

EDITORIAL OF THE SPECIAL ISSUE
“RECENT RESEARCH ADVANCES
IN AUTOMOTIVE ENGINEERING”

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The Auto-Mobility is changing to a strongly evolutionary system of functions and techniques, which require basic knowledge in horizontal areas and vertical columns. Automotive Engineering is no longer a garage development matter, but a cluster of sciences with powerful interdisciplinary skills.

Advanced Automotive Engineering – is truly a science of our time, a science with own attributes.

On the Earth are now 7.56 billion human beings (March 2018) and 1.25 billion automobiles, including busses and trucks. Every two seconds in the world are produced five automobiles. This rhythm would lead to a doubling of the cars crowd in the next 30 years. On the other hand, most people live in urban areas, and the number of megacities is rapidly increasing. The traffic achieved in such areas an extremely high density, which imposes a new consideration of local emission of substances, especially of pollutants, of noise, but also of active and passive safety and of vehicle dynamics. Furthermore, an advanced automobile must meet requirements regarding autonomous driving, connectivity, climate control and comfort.

As an example, the connectivity with internet, phone, traffic flow, tele diagnosis, service, or with other cars, imposes specific conditions for hardware – strong temperature and humidity variations, vibrations and shocks – and software – command by voice and gesture, without driver disturbance. For the more than six thousand functions, which must be electronically accomplished Controlled Area Networks have replaced the hitherto wiring harness, having specific structures for propulsion, infotainment, comfort applications navigation or phone. In this context, a major problem field is the electromagnetic compatibility.

A universal car does not appear as realistic, because of the various natural, economic, technical and social conditions in the world. From urban electric car, pickup, sedan, coupe and station wagon to cabriolet, sport utility vehicle and upper class, there will be a strong diversity, but with a noticeable modular base consisting on propulsion units or systems, vehicle body parts and materials, electronic control, sensors and actuators, lighting system, climate, safety system components, steering, carriage, suspension.

The future propulsion of automobiles will become increasingly electric in megacities, with energy storage in batteries or energy conversion from hydrogen on board in fuel cells. Nevertheless, in so numerous other applications, determined by different geographic, economic, or ecological conditions, from difficult terrain to

family transport in rural areas, there will be used advanced Diesel engines, hybrids of motor-engine, and current generation on board by means of gas turbines. The implementation of such systems in automobiles depends on mass, volume and safety of propulsion units, tanks and accumulators, on infrastructure for the distribution of fuel or electric energy, on available materials but also on realistic prices.

The car body structures for all the mentioned types must be very light but also very resistant on forces, moments, shocks, vibrations and strong temperature variations, becoming more and more a puzzle of thin shells from different materials – aluminum, magnesium, steel, plastic, carbon fiber – which must be joined by welding, soldering, sticking, staking, clinching, or screwing.

The lighting systems changed from the classical filament lamp and xenon to laser systems with thousands of moveable minuscule mirrors, light-emitting diodes and, newly, organic light-emitting diodes, which are separately actuated, generating a three-dimensional light map with focused areas.

The complexity of the *Advanced Automotive Engineering*, shown in these few examples, requires a basic research combining physics, thermodynamics, fluid mechanics, mathematics, informatics, electronics, material sciences, technology and many other disciplines, up to psychology and laws.

The aim of this special issue of the Romanian Journal of Technical Sciences is to present some of the research, development and analysis activities of the scientists in Romanian Universities in this challenging technical domain. The examples are chosen from different sectors of the Auto-Mobility: traffic noise in an urban area, valuation of modern vehicle testing cycles, strategies and capabilities for the investigation of internal combustion engines, overview of the pressure wave methods for supercharging piston engines, electric energy generation on board of motor driven automobiles using gas turbines.

The first paper is focused on the development of noise maps for urban areas which are traversed by roads with strong traffic, presenting the calculation method, the assumptions, the data sources and the main results. The noise mapping software is based on GPS, GIS and CAD techniques. In the European Union, noise maps are mandatory for urban agglomerations, main roads, railways and airports, in order to develop action plans for noise mitigation. The paper presents the methodology for noise assessment using specific indicators, which are formulated in base on the sound pressure level. The traffic flow is considered as pulsating, with acceleration and deceleration phases. The calculated results have been validated by measurements on site, showing differences, which are less than 3 dB. The noise level grid around buildings were mapped as well. The noise maps shown accurately the areas with noise values over the legal limits of 70 dB(A) for traffic noise during the day and 60 dB(A) in the night. The conflict maps and the lists of population exposure offer to the authorities useful data for noise mitigation.

