Custom Controller Embedded into Magnetic Levitation Model via external MATLAB file

A.K.Piłat, K.Słowik
AGH - University of Science and Technology, Department of Automatic Control and Robotics, Krakow, Poland

INTRODUCTION: Modern devices should be designed in a parallel way with an interdisciplinary analysis feature. The development of such complex model will enable effective and optimal designing of all components together with a control strategy. For example the electromagnetic device for an active magnetic levitation system can be prototyped with a proposed scheme (Fig. 1) [1]. The key point is to obtain a complete functionality of the model, perform a number of testing scenarios and optimizations prior to prototyping real device.

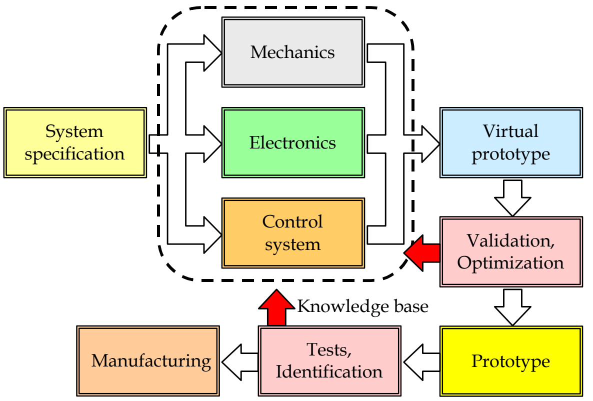

Figure 1. Proposed methodology for modern devices development [1]

COMPUTATIONAL METHODS: In COMSOL version 3 there was a possibility to embed the developed model into MATLAB/Simulink for the further studies and analysis. An example of Interdisciplinary models of Active Magnetic Levitation and Active Magnetic Bearing is presented in Fig. 2.

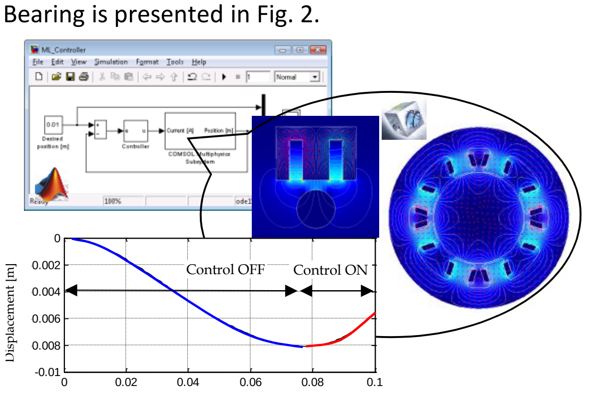

Figure 2. Interdisciplinary modelling in COMSOL 3.3 [1]

Nowadays, there is a possibility to use MATLAB code (in our case controller formula) embedded into COMSOL models. To obtain a well designed controller using typical control theory or an intelligent one (e.g. based on Fuzzy Logic) it is proposed to proceed with the following steps:

Step 1: Development of an interdisciplinary model (including geometry, materials, physics, dynamical equations (ODE)), in some cases with controller; Step 2: Run number of simulations starting at different initial conditions; Step 3: Export simulation data to MATLAB; Step 4: Develop the nonlinear dynamical model in a form of differential equations with custom functions obtained at identification stage on the basis of simulated model; Step 5: Design the controller; Step 6: Realize testing and quality checking; Step 7: Export controller form to m-file; Step 8: Embed the controller into COMSOL model using MATLAB functions node (LiveLink for MATLAB license is required).

RESULTS: We have a complete interdisciplinary model [2], now in COMSOL 5.5a with embedded controller. Time domain simulations can be realized under control in many scenarios. The analysis of physical quantities gives a deep study of control actions. Fig. 3 shows the dynamical response of the system and computed electromagnetic force. Fig. 4 presents the Magnetic flux density in a mesh mode during the stabilization stage of the magnetically suspended sphere in an axi-symmetry mode.

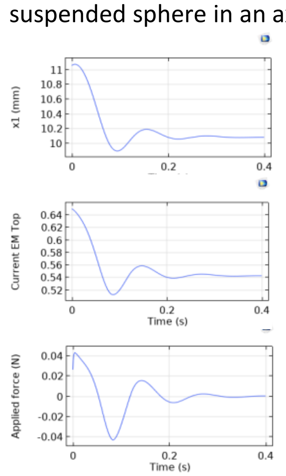

Figure 3. Position, control and applied Force

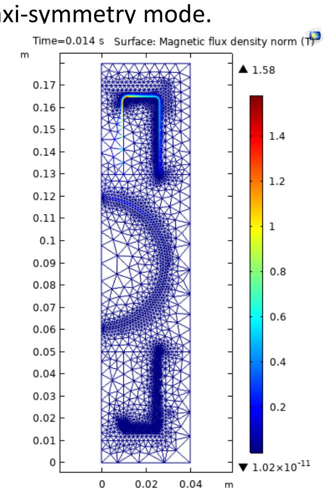

Figure 4. Magnetic flux distribution

CONCLUSIONS: A complete tool chain and a new method of developing the control strategy on the basis of COMSOL model was obtained. The designed controller embedded into model via external MATLAB code allowed to stabilize the sphere. Therefore, fully virtual prototype was achieved.

REFERENCES:

1. A. Piłat, Active Magnetic Suspension and Bearing, IntechOpen, 2008, doi: 10.5772/5971
2. A. Piłat, "Modelling, investigation, simulation, and PID current control of Active Magnetic Levitation FEM model," 2013 18th International Conference on Methods & Models in Automation & Robotics (MMAR), Międzyzdroje, 2013, pp. 299-304, doi: 10.1109/MMAR.2013.6669923.