International Journal of Automotive Technology (2024) 25:413–425
https://doi.org/10.1007/s12239-024-00034-6

CONNECTED AUTOMATED VEHICLES AND ITS, ELECTRIC, FUEL CELL, AND HYBRID VEHICLE, VEHICLE DYNAMICS AND CONTROL

Development of Indoor Wear Test Method for Passenger Car Tires Reflecting Road Driving Conditions

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Received: 5 October 2023 / Revised: 7 November 2023 / Accepted: 13 November 2023 / Published online: 16 February 2024

Abstract
This study presents a method for developing a tire indoor wear test mode that reflects road driving conditions using a Flat-trac. Using a machine learning model, the slip angle, slip ratio, longitudinal force, and lateral force change according to vehicle speed and acceleration changes are estimated. Reduced data representing the estimated data are calculated using a peak–valley (PV) algorithm. Through the blocking process, representative test modes for driving and braking, right turning and left turning are derived and converted into a test mode for application to the Flat-trac. The evolution of tire tread wear is observed through 120 repeated tests, and the applicability of the test mode developed in this study is discussed.

Keywords Tire test mode · Flat-trac · Machine learning · Peak–valley algorithm · Wear

1 Introduction

The most common dynamic tests conducted indoors for automobile tires include the drum-type tester-based endurance test, rolling resistance test, wear test, and Flat-trac-based performance test. In endurance and rolling resistance tests, a tire is put into contact with a steel drum with a diameter of 1.7 and 2.0 m, respectively (UN/ECE, 2008; ISO, 2018). Then predefined loads and speeds are applied to it. Since the contact patch area on a drum is smaller than that on actual roads, loads are greatly concentrated, which means that the test is conducted in much more extreme conditions than the actual driving conditions.

In an indoor wear test for passenger car tires, a large steel drum is used to solve the problem of the tread contact area being smaller than that on actual roads. Knisley (2002) found that the average indoor wear rate measured using a 3.0-m drum-type tester has a linear relationship with weighted shear energy intensity measured using a footprint pressure/motion machine. Stalnaker and Turner (2002) developed a method for conducting full vehicle-tire simulations with indoor tire wear testing using a 30-m drum-type tester. Although the tread loss profiles of indoor and outdoor tests are similar, the same level of wear has been generated indoors in 45% of the mileage required outdoors (Stalnaker et al., 1996). Gültlinger et al. (2014) used a 3.8-m inner drum test rig for a tire wear test. Thus, in order for the drum-type tester to accurately reflect a real road driving situation and to calculate the amount of wear similar to the real one, additional research was needed.

In this study, we used a Flat-trac-based performance test to measure the tire force and moment and to understand the relationship between three axis forces and moments that vary depending on the slip angle/ratio and the camber angle. Since a tire used in the Flat-trac can best represent the same contact area as that of the actual roads, the Flat-trac can be used to reproduce wear phenomenon of the tire. However, the Flat-trac must be optimized to evaluate the tire characteristics in a short period of time; otherwise, the Flat-trac can get damaged if it is used for long-time measurement. As a result, it is currently not used for tire wear tests. Thus, when developing a wear test method for use with the Flat-trac, it is necessary to reduce the test time, make the test a combination of several cycles, and take a break between the combinations to ensure that the temperature of the oil and

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