SIMULATION ON SINGLE CYLINDER DIESEL ENGINE AND ESTIMATION OF ENGINE PERFORMANCE USING AVL BOOST SOFTWARE

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Abstract: *The simulation and computational development of modelling for the research is use the commercial Computational Fluid Dynamics (CFD) of AVL Boost software. In this research, the one dimensional (1D) CFD modelling of four-stroke direct injection diesel engine is developed. The analysis of the model is fluid flow and combustion performance process in the engine cylinder. In this model it can to know the diesel engine performance effect with simulation and modelling in any speed (rpm) parameters before to do the physically development, so it can do the new engine design components with the economic material and time. The model simulation covers the full engine cycle consisting of intake, compression, power and exhaust. The simulation result highlighted energetically and economic performance of the engine.*

Keywords: SIMULATION, DIESEL ENGINE, MODEL, AVL BOOST, PERFORMANCE, SINGLE CYLINDER

1. Introduction

In the last decades, the legislation on internal combustion engines (ICEs) has severely reduced the limits for pollutant and noise emissions. These requirements have established the research activity at design phase as a key stage in the engine production process. Therefore, an intensive investigation on ICEs has been carried out, focusing on the optimization of performances and fuel consumption. In particular, an important effort has been done seeking the improvement of the combustion and gas exchange processes, using tools such as Computational Fluid Dynamics (CFD).

Diesel engines are typically characterized by low fuel consumption and very low CO emissions. However, the NOx emissions from diesel engines still remain high. Hence, in order to meet the environmental regulations, it is highly desirable to reduce the amount of NOx in the exhaust gas.

Simulating an intake or exhaust system is just a great exponent of this sort of problems. These systems are mainly composed of ducts, which can be accurately simulated by means of one-dimensional, non-viscous codes. However, there are several components that manifest a complex three-dimensional flow behavior, such as turbo machinery or manifolds, therefore being unable to be simulated properly by 1D codes, and thus requiring viscous, 3D codes.

Hence, it is a right choice to save computational time by simulating the complex components by means of a 3D code and modeling with a 1D code the rest of the system, i.e. the ducts. In this way, a coupling methodology between the 1D and the 3D code in the respective interfaces is required, being the objective of numerous authors [1–4].

AVL Boost is based on 1D gas dynamics which account for fluid flows and heat transfer. Each component in a AVL Boost model is discretized or separated in many smaller components. These components have very small volumes and the fluid's scalar properties in these volumes are assumed to be constant. The scalar properties of a fluid include pressure, temperature, density and internal energy. Each volume also have vector properties that can be transferred across it's boundaries. This properties include mass flux and fluid velocity.

Heywood [5] written that the engine ratings usually indicate the highest power at which manufacturer expect their products to give satisfactory of power, economy, reliability and durability under service conditions. The speed and maximum torque at which it is achieved, is usually given also.

2. Data Needed for Building an Engine Model

AVL Boost is a software tool that consists in a pre-processing program, used for initial data entry and technical characteristics of the engine to be designed as model. After forming the engine assembly with annexes systems, mathematical equations and algorithms of the model with the graphical user interface (GUI) will analyze and calculate the processes that are required during simulation [6, 7]. The model for the engine designed in AVL BOOST application is shown in figure 1.

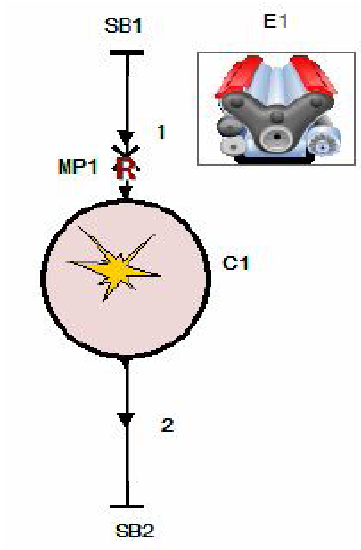

Fig. 1 *Model of Single Cylinder Diesel Engine: SB-system boundaries, MP-measuring points, C-cylinder.*

A list of information that is needed to create a model in AVL BOOST is included in library. The main features of the diesel engine that have been used as initial data to define the cylinder parameters are presented in table 1. Cylinder (C1) of the model in AVL Boost is connected with element Engine (E1), and it defines the type of engine used, operating speeds on it, moments of inertia and break mean effective pressure (BMEP). Combustion method is Mixing Controlled Combustion model that predicts the rate of heat released (ROHR) and NOx emissions on the quantity of fuel in the cylinder and the turbulent kinetic energy introduced by the injection of fuel [8].

Table 1: ***Specification of the engine.***

Engine Parameters	Value	Unit
Bore	76	[mm]
Stroke	65	[mm]
Displacement	295	[cc]
Power	4	[kw]
Speed	3000	[rpm]
Compression ratio	17:1	-
Valve lift	8,5	[mm]
Piston pin offset	10	[mm]

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. Result and Discussion

After definition of the engine parameters has been run a series of simulations, and then plot the results in Impress Chart were was analyzed.

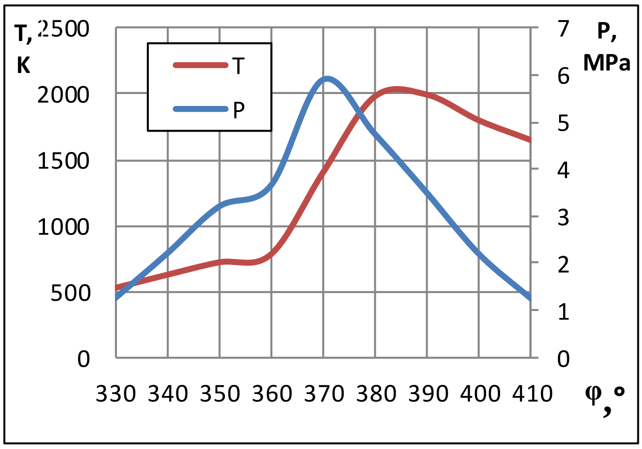

Fig. 2 *Evaluation of the cylinder pressure and temperature*

The running simulation result is all of the engine performance data with the different engine speed (rpm). This model was running at any speed from 2000 to 3000 rpm.

