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Experimental Simulation of Pressure Losses in the Combustion Chamber of a Diesel Engine

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Abstract: *The study of the influence of the fluid parameters that are introduced into the combustion chamber of an internal combustion engine has been a challenge for any engine manufacturer. as any modification of these parameters in the combustion chamber influences the energy and pollution performance of the engines.In this paper an experimental simulation of the pressure loss in the combustion chamber was performed during the operation of a diesel engine related to the pollution emitted by it respectively its power.*

Keywords: *Chamber combustion pressure, fuel pressure, leaks.*

1. Introduction

The optimum operation of an internal combustion engine involves an operation that generates as little polluting emissions as possible and consumes as little fuel as possible, while the engine must provide sufficient power depending on its destination. The increasingly stringent pollution norms imposed by the engines in the automotive industry, but for those whose destination is the agricultural field, constructions, involved a series of constructive changes without which the requirements found in the pollution norms cannot be met. The main constructive changes involved a management of the operation of the engine through an ECU (electronic control unit) that takes values of the parameters through the sensors mounted on the motor, and then on the basis of a calculation algorithm that provides information to its control elements. One of the parameters that influence the optimum operation of an engine is the maximum compression pressure retained in the combustion chamber (inside the engine cylinder), but its modification directly influences the operation in optimum engine conditions. One of the causes that can lead to the change of pressure in the combustion chamber is the loss through leaks due to wear, or due to spontaneously generated defects. In this work, a correlation was made between these pressure losses due to the leaks in the combustion chamber and the production of emissions, respectively the loss of power in a diesel engine of type M 511, correlated loss and validated through a simulation program.

2. The experimental stand

The experimental stand is composed of a motor stand fig.1, and the block diagram of the stand is shown in fig.2.. The experimental stand allowed the lifting of the power, consumption and pollution characteristics, the results being monitored with a Labview acquisition system, the engine stand also has a device to simulate a loss in the combustion chamber made by the author, respectively allowing the monitoring the cylinder pressure is also correlated with the fuel injection pressure monitoring. In the second stage, the energy and pollution parameters of the engine were determined based on the segments mounted on the engine. Thus it was determined:
-Effective power Pe [kW],
-Torque maxim [Nm],
-Hourly fuel comsumption c_h [kg/h],
-Bosch smoke degree (Opacity) [%]
At each test, the cylinder pressure for each RAC grade was purchased through the acquisition data.
The correlation between the evolution of the pressure in the combustion chamber and its degree of sealing, as well as the injection pressure for each RAC degree, was determined.

The block diagram of the stand is as follows:

