Multi-Physics with MotionSolve

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Presentation Outline

• Need for Multi-Physics simulations

• Case Study: Control of a Wind Turbine

• How other customers are doing Multi-Physics simulations
Real Models Are Complex

Hydraulics & Control systems

Flexible & Non-linear components

Virtual tires & digitized roads

Virtual driver models
Industrial Processes Are Complex

TIRE & ROAD

MBD

FATIGUE

POST

DRIVER

FE
The Conundrum

Systems

Multiple Domains
Diverse Phenomena
Many Technologies

Software

Single Domain
Single Formulation
One Integrator
Introducing MotionSolve…

• A natural environment for multi-disciplinary studies
• Open architecture for coupling domains
• Many different choices available for coupling
Model Connection Methodologies

Master

System Equations

S-1  S-2  S-2

Sharing Equations

Sharing Linear Models

Simulator-1  Simulator-2

Shared Data

Co-Simulation (Sharing signals)

A → A → A → A

B → B → B → B

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Time
MotionSolve exchanges state matrices with Matlab/Simulink
MotionSolve shares data with a variety of FE codes.
Sharing Equations: via User Subroutines

User subroutines allow users to link their own equations to MS
Sharing Equations: via Code Export

Native RTW code import from Simulink
Sharing Signals: MotionSolve + Simulink

MotionSolve is an S-Function in Simulink
Sharing Signals: MotionSolve + DSHplus

System Model

User Block (MS )

Hydraulic System

MotionSolve is a user block in DSHplus
Sharing Signals: MotionSolve + Driver

System Model

Vehicle Model (MS)

Driver Model

Controls & Switching Signals
- Speed Controller
- Gearbox Controller
- Steering Controller

Feedback Signals

MotionSolve can include complex driver models via co-simulation
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“Grid loss” – Sudden drop in generator torque

**Reaction:** Immediate blade pitching and activation of the brake disk.

**E-stop event**

- **0-60s**  Ramp up to full effect, 1MW.
- **120.0s**  “Grid loss” 100-0% in 0.1s
- **120.4s**  Maximum brake pressure & reversing pitch angle
- **135.0s**  Pitching complete

Mechanical system, Wind loads – lift and drag forces v/s pitch angle, Tower shadow - %ge drop of wind forces in front of the tower
Initial Results

- Grid loss and braking generate massive rotor torque variations
- Large blade vibrations during overshoot
- Blades vibrate during initial braking, causing high frequency variations of rotor torque.
Control Requirements

• Implement a non-linear braking pressure to:
  • Reduce blade deflection
  • Eliminate overshoot

Brake controller: Blade deflection v/s Brake magnifier
Brake release: Rotational speed v/s release factor
Low pass filter to the braking signal – to avoid rapid vibrations
Control Model in Simulink

- Rotor Velocity
- Flex Sensors
- Controller

Control Parameter
Plant Outputs

MS Model

Flex Sensors
Plant Outputs
Rotor Velocity

Flex Sensors

Rotor Velocity

Blade Deflection
Co-Simulation Results

Brake controller: Blade deflection v/s Brake magnifier
Brake release: Rotational speed v/s release factor
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Faurecia – Glass guidance simulation

• **Challenge:**
  • Find the cable positions to meet requirements on normal forces for different combinations of friction.

• **Solution:**
  • Mechanism analysis with MotionSolve to find the normal forces
  • Design optimization with HyperStudy to find the optimal cable positions.

• **Benefits:**
  • An optimal design that meets all conflicting requirements.
  • A fast & automated design process leading to fewer errors & better designs.

“Co-simulation of window regulator with MotionSolve and Matlab/Simulink gives a full mechatronics model of the system, allowing simultaneous design of both mechanism and actuator” - Dany Desrus, Leader Product Line EE & Mechatronics, Faurecia Interior Systems
Summary

• Real systems are complex
• A full understanding of these requires multi-disciplinary simulation
• MotionSolve has an architecture that facilitates coupling of different solvers to enable multi-disciplinary simulation
• Many different options for coupling are available
• The simulation requirements and coupling difficulty dictate which choice should be used.

Thank You!