Influence of Material Scatter to Simulation Results with ALTAIR RADIOSS

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Agenda

- Motivation
- Material test results: What reality shows
- Scatter in simulations
  - Geometrical scatter
  - Material and failure parameter scatter
- Examples
- Conclusion
CRASH is chaotic and material parameter sometimes, too. But there is a need for a robust response.
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What reality shows (real tests):

DP600 – Real test results: Material supplier A vs. supplier B
Material test results: What reality shows

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Material test results: What reality shows

Material instability !!!

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Material test results: What reality shows

Material instability !!! 😞
Material test results: What reality shows

(Vide)
Material test results: What reality shows

Simulation results:

Under-estimated material

Over-estimated material

All simulations run stable 😊
Material test results: What reality shows

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Material test results: What reality shows

Resultant failure in transverse direction

Resultant failure in machine direction


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Thickness perturbation – Nodal wise

Usual value for max. random displacement = 1 µm
Thickness perturbation – Element wise

This option can be used to study the robustness of a design by generating different thickness values for every shell element in the specified part group. The random noise scale factors can have either a normal (Gaussian) distribution or random distribution.

Format:

<table>
<thead>
<tr>
<th>ID</th>
<th>ID</th>
<th>C0</th>
<th>C1</th>
</tr>
</thead>
</table>

*PERTURB/PART/SHELL

Block Format Keyword

If idistri=1, the distribution of the scale factors will be random.

If idistri=2, the normal distribution of the scale factors will have the following probability density function.
Thickness perturbation – Part wise (material parameter and thickness)

(= Monte Carlo)
NEW advanced failure criteria (BiQuad)
At least: 0 fitting parameter needed!

Adding perturbation to fracture limit!

What reality shows:
- Small scattering in max. stress but
- Big scattering in rupture strain
**NEW** advanced failure criteria (BiQuad)

At least: 0 fitting parameter needed!

Adding perturbation to fracture limit!
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Failure perturbation – Integration point wise
Failure perturbation – Integration point wise

Contour Plot
Stress von Mises, Material case 1: Time = 2.000E+001: Frame 11
Elemental system
Simple Average
Max = 3.389E+02
Node 269
Min = 0.000E+00
Node 927

Contour Plot
Stress von Mises, Material case 1: Time = 2.000E+001: Frame 11
Elemental system
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Failure perturbation – Integration point wise: /FAIL/ALTER


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Failure perturbation – Integration point wise: /FAIL/ALTER

Comparison of measured and computed acceleration.

Target: Increase the Robustness – Example #1

- **Frontal Impact on Rigid wall**

  Model Unit: mm, s, Ton

  Initial Velocity: 12.3 m/s

  Total Mass: 1.219 Ton

  **Random Noise**: $1.0 \times 10^{-6}$ mm

  

  ![Simulation Images]

  - $T = 00.00\ms$
  - $T = 80.00\ms$
Target: Increase the Robustness – Example #1

25 Runs

Variation:
Random Noise: 1.0E-6 mm
Seed variation (0.00 to 0.90)

Overall Maximum RigidWall Force

What is the Source of this results Dispersion (in time and space)?
Target: Increase the Robustness – Example #1

Results: What is the Source (in time and space) of this results Dispersion?

Small variations can lead to big differences in final results.

- Sub frame hits Engine at ~ 40 ms
- Sub frame does NOT hit Engine at ~ 40 ms
Target: Increase the Robustness – Example #2

“Physical Variable”: Thickness of the Front Bumper Cross Beam

Original Thickness: 1.956 mm

- Increasing the thickness
  - +10%: 2.122 mm
  - +100%: 3.912 mm
Target: Increase the Robustness – Example #2

Conclusion after 1st run:

*Increasing the thickness of the bumper beam leads to*

- Increase of the wall force

> Sounds logically
Target: Increase the Robustness – Example #2

Conclusion after 10 runs

*Increasing the thickness of the bumper beam leads to*

- **Decrease of the wall force**

- Only 1 run leads to wrong conclusion!

The model with 10% thickness increase is more sensitive than the base model
Target: Increase the Robustness – Example #2

![Case study NEON_1M sensitivity](image)

**Base model**

**Model with 10% thickness increase**

**Model with 100% thickness increase**

- Norm max contact force wall
- Norm max SAE 180 acceleration "brake caliper right"
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Huge simulation models are not an issue, today!

25 million elements model:
Time = 0.0000e+000s
Conclusion

CRASH is chaotic!

Material properties are not always homogeneously distributed within a part. They have always tolerances.

A DESIGN IS ROBUST IF ITS SENSITIVITY TO SMALL CHANGES IS LOW

- Robustness is more important than optimality. A « good enough » robust solution is better than a sensitive optimal solution.
- Robustness of design should be a key objective for optimization
- REPEATABILITY is important in the design process (with /PARITH/ON, Radioss delivers always the same results, when run is started twice)
- Uncertainties (material, geometric tolerances, ...) must be accounted for

RADIOSS offers predictive material and failure models, applicable for modeling and considering most of known physical effects.

Anyway, there are still a lot to opportunities for improvements! Lot of work ahead!

We are fully open for participation in research projects and new developments!
Thank you for your attention!

Open for questions...

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