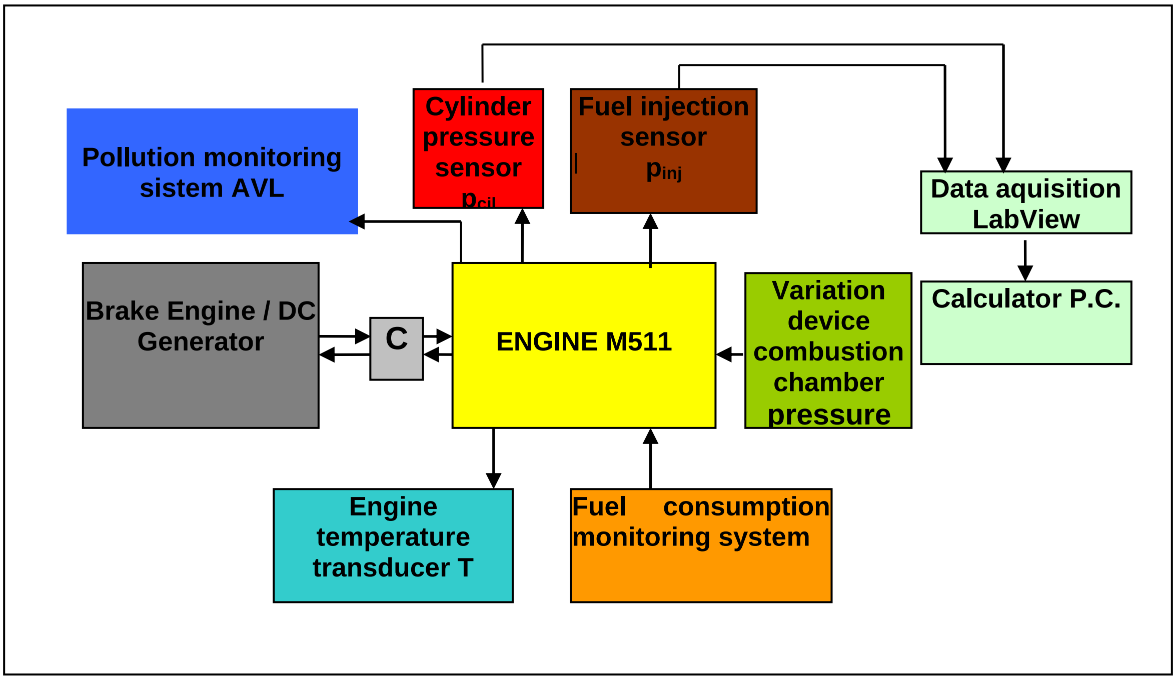

Fig. 1. Block diagram of the experimental stand

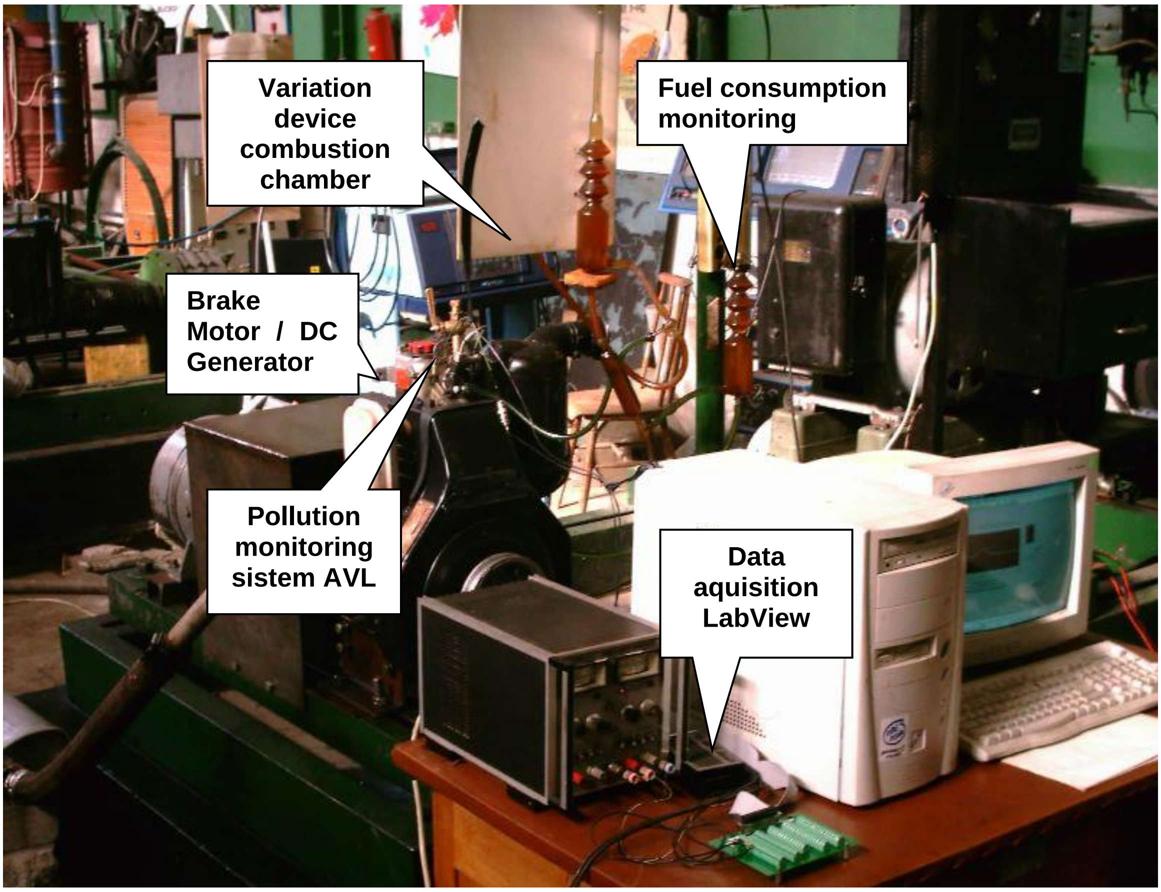

Fig. 2. The experimental stand

The pressure in the combustion chamber was monitored by means of a sensor mounted in the combustion chamber. The fuel injection pressure was p_{inj} was monitored by means of a sensor mounted on the high pressure pipe. Loss through leaks was simulated experimentally by means of a device mounted in the combustion chamber (fig.3), which can control / simulate the pressure losses in the combustion chamber, by opening a calibrated hole and correlated with the degree of wear [2], the validation of losses through non-intensities was performed on a seal set (piston rings) with high degree of wear [3]. The tests carried out aimed at determining the connection between the formation of the fuel mixture and the combustion by determining the consequences of the efficiency of the sealing of the combustion chambers on the engines with low liter compression ignition. The experimental data regarding the sealing efficiency due to the elastic contact pressure of piston rings