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# STUDY ABOUT IMPACTS OF VARIABLE CAMSHAFT TIMING IN EFFICIENCY OF AUTOMOTIVE ENGINES

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***Abstract.*** *This work has the purpose of evaluating the efficiency of Otto cycle engines with fixed and variable valve timing by Diesel-RK simulation software. First, the historical on internal combustion engines of Otto cycle was done in order to improve understanding on introduction to the mechanisms and operation of the engines. Second, the theory revision was performed to different types of valve control, specially on operating methods that include mechanical, hydraulic and electronic engine. In the next step, the presentation and use of simulation software was made with the definition of input parameters and the way to obtain the results that indicates the best valve control with real efficiency. The results showed that the Otto cycle engine efficiency equipped with variable valve timing were 15% higher than Otto cycle engine equipped with fixed valve timing.*

***Keywords:*** *Engines, Simulation, Variable camshaft.*

## 1. INTRODUCTION

For the analysis of the Impact Assessment of Variable Camshaft in Automotive Engine Efficiency, the software DIESEL– RK$^{TM}$ has been used. This is a thermodynamic simulation software for engine applications which was developed to assess the performance, rational choice of setting and constructive parameters of internal combustion engines, either two or four courses. Also, this is enables for studying the optimization of the camshafts and the design of the input ports and output of engine gases.

This paper presents that the application of variable valve timing in internal combustion engines is more efficient than the fixed camshaft.

## 2. EXPERIMENTAL DATA MANIPULATION

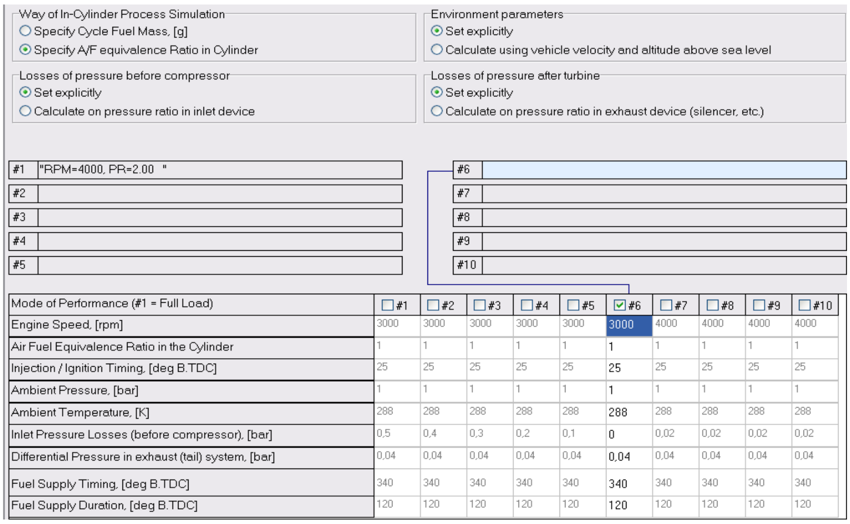
Since the start of software design were being incremented improvements expanding the range of variables and possible simulations, computational other options were introduced in software to meet the demands of industrial companies, including software users, one being one of the largest engine manufacturers in Russia. The first software version with an improved interface capable of calculating toxic emissions with EGR system, multi-parameter functions, occurred in 1991.

The multi-parameter function used in the software ensures a considerable increase in the numerical investigation efficiency improves assessment of the technical level of the engines. The calculation of emissions (NOx) is performed by the latest technologies, using the Zeldovich scheme with detailed kinetic mechanism.

The DIESEL – RK$^{TM}$ is a tool that enables the creation of a desired model by the designer, and the entered data is sent to the server in Russia which is compiled, and then presents the results. The software also allows applications to fuel consumption forecast and its optimization, construction of the torque curve and engine performance, combustion and emissions analysis including lower calorific fuel (PCI), evaluation of camshafts, EGR analysis and conversion of diesel engines to gas.

To carry out this work using the DIESEL – RK$^{TM}$ software, they were employed all data provided to the engine of a motor vehicle 2.0 140 hp, and command with 16 valves. The engine studied is composed of 4 cylinders in line with 1998 cm3 of internal volume, four stroke, spark ignition, with the fuel gas, the outer diameter of the piston is also 86.0 mm and 86.0 mm travel, and the compression ratio for this fuel is 9.6: 1, wherein the speed range to be studied shall be 1000 at 6000 rpm.

