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Research on Adhesion Control Method of High-speed Train Based on Model Predictive Control

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Abstract

Adhesion control is an essential prerequisite for ensuring the safe operation of high-speed trains. High-speed trains operate at high speed with low adhesion utilization and frequent slipping may lead to serious accidents. To address these issues, this paper took high-speed train CRH2 as the research object and designed an adhesion controller based on model predictive control to realize the tracking of train slip velocity to the optimal slip velocity, so that the train can operate stably near the peak adhesion point on both dry and wet rail surfaces, and the adhesion utilization rate is 99.2% and 98.6%, respectively. It is much higher than that of the conventional combination correction method. A simulation platform based on the realtime simulator PXIe-1082 and the simulation software StarSim was built, and the results verified the effectiveness of this method.

Simulation setup

The high-speed train CRH2 is set to run on a straight track with a simulation time of 85 s and an initial train speed of 0. To verify the effectiveness of adhesion control based on model predictive control, different track conditions (Table 3) are set as follows: track surface 1 (65-70s), track surface 2 (70-75s), and track surface 1 (75-80s).

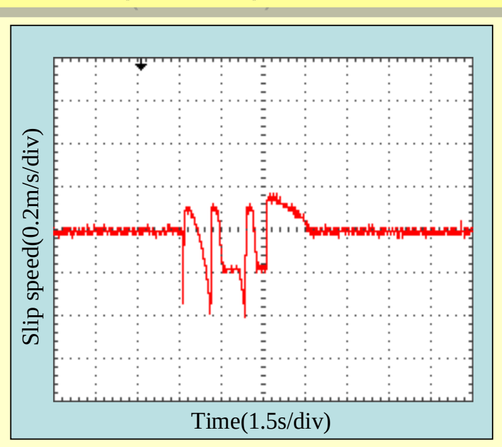

Fig.2 Slip velocity based on traditional method

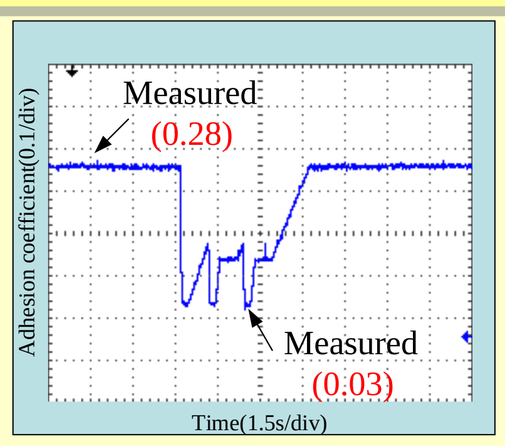

Fig.3 Adhesion coefficient based on traditional method

StarSim platform

Adhesion control is an essential prerequisite for ensuring the safe operation of high-speed trains. High-speed trains operate The simulation platform built in this paper was shown in Fig. 1, which consists of a real-time simulator PXIe-1082, an IO expansion board, a PC and an oscilloscope and its power supply. The IO expansion board is the link for signal transmission between different devices. It provides four types of interfaces for signals, including analog input (AI), analog output (AO), digital input (DI) and digital output (DO).

