Effect of ignition time and spark plug position on combustion pressure in engine cylinder in OpenFOAM

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1 Introduction

The aim of this project was to exam influence of different ignition time and spark plug position on pressure in engine combustion chamber. This project simulate physics of the premixed turbulent combustion in the Spark-Ignition engine.

2 Numerical Model

All cases was based on kivaTest tutorial. Geometry of kivaTest was used in all cases. In this project only compression and combustion phase of the engine was consider from BDC (-180 crank angle) to +60 CA. Models used in simulation: transport flame wrinkling model, k-e turbulent model, Gulders flame speed model, heheuPsiThermo thermophysical model. Inhomogenous mixture properties, Sutherland transport properties, perfect gas equation of state, the stoichiometric air to fuel ratio is 15.0336.

Bore	92 mm
Stroke	84.23 mm
Clearance	1.15 mm
Connectiong rod length	147 mm
Equivalence ratio	1
Fuel	IsoOctane
Rotation speed	1500 rpm

3 Cases

At first a case without ignition was simulated as reference. Then the ignition cases from -20 CA to + 10 CA with step 5 CA were calculated for the spark plug located within a radius of 30 mm from the center of the cylinder between the exhaust valves. Next step was calculations for different spark plug position: within a radius of 15 mm from the center of the cylinder between the exhaust valves and spark plug located in centre, those two cases were simulated for -15 CA.

4 Results

First figure show case without ignition as reference. Results that can be seen in the plots on figures 2-8 show, that the more delayed ignition the lower pressure peak and lower pressure sustain. Figure 9 show summary of different time ignition. Plots of figures 3, 10, 11 show that the closer position of spark plug to the centre the higher pressure peak after ignition and the higher pressure sustain. Figure 12 show summary of different spark plug position. Last 13 figure show summary of all cases on one plot.

