

University of Wales Trinity Saint David

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Engine Cycle Simulation

Powertrain and Simulation: M5X00404

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1 Introduction

The engine used in this simulation was a naturally aspirated Ford Sigma 1.6L. This model of engine is a straight-4 automobile engine which came into production in 1995.

The objective was to determine the in-cylinder parameters and characteristics of the test Ford Sigma 1.6L engine and create a thermodynamic engine simulation model. Cylinder 1 of the engine's data was used throughout the report to simplify results and keep the calculations within the rev ranges steady to not cause abnormal values.

This data paired with graphs aids in the understanding on how the engine runs. It allows for energy, power, thermodynamic values for a single cylinder to be calculated for better tuning of the engine. This can make the engine more efficient or more powerful depending on what the end goal is.

2 Results

2.1 Results taken from test data

The graphs below were taken at low, middle and high rpm to get an idea on how the engine performs in these three areas. The revs chosen were 1500rpm, 4000rpm and 6000rpm respectively.

2.1.1 Results at 1500rpm

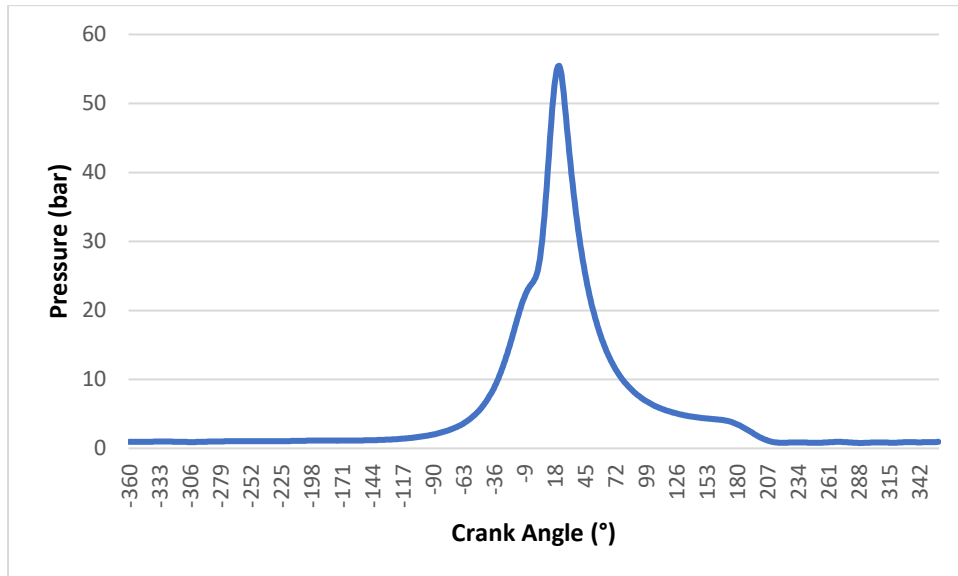


Figure 1 - Graph showing pressure against crank angle at 1500rpm

Graph not very smooth due to test data errors at low rpm.