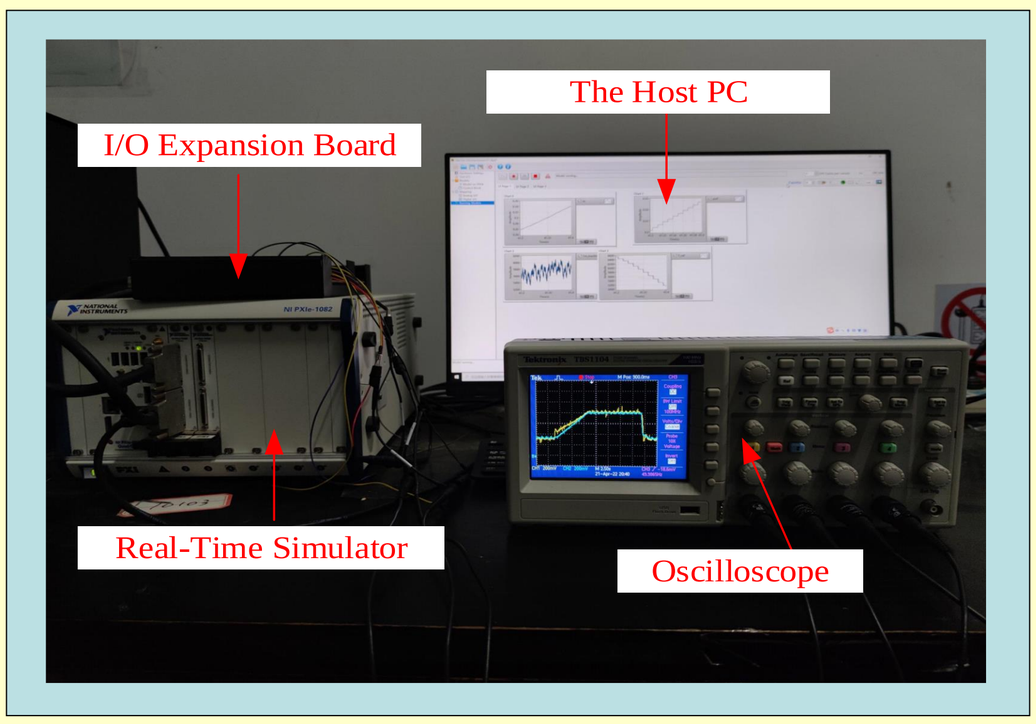

Fig.1 Real-time simulation by starsim platform

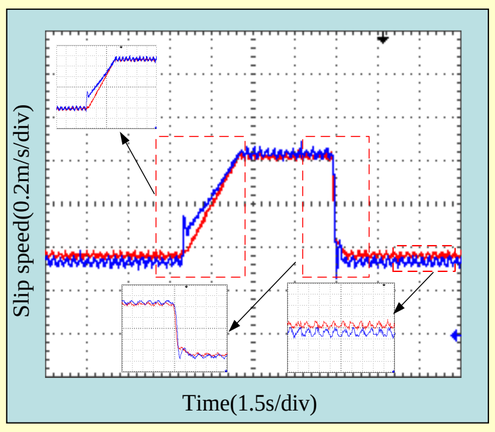

Fig.4 Comparison of actual slip velocity and desired slip velocity

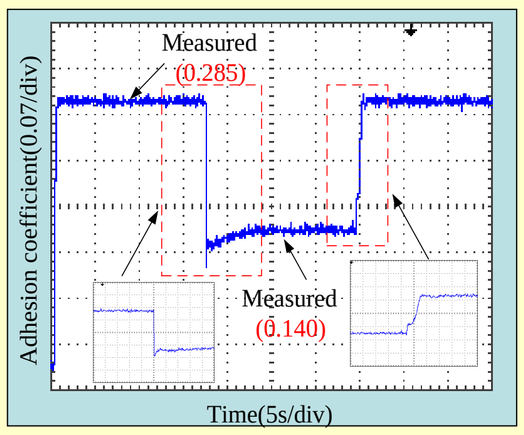

Fig.5 Adhesion coefficient based on MPC algorithm

Summary

In this paper, a model predictive control algorithm for adhesion control of high-speed train CRH2 was constructed, a simulation platform based on real-time simulator PXIe-1082 and simulation software StarSim was established. When CRH2 high-speed train operating conditions were switched, the train can be stabilized near the optimal slip velocity of the current rail surface, and the adhesion utilization rate of the train was about 99.2%/98.6% at dry/wet rail surface condition. The adhesion utilization rate of the actual train adhesion control method was about 91.5%/63.4% at dry/wet rail surface condition, which verified that the proposed adhesion control method based on model predictive control algorithm can almost achieve the optimal adhesion utilization, and the effectiveness of the proposed method were verified.