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Improving Tire Models via Optimized Tire Testing

— Enhancing Tire Model Accuracy Via Wheel Speed Control Method on Indoor Test System —

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This paper investigates the influence of indoor tire test methodology on the repeatability and accuracy of braking friction measurements used for tire modeling. Three braking control strategies—wheel torque, wheel speed, and slip ratio control—were evaluated using an indoor flat belt tire test system across multiple load conditions. Results demonstrate that wheel torque control provides superior repeatability, reduced energy input, and more consistent peak friction values. Thermal and energy analyses further show that excessive energy input alters tire friction behavior, highlighting the importance of optimized test methodology when generating data for tire models used in vehicle braking simulations.

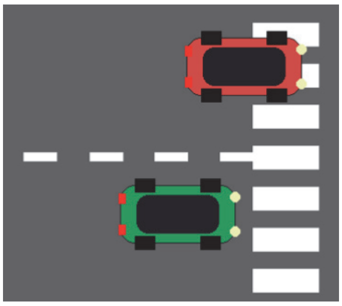

Fig.1: Stopping Distance Differences

1. Introduction

Stopping distance is directly governed by the tire–road friction coefficient (μ). Small variations in μ can lead to measurable differences in braking performance, see Fig 1, making repeatable friction measurement essential. Indoor tire test systems provide a controlled environment to evaluate braking behavior, but the applied control strategy can significantly influence measured results.

2. Test Methodology

Braking tests were conducted on an indoor flat belt tire test system at three vertical load levels (2, 4, and 6 kN), with four repeated events per load. Wheel torque, wheel speed, and slip ratio control methods were evaluated under identical warm-up and sampling conditions. Peak μ was determined from FX/FZ using polynomial curve fitting, with the peak identified where the derivative of the curve-fittd μ equation with respect to slip ratio equaled zero as in Fig 2.

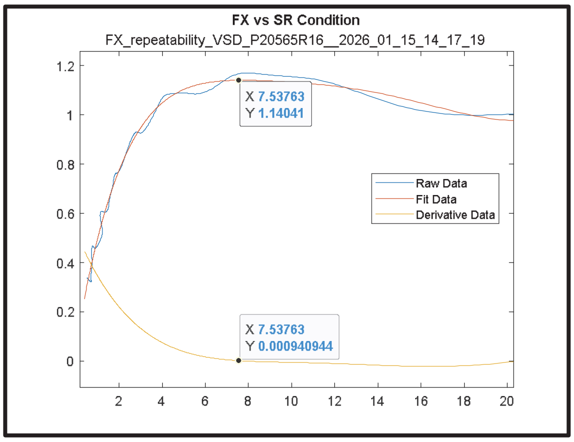

Fig.2: FX vs SR and Peak μ

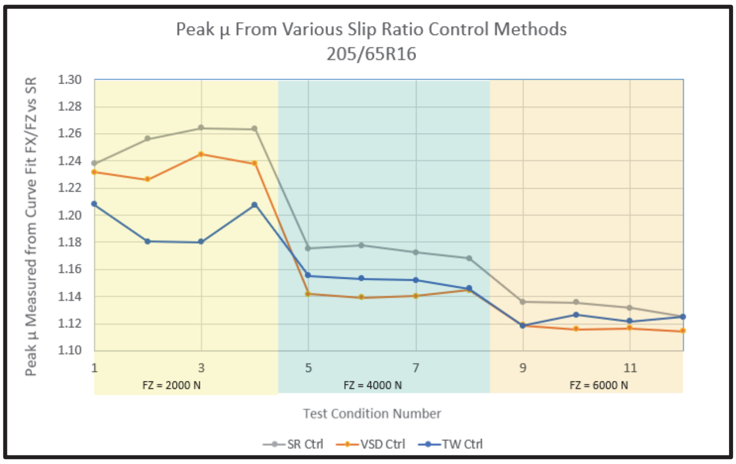

Fig.3: Peak μ by Condition and Control Method

3. Results and Discussion

Wheel torque control demonstrated the lowest overall standard deviation of peak μ (0.03), compared to wheel speed and slip ratio control (both 0.05) as shown in Figure 3. Slip ratio at peak μ was also most consistent for torque control with overall standard deviation across all test conditions less than 1%. Thermal measurements and force–time integration showed that slip ratio control introduced more energy into the tire, resulting in higher tread temperatures and different peak μ. A strong correlation between energy input and friction confirmed that μ is energy dependent.

4. Conclusions

Optimizing indoor tire test methodology is critical for generating high-quality data for tire models. These findings indicate that tire models should account for energy and thermal effects, particularly when translating indoor test data to full-vehicle braking performance predictions.