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VERIFICATION OF NUMERICAL ANALYSIS FOR THE WORKING CYCLE OF AN IC ENGINE BASED ON THE EXPERIMENTAL DATA

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Abstract: Nowadays, there is a new approach to increase the production the electrical vehicles, but it still limited compared with vehicles that used the fuel. However, based on the economic and many other aspects, it can be considered that IC engines are the main part of almost all mobile systems. Despite of many effective developments to improve of the IC engines but still there is a serious disadvantage, which it's the negative effect to the environment due to usage of fossil fuels. As the consequence of this condition, European norms specified the limits of the formation of harmful components, which are reduced year by year to ensure the protection of the environment. In order to keep producing the IC engines and the competition with the electrical vehicles, it should be taken into consideration two important points, which are: reduce the emissions to the minimum level and cost. In this research paper, the numerical analyses of the working cycle of the multi-processing IC engine have been performed. The obtained results were compared with the experimental results in order to verify the numerical analysis by using ANSYS software. It can be considered the numerical approach is necessary to analyse and develop the IC engines to reduce time consumption and cost that needed to implement the experimental work.
Keywords: IC engine, emission, numerical analysis, experimental work

1. INTRODUCTION

The constant changes in emission regulations and market, demands constant development of new or improvement of existing IC engines. In the automotive industry, especially for IC engine development, experiment was always necessary. However, the experiment requires time and money.

Before starting with the production of the new part, it is necessary to perform mathematical calculations. Today, mathematical calculations, are more and more being replaced with numerical analysis. The advantage of the numerical analysis, is because can be obtained result that are very close to the experimental. By selecting the boundary conditions corresponding to the experimental one, very precise results can be obtained, with error compared to experimental up to 1.5% [1].

For IC engine working cycle modeling, two approaches can be used. The first and the oldest are mathematical models, and other is the numerical analysis, or more accurate, the CFD (Computational Fluid Dynamics) analysis. The comparison of these two approaches van be found in research [2]. They emphasized that the mathematical model requires less time. They also said that numerical analysis is enormously larger than mathematical models. However, in contrast to these good features of this mathematical model, they said that for the modeling of the heat release, the required input is cylinder pressure that is obtained experimentally or in some other way. In contrast, the CFD simulation gives the pressure value in the engine cylinder as well as the heat release.

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Also, interest research is performed, in order to determine the heat transfer, through the cylinder walls. For such research, it is enough to observe, only the combustion process, and it as the model for the 3D analysis, it can be used only the slice of the cylinder [3].
The advantage of the numerical analysis during the development process, is testing of the different engine parameters, in order for production starting with the best possible solution. For example, for the same engine geometry, it can be tested the influence of the spark timing on combustion process, in order to achieve the best solution [4].
It is important to say, that by the usage of the numerical analysis, not always entire cycle must to be simulated. For example, it can be simulated just the intake stroke, in order to analyze the air flow in the intake port, which can be very important for cylinder charge and engine work.
The main goal of this research, is modeling of the working cycle of the multi-processing engine that is in basic diesel engine, but in this case, is modified to work as a gasoline engine. Also, the analysis results will be compared with the experimental in order to determine accuracy of the analysis.

2. EXPERIMENTAL RESARCH

For experimental research, one cylinder, air cooled diesel engine was used, that is modified to work as gasoline.