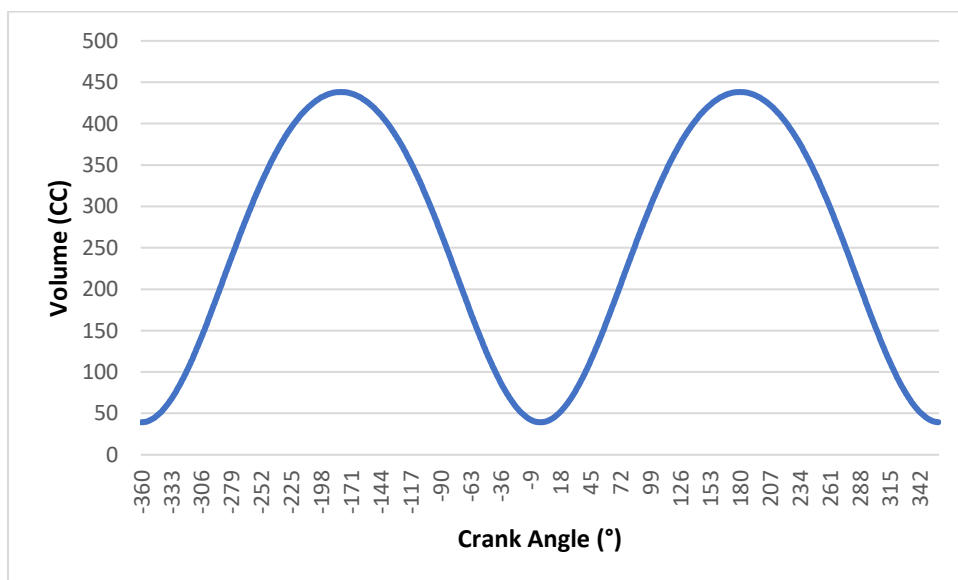


Figure 2 - Graph showing volume against crank angle at 1500rpm

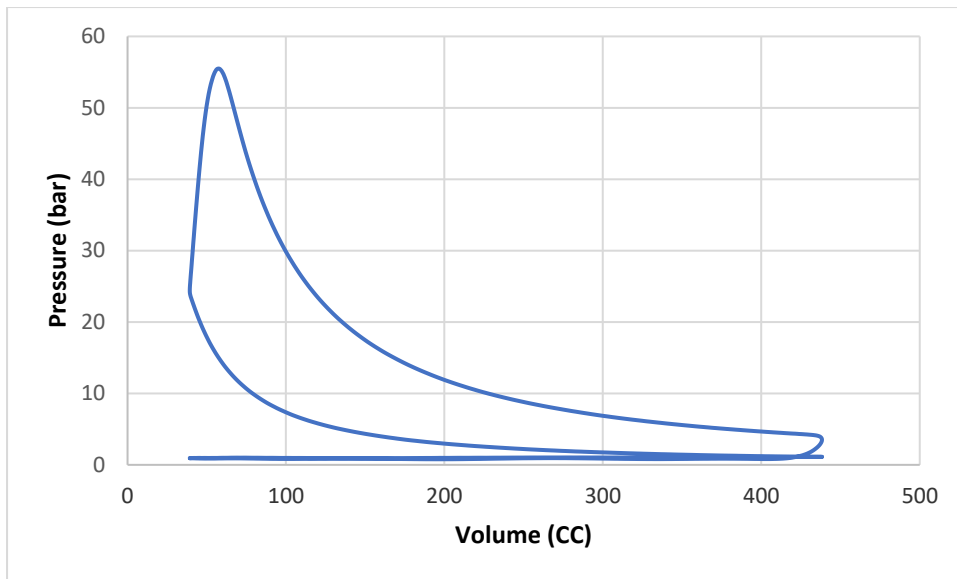


Figure 3 - Graph showing pressure against volume at 1500rpm

Graph has some rough edges for the Otto cycle due to test data errors at low rpm.

2.1.2 Results at 4000rpm

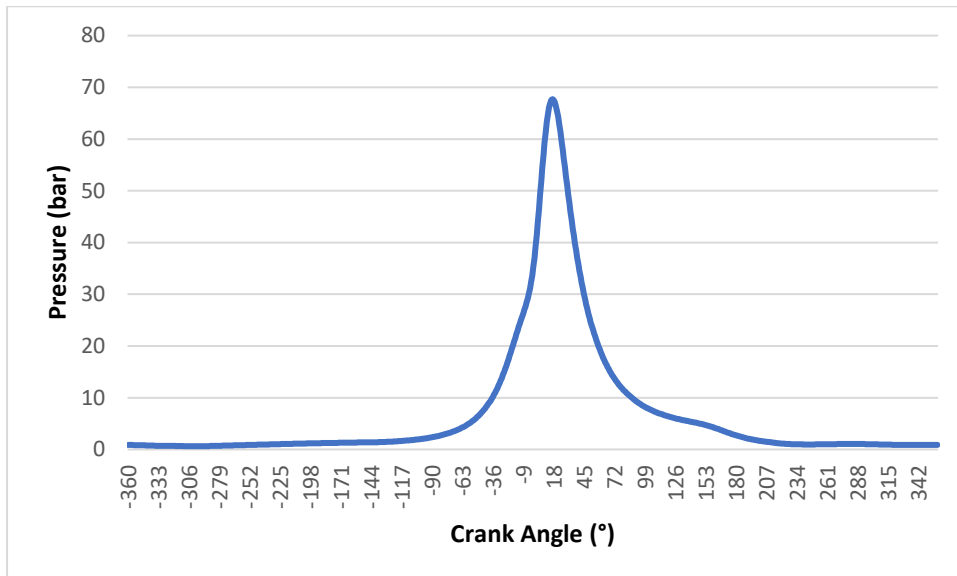


Figure 4 - Graph showing pressure against crank angle at 4000rpm

Graph smoothing out at the medium rpm range.

