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DESIGN, DEVELOPMENT, AND CALIBRATION OF A FORCE-MOMENT MEASUREMENT SYSTEM FOR WHEEL-RAIL CONTACT MECHANICS IN ROLLER RIGS

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Abstract

A force measurement system, referred to as "dynamometer", for accurately acquiring the contact forces and moment in a single-wheel roller rig using piezo-electric load cells is designed and developed. Accurate determination of the wheel-rail contact forces and moments is an essential requirement for studying the wheel-rail contact mechanics. The dynamometer is placed in the load-path between the wheel-rail interface and the ground, enabling it to measure the forces and moments at the interface. A series of tests are performed to determine the quasi-static and dynamic characteristics of the dynamometer. Additionally, finite element analysis and multi-body dynamic modeling are used to establish flexural modes and dynamic interface between the components. The simulation and test results indicate that the dynamometer is able to accurately and reliably measure the contact forces and moments at the wheel-rail interface.

Keywords: multi-component, dynamometer, roller rig, wheel-rail contact mechanics

Introduction

Assessment of contact forces between wheel and rail plays an important role in the behavior of rail cars. Full understanding of the physics behind the contact phenomenon provides a fundamental foundation for the vehicle performance study, both in terms of modeling the train dynamics and in terms of reducing operational costs in the long-term [1].

The steel on steel interface between wheel and rail is one of the most complex aspects of railroading. Although there is a broad, high-level understanding of what happens at the wheel-rail interface, much of the science behind why it happens is lacking. Additionally, much of the science and knowledge available are for "perfect" conditions in which a series of simplifications and assumptions are made for the ease of establishing the mathematical models. In practice however, such simplifications do not exist. It is vitally important to provide the means for testing, analyzing, and establishing models under realistic conditions. Since further contact mechanics studies are still highly desirable for railroad industry, the railway technologies laboratory (RTL) at Virginia Tech has developed a state of the art testing facility that is primarily designed for studying the wheel/rail interaction for railway vehicles [2].

Accurate determination of the wheel-rail contact forces and moments is an essential requirement for studying the current wheel-rail contact models or developing new rolling contact models. A large number of studies have investigated measurement of wheel-rail contact models [3]. Some have used experimental setups such as tribometers [4, 5] or roller rigs [6, 7] and some have conducted field tests [8, 9]. Roller rigs have proved to be useful for the study of various aspects of railway vehicle systems. In contrast to field-testing, roller rigs offer a controlled laboratory environment for studying the mechanics and dynamics of railway systems for a variety of operating conditions [3]. In order to study the contact mechanics at the wheel-rail/roller interface, the roller rig must be equipped with a force measurement system to accurately acquire the contact forces and moments.

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