Review of the Doctoral Thesis

“Proposal of a computer model for simulation of car tires under dynamic loads”

by Ing. Sadjiep Tchuigwa Baurice Sylvain

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Supervisor: prof. Ing. Jan Krmela, Ph.D

Reviewer: Jakub Javořík
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The work is focused on the design of an appropriate numerical model for predicting the mechanical behavior of the entire tire under various loading types that correspond to real situations and operating conditions.

a) Achieving the set goals of the thesis

The aim of the work is to provide a comprehensive and quite extensive characterization of the mechanical behavior of a tire. With the complex structure of a tire as a reinforced composite consisting of many components, this is quite an ambitious goal, even for a dissertation.

To achieve this objective, the work includes a detailed description and literature review of mathematical tools for characterizing the mechanics of individual parts of the tire, covering phenomena such as nonlinear material models, load history effects (the Mullins effect), viscoelasticity, and others. These effects have been successfully incorporated into the presented numerical models. Furthermore, these models accurately reflect the construction and composite structure of the tire.

The functionality of these models is validated by the results of numerical analyses. Agreement between these results and experiments performed on real tires which were, tested in laboratories according to standardized methodologies, has also been demonstrated.

Based on the above facts, I consider both the main goal of the work and all partial objectives to be completely fulfilled.

b) Level of analysis of the current state of art

Current state of art is described in Chapter 2 and 3 on 50 pages. This section also includes an explanation of the main motivation for the work. It describes and references all the essential theories, methods, and tools necessary for the successful solution of the dissertation and the achievement of its objectives.

The analysis of the current state of the art is of a high level. It contains all the necessary information and, above all, appropriate references to relevant resources, therefore is entirely suitable for this dissertation.

c) Suitability of the applied methods and their application

It is clear that the most appropriate, modern, and highly effective methods currently available were used to achieve the objectives of the work, which mainly concerns the use of the FEM system. The use of mesh sensitivity analysis for computational optimization was also very appropriate. Besides that, the maximum number of factors influencing the final results was included. These are mainly the viscoelastic behavior of the material, the influence of the loading history, the influence of the complex structure of the tire, among others.

Likewise, the method chosen for performing real tests on real tires to validate the numerical models is considered highly appropriate.

d) Contribution of the dissertation thesis

The work undoubtedly has several significant benefits, particularly in the field of tire design and development. The main contribution is a detailed numerical model of a tire capable of incorporating and capturing a wide range of properties of this specific product and characterizing its behavior under dynamic and static loading conditions.

The benefit for practice is primarily the methodology for creating the numerical model as well as the determination of optimal parameters for an accurate model. Furthermore, the work shows the importance of such phenomena as viscoelasticity, compressibility, hyperelasticity, etc. for the tire behavior under various loading conditions.

Equally valuable is the analysis of the influence of individual tire components on its overall behavior.

e) Formal level of the dissertation thesis

The thesis is written at a very high formal level. I would like to highlight, above all, the high level of presentation of results, which is often very challenging in works of this type. Some minor typographical errors (e.g., mismatched values for modes A1 and A2 in tables 6.11 and 6.12) do not reduce the high level of the work in any way.

Reviewer´s questions

- The validation of the model by the real tire behavior in chapter 6.2.1 was performed by comparing one component of displacement (*Uz*). Would it be possible to use some method of determining the full 3D displacement (or strain) field during laboratory tire testing?
- Can the mass of compressed air inside a tire have an effect on its behavior under dynamic stress? (i.e. could the formation and propagation of pressure waves inside the tire lead to non-uniform pressure distribution during dynamic loading?)
- Although I highly appreciate the detailed structure of the numerical model and its predictive capability, would it be possible to perform some level of homogenization and simplification — to increase computational efficiency (at least for certain applications) — and if so, how?
- How much impact would changing deviatoric strain energy density functions (e.g., Neo-Hookean or Yeoh) have on the results of the FEM model?

Reviewer´s statement

The thesis is an exceptional and above-average work with a clear contribution to the given field of science and research. I highly appreciate the detail of the numerical model, both in terms of its material structure and in terms of the definition of initial conditions, which capture most of the specific properties of the materials of the tire. Ing. Sadjiep Tchuigwa Baurice Sylvain has clearly demonstrated his knowledge of the given issue and his ability of independent scientific work.

Based on the above facts, I recommend the dissertation thesis of doctoral student Ing. Sadjiep Tchuigwa Baurice Sylvain for defense. In the case of a successful defense, I recommend that Ing. Sadjiep Tchuigwa Baurice Sylvain be awarded the academic degree of Ph.D.

In Zlín, November 11, 2025

Assoc. Prof. Ing. Jakub Javořík, Ph.D.

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