



Design and testing of an innovative measurement device for tyre–road contact forces

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ABSTRACT

The measurement of tyre–road contact forces is the first step towards the development of new control systems for improving vehicle safety and performances. Tyre–road contact forces measurement systems are very expensive and significantly modify the unsprung masses of the vehicle as well as the rotational inertia of the tyres. Thus, vehicle dynamics results are significantly affected. As a consequence, the measured contact forces do not correspond to the contact forces under real working conditions. A new low-cost tyre–road contact forces measurement system is proposed in this paper that can be applied to passenger cars. Its working principle is based on the measurement of three deformations of the wheel rim through strain gauges. The tyre–rim assembly is thus turned into a sensor for tyre–road contact forces. The influence of the strain gauges position onto the measurement results has been assessed through finite element simulations and experimental tests. It has been proven that, for a large variety of rims, the strain gauge position that leads to high signal-to-noise ratios is almost the same. A dynamic calibration procedure has been developed in order to allow the reconstruction of contact force and torque components once per wheel turn. The capability of the developed device to correctly estimate tyre–road contact forces has been assessed, in a first stage, through indoor laboratory experimental test on an MTS Flat-Trac[®] testing machine. Results show that the implemented measuring system allows to reconstruct contact forces once per wheel turn with a precision that is comparable to that of existing high-cost measurement systems. Subsequently, outdoor tests with a vehicle having all four wheels equipped with the developed measuring device have also been performed. Reliability of the measurements provided by the developed sensor has been assessed by comparing the global measured longitudinal/lateral forces and the product of the measured longitudinal/lateral accelerations times the vehicle mass. A good agreement has been found during all the performed manoeuvres.

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1. Introduction

The measurement of tyre–road contact forces is the first step towards both the redesign of existing control systems (ABS, ESP, TCS, etc.) and the development of new active controllers for improving vehicle safety and performances.

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