obtained on the test stand were corroborated with those obtained in determining the wear of the piston rings. Thus, the sets of wear piston rings for the tests were selected based on wear and elastic pressure. The losses through the cylinder-piston rings gap were quantified by a pressure capture device which is mounted in the combustion chamber (Figure 3). The device construction has the possibility of mounting some calibrated holes (figure 4) that allow the simulation of the flow through the intersection of cylinder segments.

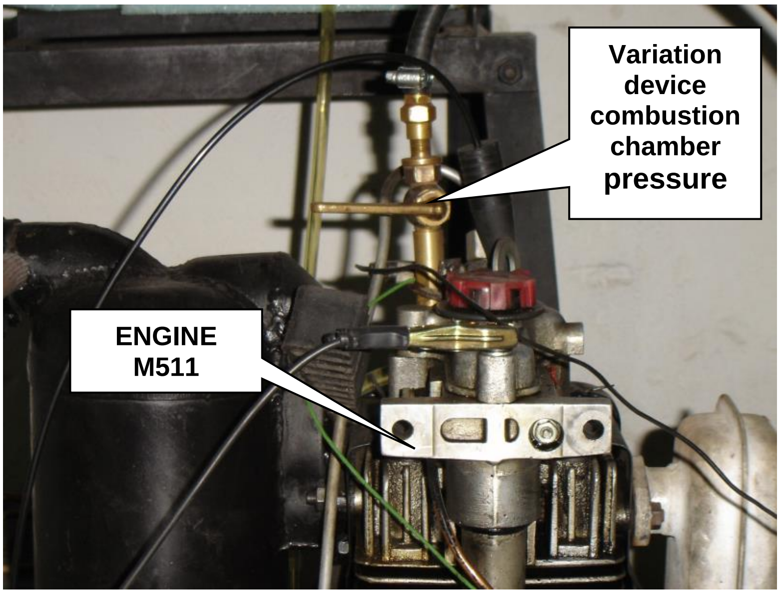

Fig. 3. Variation device combustion chamber pressure

Six nozzles with different diameters were used from the following range of values expressed in mm:

1.0 1.5 2.0 2.5 3.0 3.5

The nozzles are shown in Figure 4:

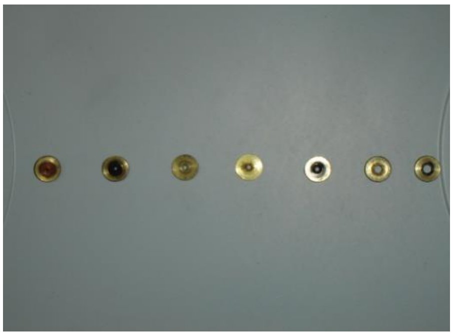

Fig. 4. Calibrated holes (nozzles)

The construction of this pressure controlled variation device is shown below fig.5, which is mounted in the combustion chamber fig.6:
1-device mounted in the combustion chamber cylinder head
2-tap closure
3-hole calibrated (nozzle)
4-hose connection cylinder-housing

