Comparison of LS-DYNA Version 7, 9 and 11 – a view of an airbag supplier

Axel Seeger[1], Sebastian Stahlschmidt[2]

[1] iSi Automotive Berlin GmbH
[2] Dynamore GmbH

1 Introduction

Several LS-DYNA versions are currently available – R7 is still in use in several projects, the currently mostly used version is R9, future projects will be run in R11. This paper will compare these three versions with focus on some airbag issues.

2 Method

The comparison will be focused on the following main differences between the LS-DYNA Versions 7, 9:

- Heat convection
- Material definition (*MAT_FABRIC)
- Enhanced venting

Furthermore, the following issues will be compared between LS-DYNA Versions 9 and 11:

- Speedup CPM in R11

Among these LS-DYNA versions, a comparison of calculation times and calculation results was also performed.

SVN numbers of the LS-DYNA versions, which were investigated are:

LS-DYNA version	SVN number
R 7.1.3	111795
R 9	125303a
R9.3_dm	129523
R11	129956 / 135722

3 Results

3.1 Heat convection

For cold gas inflators, the gas temperature is below ambient temperature. A heat flux from the outside to the inside of the airbag needs to be calculated. Starting with R9.x, heat flux from the outside to the inside is considered.

The important part of the *AIRBAG_PARTICLE card is marked in red:

```
*AIRBAG_PARTICLE
$#     sid1     stype1       sid2     stype2      block     npdata       fric
          1          1          0          0          0          1      0.000
$#       np       unit     visflg       tatm       patm      nvent       tend
tsw
    200000          0          1     296.0.00010132          0
$#     iair       ngas      norif       nid1       nid2       nid3
          1          1          2          0          0          0
$#     SIDH     STYPEH          H
          1          1   &HEATCON          0          0
$...
```

The difference between R7.1.3 (without heat convection) and R9.x (with heat convection) is shown in the following image.

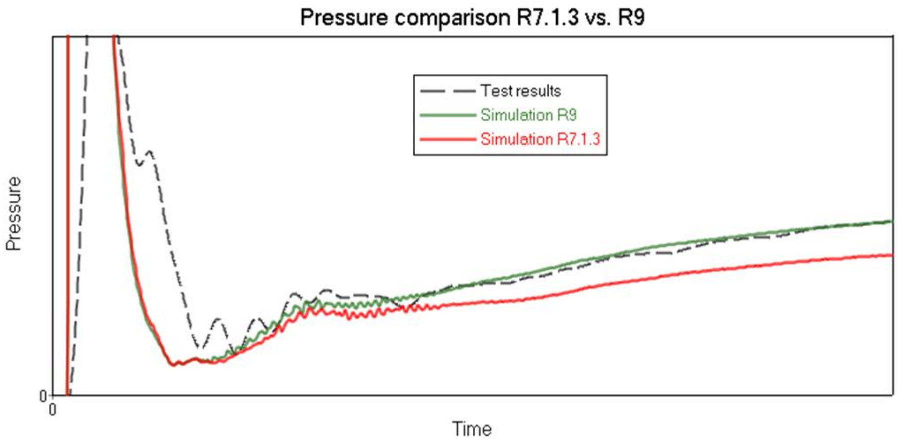

Fig.1: Comparison of a test results (black) and simulation results (red and green curves). Pressure vs. time is shown. The old R7.1.3 LS-DYNA version does not consider heat convection from the outside to the inside and underestimates therefore the pressure on the long scale (red curve). The results in R9 predict pressure vs. time correctly.

3.2 Material definition (*MAT_FABRIC)

The *MAT_FABRIC card is changed on its first line – PRCA was changed. The meaning changes, which may lead to problems. Check these values, if you change from 7.x to 9.x

```
*MAT_FABRIC_TITLE
Title_Fabric
$#     MID        RO        EA        EB        EC      PRBA      PRCA      PRCB
     62000   7.24E-7     0.330     0.281        0.        0.       0.0       0.0
```

3.3 Enhanced venting

The enhanced venting option should be well known until today. It is used to get a proper vent rate also by having small vent sizes. This feature is often used for vent holes which are defined to the surrounding (external vents).

Enhanced venting=1: this option will move the particles within the characteristic length (vent hole radius) towards the vent to get proper vent rate based on the flow equation. CPM particles move in one direction from high pressure to low pressure areas.

For some time, it has been necessary to model also internal vents, which are passed by the particles in the Airbag volume. These are necessary to define chambers in an airbag. In this case, if the pressure difference between two chambers is high, the entire CPM particles on high pressure area side may move aggressively to the low-pressure area and create a "suction" effect. To prevent this effect, the enhanced vent option 2 was generated in R9.

Enhanced venting=2: this option will move the particles within the characteristic length (vent hole radius) towards the vent to get proper vent rate without the flow equation. CPM particles can move from both sides, but the high-pressure side should give higher probability density function.

Images concerning this problem will be shown in the presentation.

3.4 Speedup CPM in R11

Since versions R10 the CPM Method in LS-DYNA is recoded. That means the algorithm for the Particle 2 Particle (p2p) and for Particle to Fabric (p2f) contact is renewed.

For p2f contact, the focus was on changing bucket sort, which tries to find potential new contact partner and neighbors efficiently. Also, the communication itself is improved.

For the p2p algorithm the work was more on the decomposition of the single particles. By improving this, the distribution of the particles itself is much better, and no domain has to wait for another in the new logic.

Due to these changes the speedup of the CPM Method itself is up to three times faster. In single airbag simulations, without any other surrounding we observed in some simulations a speedup of about 100%. Therefore, the solution time was about a half of R9 version.

But this speedup can only be seen, when the CPM algorithms is the bottleneck of the solution. Sometimes in airbags, expensive contact definitions are used, which dominate the solution time. In these cases, there might be seen only a very small speedup! But this must be checked in each singe case.

3.5 Calculation results / times

3.5.1 R7 vs. R9

In general, calculation results of R7 and R9 have a good till very good agreement in energy absorption behavior as well as airbag pressure – if the changes mentioned above like heat convection effects are neglected. However, unfolding behavior might be little bit different. Calculation times were slightly higher in R9 versions (less than 10%).

3.5.2 R9 vs. R11

Concerning energy absorption and unfolding behavior, we saw a good agreement between version 9 and 11, if the airbag had no permeability and no vent. However, for airbags with vents and permeability, the pressure vs. time was slightly different, even among the R11 versions.

R11 was about 30% faster in a validation at iSi Automotive. Dynamore measured in special models a calculation reduction of up to 50%. This was due to the new particle algorithm, which was about 50%-66% faster than in R9.

4 Conclusions

The major improvement for iSi Automotive in R9 concerning airbag pressure prediction is the improvement in heat convection – heat flow from the outside to the inside.

For a change from version R7 to R9, only few differences were found for the investigated models.

Impermeable airbag models showed no differences, if LS-DYNA version is changed from R9 to R11. However, permeable airbag models showed slight differences.