It first carried out a simulation engine for this considering that it has fixed valve timing and the point of optimum ignition, respecting a rule the number of octane (90) for fuel, gasoline. In this condition the scan simulation was performed by varying the ignition timing for the main speed ranging 1000-6000 rpm. It also evaluated when operating in minimum speed rotation of maximum torque, maximum power rotation and last rotation, where for every speed range were analyzed various loads by varying the pressure in the intake manifold of 0.5 [bar ] to WOT, as shown in Fig. 1.




| Mode of Performance (#1 = Full Load) | #1 | #2 | #3 | #4 | #5 | #6 | #7 | #8 | #9 | #10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Engine Speed, [rpm] | 3000 | 3000 | 3000 | 3000 | 3000 | 3000 | 4000 | 4000 | 4000 | 4000 |
| Air Fuel Equivalence Ratio in the Cylinder | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Injection / Ignition Timing, [deg B.TDC] | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 | 25 |
| Ambient Pressure, [bar] | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Ambient Temperature, [K] | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 | 288 |
| Inlet Pressure Losses (before compressor), [bar] | 0,5 | 0,4 | 0,3 | 0,2 | 0,1 | 0 | 0,02 | 0,02 | 0,02 | 0,02 |
| Differential Pressure in exhaust (tail) system, [bar] | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 | 0,04 |
| Fuel Supply Timing, [deg B.TDC] | 340 | 340 | 340 | 340 | 340 | 340 | 340 | 340 | 340 | 340 |
| Fuel Supply Duration, [deg B.TDC] | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 | 120 |

Figure 1 - Ideal ignition point of retrieval.

With ignition points obtained by simulation of one-dimensional scan with fixed command, the next step was to conduct a 2D scanning a two-dimensional scan of the valve opening points where the optimal values were obtained for variable valve timing controlled opening of the intake valve IVO ( intake valve opening) and exhaust opening of the (exhaust valve opening) EVO valve. With IVO and EVO values, simulations similar to the engine with fixed valve timing for the optimal values of ignition timing / spark were held. Figure 2 shows the results of the 2D scanning.

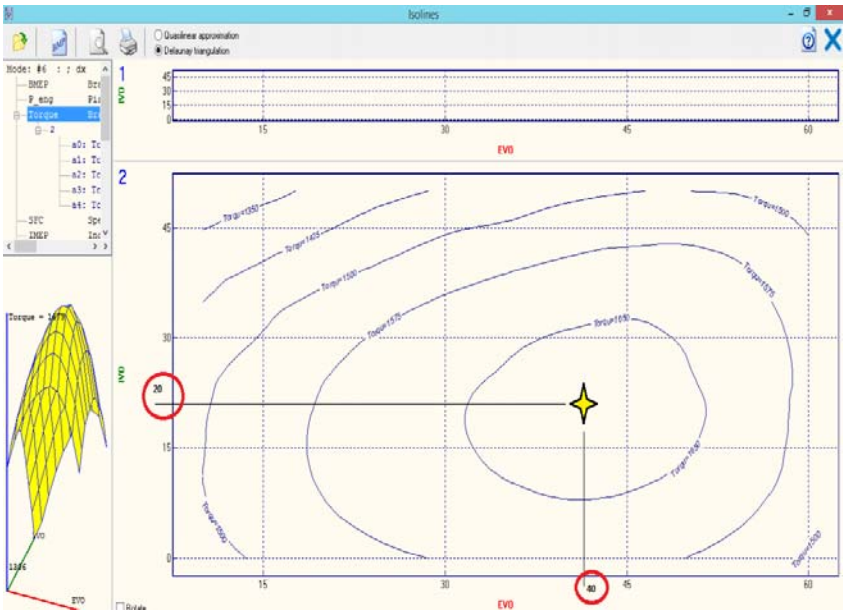



Figure 2 - Scanning 2D results.

With the motor values with fixed command and motor with variable command to parse the friction surface results, volumetric efficiency, torque & power curve, exhaust temperature and then for NOx for both commands are discussed. The friction surface shows that the frictional power increases with the load and rotation. With increasing rotation, the shear rate increases in plain bearings, so resulting in a higher drag force. By analyzing the internal phenomena should be considered the oil film as a Couette flow, a phenomenon explained by Fox and McDonald (2006).

According (Taylor, 1976) when the shear rate is increased with an increase in counter-force to slip from the oil viscosity, which explains the greater power required to overcome the friction at high speed as shown in Fig. 3.