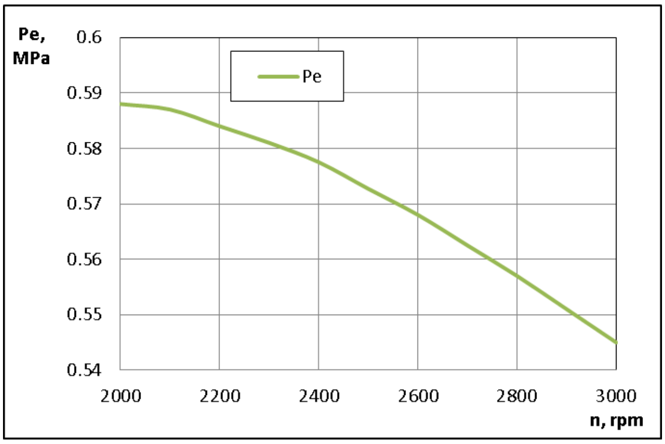

Fig. 3 *Mean effective pressure of engine model*

In figure 1 show 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°, 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. 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.

Mean effective 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.

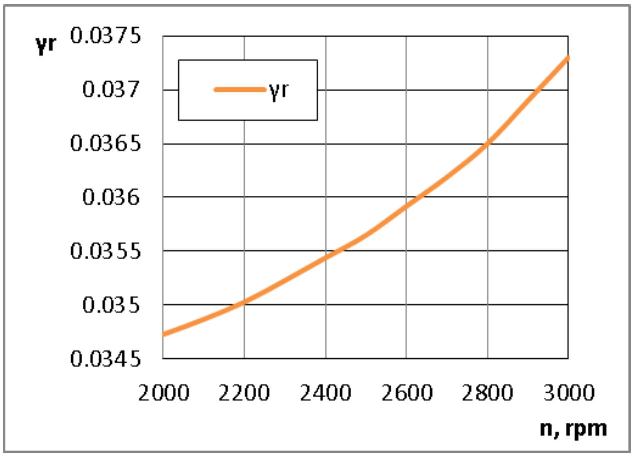

Fig. 4 *Residual gas coefficient*

Figure 4 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.

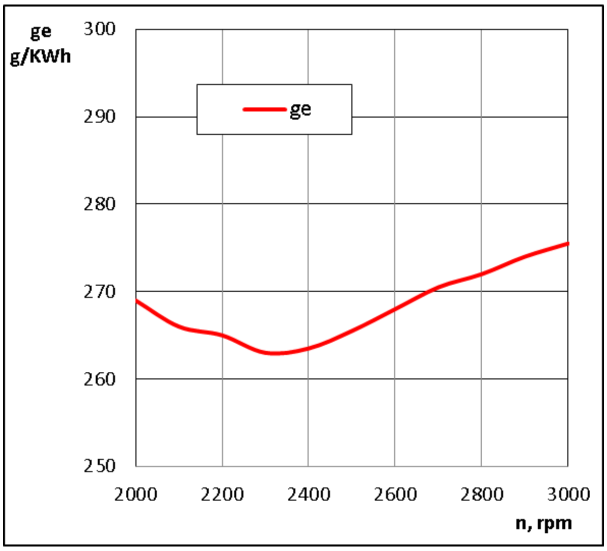

Fig. 5 *Brake specific consumption of engine model*

The brake specific fuel consumption is shown in Figure 5. The model simulation result shown that the minimum brake specific fuel consumption is 263 g/kWh at 2300 rpm.

The brake power of the engine model is shown in Figure 6. Brake power is usually measured by attaching a power absorption device to the drive-shaft of the engine (any type of brake). If the engine speed is increased the brake power is increased too until engine speed 2900 rpm. The maximum brake power of the engine model is 3.95 kW at engine speed 2900 rpm and after that the brake power decreases.

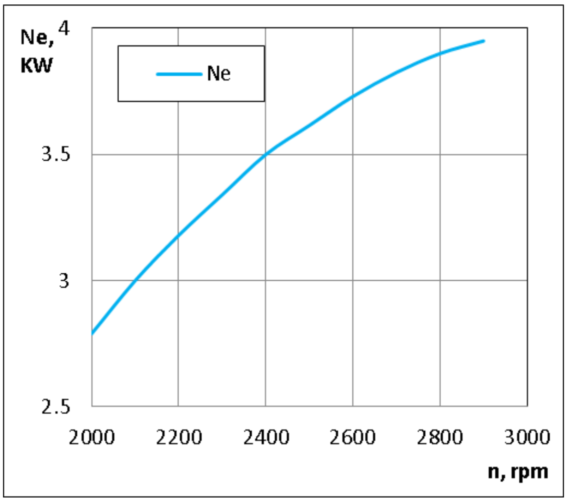

Fig. 6 *Brake power of engine model*

3. Conclusion

This paper present the results of the engine cycle simulation of a single cylinder direct injection diesel engine using AVL Boost software. The engine cycle simulation processes shows the evolution of the main specific parameters. Analyzing the obtained results, it finds that they correspond to the real range of variation for this type of engines. The residual gas coefficient can be improved by optimizing the intake and exhaust systems of the engine. The results obtained by simulation shows that engine cycle simulation offer an accurate picture of the progress of real processes from a diesel engine.

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