Single Cylinder Diesel Engine Performances Estimation Using AVL Boost software

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Abstract: - The objective of this paper is to present the results and advantages of the engine cycle simulation of a single cylinder direct injection diesel engine using AVL Boost software. The simulation results highlighted the energetically and economical performances of the engine and the evolution and the control of engine cycle parameters.

Key-Words: - simulation, model, engine cycle, performances, estimation, parameter

1 Introduction

AVL BOOST represents an advanced and fully integrated "Virtual Engine Simulation Tool" with advanced models for accurately predicting engine performance. The code can simulate the entire engine cycle including combustion [1].
Some typical applications include [1]:

- Torque curve prediction;
- Fuel consumption
- Manifold design and tuning
- Valve timing optimization
- Turbocharger matching, waste gate, VTG
- Acoustic analysis (intake/exhaust orifice noise)
- Combustion and emission analysis
- EGR with Boost-Fire Link
- Turbocharger response.

2 Engine Cycle Simulation

2.1 The simulation main steps

- Design the model (the model can be designed by placing the elements in the working area first and then connecting them with the pipes)
- General input data (e.g. engine speed, mixture preparation, fuel, reference conditions, cycle, etc.);
- Element input data (e.g. engine constructive characteristics, combustion model, heat transfer, valve port specifications, etc.);
- Run simulation;
- Post-processing (e.g. engine overall performances);

2.2 The model

In figure 1 is presented the single cylinder diesel engine model used for the analysis. The model consists of the following elements:

- SB - system boundaries;
- MP - measuring points;
- C - cylinder;

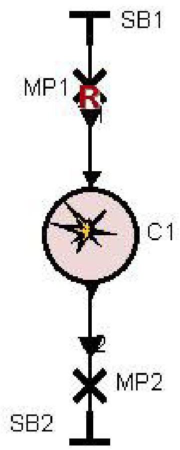

Fig.1

2.3 Engine characteristics

The characteristics of the engine are:

- bore: 76 mm
- stroke: 65 mm
- displacement: 295 cm3

- power: 4 kW
- speed: 3000 rpm
- compression ratio: 17:1

The Diesel engines by small power have a wide range of application for the mechanization of the most activities in industry and agriculture. This type of engines, with power up to 10kW, is using, in most of the cases, the air-cooling.

3 Simulation Results

The general performances of engine torque, power, specific and per hour consumption against engine speed are shown in figure 2.

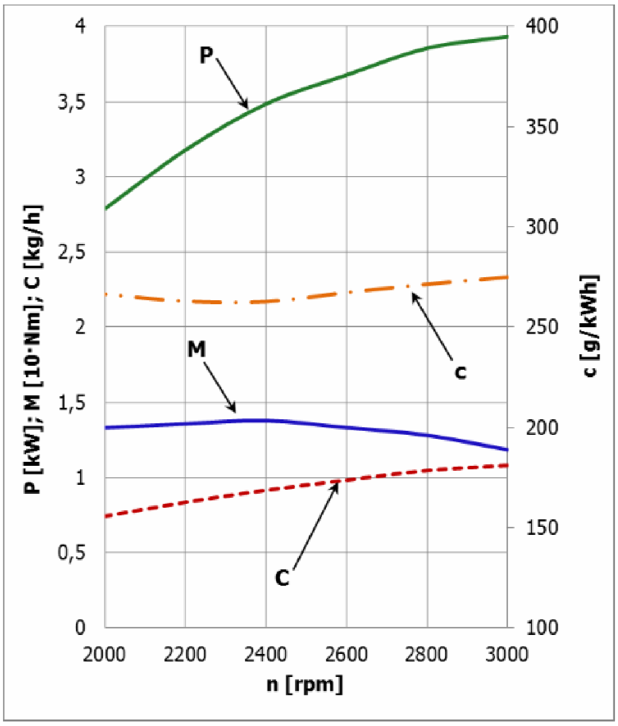

Fig.2

Table 1

Parameter	*Unit*	*Results*
Power	kW	3,93
Maximum torque	Nm	13,79
Specific consumption at nominal power	g/kWh	275
Specific consumption at maximum torque/speed	g/kWh	262,8
	rpm	2400

Effective mean pressure variation is illustrated in figure 3. The range of it is between 0.54 to 0.58 MPa, the values are close to the real case of engines in this class. Figure 4 shows the variation of excess air ratio and the volumetric efficiency relative to speed. By increasing the speed, the volumetric efficiency will decrease, it reduces the intake valve opening time and the filling worsens. The volumetric efficiency values are in the range from 0.91 to 0.93. The coefficient of excess air is in the range from 1.54 to 1.55, values characteristic of diesel engines.