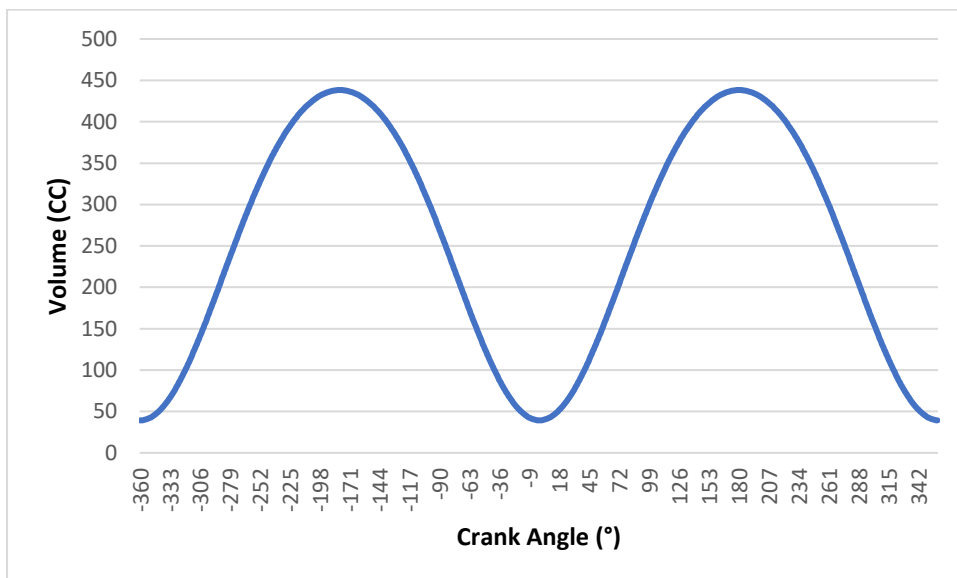


Figure 5 - Graph showing volume against crank angle at 4000rpm

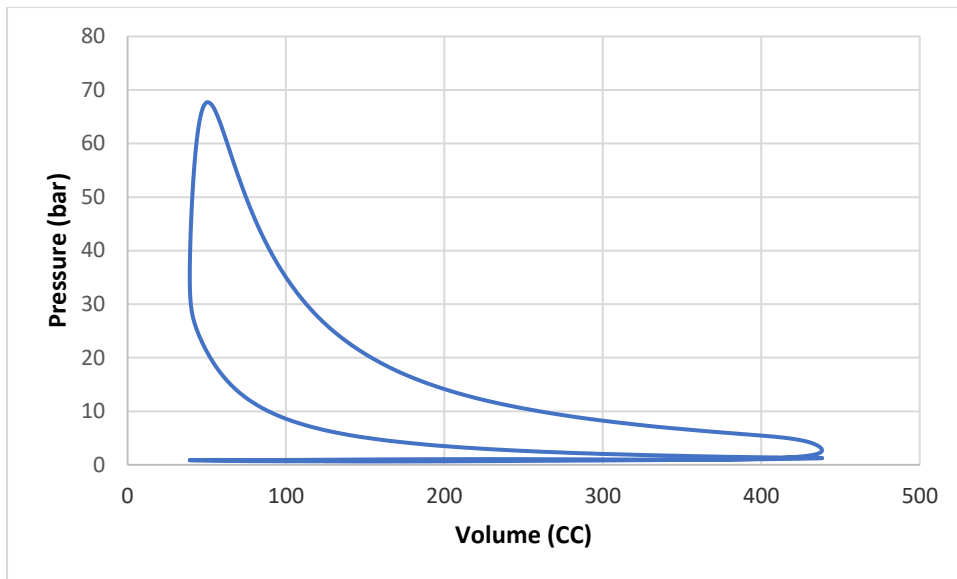


Figure 6 - Graph showing pressure against volume for 4000rpm

Graph has fewer rough edges for the Otto cycle due to test data errors at medium rpm.