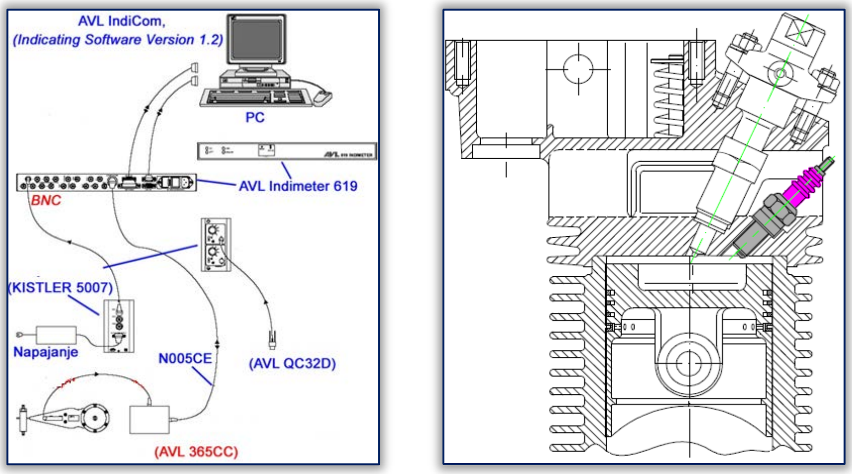


Figure 1. Measurement installation and engine modification

As control parameter for the analysis accuracy, the cylinder pressure was chosen, so during the experiment, only cylinder pressure was measured. The measurement installation and engine modification, is shown on Figure 1. The pressure is measured on one regime. The experimental conditions are:

— Engine speed $n = 2690$ rpm
— Engine load $F = 29$ N

3. 3D MODEL AND BOUNDARY CONDITIONS

In order to perform the working cycle simulation, it is modelled the engine geometry that corresponds to the experimental engine. This is important because of the compression ratio, which depends from engine geometry. The 3D model used for the analysis, is shown on Figure 2.
It can be seen that injection position and spark plug position are defined. This two position corresponds to modifications that are made to the experimental engine.

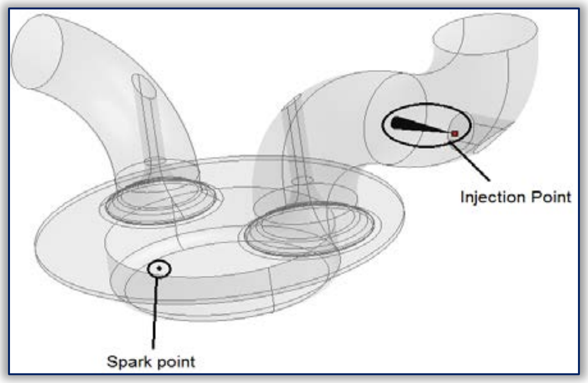


Figure 2. 3D model

The boundary conditions that are used for the analysis, are experimentally obtained data. This boundary conditions are next:

— Amount of injected fuel per cycle $m_g = 0.021$ g
— Spark timing $s_t = 12$ °CA BTDP
— Engine speed $n = 2690$ rpm

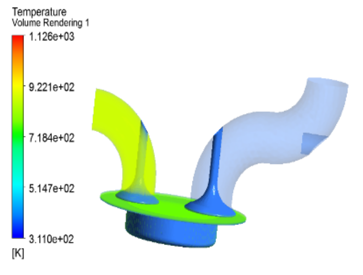
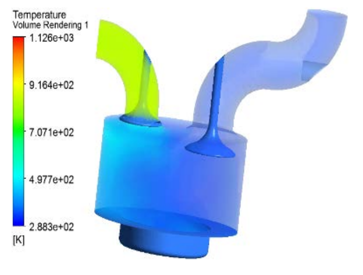
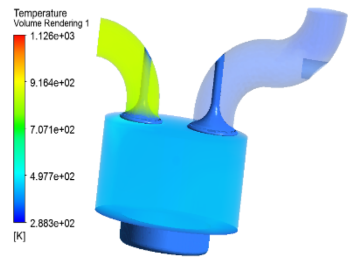
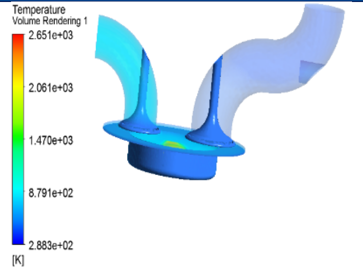
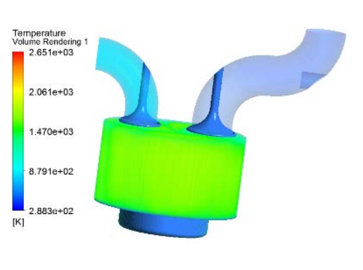
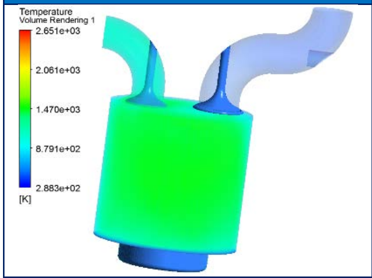
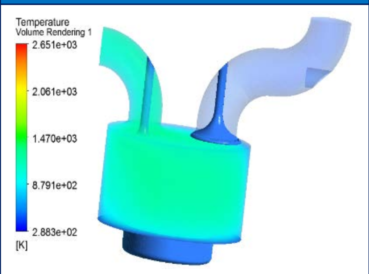
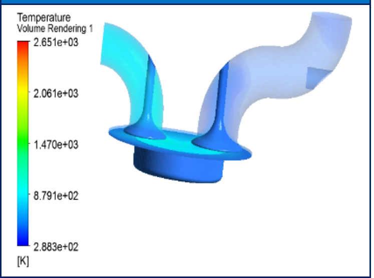
Also, important input is fuel composition. The experiment was performed with the fuel that have octane number 95. Because of this, fuel is defined as a mixture of 95% of octane, and 5% of heptane.

