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HABILITATION THESIS

STUDIES AND RESERCH ACTIVITIES FOR EFFICIENT PROPULSION POWERTRAINS FOR INCREASING ROAD VEHICLE'S DYNAMIC PERFORMANCES

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A B S T R A C T

Domain: AUTOMOTIVE ENGINEERING

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Abstract

The habilitation thesis "**STUDIES AND RESERCH ACTIVITIES FOR EFFICIENT PROPULSION POWERTRAINS FOR INCREASING ROAD VEHICLE'S DYNAMIC PERFORMANCES**" presents a part of the activity and the research results obtained by the undersigned, conf.dr.eng. Nicolae Liviu MIHON, currently enroled in the Department of Mechanical Machines, Equipments and Transportation of the Politehnica University of Timișoara, on the main directions of study and interest, developed after the public presentation of the doctoral thesis in 1999.

The habilitation thesis is structured and developed on three major chapters/sections, respectively (I) academic and professional achievements, (II) the results obtained in scientific research and (III) the perspectives of scientific and professional career development.

In the first section are briefly presented the milestones of the teaching career, starting with 1991 and up to the present. After the public support of the doctoral thesis, with the title *Researches on the implications of the heat exchange on the thermoelectric phenomena* (scientific coordinator professor Virgiliu Dan Negrea, PhD), in the field of Mechanical Engineering, I continued the teaching and research activity in the field/specialization that I graduated in 1986, respectively Machines and Thermal Equipment/Internal Combustion Engines. Thus, the transition to the field of Automotive Engineering/Road Vehicles became natural, gradually and irreversibly, by increasing the interest and the number of students towards this specialization and diminishing/disappearing the interest of students for the specialization of Thermal Machines and Equipment, but with maintaining the whole activity, of teaching and research, for internal combustion engines. During the more than 28 years of teaching career I have continued the Timisoara engineering school tradition in the field of internal combustion engines and, since 2006, I can say with great confidence, I have had a decisive role in increasing and consolidating the specialization of Road Vehicles in the Politehnica University of Timișoara.

The professional results of the teaching career as well as those of the scientific research motivated and determined me to continue these activities in the field of Automotive Engineering, at a higher level, by obtaining the habilitation certificate.

The second section describes, in a succinct and concise form, the most important results of the research activity carried out within research projects/grants won through competition or with the economic environment in Romania, but also by active participation in certain support/coordination/tutoring/guidance activities of students and PhD students of the specialization of Road Vehicles or of the teaching staff of our department.

The research directions described in this habilitation thesis refer to the studies of the classic propulsion systems, in turn detailed in two main subchapters: (i) the efficient propulsion systems and (ii) the experimental researches and the simulations of the exploitation of these engines on motor vehicles and, (iii) the studies of the dynamic behavior of the vehicles to increase their dynamic performance and comfort.

The efficiency of the propulsion systems was tracked by the fuel consumption values and/or the pollutant emissions and was applied on the spark ignition engines and compression ignition engines under the conditions of their supply with conventional fuels or with unconventional solutions.

Thus are presented the results of the research activities in the case of a spark-ignition engine with modifications of the air filtration system, using five other densities/properties of the filter material compared to the original one and then testing this engine under the conditions of fuelling with gasoline and isopropanol mixture. In order to measure the degree of pollution, measurements were made in two situations, namely running the engine at partial loads, as well as at full load. The parameters followed were CO_2, CO, HC and NO_x emissions, oxygen concentration in the

exhaust gases and the values of the excess air coefficient. It could be concluded that by the use of alcohols, the temperature per cycle decreases, which inhibit the formation of nitrogen oxides, and the combustion is more efficient, so with lower CO and HC emissions, but the degree of pollution of a car fueled by gasoline-alcohol mixtures it may be larger than in the case of using conventional fuel. Regarding the behavior of the internal combustion engine when changing the filter parameters of the air filter, the results have worsened the performance of the engine as the filtration rate increases, but also due to the missing of the filter cartridge, which brutally changes the air flow rate that it passed through the air filter housing, eventually worsening the engine filling.

For a spark ignition engine that equips a car for sports competitions, several researches were conducted that aimed the using of a different engine management system, with changes in the coefficient of air excess to about 0.75, with the purpose to achieve superior energy performance. Sensors and transducers with extended reference ranges were used for this purpose and were connected to a programmable ECU equipment, which managed the engine operation under the new conditions.

A special effort was needed to complete the researches on a spark ignition engine, which resulted in modifications of the parameters and algorithms for controlling the injection times, by applying fuzzy logic, based on new concepts, but with the purpose of maintaining the consumption and pollutant emissions parameters of the original solution. The results, however, showed even a decrease in CO concentrations due to a faster and more rigorous control of the stoichiometric balance between air and injected fuel.