2.1.3 Results at 6000rpm

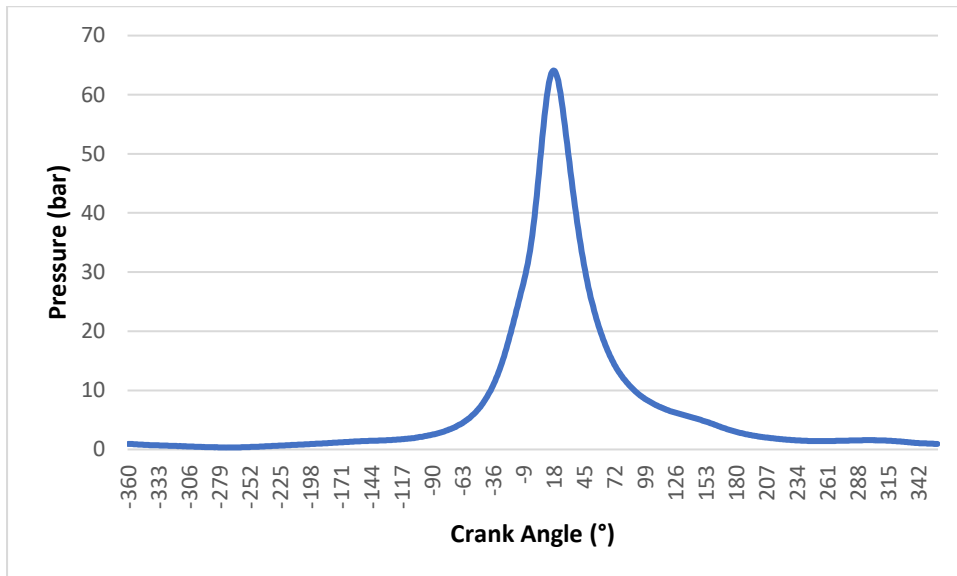


Figure 7 - Graph showing pressure against crank angle at 6000rpm

Graph completely smooth at high rpm range of data.

