SSA 3

PV diagram with given data set

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Goal

- Make a pV diagram with the given data set

Conclusion

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Problems

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Follow up Steps

- Summary report of findings
- How to get crank angle from the pulse voltage
- How to exactly get the volume from this crank angle for each time period

Work Division

- Writing SSA: Joey
- Watching video lectures: Joey + Mihai
- Research: Joey + Mihai
- Matlab coding: Joey + Mihai

Time Division

- Watching video lectures about analysis of measurement data: 1 hour
- Writing SSA: 2 hours
- Matlab pressure coding Joey + Mihai: 1.5 hour
- Matlab volume coding Joey: 2 hours

Overleaf Link

Given data set

So firstly, I will explain the given data set. Basically 3 different text files are given, with full, half and no load. These .txt files are imported into Matlab. The 1st column represents time, the 2nd column the voltage of the pressure sensor and the 3rd column the voltage of the pulse sensor. Another important thing to mention, is that time goes from 0s to 0.5s with steps of 0.00001 second. Since it is known that motor goes 3000rpm. This means that one full Otto-cycle takes 0.04 seconds and that each rotation of the crankshaft (so also piston) takes 0.02 seconds. This is because each Otto-cycle consists of two cycles of the piston. With these values both the pressure and volume can be determined.

Pressure

The pressure with the use of the output voltage can be determined using the following formula:

$$V = (0.115 + 0.00385 * P) * Vs$$

This is the formula which Mats and I already used in our last SSA. By rewriting this in the form:

$$P = (V/Vs - 0.115)/0.00385$$

The pressure for each output value V can be determined. Since the input voltage (Vs) is given 5Volt and the output is given in a percentage of this input voltage. The output voltage V can be calculated using:

$$V = Vs * Column2(importeddata)$$

Now a column with the pressure at each time period is created. With this a Pt-diagram can be made as can be seen in the two figures below.

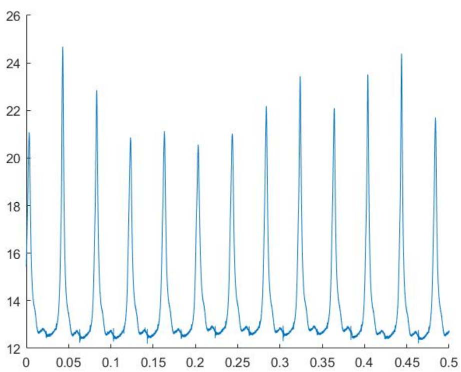

Figure 1: Pt diagram full time period

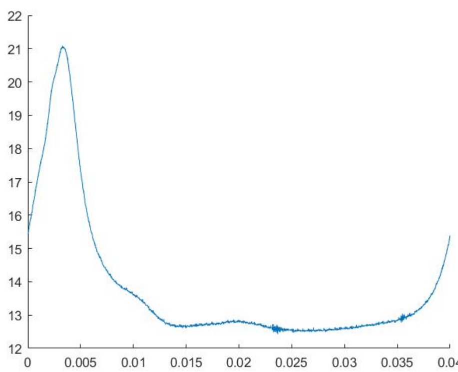

Figure 2: Pt diagram 0 - 0.04s

So the two figures above show the pressure against time for full load. In figure 1 the full diagram is seen and in figure 2 only one Otto-cycle is seen. The pressure on the y-axis is in kPa. In this figure 2 it can nicely be seen what happens in the combustion chamber during the process. The diagrams for half and no load are also made. From this is could be seen that the peak pressure in both half and no load are lower than in the full load diagram. A lower peak pressure means that less fuel is used during combustion. This is logical.

Volume (pulse sensor)

Next what is needed to make the pV diagram is the volume. This volume can be determined using the 3rd column (pulse output in Volt). Firstly the Pulse Time diagrams for full load were plotted, see figure 3 and 4 below.

