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Model Based Design of Fuel Pump Control

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Abstract: This paper presents a co-simulation method to design of speed controller for turbojet fuel pump. Expected fuel pump is used for small turbine engine concept with reducer driven by free turbine. The amount of injected fuel into the combustion chamber is based on the speed of the fuel pump which is controlled by the engine control unit. The final flow of fuel into the combustion chamber is restricted by fuel bypass which constricts the return fuel according to pressure in the nozzles. This back fuel bypass has nonlinear and fixed characteristic determined by its structure. The only way how to control the amount of incoming fuel to the engine is the pump speed control. Effect of the bypass represents a variable component in the fuel pump load and from the view of the speed controller it is a disturbance variable. This paper describes the co-simulation model based on the use of MATLAB/Simulink and MSC Adams environment. This simulation uses interconnection of Simulink controller design and simplified model of the fuel pump dynamics in Adams (without hydraulic modeling).

Introduction

The fuel - oil pump supplies the fuel to combustion chamber and also the oil for motor lubricating. The pump is driven by a couple of three-phase motor with permanent magnets supplied from the engine control unit. The fuel - oil pump consists of three main segments – the oil pump, the high pressure and the low pressure fuel parts. Block diagram of mentioned pump is shown in Fig. 1. The fuel pump is equipped with a pair of electronically commutated motors (EC, BLDC) located on a common shaft. It represents full mechatronic system [1, 2].

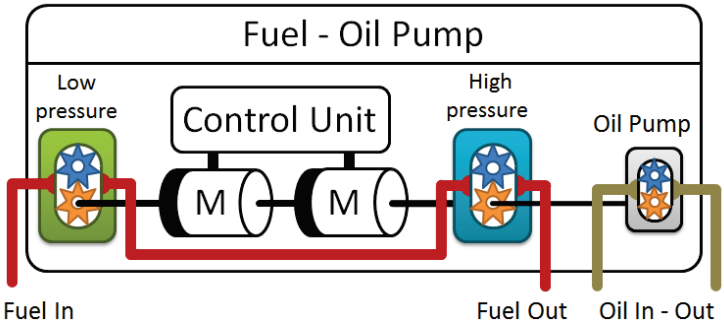

Fig. 1: Block diagram of the motor fuel – oil pump

Creating of co-simulation model

According to the model-based design methodology [3] the simulation model was developed. Proposed control design is based on co-simulation model which connects controller design in MATLAB/Simulink environment with simplified model of the fuel pump dynamics in Adams, Fig. 2. According to [4, 5], EC motor model can be approximated by a DC motor model with a corrected design parameters (constructional constants of the motor). The presented design is based on a simulation model of a pair of BLDC motors mounted on a common shaft with oil and fuel pump in MSC Adams environment. BLDC motors have been approximated by modified DC motors

models. Commutation of BLDC motors is handled by lower layer control system. In simulation scheme, there are also power components and sensors which were approximated by models of the first order dynamic systems. There was implemented discrete speed controller with subordinate current/torque controllers for each motor with the ability to switch between them according to prescribed distribution of performance.

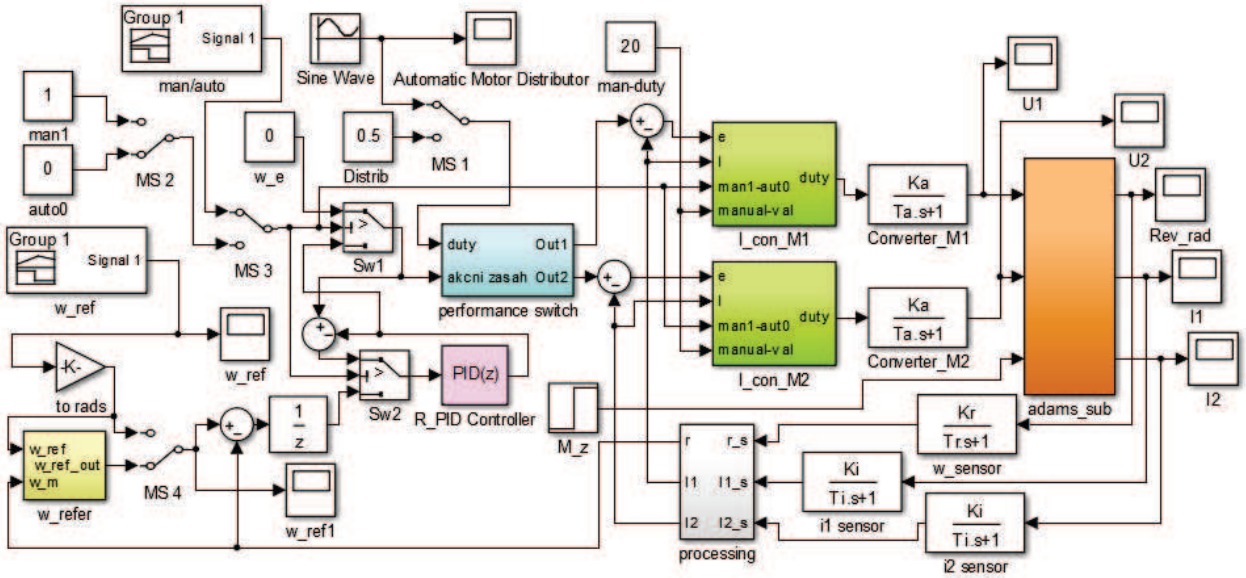

Fig. 2: Simulation model of the co-simulation control structure

Summary

Simulation results verify the functionality of the proposed control design. The proposed scheme can be used as the upper layer for the layer providing of measuring process, generating control signals and providing self-commutation of motors.

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