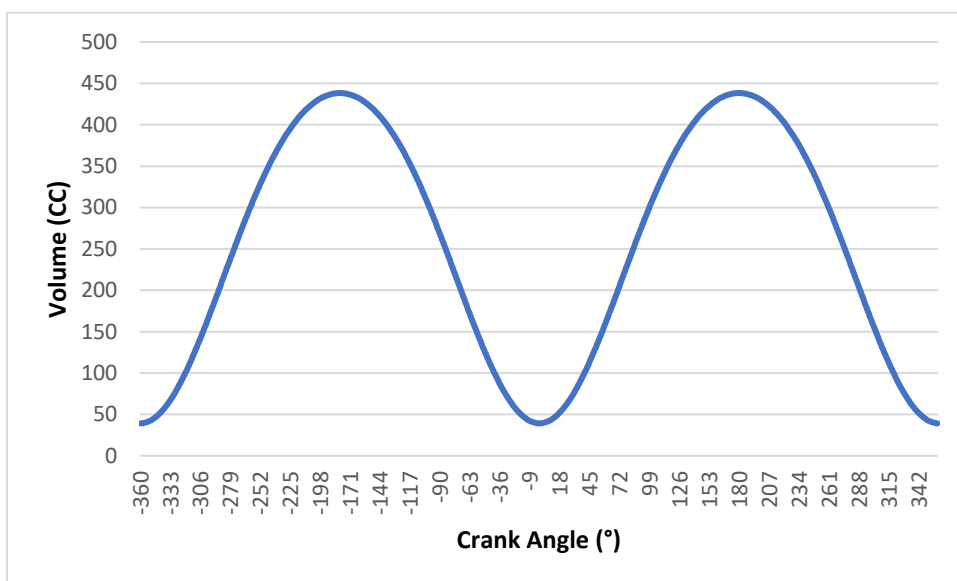


Figure 8 - Graph showing volume against crank angle at 6000rpm

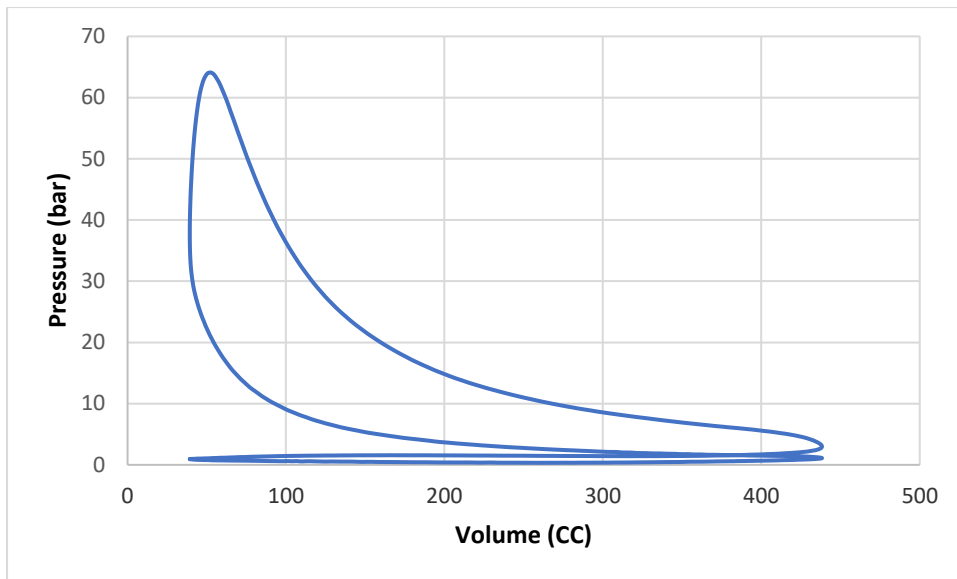


Figure 9 - Graph showing pressure against volume at 6000rpm

Graph completely smooth for the Otto cycle at high rpm data ranges. Work done calculated using this graph and was found to be 255.77kJ.

4 Analysis

The graphs at 1500rpm were not very smooth. This is due to the test data at such a low rpm is difficult to attain good measurements. As the rpm increased the smoothness of the graphs also increased. This allowed some decent results at high rpm.

Figures 1, 4 and 7 show how combustion pressure changes with crank angle. Figure 1 has unusual curves at crank angles of about -9° and 180° which get smoothened out in figures 4 and 7. These graphs show when the spark occurs, when the piston gets to TDC and BDC. Maximum pressure occurs when the piston starts moving down from TDC to BDC. This is done so maximum force can be applied to the piston as it moves to BDC. If maximum pressure occurs while the piston is still moving to TDC, less force will be applied downwards as it will be moving opposite to the combustion force. This process can also cause damage to the piston as the forces acting on it will be very high. This is called knocking as it has a distinctive “knocking” sound.

Figures 2, 5 and 8 show how the volume in the cylinder changes as the piston moves from BDC to TDC and back again. This type of graph easily shows how the piston moves throughout the four stroke cycle. All three graphs are identical as the volume doesn't change when rpm increases.

Figures 3, 6 and 9 show the Otto cycle, or four stroke cycle, of the engine. This cycle is a description of what happens to a gas when it undergoes changes of pressure, volume and temperature, and the thermodynamics during all this process. Furthermore, the Otto cycle shows that each piston requires four strokes to complete the combustion sequence in a piston. The four strokes are; intake stroke, compression stroke, power stroke and exhaust stroke. Intake stroke sucks in air from the surroundings as piston moves down to BDC, compression stroke compresses the air as piston moves to TDC, power stroke forces the piston down to BDC after combustion, and exhaust stroke releases the exhaust gases (J.B.Heywood, 1988). This entire cycle is shown clearly in Figure 9. Work done is also found using the Otto cycle which shows how valuable this cycle is for engine simulation.

5 Conclusion

The results collected from the data gave accurate depictions of what happens during the combustion process of an internal combustion engine. The data at low rpm was not very accurate but as the rpm increased, the data gave more acceptable values and good results were taken. Furthermore, these results can be used to find multiple ways to make this engine more fuel efficient and also create more power for the amount of displacement. This also aids beginners to understand better how the internal combustion engine works and creates power.

References

J.B.Heywood (1988) 'Internal Combustion Engine Fundamentals, McGraw-Hill Books', p. 1056. doi: 10987654.