Accepted Manuscript

Magnetism of automotive wheels with pneumatic radial tires

S. Brol, A. Szgda

PII: S0263-2241(18)30415-9
DOI: https://doi.org/10.1016/j.measurement.2018.05.034
Reference: MEASUR 5535

To appear in: *Measurement*

Received Date: 3 June 2017
Revised Date: 11 April 2018
Accepted Date: 8 May 2018

Please cite this article as: S. Brol, A. Szgda, Magnetism of automotive wheels with pneumatic radial tires, *Measurement* (2018), doi: https://doi.org/10.1016/j.measurement.2018.05.034

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Magnetism of automotive wheels with pneumatic radial tires

Brol S. [a⇑], Szgda A. [a]

[a] Department of Vehicles , Faculty of Mechanical Engineering ,Opole University of Technology, Poland

article info

Article history:
Received 19 December 2016
Received in revised form 17 May 2017
Accepted 12 June 2017 Available online 15 June 2017

Keywords:
Automotive tire
Magnetic flux density
Profile
Scan
Parameters

abstract

This paper shows enhancement of knowledge about magnetic flux density of automotive wheels with radial pneumatic tires equipped with ferromagnetic belt made of tangled steel wires. The investigations were focused on the measurement of magnetic flux density vector (**B**) over tire's tread using sensor ability to measure 3 Cartesian projections of **B**. The other aim of the article is to introduce the prototype of a measuring device as well as measurement technique the purpose of which is to obtain a single or a collection of so called magnetic profiles. Circumferential and crosswise to the tread magnetic profiles and scans over tread surface were presented and analyzed. Moreover, magnetic profile's parameters were proposed in order to quantitatively characterize magnetic flux density changes in circumferential profiles. Usefulness of them was analyzed and discussed in the context of the measurement technique and the practical utilization. The results revealed that the magnetic flux density is not uniform over tire's tread surface and the "magnetic surface" is not anisotropic but highly directional. What is more, there are preferred sensor's locations and measurement directions. The Authors also pointed out some potential application of gained knowledge in domain of vehicle state measurement such as speed, distance and wheel slip.

1. Introduction

The pneumatic tire is a sophisticated product of human mind and ingenuity. It combines many contradictory requirements such as stiffness, damping, low rolling resistance and high traction. Therefore, it is made of many coexisting sub-designs joined in the vulcanization process. One of the most important designs are a belt made of tangled steel wires and a bead, which assure required stiffness and the puncture resistance [1,2,15,17,19].

Especially the belt, as an element made of the over-eutectic (ferromagnetic) steel shows some permanent magnetic properties [2,6,14,18,21].

Only a limited number of formal literature positions concerning the magnetic field of automotive wheel can be found. Little more on this subject can be found in the patent documentation [4,10,11] and government funded reports [6], which focus mostly on the exposure on electro-magnetic fields (EMF) and its influence on human's health rather than on the nature of magnetic phenomena itself. These sources prove that the automotive specialist community is aware of the tire magnetism but only a partial knowledge about it is shared with the general society. This implies that only basic facts about the tire or the wheel magnetism are available. The information may be found mainly in Vedholm, Dietrich and Jacobs, Milham et al., Stankowski et all, Brol, Szegda and Brol works as well as in patents by Kawaze et al., and Brol et al.

⇑ Corresponding author.
E-mail address: s.brol@po.opole.pl(S. Brol).

The magnetic field is produced by ferromagnetic elements of a tire [6,14,18,21]. The origin of the magnetism is not explained yet and there is no clear information about it in papers. Dietrich and Jacobs suspect, that magnetic properties are created during the production process. Milham el al. in letter to Editor published in 1998 state that after degaussing procedure "magnetic fields (…) stays low over period of a few months" [13]. This behavior was also reported by Stankowski et al [18], but in 1999 Milham writes that AC component (the alternating one) of the magnetic field has gradually increased over 6 months [14].

The magnetic flux density (B) change frequently around tire circumference (along tread). Until now, there have been 2 or 4 distinctive peaks has been observed [2,4,10,11,14,18] around circumference. I was also reported that across the tread there is a significant change of magnetic flux density with measured amplitude up to 500 μT [14] The peak-to- peak value during one rotation differs for distinct wheels or tires and varies according to the reported investigation from tenths of μT to even thousands of μT [16, 8]. The amplitude of peaks diminishes with the distance from the wheel. The measured value varies from tenths of micro Teslas to the fraction of milliTeslas [14, 19, 20]. The amplitude spectrum of the circumferential magnetic profile is complex and has many sub-harmonics which diminish in inversely proportional manner with the frequency and the distance [6,14,18,21].

Rotating wheels changes frequently the magnetic flux density measured at car's windshield. The changes are small (a few μT), but strong enough to affect "magnetic compass" sensors placed on windshield inside a car [3]. The frequency of changes is related to wheels rotational speed. The basic application of these magnetic phenomenas is measurement of distance traveled by a car, velocity of the car [4,10,11] and also the tire slip [4]. The Authors also point out that in practical use the methods are liable to disturbances coming from working electrical subsystems in the car and the ferromagnetic road equipment such as road signs, steel poles and bridges. As mentioned above, the following observations and conclusions may be pointed out.