The functional researches of a bioethanol fueled engine have enabled us to obtain NO_x, CO and HC emission values and which, in turn, have been used to model the engine's functioning with this fuel. Thus, starting from the fact that the ethanol vaporization enthalpy is higher at the end of the air intake and the fuel and/or alcohol mixture, a lower temperature of the mixture will be obtained in the combustion chamber, thus being able to improve the filling degree of the engine and implicitly its energy performance.

Engines with compression ignition also had an important place in the research activities carried out and widely presented in the content of the habilitation thesis. The influences of the constructive and functional changes of the injection nozzles from a medium capacity engine on the energy performances were followed, by applying helical channels at the injectors level, but also by changing the number and geometry of the spray holes, under certain operating conditions, on polluting emissions. The new solutions applied have increased the engine performance in the field of maximum loads by about 5-7% and a reduction of the pollution degree by 30-40% for some partial load regimes. The diesel injection equipment has been carefully analyzed and diagnosed for the problems of malfunctioning of the engine, which it can generate under improper operating conditions. Thus, causes of independent injector failures due to insufficient or inefficient fuel filtration have been established. A very elaborate and interesting study aimed at analyzing and establishing the electronic control parameters of the compression ignition engine under the conditions of using a mixed combustion cycle of a mixture of air - gas fuel with a pilot diesel fuel injection to initiate the ignition. The research focused on the use of compressed natural gas in engines for trucks and agricultural tractors, with encouraging conclusions on decreasing polluting emissions for all load regimes. For the components of the injection system used in the diesel engine experiments where modifications were made to the injection nozzles, it was necessary to design and analyze with finite elements of these components, and the results were then applied in the manufacturing solutions of these components. The results of these analyzes are part of the content of the habilitation thesis. Also briefly presented are the results of the analysis and modeling of the intake manifold of the spark ignition engine, in which the studies were performed to modify the filter parameters, models

constructed using computer aided design and analyzed with computer fluid dynamics software, by the finite element method.

The material base existing in the Laboratory of Road Vehicles of the Politechnica University of Timișoara, in particular by the existence of the dynamic test bench MAHA LPS 3000 and the devices for the determination of the exhaust gases pollution, MAHA MET 6.1 and MAHA MDO2-LON, respectively AVL Digas 4000, allowed, together with the evaluation/calculation/simulation software offered by AVL GmbH Graz/Austria, through the AST (Fire, Boost, Exchange, Cruise) package, a series of combined research, experiment – simulation, on the vehicles that are operated/tested on different operating cycles, with the consumption and exhaust emissions measurements. Thus, in the content of the habilitation thesis are presented the results of the experiments for a car equipped with a spark ignition engine that works with classic fuel and liquefied petroleum gas fuel, of a car equipped with a compression ignition engine under the conditions of its virtual testing on an imposed test path, modeled in turn with the IPG CarMaker software, but also for a car equipped with a spark ignition engine when using the AVL Cruise software, on which, in turn, virtual modifications were made on the vehicle's operating characteristics and parameters on various test cycles, following the consumption values and emissions. The use of another simulation program, ADVISOR, with direct applicability in the case of hybrid propulsion solutions, allowed analyzes and simulations corresponding to these vehicles. The correlation of the experimental data with the test regimes applied to the vehicles installed on the test bench MAHA LPS 3000 allowed to obtain and especially to validate, and appropriate interpretation of the operating parameters of these vehicles in the area of lower speeds than the test speeds (below 50 km/h), by extrapolating the values measured by higher-order mathematical functions and by the analysis and filtering of valid experimental results, in order to determine the efficiencies of the transmission of the tested vehicles.

A final chapter of the habilitation thesis presents the results of the current concerns of the author, which aims at modeling the dynamic behavior of vehicles in different operating regimes, by using the Matlab/Simulink software package together with the specific applications MSC ADAMS and AVL-AST. Thus, a clutch and a proportional-integral controller for the engine speed, respectively for the lambda sensor, and for the dynamic behavior of the virtual vehicle were modeled and verified by HIL-SIL loops and the behavior of a braking system with ABS was modeled and analyzed on various surfaces and with different adhesion coefficient values. The operation of the vehicles in comfort conditions was also pursued, by means of the models built for this purpose, by modeling and evaluation/simulation the behavior of the suspension system of the vehicles in conditions of modification of the characteristics of the components of vehicle-ground connection, respectively tire/wheel, suspension and shock absorber, models validated by experiments.

The scientific part of the habilitation thesis ends with a selective bibliography, containing 184 titles of books and articles, of which 55 of them I am co-authors (with 24 as first author).

Then the career on research activities and development directions are briefly presented. For the didactic part, the improvement of the teaching methods and the permanent updating of the content of the taught courses are aimed, and for the research part, the main directions targeted by the author are drawn, on strictly current topics for the classic and hybrid/electric propulsion systems and dynamic behavior of the vehicles, within following research projects, with mixed groups of teachers and students and doctoral students, with the economic environment or through grants attracted following national or European competitions.