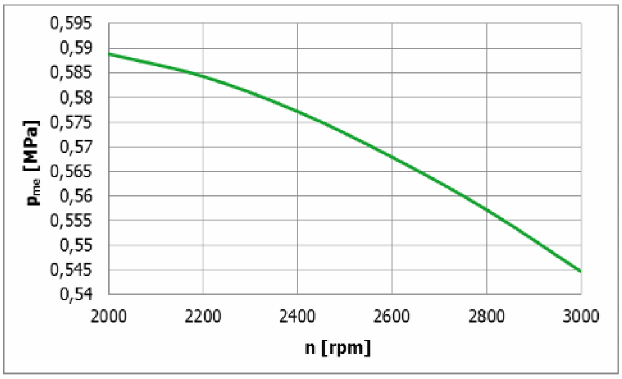

Fig.3

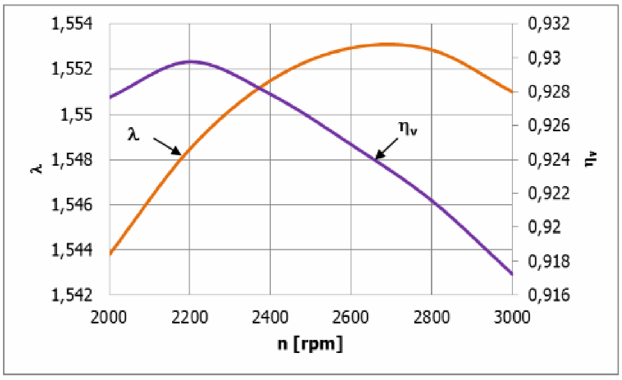

Fig.4

Figure 5 presents the influence of speed on residual gas coefficient. Specific range of diesel engines is between 0.03 and 0.06. The values obtained indicate a proper discharge of the cylinder.

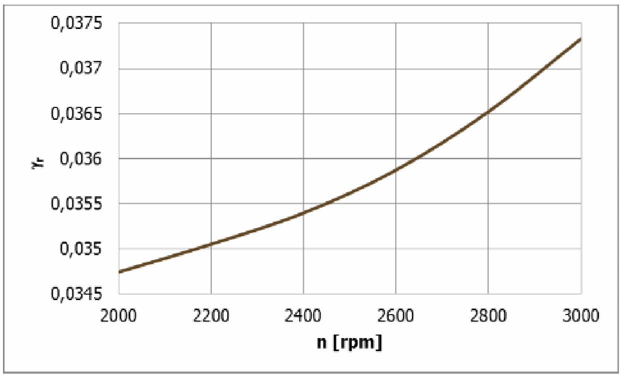

Fig.5

The main results of the simulation, from the two

measuring points MP1, MP2 located in inlet and exhaust manifolds, are represented in the following figures.
Figure 6 illustrates the air mass flow, figure 7 the air rate and figure 8 mean air pressure in inlet manifold.

