Research on the impact of improved coupler structure on the dynamic performance of 20,000-ton heavy-haul train

Xianhong Meng [1], Lan li [1], Fengwei Kang [2], Binjie Xu [3], Kaiyun Wang [3]

[1] CHN ENERGY SHUOHUANG RAILWAY DEVELOPMENT COMPANY LTD, Suning 062350, China

[2] CHN ENERGY INVESTMENT GROUP COMPANY LTD, Beijing 10001, China

[3] State Key Laboratory of Rail Transit Vehicle System, Southwest Jiaotong University, Chengdu 610031, China

Corresponding author email: Kaiyun Wang, e-mail: kywang@swjtu.edu.cn

Abstract: Aiming at preventing coupler jack-knifing in slave control locomotives of 20,000-ton heavy-haul trains, a theoretical and simulation study on enhancing the coupler stability has been conducted. The force characteristics of the slave control locomotives under braking conditions are determined through field testing. The dynamic model considering the locomotives, adjacent wagons, and attached coupling devices is established and validated. The cause of coupler jack-knifing is discussed by using this model, and a method is proposed to improve the stability of the coupler by improving the coupler structure and transforming the front follower structure. Simulation results show that this method can control the maximum free yaw angle of the coupler at 4° when the slave control locomotive undergoes longitudinal impulse. Keep the train derailment coefficient, rate of wheel load reduction, and wheelset lateral force lower than safety limits. These research findings provide an important theoretical basis for improving the stability of couplers in China's heavy-haul trains, which is expected to reduce coupler jack-knifing and improve train operation safety.

Keywords: 20,000-ton heavy-haul train, coupler jack-knifing, coupler with friction arc surface, longitudinal impulse, operational safety

Longitudinal Dynamics of Heavy-Haul Trains: Impact of Traction Rod Arrangements on Cyclic Braking Conditions

Yunxin Fan[1,2], Jixiong Jiang[1,2], Xinping Peng[1,2], Yuxiang Cai[1,2], Bo Zhang[1,2], Xuancheng Yuan[1,2], Guoyun Liu[1,2]

[1] The State Key Labboratory of Heavy-duty and Express High-power Electric Locomotive, Zhuzhou, China.
[2] CRRC Zhuzhou Locomotive Co., Ltd., Zhuzhou, China.

Abstract

With the escalating global demand for transportation, heavy-haul trains have emerged as a pivotal means to enhance transportation efficiency and economic viability. However, these trains face longitudinal dynamic challenges during operation, posing threats to their stability and safety. As a critical component, the arrangement of traction rods significantly impacts the longitudinal dynamic characteristics of heavy-haul trains. This study aims to investigate the effects of internal and external traction rod arrangements on the longitudinal dynamics of heavy-haul trains under cyclic braking conditions.

Utilizing numerical simulation methods, this research comparatively analysed the influence of internal and external traction rod arrangements on the coupler force, coupler lateral deflection angle, and coupler vertical displacement of heavy-haul trains during cyclic braking. Simulations across various braking scenarios revealed similar longitudinal dynamic performances for both arrangements. This finding holds significant implications for guiding the design and optimization of traction rods in heavy-haul trains, offering increased choices and flexibility for manufacturers and operators.

This study not only provides a thorough theoretical analysis of the longitudinal dynamic behaviour of heavy-haul trains but also lays a solid foundation for future research and practical applications. By continuously optimizing traction rod arrangements, we can further enhance the safety and operational efficiency of heavy-haul trains, contributing to the sustainable development of the global railway transportation industry.

Keywords: Heavy-haul trains, Longitudinal dynamics, Traction rod arrangements, Numerical simulation, Cyclic braking conditions.

Influence of Coupler System Degradation on Longitudinal Dynamics and Running Safety of Rakes

Atul Anand[1] and N. S. Vyas[2]
[1] Department of Mechanical Engineering, Indian Institute of Technology Kanpur, India, atulm21@iitk.ac.in
[2] Department of Mechanical Engineering, Indian Institute of Technology Kanpur, India, vyas@iitk.ac.in

Introduction

Indian Railways employ the Centre Buffer Coupling (CBC) mechanism for connecting two coaches in their passenger trains. The Association of American Railroads (AAR) type "H" couplers are used in the passenger trains of Indian Railways, which earlier was the conventional screw coupler system with side buffers. This coupler system is equipped with polymer based balanced draft gear. The polymer pads used in the draft gear can experience significant variation in their dynamic characteristics under real operational conditions, such as temperature change, cyclic loading, etc. Therefore, there is a need to characterize the possible variations in in-train forces to assess operational safety and to devise the maintenance requirements. The temperatures in India may range from low (≈ -5^{o}C) to high (≈ +50^{o}C). In this context, the changes in dynamic characteristics of draft gear with temperature and material degradation over time are considered in this work.

A mathematical model describing the longitudinal dynamics of a train consisting of one locomotive and twenty coaches has been developed using the MATLAB/SIMULINK platform. The model is first validated against a benchmark model and then extended to an Indian passenger train. This study utilizes the experimental characteristics of the balanced draft gear employed in Indian passenger trains. The draft gear characteristics with temperature variation and degradation have been manually designed, considering the variation trend in the literature. While the results may not provide the actual quantitative assessment, they give a good qualitative description of the considered scenarios. The methodology developed in this work can be extended using the basic variations in dynamic characteristics of draft gear obtained from experiments.

Further, this study aims to propose running speed limits by considering environmental temperature and permissible degradation limits of polymer pads. Such a study will help to standardize the operational and maintenance practices for the passenger trains equipped with polymer-based draft gears.

References

1. Gozdur, R.; Gębara, P.; Chwastek, K. A Study of Temperature-Dependent Hysteresis Curves for a Magnetocaloric Composite Based on La (Fe, Mn, Si)13-H Type Alloys. Energies 2020, 13, 1491. https://doi.org/10.3390/en13061491