COUPLING OF STRUCTURAL AND MULTIBODY MECHANICS IN SWITCHGEAR DEVELOPMENT

Dr. Christian Simonidis*, Robert Schmoll,**
Prof. Dr. Bernhard Schweizer***

***ABB Corporate Research Germany, ** Universitaet Kassel,**
***** Technische Universitaet Darmstadt**

ABSTRACT

The competitive energy market requires innovative and reliable switchgear solutions with long life time at affordable cost. Switchgear in high-voltage and medium-voltage undergo relatively high mechanical loads through impacts with subsequent oscillations when making or breaking the power transmission. Arcing and fluid dynamic effects go along with the electrical contacting. Spring loaded drives or electromagnetic coil actuators provided the power for acceleration of the breaker mechanism.

Simulation of switchgear involves multiphysics modeling and co-simulation is an adequate method to couple different physical domains in a transient way as well as to share models or parts of models between experts.

Multibody simulation is the state-of-the-art technique to predict the kinematic and dynamic behavior of switchgear mechanism. Coupling to structural finite element tools extends its application range not only to stress analysis with dynamic mechanism loads. It can further introduce temperature and hysteresis dependent hyperelastic and plastic material behavior feedback in multibody models and allows for material wave driven impact models.

In this article we present a co-simulation approach for coupled MBS-Structural models and we demonstrate its application on a simulation of a drop tower with hyperelastic and plastic samples. Further we show its application on a medium-voltage electromagnetic driven recloser where the MBS-structural co-simulation can be extended with an electromagnetics model [SSS13].

To create and simulate the MBS- and the structural FE subsystem commercial software tools are used. These tools restrict the co-simulation interface to explicit coupling schemes. In contrary to implicit (iterative) coupling algorithms, explicit coupling schemes have no need to repeat macro (communication) time steps [BS10]. In our work we have implemented the parallel Jacobi scheme [BS10, Bus12]. The extrapolation for the Jacobi scheme is done by Lagrange polynomials with fixed but user-defined degree [Arn09, BS11, Bus12]. In order to realize a zero-stable coupling, algebraic loops between the subsystems must be avoided [KS00]. In the case of algebraic loops a

constraint coupling is created, which have to fulfil a contractivity condition to be numerical stable [AG01, Arn10]. For this reason we use a zero-stable force-displacement coupling [BS10, Fri11]. That means, the MBS subsystem gets forces as inputs and provides displacements and velocities as outputs. The structural FE subsystem obtains displacements and velocities as inputs and calculates the coupling forces and torques as outputs.

LITERATURE

[AG01] M. Arnold and M. Günter. Preconditioned dynamic iteration for coupled differential-algebraic systems. BIT Numerical Mathematics, 41:1-25, 2001.

[Arn09] M. Arnold. Numerical methods for simulation in applied dynamics. In M. Arnold and W. Schiehlen, editors, Simulation Techniques for Applied Dynamics, volume 507 of CISM Courses and Lectures, pages 191 – 246. Springer, 2009.

[Arn10] M. Arnold. Stability of sequential modular time integration methods for coupled multibody system models. Journal of Computational and Nonlinear Dynamics, 5, 2010.

[BS10] M. Busch and B. Schweizer. "Numerical Stability and Accuracy of Different Co-Simulation Techniques: Analytical Investigations Based on a 2-DOF Test Model". In "The 1st Joint International Conference on Multibody System Dynamics", Lappeenranta, Finland, May 2010.

[BS11] M. Busch and B. Schweizer. "Stability of Co-Simulation Methods Using Hermite and Lagrange Approximation Techniques". In “ECCOMAS Thematic Conference - Multibody Dynamics 2011”, Brussels, Belgium, July 2011.

[Bus12] M. Busch. Zur effizienten Kopplung von Simulationsprogrammen. PhD thesis, Universität Kassel, 2012.

[Fri11] M. Friedrich. Parallel Co-Simulation for Mechatronic Systems. PhD thesis, Technische Universität München, 2011.

[KS00] R. Kübler and W. Schiehlen. Two methods of simulator coupling. Mathematical and Computer Modelling of Dynamical Systems, 6(2):93–113, 2000.

[SSS13] Robert Schmoll, Bernhard Schweizer, Christian Simonidis, Octavian Craciun, and Veronica Biagini. Solver coupling between multibody and electro-magnetic systems. In ECCOMAS Thematic Conference - Multibody Dynamics 2013, Zagreb, Croatia, July 2013.