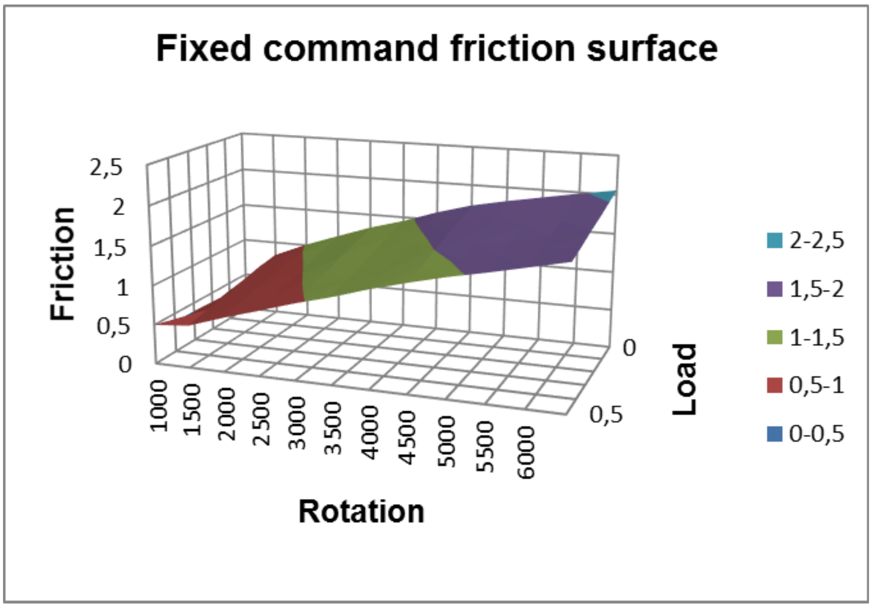



Figure 3 - Fixed command friction surface.

In the friction surface with a variable command, shows that as the load behavior, it may be noted that the frictional power increases as the engine tends to higher loads WOT to explain this behavior have to look for the piston mechanism – rod.

Except in the dead points, there is always an angle between the connecting rod and the piston axis such that decompose forces arising from the pressure in the combustion chamber always have horizontal component, forcing the piston against the cylinder. The greater the pressure exerted on the piston, the greater the horizontal force component, so the higher the load exerted by the engine, the larger the frictional force between the piston rings and cylinder, as shown in Fig. 4.

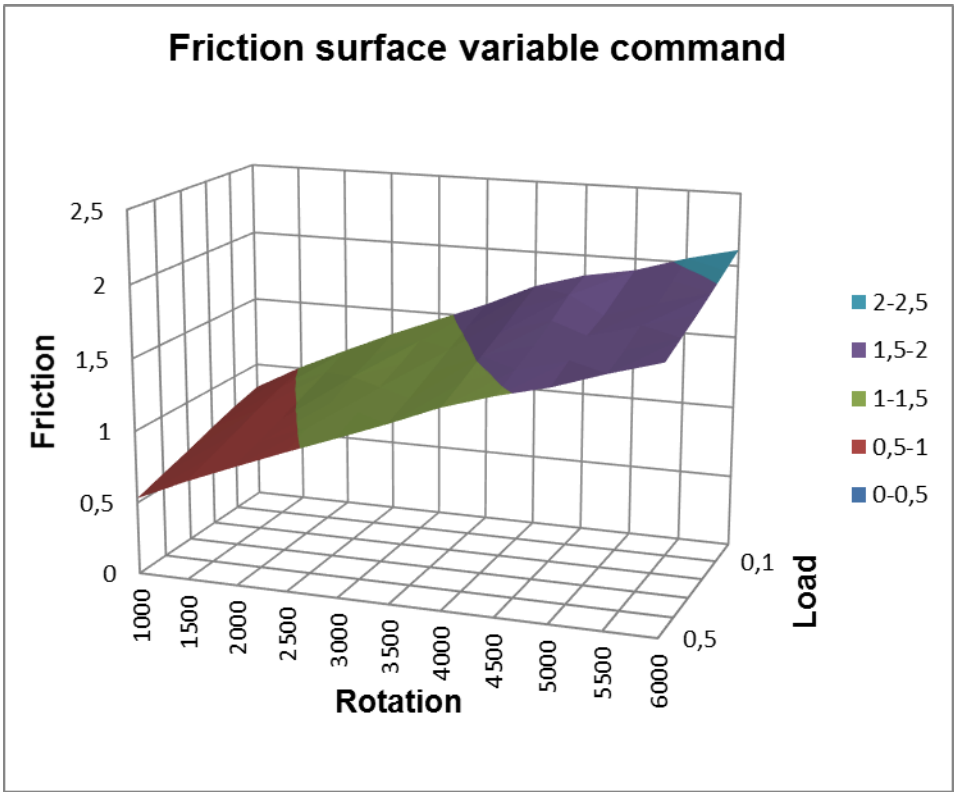



Figure 4 - Command variable friction surface.

As a result of this effort, we have the “roundness cylinders ", a phenomenon quite found in remanufactured engines.