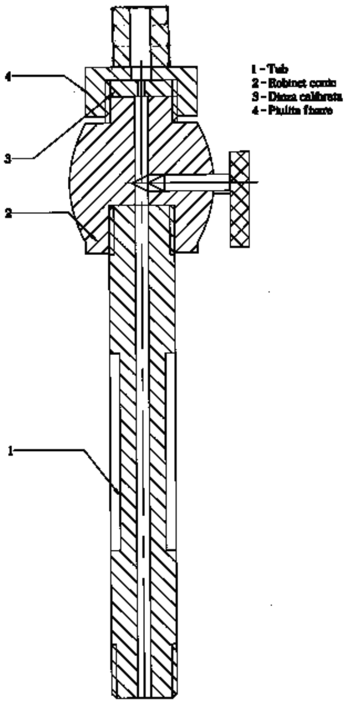

Fig. 5. Variation device combustion chamber pressure

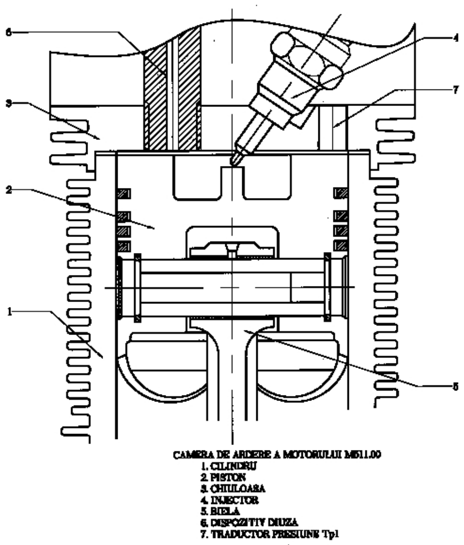

Fig. 6. Section through the combustion chamber

The tests were performed with the determination of the energy parameters obtained on the characteristic of regulator at partial loads, as well as those of pollution by determining the Bosch smoke degree (opacity) for all cases:
1.New piston rings-optimal sealing
2 Wear piston rings-low sealing
3.New piston rings with device / nozzle loss simulation
4.New piston rings with device losses / nozzles and high injection pressure at 200 bar, compared to the standard 175 bar variant.
The external determinations were corroborated with the data acquired through the LabView 6.6i acquisition system, which allows the acquisition of the pressure in the pcil cylinder, as well as the acquisition of the injection pressure p_{inj}. These acquired data will be able to be compared with those obtained through the simulated data through WordStar Professional Release 4, a program that allows numerical simulation of the process inside the combustion chamber.

3. Experimental results

The data obtained by acquisition from the experimental stand were juxtaposed with those obtained by simulation, with the help of the simulation program, the obtained results are validated.
In the case of equipping with new piston rings in which the wear was modeled only by different caliber of nozzles, it was proved correct from the point of view of the wear modeling, which can be confirmed with the situation of wear piston rings (new piston rings with 2mm nozzle molding is equivalent confirmed by allure of the p-v diagram with the situation of the wear piston rings).
In the case of simulation processing using the dedicated software, an optimal correlation of the pressure taken from the combustion chamber is observed with the pressure resulting from the simulation performed using the dedicated software.
Figure 7 shows the variation of the cylinder pressure retained on the engine but also through simulation.

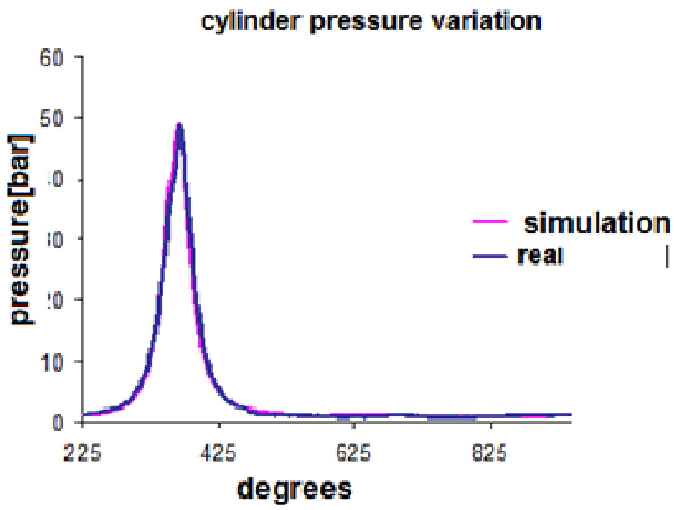

Fig. 7. Variation of cylinder pressures

The loss of pressure through leaks from the engine combustion chamber if the sealing piston rings have a wear of 0.0059mm at an engine speed of 2000 rot/min, was corroborated with a simulation that corroborates with the experimental results (fig.8).

