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THE STUDY OF COMPUTER MODELLING POSIBILITY FOR AN INTERNAL COMBUSTION ENGINE EQUIPED WITH AFTER-TREATMENT AND POLUTION REDUCTION SYSTEM FOR EXHAUST GASES IN ORDER TO ECOLOGIZE THE ROAD TRANSPORT

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Rezumat. Articolul de faţă oferă o analiză comparativă a sistemelor de evacuare de la motoarele cu aprindere prin scânteie moderne cu elemente de depoluare (cu şi fără a avea montat catalizatorul), prin dezvoltarea unui studiu complex de simulare a fenomenologiei funcţionale. Se dezbate problematica sistemelor de depoluare (cu element catalitic reactiv) pentru motoarele cu aprindere prin scânteie, dar în special posibilităţile îmbunătăţire a performanţelor prin simularea procesului de evacuare. Se consideră că arhitectura sistemului de evacuare şi catalizatorul au o mare influenţă asupra procesului de evacuare a gazelor şi asupra performanţelor motoarelor cu aprindere prin scânteie. Modelarea şi simularea sistemelor de depoluare ale acestor motoare poate prevedea o serie de soluţii constructive şi de planuri de optimizare pentru a reduce emisiile poluante şi consumul de combustibil, în timp ce performanţele de putere ale motorului nu vor fi mult diminuate. Actualmente în Europa normele antipoluare şi independenţa energetică în raport cu petrolul sunt abordate tot mai des, fiind în realitate priorităţi pe masa de lucru. Prin lucrarea de faţă se studiază tematica modelării unor motoare noi şi a simulării sistemelor existente, dar cu oarecare îmbunătăţiri majore care trebuie să satisfacă cerinţele în vigoare de poluare scăzută şi consum redus.

Cuvinte cheie: ardere, contra-presiune, evacuare, performanţe, poluant, post-tratare, simularea-motorului.

INTRODUCTION

Through the simulation process 2 it is analyzed the spark ignition engine’s behavior in operating conditions at different states of the exhaust and after-treatment system in comparison with a configuration case of no-after-treatment elements178. The modern simulation applications (that exist nowadays in the virtual environment with online operation capabilities, directly on the internet or upon special computing-stations dedicated for complex analyzing operations and electronic processing of various specific phenomena or different efforts and processes which take place inside engines or in their components) allow the determination of particularities of the mechanical stress and of some constructive and functional characteristic parameters, even in dynamic working conditions3913.

MATERIAL AND METHODS

Lotus Engine Simulation is a software tool for computer simulation of operational cycle, relatively easy to use, for engine performances prediction, which combines models of variable gas flow in multiple components with those that are defining the combustion process.

The application may be used for calculating and modeling:

- the engine's performance at full load and partial loads in steady state regime and transitory state of the operating conditions;
- heat transfer data toward/from cylinders;
- variations of the instant properties of the gases in engine's manifolds;
- turbocharging and conditions of correlating the supercharging equipment.

The researcher builds the simulation input model of the engine by using multiple specifications. This includes data for cylinder bore, piston stroke and connecting-roads dimensions; compression ratio; valves dimensions and their overlapping interval; gas flow through intake valve port and through exhaust port; intake and exhaust manifolds dimensions; data maps that defines superchargers' performances; engine speed; heat release data (which is defining for the combustion process); air/fuel rate and intake air temperature and pressure.

After defining the engine data (Fig. 1) and the state data the simulation test is realized. The results of data processing (as the volumetric efficiency, torque and power) and those data related to operation cycle (as pressure, temperature and mass flow) are available for analyze, in the shape of a report and of some easy to use graphic representations. The software program is capable of simulating the majority of auxiliary systems from existing engines and also from those recently designed.