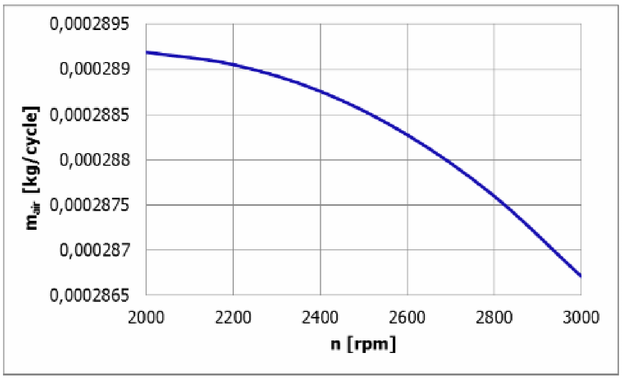

Fig.6

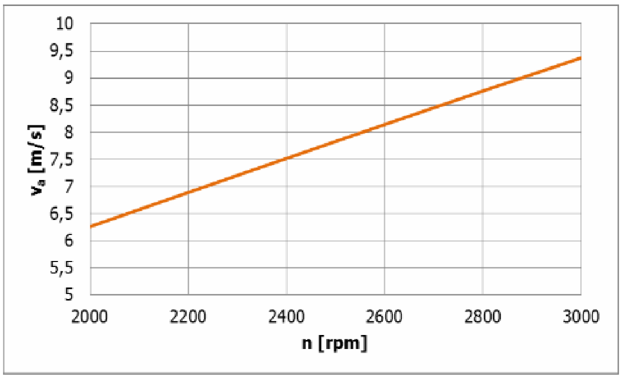

Fig.7

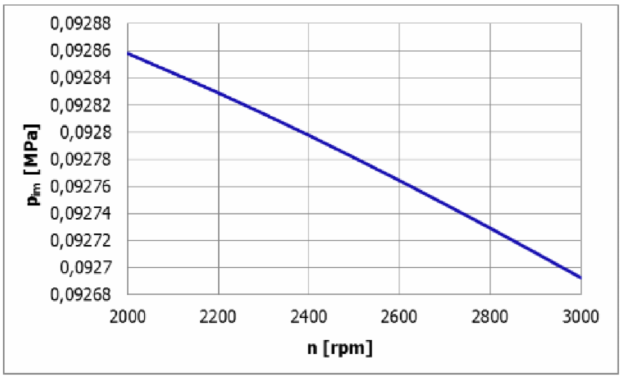

Fig.8

Once engine speed increases, both, mass flow of fresh air that enters the cylinder and inlet pressure decrease because of the increased admission rate that diminishes the volumetric efficiency. In the same time an increase of exhaust gas rate occurs, that accelerate the gas column (figure 9). In figure 10 is presented the mean pressure of exhaust gas.

Figure 11 illustrates exhaust gas flow.

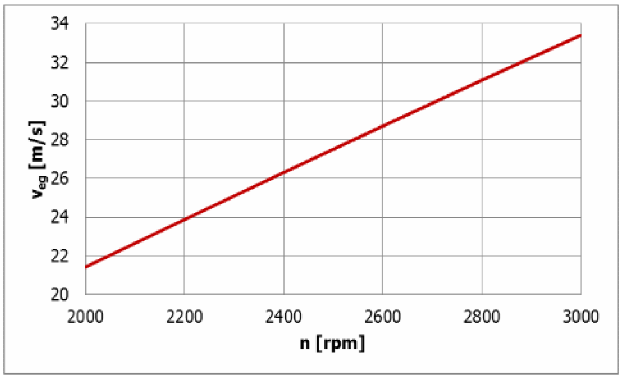

Fig.9

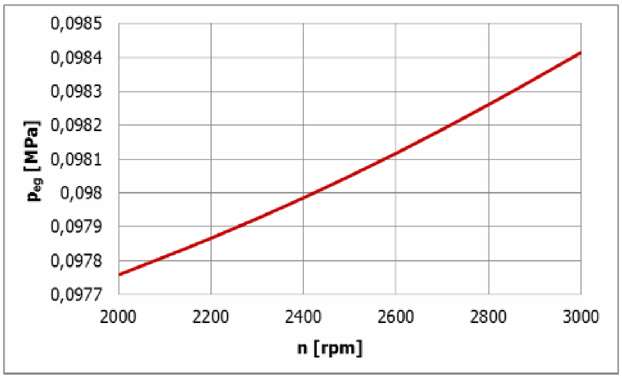

Fig.10

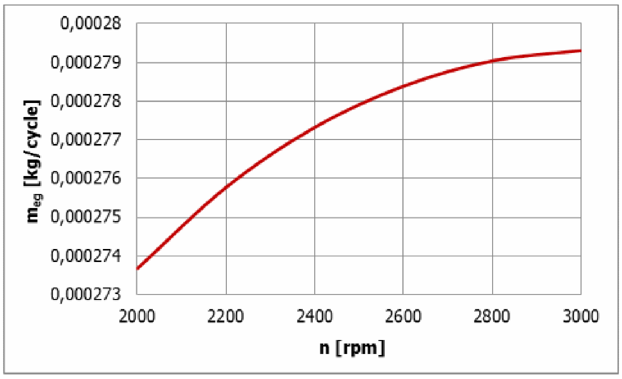

Fig.11

In figure 12 are presented the evolution of the cylinder pressure and temperature for the 3000 rpm engine speed. Maximum cycle pressure is 5.9 MPa and temperature of 2065.97 K. The maximum duration of the ignition delay is ~ 5.5 °CA, at this stage are visible the processes resulting with heat absorption (latent heat vaporization of diesel fuel, the first reaction of oxidation) and causes a reduction in air pressure and temperature increase. Growth rate of the pressure is within normal limits, causing a quiet running engine (figure 13). Heat release rate (figure 14) captures the typical phases of the combustion process: the ignition delay, premixed (chemistry-controlled), heat release rate reaching the maximum at about 6 °CA after TDC and then the diffusive burning (mixing-controlled). The premixed combustion lasts ~ 10 °CA and total combustion duration is about 30 °CA.