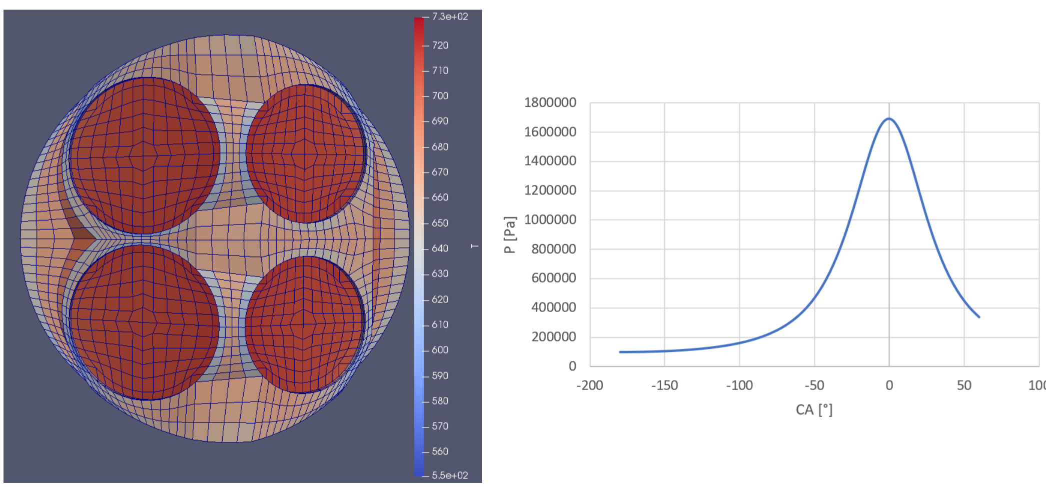

Figure 1: No ignition

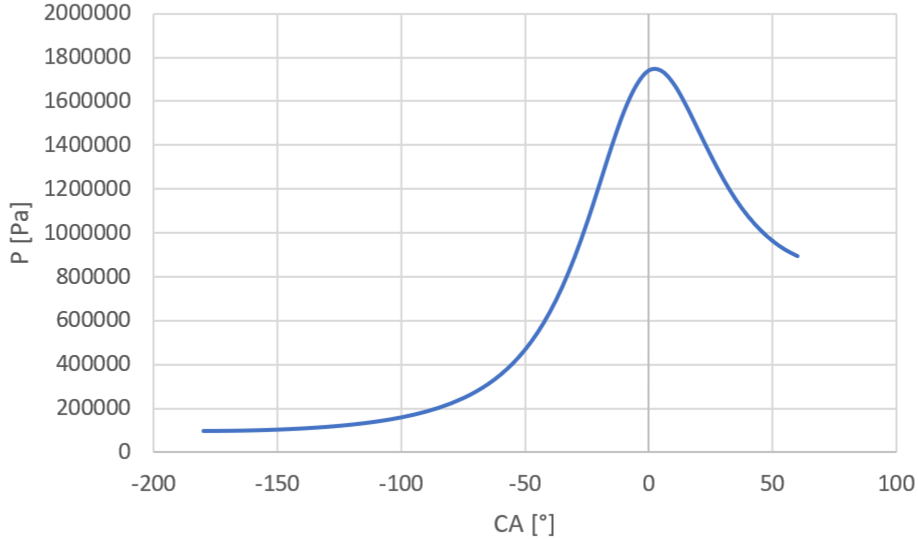

Figure 2: Ignition at -20 CA and 30 mm radius

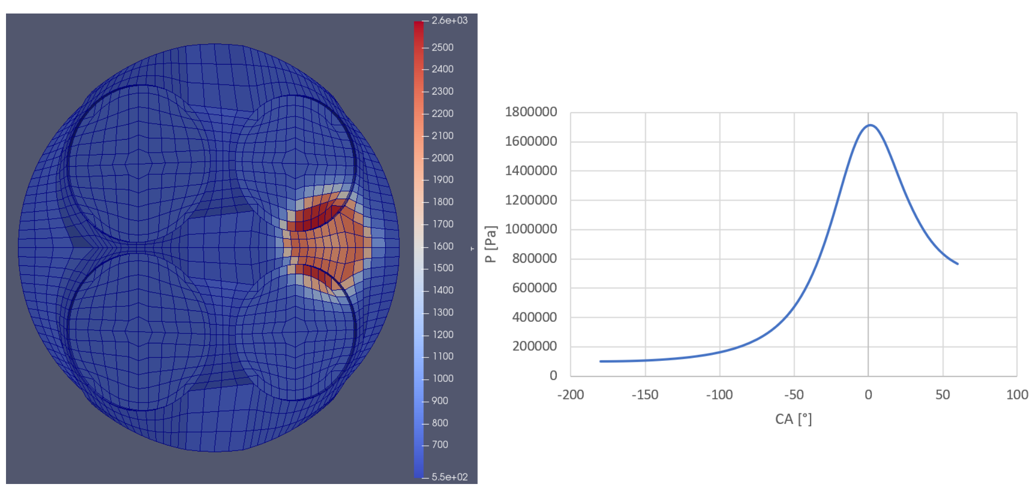

Figure 3: Ignition at -15 CA and 30 mm radius

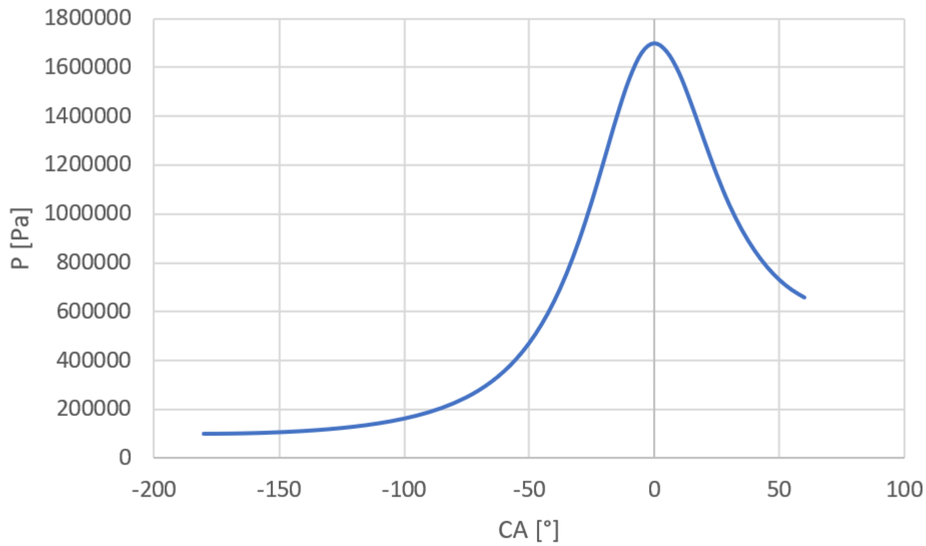

Figure 4: Ignition at -10 CA and 30 mm radius

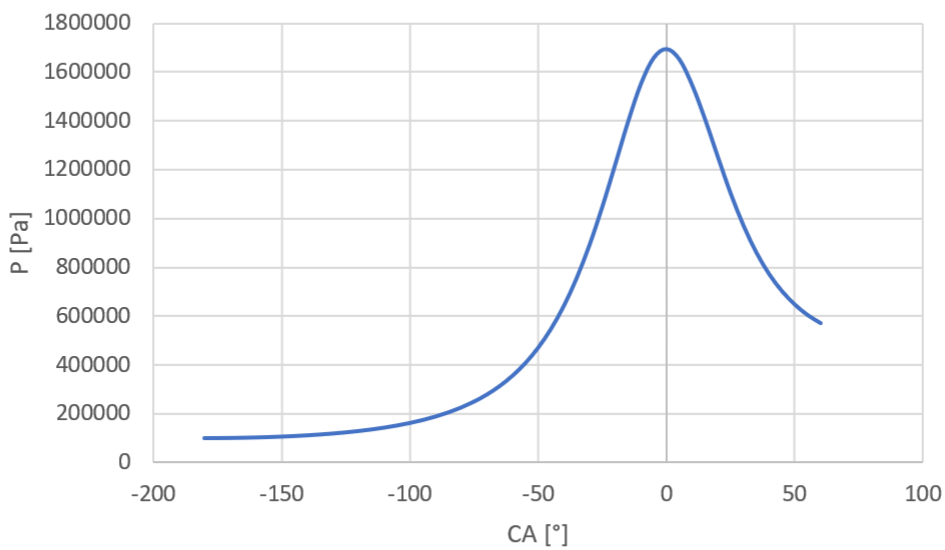