Simulation-acquisition (real)

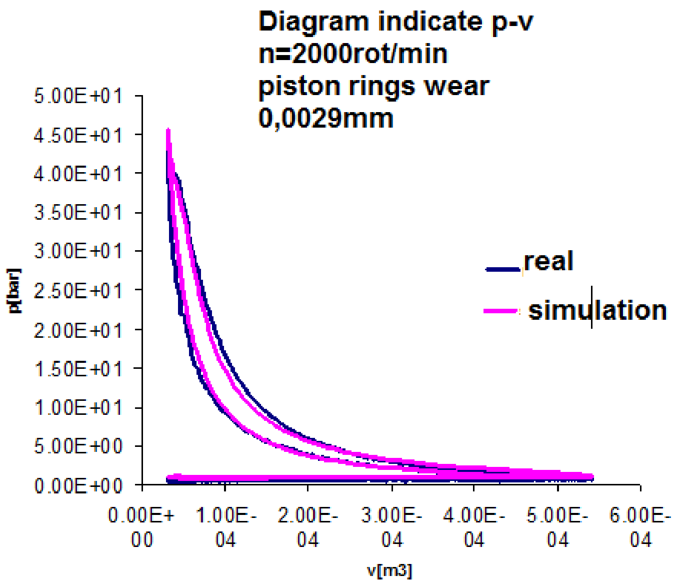

Fig. 8. Diagram indicate pressure

The evolution of the pressure losses in the combustion chambers due to their wear is appreciated by comparing the variation of the mechanical work indicated according to the engine speed (figure 9). It is observed a reduction with increasing wear due to the pumping in the cylinder, but with the tendency of increase with the engine speed.

The evolution of the coefficient of excess air is important from the point of view of the formation of the respective mixture of the combustion, but especially by its evolution with pollution that are formed. As the wear increases, the overall coefficient of excess air decreases, resulting in an increase in the degree of smoke (figure 9).

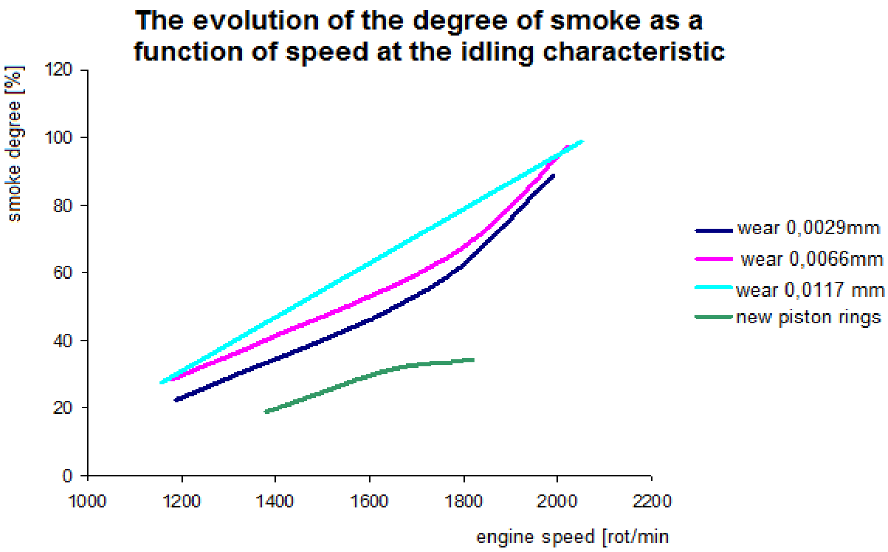

Fig. 9. The evolution of the degree of smoke as a function of speed at the idling characteristic

An important aspect was highlighted by increasing the fuel injection pressure, a parameter that can be increased in conjunction with the pressure losses in the cylinder, in this case the standard fuel pressure is 175 bar and the incresed pressure is 200 bar, resulting in a decrease in the degree of smoke and an increase in power, an aspect synthesized in the diagrams shown in figure 10 and figure 11.