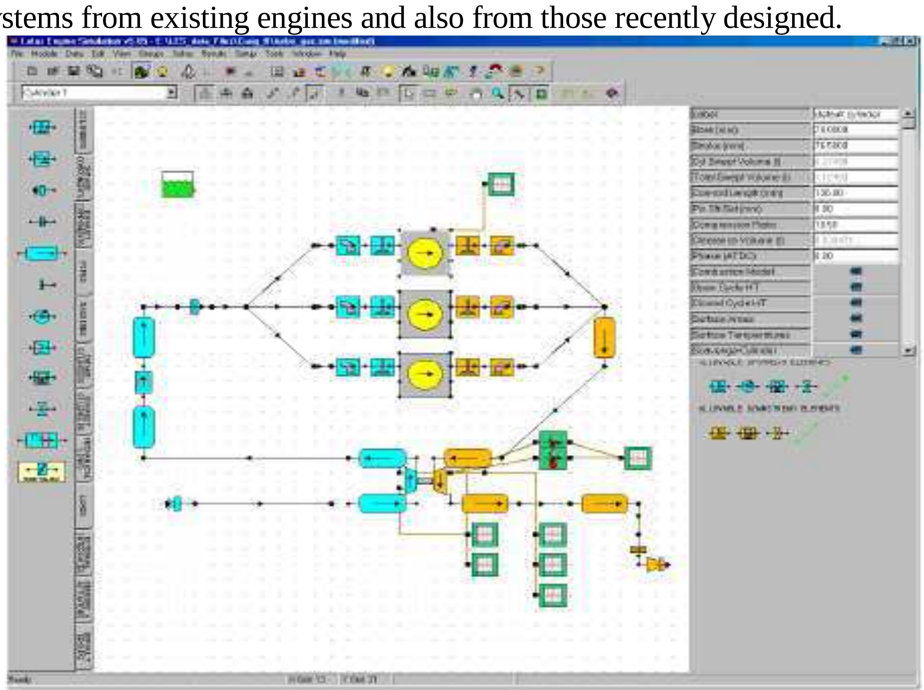

Fig. 1. Menu for developing the Lotus Engine Simulation model [12]

Lotus Engine Simulation is a modeling environment for performance estimations at steady-state and transitory regime both of two strokes and four strokes engines, naturally aspirated or supercharged. It combines the models for variable gas flow in multiple components with those which characterize the combustion process and it has an intuitive user interface that allows the engine models to be rapidly configured and then verified. The built-in post-processing instruments allow the engineers to gain important perspectives on their engine performances.

Main steps necessary for generating and instrumenting an engine’s model for simulation in LOTUS are:

Step 1 – configuration of a model either through „drag-and-drop” (Network Builder, loading and editing the data from an existing model), or by using the "Concept" integrated tool.

Step 2 – defining the operational necessary parameters of the engine ready for test.

Step 3 – launching the solving of simulation (simulation solver).

Step 4 – upload the simulation results, either as text or as graphic display, in order to review the calculated value [12].

In figure 2 is presented the module for defining the dimensions and characteristic values of the exhaust system (for residual gases), more precisely dimensional characteristics of the exhaust piping and silencer in the case of absence of after-treatment system.

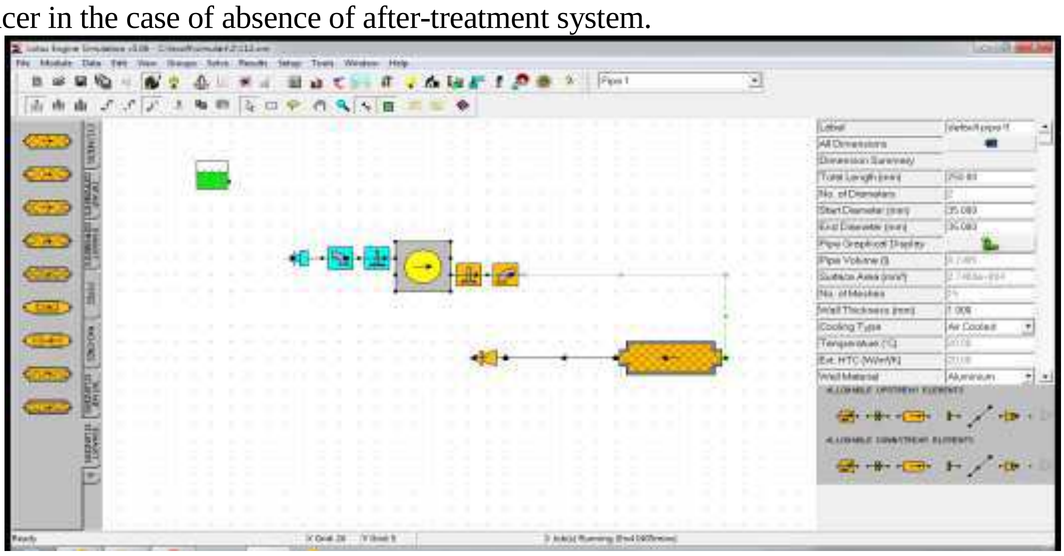

Fig. 2. Defining the engine model without after-treatment system

Through this module there may be established the diameters and the remaining dimensions of the exhaust manifold, of the silencer, total length and silencer section shape etc.