Figure 5: Ignition at -5 CA and 30 mm radius

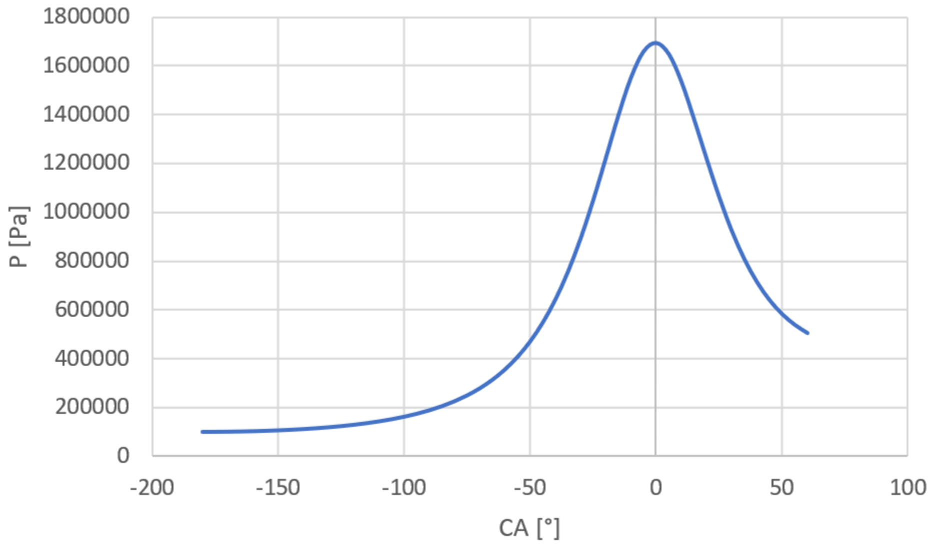

Figure 6: Ignition at 0 CA and 30 mm radius

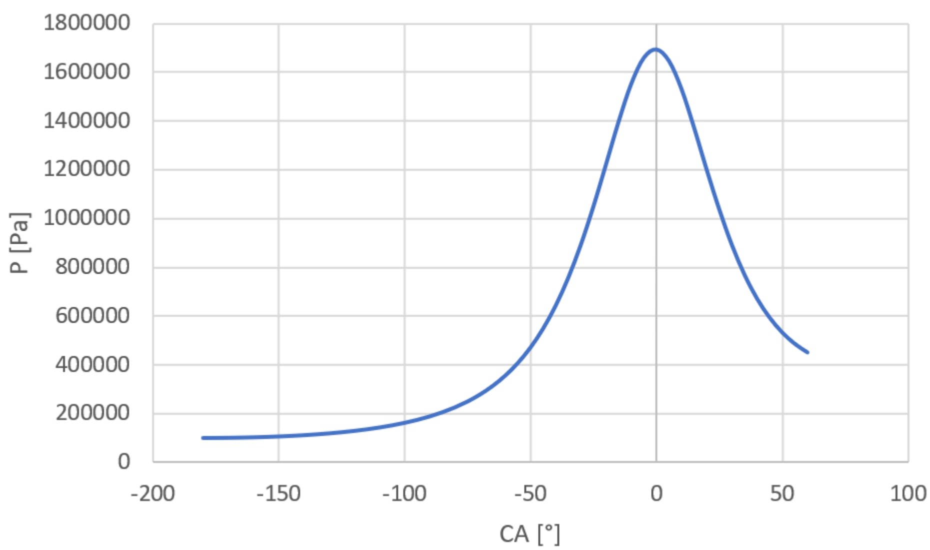

Figure 7: Ignition at 5 CA and 30 mm radius

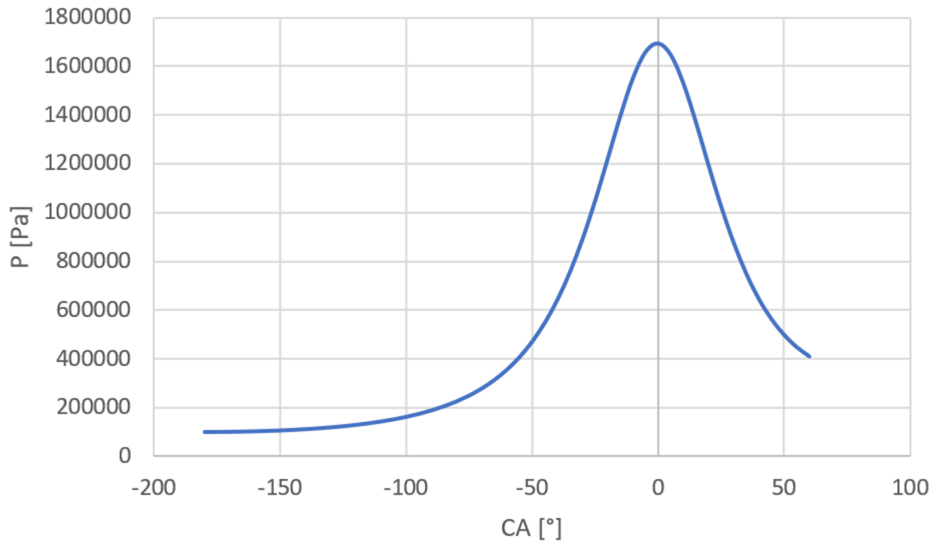

Figure 8: Ignition at 10 CA and 30 mm radius

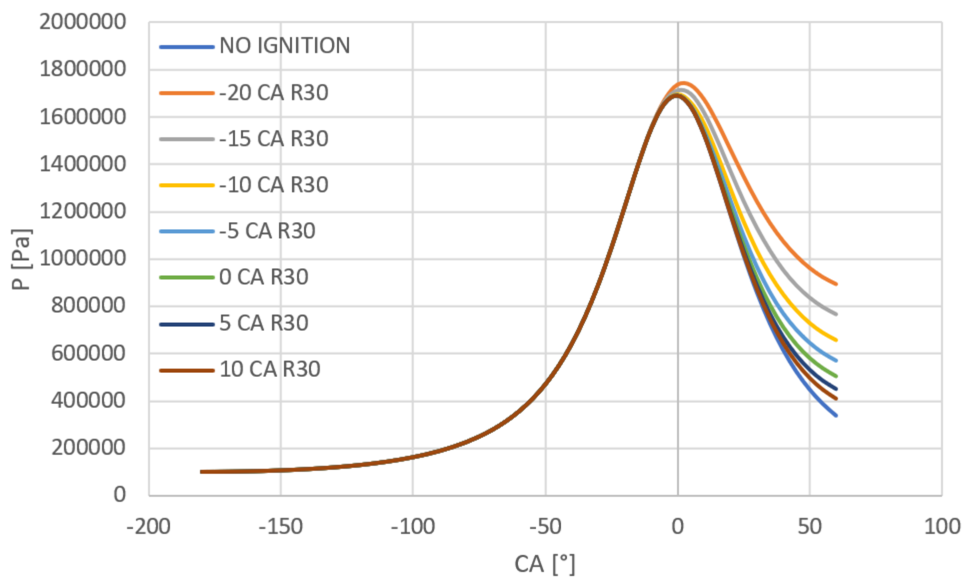

Figure 9: Summary of different ignition time