4. RESULTS AND DISCUSION

One of the best characteristic of numerical analysis with respect to the mathematical model is a visualization of the working cycle. This can be seen in Figures in Table 1.
From Figures that are shown in Table 1, it can be seen that the highest temperature, obtained during the simulation is 2651 K. This temperature corresponds to the temperature of the gasoline combustion, so this can be one more parameter that is showing the accuracy of the simulation. But

as the control parameter, cylinder pressure was taken, so the comparison between experimentally obtained and numerical can be seen in Figure 3.

Table 1.Visualization of the simulated working cycle

		
0°CA	90°CA	180°CA
		
270°CA	360°CA	450°CA
		
540°CA	630°CA	720°CA

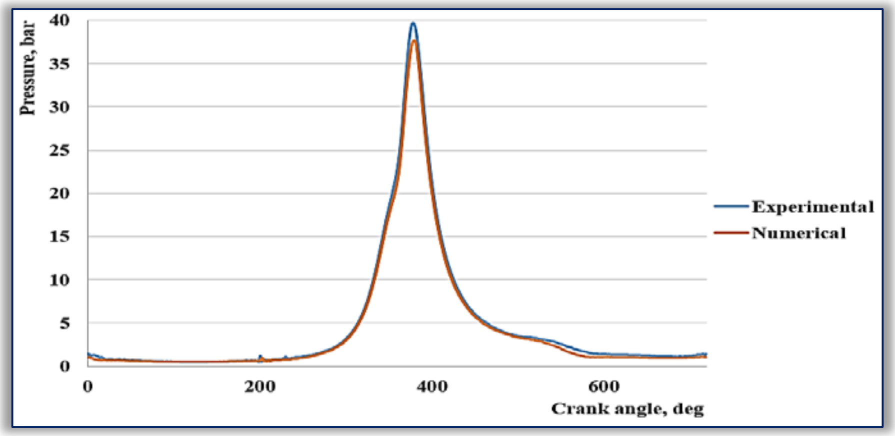


Figure 3. Cylinder pressure

By analyzing the Figure 3 it can be concluded, that these two curves are very similar. For more accurate analysis, it was found that the maximal pressure, obtained from the experiment is 39.68 bar, and it is found at 19°CA ATDP. Maximal pressure obtained by numerical analysis is 37.44 bar, and it is found at 20°CA ATDP. Based on this, it can be said that the differences between maximal values and their position are not big, so it can be said that the analysis is successful.

5. CONCLUSION

The numerical analyses can be very useful in the period of the product development. It is proved that the obtained results, can be very similar to the experimental. Of course, very important are the boundary conditions that are applied.

Because of this, numerical analyses, cannot completely replace the experiment. However, the numerical analysis is much better than mathematical models. One of the reasons is a visualization of physical phenomena that is simulated.

In the case that is observed in the paper, it can be concluded that the numerical analysis, has given the best results, so it can be said that the research goal has been achieved.

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