

A New Heat Transfer Capability Between CPM Gas and Its Surroundings

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Corpuscular particle method (CPM) was developed for airbag deployment simulations. It took into account specifics like airbag folding technique, vent hole design, and interaction between discretized gas flow and airbag fabric to capture the effects of dummy impact on airbags, both fully inflated and out-of-position. It's numerically very robust and the particle-based nature leads to elegant treatment of venting, porous leakage and gas mixing. Users find novel situations to apply the method and oftentimes new features are needed to better support these scenarios. Among these is the need of more comprehensive treatment of heat transfer.

Based on kinetic molecular theory, CPM model behavior is heavily influenced by heat transfer. Yet, a full-blown coupled thermal analysis might not always be viable for a refined model. To enable modeling of heat transfer just in the neighboring structures of the CPM gas can provide a solution to this quandary. The design and implementation status will be discussed.

Some other recent advances in CPM in LS-DYNA® will also be discussed. For example, airbag integrity checking reports to the user hard-to-discover abnormality in the airbag structure definitions in the input phase.

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Outline

- Background on CPM
- Motivation of new feature
- Heat transfer between CPM gas and neighboring structure
 - Design
 - Implementation status
- Recent advances in CPM
 - New airbag integrity checking option in CONTROL_CPM keyword
 - Numerical examples using new options

Corpuscular particle method (CPM)

- Based on kinetic molecular theory; one particle represents many molecules.
- Spherical shape leads to easy contact treatment
- Numerically robust and easily solved
- Noisy pressure needs internal smoothing

Motivation

- AIRBAG_PARTICLE is used in many applications not related to airbags
- Thermal convection is not important in airbag deployment simulations
- Based on kinetic molecular theory, CPM models' behavior are heavily influenced by heat transfer. Yet, a full-blown coupled thermal analysis might not always be viable for a refined model. To enable modeling of heat transfer just in the neighboring structures of the CPM gas can provide a solution to this quandary.

New keywords

- A new particle general (PG) namespace
 - PARTICLE_GENERAL
 - CONTROL_PG
 - DEFINE_PG_GAS_PROPERTIES
 - DEFINE_PG_VENT
 - DEFINE_PG_CHAMBER
 - DATABASE_PGSTAT
 - DATABASE_PG_SENSOR

Current status

- Duplicated all features up to R7.1
- Both SMP and MPP
- Duplicated airbag integrity checking from CPM
- Changed the duo of complete bag part set and internal part set to the pair of external part set and internal part set (not turned on by default yet)

*CONTROL_CPM

*CONTROL_CPM

NCPMOUT NP2P NCPM_TS NCPM_ERR

CPMOUT: CPM d3plot output format

EQ.11: full database in version 3 format (default)

EQ.21: full database in v.4 format

EQ.22: coordinates only in v.4 format

EQ.23: summary only in v.4 format

NP2P: number of cycles for CPM repartition among processors (default 5)

NCPM_TS: check time step size for CPM

NE.0: turned on

NCPM_ERR: airbag integrity checking

NE.0: turned on

Example: Volume not closed because of missing elements

...

2798 2716 2717

*** Error 30378 (INI+378)

PARTICLE bag has open volume, ID = : 1

Total number of segment without neighbor found : 4

...

2798 2716 2717

*** Error 30379 (INI+379)

PARTICLE bag has wrong orientaion, ID = : 1

Total number of segment : 104356

Total number of inconsistent segment found : 4

...

*** Error 30278 (INI+278)

*AIRBAG_PARTICLE: 1

Bag is not a closed volume 2553 2635 2634

*** Warning 30346 (INI+346)

There are 4 segments found without neighbors which indicates airbag without closed volume. Please check individual MPP message files.

Example: some missing elements in chamber definition

...
90 97 89

*** Error 30380 (INI+380)
PARTICLE bag (CHAMBER) has open volume
Bag ID = : 1, Chamber ID = : 1
Total number of segment without neighbor found : 4

...
90 97 89

*** Error 30381 (INI+381)
PARTICLE bag (CHAMBER) has wrong orientaion
Bag ID = : 1, Chamber ID = : 1
Total number of segment : 680
Total number of inconsistent segment found : 4

...
90 89 97

*** Error 30380 (INI+380)
PARTICLE bag (CHAMBER) has open volume
Bag ID = : 1, Chamber ID = : 2
Total number of segment without neighbor found : 4

Other airbag integrity violations

- Volume not closed because of missing elements
- Volume not closed because PID is missing in CV set
- Some/all normals are flipped
- Missing elements in chamber definition
- PID missing in chamber definition
- PID with wrong normals in chamber definition