Application of Software Tool CASIMIR within HyperMesh for the Assessment of static and dynamic Seating Comfort

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Overview

- Motivation
- Process Chain
- Seat Model
- Occupant Model CASIMIR
- Software Tool CASIMIR/Automotive
- Simulation & Results
  - Statics
  - Dynamics
- Conclusion
Motivation

- number of versions
  - e.g. > 120 motor-/body-versions of a major OEM

- diversification of market

- consistent application of CAE
  - precise forecast needed
  - from physical to digital prototyping
  - broader applicability due to enhancements of CAE software performance

CAE-Analysis of the occupied seat is feasible!
Process Chain: CAE-Analysis

- Material Tests & Identification
- Material Database
- Material Models Upholstery
- SAE-Dummy J826 (ASPECT)
- H-Point Backset
- Unoccupied Seat
- Occupied Seat
- CAD-Data Structure
- Material Models Structure
- EMA (for validation)
- CAD-Data Upholstery
- Pressure Maps C&B Occupant Position
- Meat-to-Metal Seat Transfer Fct
- Dynamic Responses Load on Components
Process Chain: CAE-Analysis

Strong simulation requirements:
- Contact foam pads – structure
- Foam and cover material properties
- Contact occupant – seat
- Nonlinear and frequency dependent properties of human.

STRUCTURE
- els: 45k, dofs: 300k

UNOCCUPIED SEAT
- els: 110k, dofs: 750k

OCCUPIED SEAT
- els: 240k, dofs: 1,000k

Contact foam pads – structure
Foam and cover material properties
Contact occupant – seat
Nonlinear and frequency dependent properties of human.

Seat: Mercedes Benz
Seat: Structural Frame

Adjustment of seat due to influence on static and dynamic:
- required joint moments
- deformation of foam cushion
Seat: Upholstery

Modelling:
- Based on CAD-geometry
- Appropriate choice of element size
- High quality of mesh required
- Padding and foam merged

Material properties:
- Based on experiments
- Hyper- & Viscoelastic material laws
- Parameter identification by optimisation

\[ U = \sum_{i=1}^{N} \frac{2\mu_i}{\alpha_i^2} \left[ \lambda_1^{\alpha_i} + \lambda_2^{\alpha_i} + \lambda_3^{\alpha_i} - 3 + \frac{1}{\beta_i} \left( (\mu_i)^{\alpha_i\beta_i} - 1 \right) \right] \]
Occupant Model CASIMIR

- lumbar spine model
- musculature
- dynamic model of viscera
- skeleton model: pelvis and legs
- upper torso: head, neck and arms
- back model
- buttocks model
- compliant body surface

Detailed Model of lumbar spine and abdominal & back muscles
Occupant Model CASIMIR
Variations in percentile & posture

**Percentile:**
Model family based on data of f05, m50, m95 and individual anthropometric data

**Posture:**
Change according possible driver postures
CASIMIR/Automotive Process Chain

Process Steps:
- CASIMIR definition: percentile and posture
- Computation of postural adaption and application on model
- Import of seat model
- Positioning of CASIMIR
- Definition of contact pairs
- Definition of load cases:
  - Statics: Seating process under gravitation and stabilising muscle forces
  - Dynamics: Excitation at seat rail, hands and feet
- Start of simulation
CASIMIR/Automotive Occupant Definition

Percentile

Cushion angle

Posture

Angle of view

Muscle activation

Lordose angle

Offset numbering

Orientation driving direction
Simulation – Static Seating

**Simulation:**
- Gravity acting on all model parts
- Muscle forces to maintain equilibrium
- Geometrically nonlinear simulation (Newton-Raphson-method)

Seat: Mercedes Benz
Simulation – Static Seating Results – Seat pressure distribution

Posture

CASIMIR (simulation)

XSENSOR (measured)
Simulation – Dynamics

Basics
- Linearisation: tangent stiffness of all nonlinearities
- „Freezing“ of contact status: open remains open, closed remains closed

Simulation
- Direct solution in the frequency domain: steady state
- Consideration of frequency dependent stiffness and damping properties
- Consideration of local, non-proportional damping
- Excitation: dynamic BCs at the seat rail, hands and feet

Results
- Seat transfer functions $H_{B/S}(\Omega)$ in x, y and z
- Transfer functions to comfort analysis locations (on seat & occupant)

$$H_B^{x/y}(\Omega) = \frac{-x/y}{q_B}$$
$$H_S^z(\Omega) = \frac{q_S - z}{q_0 z}$$

![Simulation diagram](image)
Simulation – Dynamics
Results – Seat transfer function

Seat: Mercedes Benz

STF seat cushion: excitation z - response z

STF backrest cushion: excitation z - response x

Simulation – Dynamics
Results – Seat transfer function

Seat: Mercedes Benz

STF seat cushion: excitation z - response z

STF backrest cushion: excitation z - response x
Conclusions

**CAE-analysis of occupied seat has following benefits:**
- Late & expensive design changes of vehicle & seat can be avoided
- New possibilities for seat optimization (weight...) can be explored
- Early detection of resonance / vibration problems
- Targeted preparation of testing (sensor placement, expected vibrations)
- ...

**Application of CASIMIR / Automotive has following benefits:**
- Easy integration in workflow through HyperMesh plugin
- Handling of numerical complex comfort simulation simplified
- Standardised procedure for comfort simulations
- Enables Comfort evaluation without hardware prototypes
- .......

Thank you for your attention!!!