A Solenoid Valve Multi-physics Model for Railway Braking System Diagnosis: Development and Validation

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ABSTRACT

Solenoid valves are an electromagnetically-operated valve that can be used to control the movement of air in railway braking systems. To develop a physics-based diagnostic model for fault detection, it is critical to build a valid model that describes the behavior of solenoid valves accurately. This study presents an experimentally-validated multiphysics analytical model to predict solenoid valve behaviors. The activation of solenoid valves is associated with multi-physics mechanisms that are coupled together. Electromagnetic, fluidic, and mechanical mechanisms are modeled with ordinary differential equations. The results from the multi-physics analytical models are validated with those from the experiments. The undefined parameters of the model are statistically calibrated. The proposed model can be promising for solenoid valve diagnostics in two aspects. First, the computational cost of the analytical model is extremely low in comparison with that of a commercial finite element method (FEM). Second, the model provides an insight regarding explicit relationship between the inputs and outputs of solenoid valves.