The second paper is centered, as well, on a brand-new problem, consisting on the method of vehicle testing for the determination of the pollutant emission, especially of the most discussed component, which is the nitrogen oxide. A measurement on road, in the moving vehicle is not only sophisticated and limited in results, but also mostly featureless: in order to compare different types of vehicles and engines with

different power levels and dynamic behavior similar measurement conditions are mandatory. Furthermore, for the same vehicle with the same engine at same operating point, changing atmospheric conditions – pressure, humidity, temperature, or different road surfaces can strongly change the results. Therefore, measurements on vehicle test bench at same atmospheric and road conditions, with similar acceleration and deceleration profiles, with similar power history, are very useful. However, such profiles, which are developed in base on statistical data are strongly different from country to country, but also depending on the considered theory. The paper presents a comparison of simulation results following driving cycles: NEDC (New European Driving Cycle)/EU, WLTP (Worldwide Harmonized Light Duty Test Procedure)/EU, FTP75 (Federal Test Procedure)/USA, JC08 (Japanese Cycle)/Japan. The strong differences in nitrogen oxide emissions between real measurements and test bench results, which are matter of dispute at the present, determined the increased use of WLTP instead of NEDC, reducing some flexibilities and eliminating many loopholes. The paper presents the emission behavior in terms of nitrogen oxide, carbon dioxide, carbon oxide and unburned hydrocarbons for the four mentioned driving cycles. WLTP is considered as the most realistic method.

The third paper present strategies and capabilities for the investigation of internal combustion engines running with biofuels, used in the research laboratory of the technical University of Cluj-Napoca. The laboratory disposes on a dynamometer for testing engines with different power level, with a software package facilitating the control and management of all subsystems integrated in the test chamber and in the cold chamber. An useful base of result analysis is the single cylinder research Diesel engine with variable configuration of parameters. The paper presents, as an example, the pressure history within the combustion chamber of a Diesel engine for different direct injection strategies. The measurements form the base for the numeric simulation of the distribution fields of fuel droplets, combustion temperature or concentration of burned gas components. A particular facility is the optical access in combustion chambers using endoscopic cameras. The paper presents a comparison of simulated and measured distribution fields during combustion. Another facility in the laboratory is the computer simulation of a vehicle traveling on a specific road, with certain maneuvers and with a well-defined driver. The system is useful when implementing new sensor on vehicles, but also for the analysis of the vehicle behavior, of the engine response, of the transmission effects, and of suspension or brake reactions.

The fourth paper presents an overview of methods based on air pressure waves for supercharging piston engines. Charging has the aim of torque increase of an engine, by growing the fresh air mass in a cylinder with given swept volume. The charging is possible in both forms, with or without compressors. With compressor and exhaust gas support, as in turbochargers, with compressor without exhaust gas support, as in engine driven or electrically driven compressors; without compressor and exhaust gas support, using resonators, and finally, with exhaust gas support, using pressure waves. The last mentioned method is the object of analysis in this paper, which presents the operation and the design of the most interesting solutions. The basic principle consists on the fresh air compression by burned gas flows in

long, parallel ducts, with direct contact of the burned gas front with the fresh gas front, preferably without mixing. The long parallel ducts are designed in a rotating cage with inlet and outlet ports for the two components burned gas and fresh air. The cage is put into rotation by a transmission from the engine itself or by a separate motor. A section of the paper is dedicated to the history of the pressure wave charging methods. The characteristics and performances of such a supercharging system is illustrated for the case of a Compres type solution. The modeling of a pressure wave supercharger is based on the flow equations for compressible, viscous fluids. Some performance difference, in form of power /torque related to engine speed - when using supercharging by Compres, mechanically driven compressor and turbocharging are presented for different automobile and car engines.

The fifth paper presents an unconventional but very promising alternative for the future propulsion systems of automobiles. The electrical propulsion, especially by hub motors, integrated in the wheels is considered at the present as the key of the long-term automobile development. The motor propulsion offers remarkable advantages, from the zero local pollution and maximum torque at start to the degrees of freedom at wheel movement. A major disadvantage derives from the availability of electric energy on board: the energy storage in batteries at low energy density implicates low operation range at high mass, volume and costs; the energy conversion in fuel cells in base on hydrogen shows similar disadvantages. The energy density during the conversion from a chemical source into electricity can be remarkable increased replacing the chemical reaction in a battery or the proton exchange in a fuel cell by combustion, which implicate high turbulence and high temperature. As such current generator can be well used a two- or a four-stroke piston engine working at fixed load, without participation on vehicle propulsion. However, it appears as more efficient to replace the successive stages of the thermodynamic process in the same space by simultaneous stages in different modules of the machine. A continuous flow of air and fuel can be better optimized in every stage of the process: compression, combustion, expansion. The expansion is notably extended in comparison with the process in a piston engine, which is benefic for specific work and thermal efficiency. The paper presents, in base on diagrams, equations and machine configurations, a method to use the fluid energy after the expansion down to the atmospheric pressure. Such a turbomachine with additional heat exchanger can operate with a multitude of renewable fuels: alcohols, ethers or hydrogen.

The authors and the editor of this special issue are looking forward, hoping that this multidisciplinary platform offered by the Advanced Automotive Engineering will inspire the specialists in physics, mathematics, thermodynamics, acoustics, material sciences, electronics or informatics in their work.

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