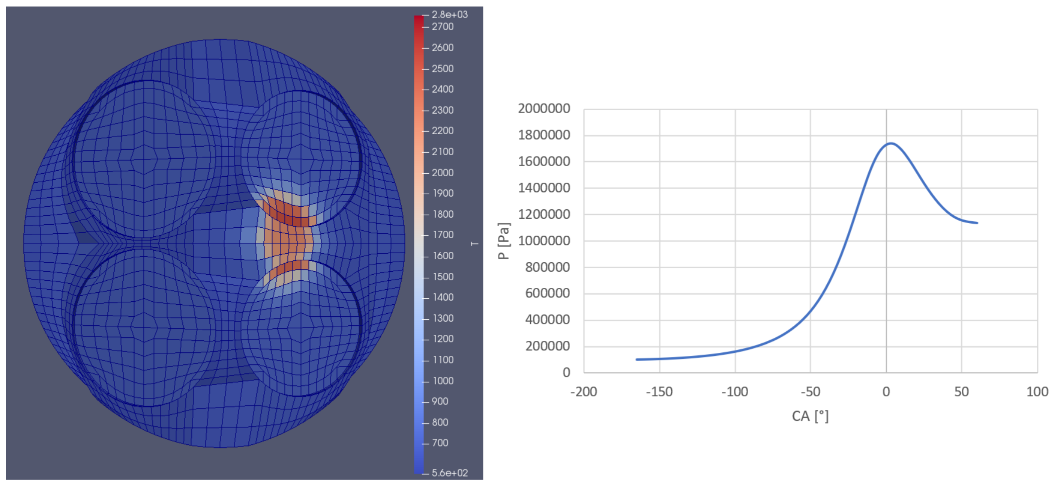

Figure 10: Ignition at -15 CA and 15 mm radius

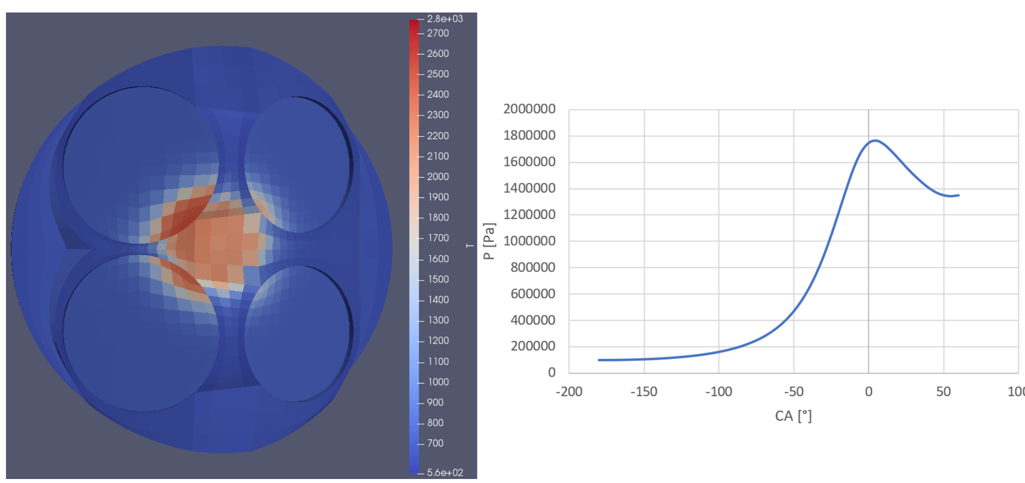

Figure 11: Ignition at -15 CA at centre

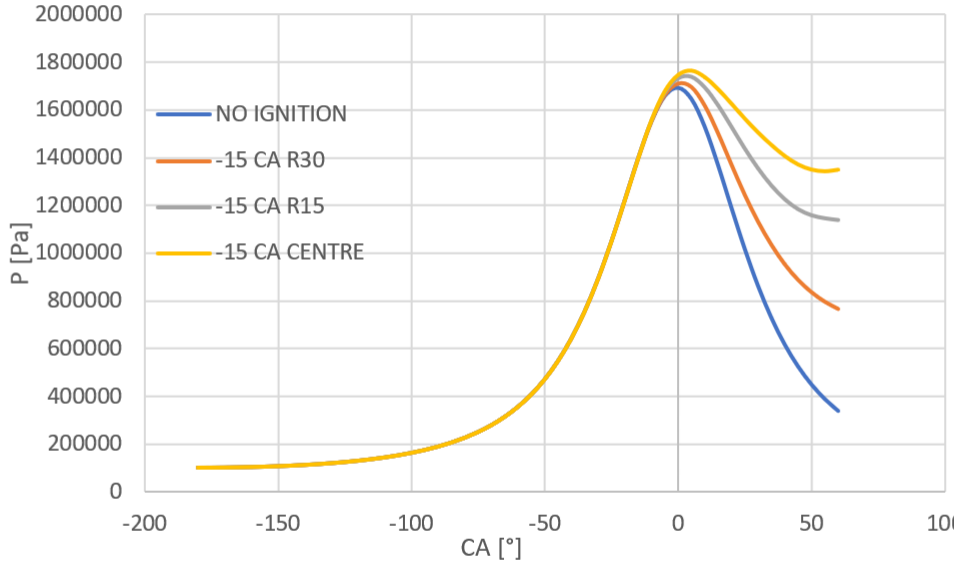

Figure 12: Summary of different spark plug position

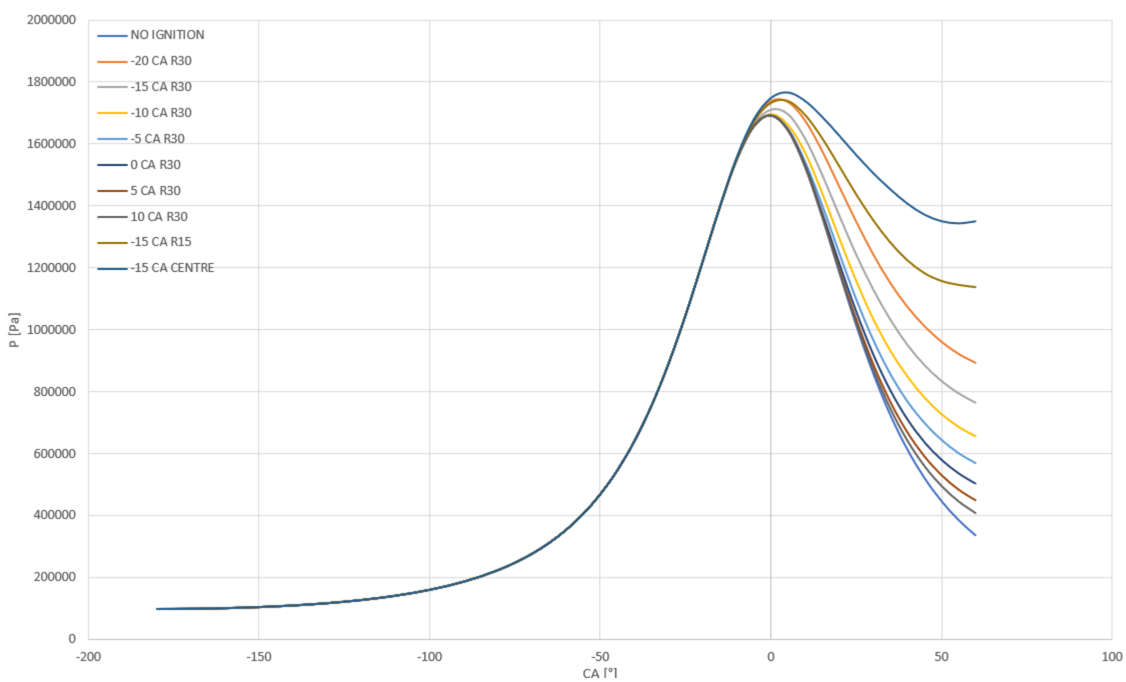

Figure 13: Summary of all cases

5 Conclusion

In general, results of this project are consistent to other sources. The most probably reason why pressure peak after ignition is low is the transport flame wrinkling model, for more realistic results better to use Zimont or Muppala model. Moving the spark plug closer to the center (or using multiple spark plugs) improves engine performance. Setting spark plug at the centre gives irregular result. Setting time ignition before TDC results in higher pressure peak than after TDC, but too fast growing pressure will disturb piston movement.

6 Sources

1. http://www.tfd.chalmers.se/ hani/kurser/OS$_{C}FD_{2}018/SandipWadekar/revisedReport_{S}andipWadekar$

2. https://pdfs.semanticscholar.org/ec8e/5058c6093617897295a4b485e33d71d37b22.pdf (18.06.2020)

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