Control of Real Distributed Parameter Systems Modeled By COMSOL Multiphysics® Software

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Abstract

Many technical and non-technical systems and processes in the practice have the dynamics, which depends on both position and time. Such systems are classified as distributed parameter systems (DPS). The time-space coupled nature of the DPS can be mathematically described by partial differential equations (PDE) with boundary and initial conditions. For the last period we have witnessed a big boom using methods for numerical modeling of a wide variety such systems in the software environment COMSOL Multiphysics®. Resulting models obtained through finite element method (FEM) solution of PDE give possibilities not only for analyzing the dynamics, but also for optimization and control of these systems as DPS.

Paper started out with base concept of the engineering theory of distributed parameter systems, where controlled systems are interpreted as lumped input and distributed parameter output systems. Based on numerical models distributed parameter step responses are generated for step changes of manipulatable - control quantities. General decomposition of the controlled system dynamics is performed into the space and time components. Next, also the control synthesis is decomposed to the space and time tasks. In space direction approximation problems and in time direction lumped parameter control synthesis problems are solved for each control quantities. For non-linear controlled systems the control takes place in the linearized surrounding of the given steady-state operation mode. Transitions between steady-states operation modes are realized using segmentation of nonlinear controlled system dynamics by means of co-simulation joining the COMSOL Multiphysics® and MATLAB® & Simulink® software environment. At the end of the methodological part, systems of control are arranged using blocks of the software product Distributed Parameter Systems Blockset for MATLAB® & Simulink® third-party software product of The MathWorks Company (DPS Blockset for MATLAB® & Simulink®).

Methodical approach of FEM based modeling of real DPS in the software environment COMSOL Multiphysics® with generation of necessary distributed parameter dynamic characteristics and design of feedback control in the software environment DPS Blockset for MATLAB® & Simulink® is demonstrated on some results. Base conception of modeling and control of temperature fields in casting mold is depicted on (Figure 1) and similar approach for extruder body represents (Figure 2).

COMSOL Multiphysics® is a powerful interactive software environment for modeling and

dynamical analysis all kinds of scientific and engineering problems based on PDE. In this way COMSOL Multiphysics® opens new possibilities for control of distributed parameter systems described by numerical structures along with Distributed Parameter Systems Blockset for MATLAB® & Simulink® in practice.

Reference

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Figures used in the abstract
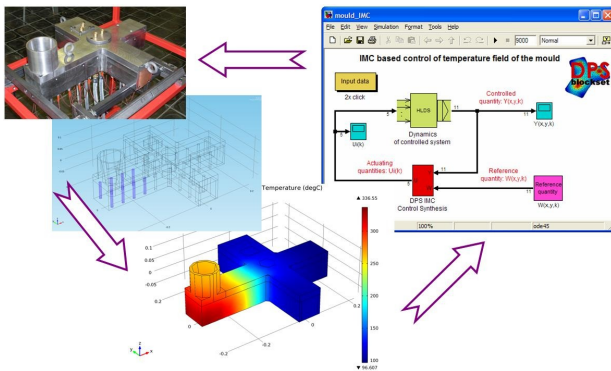
Figure 1: FEM based modeling of temperature fields of the casting mould in COMSOL Multiphysics and design of control synthesis in MATLAB & Simulink/DPS Blockset software environment.
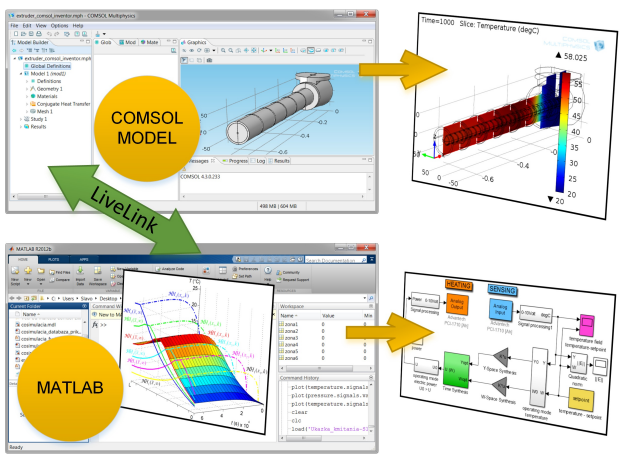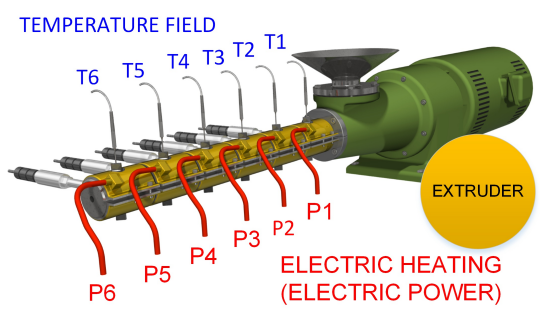
Figure 2: Modeling and control of temperature field of the extruder body by means of cosimulation joining COMSOL Multiphysics and MATLAB & Simulink software environment.