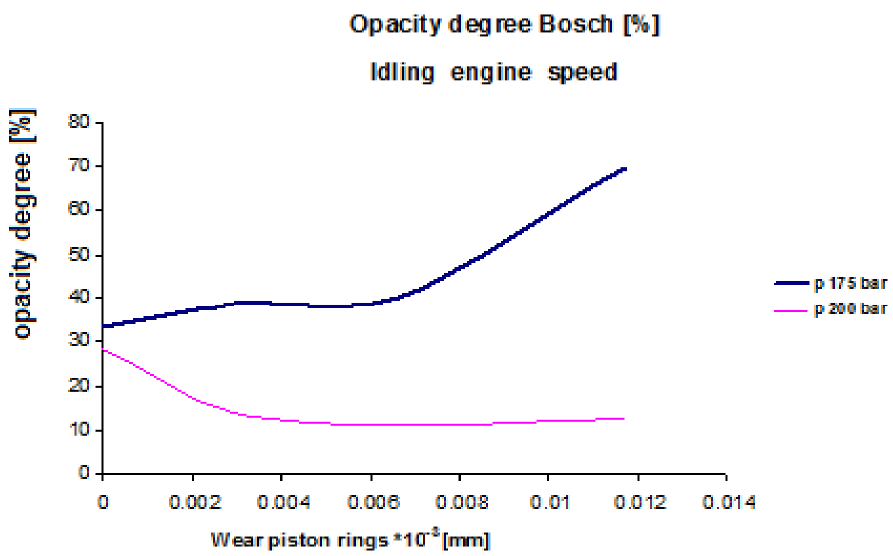

Fig. 10. Opacity variation with wear at different fuel injection pressures

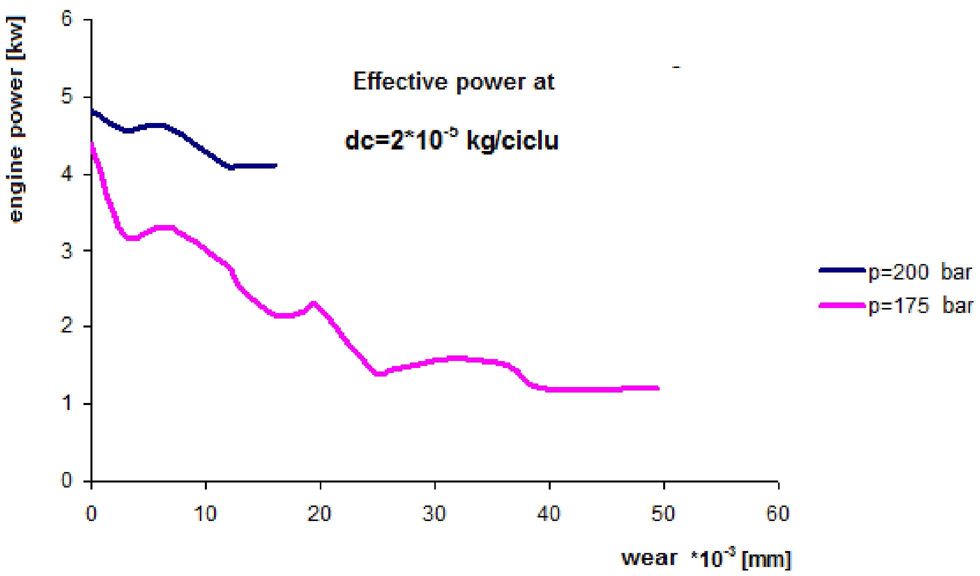

Fig. 11. Variation of the effective power at the same speed and cyclic dose as a function of wear

4. Conclusions

Following the study, it can be concluded that by quantifying the pressure losses through leaks inside the combustion chamber of a compression ignition engine, a correction can be made to the other parameters that contribute to the engine's functioning.
One parameter that can be adjusted by a modification of the ECU calculation algorithm without constructive intervention on the mechanical components, is the change of fuel injection pressure, so that the pressure reduction due to losses due to leaks in the cylinder can be compensated by an adjustment of the injection pressure within certain limits that return the output parameters of an engine to values close to the initial ones, but the proposed method involves a monitoring of the pressure on each of the cylinders of an engine correlated with the modification of the calculation algorithm from ECU.

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