Development of Advanced Finite Element Models of Q Child Crash Test Dummies

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COMPUTER-AIDED ENGINEERING AND Q MODEL DEVELOPMENT
Child Safety and CAE

General CAE benefits
► Early and better analysis of design problems
► Optimization to solve design problem
► Shorten design time and reduce costs

Current bottlenecks for broad use of CAE in child safety domain
► Physical testing costs are relatively low
► No urgent need for OEM’s
► Availability of quality models:
  Child dummies, child restraint system, test procedures
► Limited experience at CRS industry
Child Safety and CAE

Expected developments

► Introduction of Q dummies increases testing costs
► Meeting future requirements is getting harder
► Euro NCAP is likely promoting older children
  – Car restraint system is getting more important for child safety rating
Q Modeling projects

- TUB: Q0 (2002...2006)
- Humanetics in-house: Q3, Q3s (2006..2007)
- Casper project - Humanetics & VFSB: Q1, Q1½, Q6 (2009..2010)
  - 7 OEM’s, Humanetics, TUB, VFSB, Simulia
  - LS-DYNA and 2 other FE codes
CAR INDUSTRY REQUIREMENTS FOR DUMMY MODELS
Car industry requirements

General:
► Harmonisation of hardware (Denton and FTSS)
► Models must represent the latest hardware
► Correct implementation of the hardware
  – Geometry, mass and inertia
  – Correct material properties
  – Implementation of all sensors
► Close collaboration between manufacturer of hardware and developer of models
  – Knowledge about the manufacturing process

Source: Dr. -Ing. Christian Gehre
Partnership for dummy technology and biomechanics
Automotive CAE Grand Challenge 2009
Car industry requirements

Technical:
► Time step of approx. 1 microsecond (dummies) without mass scaling
  – No need to use highly detailed models in general
► Same geometry, mesh, joint angles for all codes (if possible)
► Numerically robust
► High level of predictability
► Detailed report of the validation process

Support:
► Quick response time
► Regular updates and improvements

Source: Dr. -Ing. Christian Gehre
Partnership for dummy technology and biomechanics
Automotive CAE Grand Challenge 2009
HIGHLIGHTS RECENT Q6 MODEL DEVELOPMENT
Q6 Model Development

Rib cage molding and skin: Three layers of solid elements

Constraints between thoracic spine box and rib cage at screw location

Detailed mesh of clavicle and clavicle retainer to capture contacts
Q6 Model Development

Front and Lateral IR-TRACC

Contact of rigid pin and rubber stops to define the lower arm joint stop angles

Continuous jacket mesh
Two layers of solid elements.
Recent Q6 hardware change: Neck cavities filled with rubber to improve bonding area
Q CHILD MODEL VALIDATION
Head – Q6

Frontal

Lateral
Lumbar Spine - Q 6

Frontal

Lumbar Spine Rotation - Frontal

- Maximum Rotation Upper Bound 69 Degree
- Maximum Rotation Lower Bound 54 Degree
- Minimum Rotation Upper Bound -23 Degree

Lumbar Spine Rotation - Lateral

- Maximum Rotation Upper Bound 70 Degree
- Maximum Rotation Lower Bound 55 Degree
- Minimum Rotation Upper Bound -23 Degree
- Minimum Rotation Lower Bound -33 Degree

Test
Test
FEA v0.2
Full certification - Q 6

Lateral Impact Force

Upper Bound 1.95 kN
Lower Bound 1.65 kN

Test
Test
FEA v0.2
Design of Q6 Frontal sled test

Target data

Pre simulation of validation test

Courtesy of Adam Opel GmbH

Current Q6 consortium task
Design of Q6 Frontal sled test

Time=0ms

Time=40ms

Time=80ms

Time=100ms

Time=120ms

Time=140ms
SUMMARY
Summary

► For the introduction of CAE methods in the development process high quality Q Child Dummy Models are necessary

► LS-DYNA models of the Q1, Q1½, Q3, Q3s and Q6 have been developed
  – Models are validated on material, component and full leg form level for several loading conditions

► Q6 models are being further developed and extensively validated in a 3-year consortium project to develop CAE and hardware related knowledge and target fully reliable simulation.

► Humanetics LS-DYNA Models are supported and can be made available by Alyotech, DYNAmore, ERAB and ARUP
THANKS!