The volumetric efficiency, we find that there is a drop at high rotation (*rpm*). To explain this fall we must analyze the air flow into the engine as shown in Fig. 4. The period in degrees that the valve is open is constant because the cam format, 240 of crankshaft, however, must be analyzed in the time domain. Note that with increasing rotation, the time the valve is open is reduced, requiring more air inlet velocity, so there is greater loss of load on the valve, hindering the filler piston, which explains the decrease in volumetric efficiency at high speeds.

The difference between the curves with fixed and variable command shows the importance of valve opening point. The variable opening command has the same duration as the fixed command, and thus suffers from the high flow velocities in the high revs, but translate the beginning of opening valves cause's adjustments in the pressure regime and the residual fraction of exhaust gases, resulting in effects beneficial to the filling of cylinders.

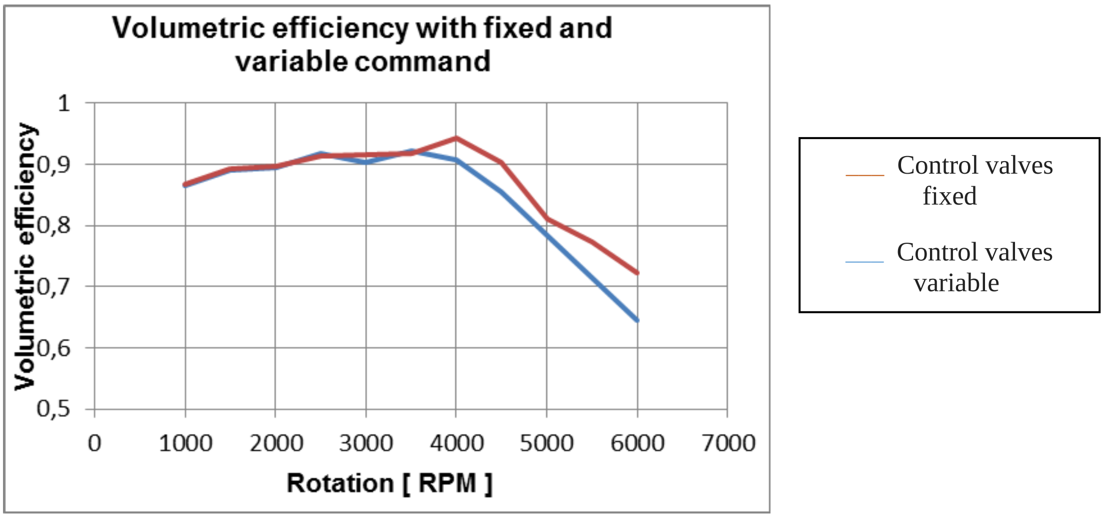



Figure 4 - Volumetric efficiency with fixed charge and variable charge

Throughout this work performed by the simulation it is concluded that the application of variable valve timing in internal combustion engines is more efficient than the fixed camshaft for the following reasons:
a) The command variable reduces the pumping work in the gas exchange, e.g., the pressure loss in the intake air flowing into the cylinder and the pressure loss in the flow of combustion products out of the engine are reduced;
b) The engine volumetric efficiency is increased due to adjustments made by varying commands, the opening and closing point of the intake and exhaust valves resulting in beneficial effects on cylinder filling;
c) Friction surface for the engine with variable command is 15% more efficient when compared to the motor with fixed command;
d) The torque and engine power equipped with variable valve timing is superior to that observed in motor equipped with fixed valve timing, in which the behavior is a reflection of the adjustment made by the variable valve timing at the opening of the valves;
e) For the variable valve timing, there is versatility in the engine adjustment, that is, for each engine operating condition there is a great setting for opening and closing the intake and exhaust valves;
f) The specific fuel consumption showed little variation, but signaling to the variable valve timing engine as more economical when compared to the fixed valve timing engine, by reducing the pumping work, as discoursed.

## 3. CONCLUSION

It is known that the torque and power are directly connected by the rotation, and it was possible to note that the maximum torque is attained at 2500 *rpm* from 2500 *rpm*, the torque begins to decrease due to constant high speed fresh air filling the cylinder. It makes it harder for the opening and closing of the valve is very fast in high gear with this result. It may also be noted that the power increases from 1000 to approximately 4500 *rpm* at this point from the power begins to drop due to frictional force between the piston and the jacket, and between the thin oil that lubricates the roller bed that force friction increases the greater the rotation.

The direct connection of the exhaust temperature with the formation of *NOx* during the combustion shows that temperatures reach levels that favor *NOx* formation (over 1700 *K*), and the higher the temperature, the greater the occurrence of the phenomenon.

From the energy point of view, the mass fraction of nitrogen oxides is so low that can usually be neglected, but its study is important for the environmental problems it causes.

## 4. REFERENCES

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## 5. RESPONSIBILITY NOTICE

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