial model. The adjustments include higher mesh density, allowing a better representation of the geometry. A tensile strength test has been performed on one critical component which showed a lower yield strength than that provided by the supplier which called for a model update. Physical tests have been carried out and simulation results have been compared to these tests. While doing so, the rails at which the seat is mounted on and the lock sleeves that keep the rails in its position were considered to be too week in the model. By incorporating thick shell elements, this issue was solved.

It is believed that these combined modifications significantly improve the performance of simulating a pull test.

KEYWORDS:

Seat belt anchorage pull test, quasi static, tshell, ECE R14/05, 76/115/

INTRODUCTION

Requirements for increased road safety has a high influence on the design of motor vehicles and are gaining importance with increased traffic flow on the roads. To make it easier for vehicle manufacturers, attempts to harmonize the different national regulations in Europe have been made through regulations issued by the United Nations Economic Commission for Europe (ECE) and by directives and regulations within the European Union.

Safety regulations are needed to make sure that manufacturers design their vehicles so that unnecessary injuries can be prevented in case of an accident. The seat belt anchorage pull test is a static test that is thought to correspond to the load that the seat is exposed to during a frontal crash and is defined in the following directive and regulation.

Directive 76/115/EEC states that all anchorages shall be capable of withstanding the seat belt anchorage pull test. Permanent deformation, including partial rupture or breakage of any anchorage or surrounding area shall not cause failure if the required force is sustained for the specified time.

ECE regulation 14/05 specifies the allowed displacement of the upper anchorage(s) during the pull test. It states that the upper safety-belt anchorage shall not be displaced forward of a transverse plane inclined 10° in forward direction and passing through the seat reference point. The maximum displacement of the effective upper anchorage point shall be measured during the test. The purpose of this test is to demonstrate that the seat structure will not fail to provide sufficient survival space inside the cab in case of a crash.

In the design phase, computer modelling and finite element analysis in particular can save a lot of money and time. However, component testing is very useful and often necessary when it comes to verifying the FE model. The updated model obtained from this project shows a close correspondence between experimental evidences and numerical results.

1. SIMPLIFIED MODEL OF THE SEAT STRUCTURE

To start off the project, a simplified model was used and compared to previous pull tests. The FE analysis was performed as a quasi-static simulation using the explicit solver LS-DYNA version 970. One of the reasons for choosing an explicit solver for the analysis was the risk of convergence problems when using an implicit solver combined with the presence of large deformations. The disadvantage with explicit solvers is that the "correct" time can not be simulated within a reasonable time frame.

1.1 FE MODEL

The FE model comprises of the seat rails, seat adapter, lock sleeves, lock pins, floor parts and the seat it self. The seat however is only schematically modelled using beam elements. The same goes for the lock sleeves and the lock pin which are used to assemble the seat. The sheet parts were modelled with linear shell elements, and fully integrated elements were used for the rails to avoid hourglass energy.

The load was applied using a sinus curve in order to minimize dynamical responses in the simulation and the strain rate effects were turned off for the materials.

1.2 EXPERIMENTAL TESTS

The way to perform the seat belt anchorage pull test is thoroughly described in the regulations. It is however allowed to change the way the test is performed if it can be showed that the new test set-up is equivalent. See Figure 1 below for a typical test set-up. There are three load levels denoted as N3, N2 and N1. N3 is for motor vehicles weighing more than 12000 kg and N2 is for motor vehicles weighing between 3500 kg – 12000 kg and N1 is for passenger cars and light trucks. The current European legislation demands that directive 76/115/EEC is fulfilled with N3-load for trucks sold in Europe.

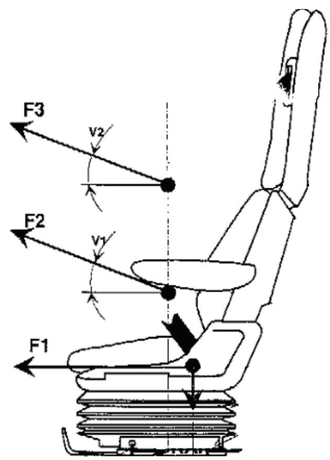

Figure 1: Typical set-up for a seat belt anchorage pull test.

During the test, the displacement of the upper belt anchorage is measured and the deformation behaviour of the seat assembly is recorded.

2. IMPROVED MODEL OF THE SEAT STRUCTURE

Results from the comparison between the experimental test and the FE analysis using the simplified model showed a correlation concerning the deformation of the seat assembly that was not considered to be acceptable. It was assumed that the simplifications made to the model were too great.

2.1 MATERIAL UPDATE

The correlation between the FE analysis and the actual test was not acceptable when the deformation behaviour of the seat adapter was compared to the actual test. This called for an investigation to see if the adapter met the specified material requirements. A tensile test was performed on a piece of the adapter and the results showed a lower yield strength than that provided by the supplier. The deviation was too large to ignore and therefore the model was updated with the new material information.

