Universitatea *Transilvania* din Braşov

HABILITATION THESIS

SUMMARY

Theoretical and experimental contributions regarding the optimization of the correlation between automotive steering and suspension systems

Domain: Mechanical Engineering

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The habilitation thesis in the field of Mechanical Engineering, entitled ***"Theoretical and experimental contributions regarding the optimization of the correlation between automotive steering and suspension systems"*** presents a summary of the author's activity in the field of education and scientific research at the Department of Food and Tourism Management and Engineering, "*Transilvania* University of Braşov. This activity represents a continuation of the main research directions pursued by the doctoral thesis, which was successfully defended on 20.06.1998, the author earning a *PhD engineering degree* in *Mechanical Engineering*, awarded by the Order of the Minister of Education no.4090/03.07.1998.

The research directions pursued by the author have approached multiple fields, mainly in the area of mechanical engineering, such as identification, modeling, simulation, testing, and optimization of constructional solutions intended for risk mitigation and improvement of dynamic behaviour of automobiles, applicable to the wheel suspension mechanism, the steering mechanism, the wheel positioning and steering system. The reasons for the choice of this topic are based on the need to improve vehicle dynamic behaviour so as to provide safety and comfort when driving on mountain tourist routes. The outcomes of this research activity allowed to identify several current issues affecting the approached research topic. The use of original and non-conventional methods allowed the author to formulate relevant conclusions and to achieve effective applicative solutions which were presented in the published scientific papers and books

Therefore, the habilitation thesis ***"Theoretical and experimental contributions regarding the optimization of the correlation between automotive steering and suspension systems"*** is based on the author's most significant researches and original contributions in the field of Mechanical engineering, presented in papers published in journals belonging to the main scientific communication networks (Web of Science or other international data bases), ISI quoted and with an impact factor. These achievements are the result of scientific research activities conducted at the *Transilvania* University of Braşov, after obtaining the doctoral degree in engineering in 1998. The thesis consists of three parts which will be presented summarily below.

Part I, ***Professional and scientific achievements***, constitutes the core of the habilitation thesis, and represents the outcome of multiple scientific activities conducted within the context of several research contracts. This part of the thesis indicates Mechanical Engineering as the main scientific research field, approached after completion of the author's doctoral thesis. It is organized around four sections asociated with the addressed research directions. The four sections deal in an unitary manner with the global context of the scientific researches, the goals of the conducted researches, research methodology, the main results obtained, and conclusions.

The *First section, A study about the influence of the steering and wheel suspension on passenger car driving behaviour*, presents the researches conducted during the last years on mechanical and technical systems which influence the comfort and respectively, the dynamic behaviour of cars, particularly when travelling on circular trajectories. The directions of the research topics, which are extemely present, were selected in accordance with the practical requirements, regarding the driving behaviour of passenger cars and trucks used not only in tourism industry but also in other areas of activity.

The stability of steering mechanism operation, characterizes a good roadholding and implicitly a high active safety. This involves a complex problematic which requires theoretical studies, resulting in the development of mathematical dynamic models of the distributor-controller system and the steering mechanism as a whole. The developed models allow for the analysis of the working conditions of these systems in form of computer simulations as well as for further researches based on experimental testing of vehicle dynamics in general and stability-driveability in particular conducted in a very extensive and detailed manner, in order to verify the correctness of the adopted hypotheses and to validate the proposed mathematical models.

These researches allowed for the development of a constructional solution intended for reducing the roll movements, which is the object of patent application no. RO 126654 A2/ 08.03.2010 (http://pub.osim.ro/publication-server/pdf-document?PN=RO126654%20RO%20126654&iDocId=1537&iepatch=.pdf) [74] and a further constructional solution for the optimization of the steering mechanism operation ([11, 21] in the list of scientific papers /BOOKS). Both solutions are very adequate for the conditions required in practice.

Section 2, *Modeling the adaptive control of the steering-suspension system*, presents the analytical models used for the theoretical study of the dynamic behaviour of the power steering controller but also of the car as a whole, when moving both rectilinearly as well as curvilinearly, equipped with the classical solution and the solution proposed for the mechanical–hydraulic power steering operation stability optimization as well as the constructional solution proposed for reducing the roll movements. Sizing up perturbations and determining the causes that alter the stability condition of the steering mechanism constitutes the basis of the analysis and the modeling of technical systems stability. Since the stability analysis procedures are not universally applicable, the use of specific methods is required depending on processes, equipments or technical systems characteristics.