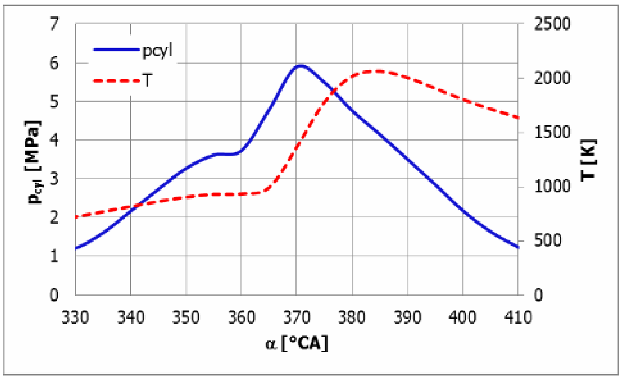

Fig.12

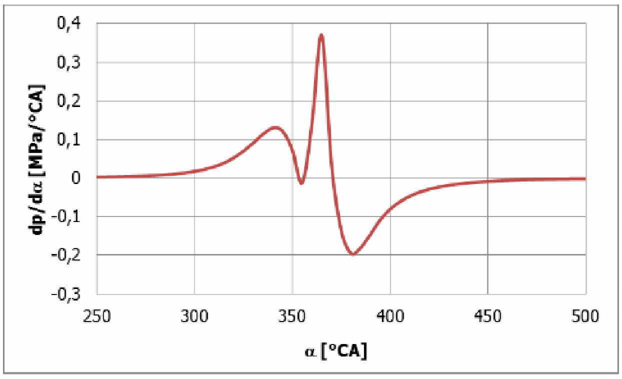

Fig.13

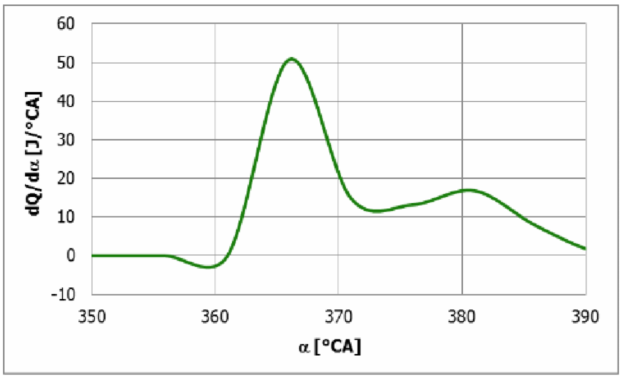

Fig.14

In figure 15 is represented the total heat flow through walls.

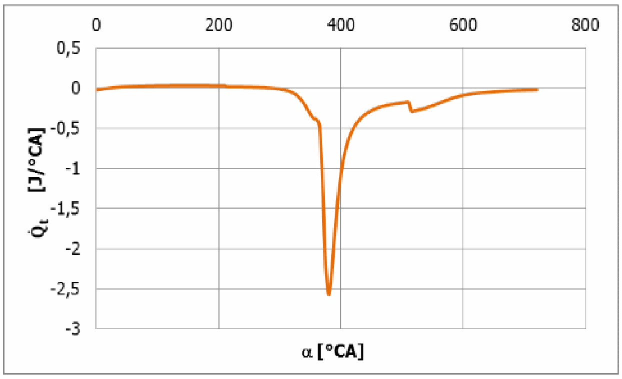

Fig.15

Largest amount of heat lost through the walls is concentrated around the combustion process, a lower proportion belonging to expansion stroke, this indicating an optimum combustion process.

4 Conclusion

The simulation of the engine cycle processes highlighted the evolution of the main specific parameters. Analyzing the values of the energetically and economical parameters obtained, it finds that they correspond to the real range of variation for this type of engines.
The results obtained by simulation shows that this method offers an accurate picture of the progress of real processes from a diesel engine.
Concluding it can be mentioned that AVL Boost software represents a powerful tool for engine cycle simulation of internal combustion engines.

References:

[1] www.avl.com

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