Universitatea *Transilvania* din Braşov

HABILITATION THESIS

SUMMARY

CONTRIBUTIONS TO THE OPTIMISATION OF HEAVY DUTY DIESEL ENGINES

Domain: MECHANICAL ENGINEERING

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This habilitation thesis represents a condensed presentation of my professional activity after being awarded the doctoral degree in the domain of Heat Engines and Thermal Equipment, for the Ph. D. thesis entitled *Chemical and acoustical treatment of diesel engine exhaust gas,* held in 20.06.1998 at Transilvania University, Brașov.

My main achievements were focused on the research and development of compression ignition engines or diesel engines.

The results of applied research work were accomplished, in a great extent, in the field of experimenting direct injection heavy duty diesel engines, typically used on lorries or buses over 3.5 tons payload.

The four research areas regarding diesel engines included the abatement of the chemical pollutants from exhaust gas, the reduction of engine noise, the improvement of the processes efficiency, as well as the design and functional optimisation according to the prerequisites of a given application.

The research work was undertaken at Road Vehicle Institute INAR Brașov, an accredited research institution and at Transilvania University, Brașov.

Chapter 1 encloses the results of the research work upon the reduction of exhaust gas pollutants, being emphasized the original contributions belonging to passive methods (exhaust gas after-treatment, ch.1.1) applied to diesel oxidation catalysts, urea catalytical reduction of NO_x in copper-ion zeolites and to diesel particulate filters (ceramic monolith and ceramic fibers types). It is worth mentioning the particulate –smoke equivalence applied to steady operation modes, adapted according to European emission standards, in ch.1.1.3.

As active methods to reduce the emissions there were considered those which improve the combustion process (ch.1.2), limiting at the origins the formation of the emissions; I have experimented exhaust gas recirculation, the fuel injection metering and timing.

Fuel reformulation significantly contributes to the reduction of particulate and smoke emissions, being investigated the effect of sulphur content and antismoke additives (ch.1.3).

The chapter also includes data on the implementation of two original research instruments elaborated in Ph. D. thesis and applied in subsequent studies (a set of engine emission test cycles in ch.1.4 and overall toxicity indices applied to combustion system in ch.1.5).

Chapter 2 deals with engine noise abatement, regarding exhaust gas noise, overall engine noise and by-passing noise.The exhaust gas noise (ch. 2.1) produced in the exhaust system was analysed in ranges of frequencies, being designed three silencers with improved noise performances than those of previous five silencers presented in Ph. D. thesis and of serial production silencers. The redesign involved the tuning effect of Helmholtz resonators and the use of higher performace phono- absorbent materials, such as basalt and stainless steel wool.

The overall engine noise was measured (ch. 2.2) being identified the most dominant noise sources (combustion noise, mechanical noise and aerodynamic fan noise), upon which should be applied abatement techniques. It was also investigated the effect of partial screening of the engine surface (40%) with phono-absorbent polyurethane foam.

The engine noise was also considered from the perspective of the receptor (ch. 2.3), as environmental noise which may disturb the inhabitants from a district of Brasov city; the measurement of the engine noise produced in a power plant indicated the propagation paths from sources to receptors, emphasizing the contribution of the reflexions of the sound waves due to several block of flats. For this case, two attenuation techniques were designed and applied - acoustic screens and noise silencers.

Chapter 3

The actual requirements imposed on internal combustion engines are the same as in the past, the increasing of effective power and torque and the reducing fuel consumption, with the supplementary requirement, in a certain extent contradictory, of lowering emissions. I have investigated several techniques aiming to increase thermodynamic efficiency and to reduce the mechanical losses.

The architecture of exhaust gas ducts has a significant influence on the scavenging energy which reduces the effective work and, finally, the engine power, thus being numerically analysed in 3.1.

By applying the air charge intercooling (ch. 3.2) the gain of engine power and fuel economy along with lower emissions has been a win-win solution; also the match of the engine with the turbocharger by the proper adjustment of a by–pass valve demonstrated fair increase in performance along with the reduction of smoke emission (ch. 3.3).

The study of engine energy balance,(ch.3.4), yielded experimental data of combined convection –radiation heat transfer coefficient of engine surfaces and emphasized the potential of thermal energy harvesting when a thermoelectric generator is placed on the exhaust duct.

The optimisation of engine cooling system (ch.3.5) was focused on the integration of mechanical characteristics of three distinct components: coolant pump, fan and heat exchanger (coolant radiator) with those of the engine, resulting a procedure for design and certification of the cooling system.

The measurement of the mechanical losses on the dynamometric test bench by motoring method (ch.3.6) is useful for the finding of the engine mechanical efficiency.This is a valuable indicator of the accuracy of manufacturer metal processing, especially for the components of the crankshaft mechanism. The mechanical efficiency variation was analysed with second order polynomial regression, yielding two equations specific for each of the two tested engines.

The engine mechanical losses can be reduced when the fan and the cooling pump are mechanically driven by the crankshaft, so their driving power had to be lowered (ch.3.7); for the cooling fan, it was investigated on a dedicated test bench the power consumed by the fan drive, as well as the usefulness of intermitent drive using a visco type coupling.

Finally, the quality of engine lubricants was analysed, mainly their behaviour at extreme pressures, by means of a Falex type tribometer, having as main objective keeping the lubrication regime in the area of the minimum coefficient of friction on the Stribeck curve (ch. 3.8).

The research instruments were infrared thermography for finding the mean temperature of engine surfaces and data aquisition software for the thermo-electric generator.

Chapter 4 deals with the integration of the diesel engine into dissimilar applications; being very flexible, it can be adapted with a series of specific redesigns to most of customer demands.Two applications are illustrated, the integration into a generator set and the integration into a multipurpose vehicle with power take-off for agriculture, forestry and communal works.

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