2.2 FE MODEL UPDATE

As a first step the element length on the rails was decreased so that a better representation of the geometry could be obtained. Also the "teeth" of the rails were modelled. Although these modifications significantly improved the behaviour of the rails, judging from early simulations, they were not enough to capture the complete seat assembly's deformation behaviour.

As a second step, the lock pins were modelled using solid elements instead of beam elements and the lock sleeves were modelled using shell elements. These modifications resulted in a better correlation at lower forces. At higher forces, however, the rails appeared to be too weak and the same was true for the lock sleeves that were pulled out through the seat adapter. There was also an issue concerning the contact definition between the lock sleeves, the rails and the seat adapter as they contained shell edge to shell edge interfaces.

2.3 INCORPORATING THICK SHELL ELEMENTS

From previous projects, it was known that thick shell elements behave in a stiffer manner than ordinary thin shell elements. In fact, in some cases, thick shell elements are more suitable than thin shell elements, for example in sheet metal forming with large curvature [2].

To achieve a stiffer performance from the rails and the lock sleeves, thick shell elements were incorporated in to the FE model.

2.4 RESULTS

The accuracy of the simulation results was evaluated by comparing against photos and movies taken during the test. As can be seen in Figure 2, where the results from the simulation have been put over the actual test specimen, the correlation is very good.

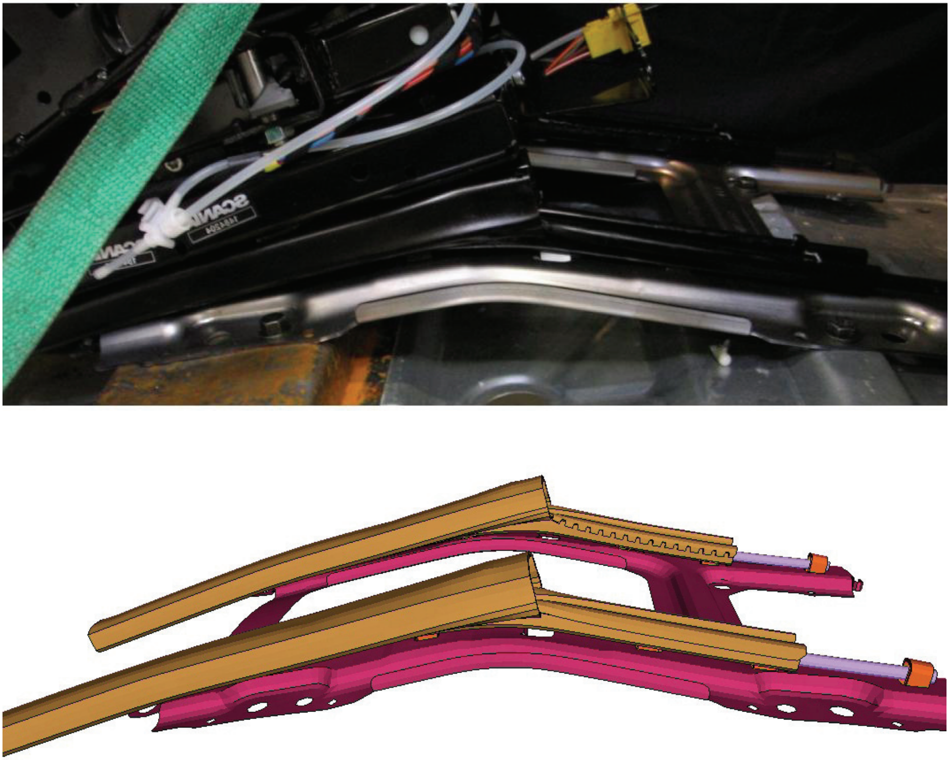

Figure 2: Comparison between FE-model and test.

4. SUMMARY AND CONCLUSIONS

During this project a seat belt anchorage pull test have been simulated using LS-DYNA version 970. To start with, a simplified model was used and compared to previous tests. Based on comparisons between test and simulation, the FE model has been modified to achieve better correlation with the real test. Thick shell elements have been used to model the rails and the lock sleeves that keep the rails in their position.

A disadvantage with thick shells is that thin shells need to be modelled first and then converted into tshell elements. For this application the higher accuracy when using thick shell elements is considered to outweigh the disadvantage.

It is believed that these combined modifications significantly improve the performance of simulating a seat belt anchorage pull tests. The simulations have been dependant on testing results for verification and therefore, when possible, component testing should always be made so that the FE model can be verified.

REFERENCES

1. Hallquist, J. O., LS-DYNA. Keyword User's Manual. Version 971, Livermore Software Technology Corporation, Livermore, 2007.

2. Guo, Y., Eight-Node Solid Element for Thick Shell Simulations, Livermore Software Technology Corporation, Livermore, 2000.