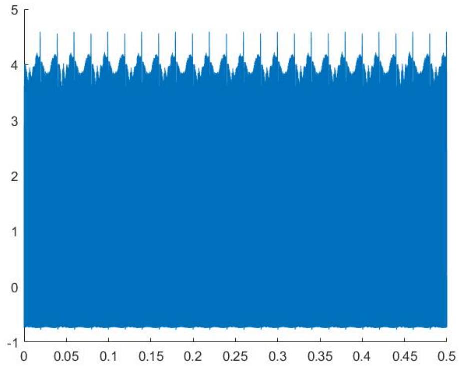

Figure 3: Pulse t diagram full time period

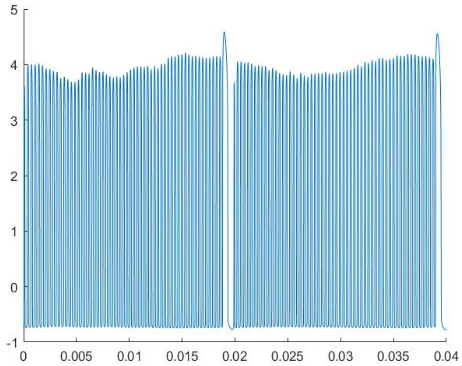

Figure 4: Pulse t diagram 0 - 0.04s

Again, firstly the diagram for the full time period was plotted and next to it only one full Otto-cycle was plotted. In figure 4 it can also be seen that there are basically 2 waves. Each wave represents one full rotation of the piston. After each wave there is some deviation, this is caused by the double tooth. As can be seen in the first wave in figure 4, there are a lot of small deviations in the wave. We think these are caused by the ignition of the fuel which causes some vibrations. What we also do know is that the volume is biggest at BDC (when the piston is at the lowest position) and that the volume is lowest at TDC (when the piston is at the highest position). One other thing we do know is that the angle between TDC and BDC is 180 degrees and that the double tooth is not located at TDC or BDC. Mihai and I were having a lot of trouble on how to determine the exact crank angle from the figures above. We asked help to the group and several people tried to help us, but they could also not figure out how to do it. When writing this SSA, no solution has been found yet. This should be done for a future SSA. We decided to work further on how to get the volume using the crank angle.

Compression ratio

Before trying to determine the volume, we first looked at how to get the compression ratio. We decided to use the static compression ratio instead of the dynamic compression ratio because this dynamic ratio is almost impossible to determine using the values we have. Also the static compression ratio would be a good estimate to use. The static compression ratio is the ratio (CR) between the volume of the combustion chamber and cylinder when the piston is at BDC and the volume of the combustion chamber when the piston is at TDC. This formula is used:

$$CR = (Vd + Vc)/Vc$$

- Vd = Displacement volume. This is the volume inside the cylinder displaced by the piston from the beginning of the compression stroke to the end of the stroke.
- Vc = Clearance volume. This is the volume of the space in the cylinder left at the end of the compression stroke.

With Vd:

$$Vd = (\pi/4) * b^2 * s)$$

- b = Cylinder bore (diameter)
- s = Piston stroke length

These formula's were directly taken from Wikipedia. During the experiments, the values needed to calculate CR are determined. If the compression ratio is 10, this means that the volume during TDC is 10 times smaller than during BDC. This compression does not happen gradually. If it would be gradually then it would be possible to determine the volume at each moment during the process. For example, if it is taken that at BDC the angle is 0 degrees, the volume is 1 and the CR is 10. Then at 90 degrees the volume would be 5, at 180 degrees 10, at 270 degrees 5 and at 360 degrees 1 again. When looking at the pV diagram in the ideal Otto-cycle this is not the case.

pV diagram

Since we were not able to compute the Volume in a column, the pV diagram can obviously not be made yet. A plot has to be made with the Volume on the x-axis and the Pressure on the y-axis. Firstly only the values for one full Otto-cycle have to be taken. So first all pressure and volume values between 0s and 0.04s have to be taken. Then it is just making the plot, giving it some nice labels and eventually add numbers for each stroke.

Summary report

As you might have read in the project information file, we will need to hand in a summary of our findings with the measurement data. This is something which needs to be handed in as group and which counts 10% to the end grade. More info will be announced later in February. I think it would be nice to keep this in mind and also add it to the Trello board.

References

[1] https://en.wikipedia.org/wiki/Compression_ratio