In many practical applications the technological problems are modeled using the solutions of nonlinear differential equations. Because the accurate solutions are difficult or often even impossible to determine, the approximate analyitical solutions are extremely important to the study of dynamic systems.

Thus, a quarter car model was considered as well as a generalized dynamic model with seven degrees of freedom for the case of the constructional solution devised to reduce the roll and implicitly the induced wheel deflection. With regard to the constructional solution using different plunger diameters for the mechanical-hydraulic controller of the steering mechanism, three models of hydraulic subsystems were developed. These models are exposed to the action of external perturbing factors, which are generated by the road surface as well as to the action of internal factors induced by the hydraulic compensator or by the roll motion compensation systems and also by those induced by the hydraulic controller or by the motion compensation device of the power steering rack. This section also presents the methods applied to determine the physical and geometrical quantities which characterize the theoretical study models.

Section 3 of the habilitation thesis, *The numerical analysis of the cooperation control of steering and suspension and the power steering stability, using the mathematical models of the proposed solutions*, presents the integration methods of the systems of differential equations describing the motion of the vehicle when moving rectilinearly and respectively, curvilinearly. For this purpose were considered the possibilities of approximate analytical and numerical integration offered by PCs. Also, a set of results obtained by calculations were presented. These results were obtained by plotting the variations over time of the motion parameters.

An important portion of this section presents the results obtained after processing the experimental data, alongside strengths and weaknesses of the constructional variants of the new solutions, proposed for reducing the roll motion of the studied car and respectively, for the stable operation of the steering mechanism while specifying which are the most adequate solutions for the established purpose. The selection of a particular constructional variant offering the best possibilities for practical implementation was made by considering both the theoretical results, obtained by calculation, as well as the experimental results.

This chapter also presents a comparison between the theoretical research results and the experimentally obtained results, showing the variations of motion parameters of the system measured and recorded using Xsenz and BMC equipments. After comparative analyses it was found that the analytical models are adequate for studying the optimization of the correlation between steering and suspension as well as for studying the stability of the power steering mechanism.

The section also presents some aspects regarding the association between theoretical methods and experimental techniques in order to understand the effects produced by these systems and devices on both vehicle and road traffic safety. Actually, several distinct mechanical constructional solutions were implemented in form of different variants, with the purpose to attain higher performances in terms of the vehicle's dynamic behaviour and traffic safety.

Since the dynamic behaviour of the automobiles is part of an interdisciplinary field and consequently, represents more than a simple link between consecrated engineering subjects such as Automotive dynamics, Mechanisms or Hydraulics, experience in these specialties is crucial in developing novel constructional solutions allowing for well-defined applications. The presented analytical approaches are accompanied by numerical simulations and compared with the experimental results, allowing for an original manner of approximation of dynamic systems trajectories.

Section 4, Conclusions, presents the unitary character of the thesis highlighting the most important results obtained after conducting experimental tests and performing theoretical-experimental comparative analyses. The results are presented in form of a genuine database, which makes them available to automotive construction experts, judicial technical expertise specialists, as well as doctoral students for research purposes.

The idea of using the new constructional solutions means not only to simply replace the obsolete ones but to use them in a constructive manner, considering their special characteristics and the possibilities offered, in order to create new, intelligent technical systems, applicable to multiple types of automotives.

The habilitation thesis includes issues that were studied and subsequently the results published by the author and collaborators in papers appeared in scientific journals as well as in national or international conferences and congresses. Some of the results are integrated into the courses in form of viva voce lectures that are delivered by the author to undergraduate and graduate students but are also useful for doctoral students.

The unpublished data were deliberately ruled out since they are object of patent applications.

Part II, ***Planning career furthering and development***, includes the main principles and directions of action to be pursued for developing the personal academic career.

The final part of the habilitation thesis entitled ***References*** presents the bibliographic references associated to the first part and includes the author's and other researchers' publications These can easily be identified within the stream of publications provided by the most important databases.