RESULTS AND DISCUSSIONS

The considered simulation in this research paper is defined by a series of input values and a set of output quantities. In the first set of values it may be recalled the engine type, after-treatment system architecture, volume and flow rate of injected fuel, as well as functional-constructive features during the process of injection and residual gases exhausting through exhaust system pipes.

In figure 3 are graphically represented the engine’s performances (output data) through comparison (with a catalytic converter and without after-treatment system) through successive modification of exhaust system (respectively of catalytic converter) in the virtual model.

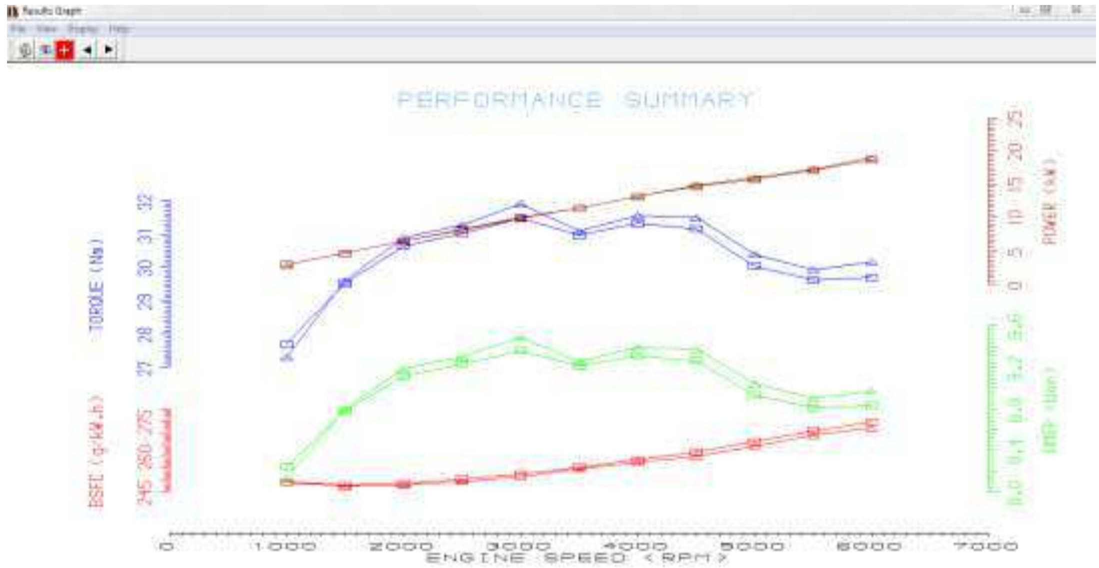

Fig. 3. Graphic representations obtained through engine simulation with and without catalytic converter

In the model creation, conventionally the BSFC (c_e) is determined by considering few (but significant) operating characteristics in the mathematical relation 5:

$$c_e = \frac{3600}{Q_i \cdot \eta_e} = \frac{3600}{Q_i \cdot \eta_m \cdot \eta_r \cdot \eta_t}, [g / kWh] \qquad (1)$$

where: c_e is brake specific fuel consumption, [g/kWh]; Q_i – fuel's inferior calorific power, [kJ/kg]; η_e – effective (brake) efficiency; η_m – mechanical efficiency; η_r – relative efficiency; η_t – thermal efficiency.

CONCLUSIONS

It further makes a number of conclusions on the simulation process initiated based on the theme addressed by the survey.

The simulation research of the after-treatment system from the S.I. engine supplied with port fuel injection, based on gasoline, at different engine speeds and load regimes, highlights the fact that in all situations the engine may operate in acceptable conditions, but on the other hand there may be used solutions to eliminate the undesirable effects. Even if there are a series of limitations or restrictions in changing the flow regime (laminar or turbulent) of exhaust gases in the exhaust pipeline there may be realized the adjustment of systems (including the after-treatment systems) as engine's default and of management system related with the injection process, respectively of mixture formation and ignition so that the apparent undesirable differences in the process may be tackled.

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