

University of Wales Saint David

Wales Institute of Science & Art

Engine Performance Characteristics

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1 Introduction

The dynamometer is used for assessing the general performance of an engine in a controlled environment, by recording various parameters of the engine, like the pressure in the cylinders, the fuel consumption the engine revolutions the temperature at various parts of the engine, the load on the engine and other parameter an engineer wishes to check. This information helps in assessing the performance on the engine (Power and torque) and in making the required adjustments in order to obtain optimum engine performance.

(Paydarfar, 2021)

This report will be focused in analysing the dynamometer readings which were obtained after running a sweep dynamometer test for the Honda 1.6 Vtec engine D16 (2000-2001) (James, 2022)

1 1.1 Objectives

The objectives of this report are the following:

1. Analyse the dynamometer readings which were provided (James, 2022) using MATLAB
2. Investigate how the Power and torque varies with the engine speed
3. Investigate how SFC varies with engine speed and load
4. Investigate how the Thermal Efficiency and the BMEP vary with the engine speed
5. Investigate the values of cylinder pressure at the different engine strokes.
6. Discuss the general behaviour of the engine.

2 Test equipment and method used

The test on the engine was carried out with the use of a dynamometer. The dynamometer is located in two rooms. The first room is the dynamometer cell and the second is the control room.

The dynamometer cell is where the dynamometer is located and is connected with the engine with a drive shaft. The engine is feed with fuel from a fuel tank with a fuel line which is passing through a filter, a fuel pump fuel, a flow meter, a secondary fuel pot, a main fuel pump regulator and ends up to the engine. The exhaust gasses from the engine while running are removed from the dynameter cell with an exhaust extraction system. While the engine is running load is applied to the engine by passing current to the dynamometer which creates magnetic field. The magnetic field slows the engine down. A calibrated stain gauge which is attached to the dynamometer measures the load on the engine. Because heat is generated by the use of dynamometer, the dynamometer is kept as certain temperature using a cooling system. The throttle of the engine is controlled by the computer and various sensor and recording modules feed the computer with the required readings. (UWTSD WISA WORKSHOPS, 2020a)

The dynamometer model is SCHENCK WC230 and can apply 230kw load to the engine.

The control room is where the computer is located. The computer controls the engine and the dynamometer and records the readings from the various sensors that are installed on

the engine (UWTSD WISA WORKSHOPS, 2020b). The computer software enables the user to run the dynamometer tests on an engine in three ways:

- Manually. The throttle of the engine and the load are controlled manually by the user.
- Test sequencing. The user specifies the parameters that the computer has to record by selecting these parameters for each step on the test manager. The system then runs in sequence the steps which were selected in the test manager using the parameters which were selected for each step.
- P-Curve Test. Produces a graph on the screen and at the end of the test it provides the requested data. There are two types of P-Curve Test, the Step test where the engine accelerates in specified time steps, in this case more accurate results can be obtained but there is a risk of overheating the engine and the sweep test where the computer records the readings of the various sensors as the engine accelerates. This type of test is not so accurate since the sensors cannot log the reading fast enough.

The dynamometer data which were provided for analysis were done with a sweep test. (James, 2022)

3 Engine data and Dynamometer readings

The dynamometer readings like, dynamometer force at various RPM for various loads, the engine speed at various loads, the fuel consumption at various RMPs per 45s and the cylinder pressures at various angles of the crank shaft at various RPMS were given (James, 2022). Also, the following engine data which are presented in table 1 were also given excerpt the calorific value of the fuel and the specific gravity of the fuel which were obtained after research.

Table 1– Honda 1.6 Vtec d16 – Year 2000-2001 (Engine data)

Property	Value	Comments
Ambient Pressure (mBar)	1024.00	Given
Ambient Temperature (°C)	24	Given
Dyno Radius (mm)	800	Given
Bore (mm)	71.9	Given
Stroke (mm)	82	Given
No of cylinders	4	Given
Fuel	95 ron	Given
Specific gravity of Petrol	0.72	(Engineers Edge, 2022)
Calorific Value of Petrol (J/kg)	45,000,000	(Collegedunia, 2021)

4 Analysis of Dynamometer readings using MATLAB

Using the values in table 1, the readings from the dynamometer test, the Dyno Worksheet shown in Appendix A and the instructions in the provided MATLAB script, the data from the dynamometer were analysed and the values of torque, Power, Break Mean Effective pressure (BMEP), the Specific Fuel Consumption (SFC) and the Break Thermal Efficiency were calculated and are presented in the following graphs.

4.1 Torque -Power at Full load

After analysing the data from the dynamometer, the Torque-Power curves at full load in relation with the RPMS of the engine were plotted and are presented in Figure 1. As it can be seen from figure 1, the Maximum torque of this engine occurs at 3000 RPMs and its value is 202.4Nm. The value of the maximum power of the engine is 92KW and it occurs at 6000RPM. The maximum torque of the engine occurs at this RPM because the force on the dynamometer is maximum at this point. This behaviour is not in agreement with the expected maximum torque of this engine which is 144Nm and it occurs at 5500 RPM (see figure 2). The maximum Power of the engine though is in agreement with the expected results but it occurs at 6000 RPM instead of 6600 RPM (see figure 2).

As it can be seen from figure 1 the torque of the engine increases as the RPM increases from 1000 RPM to 3000 RPM and drops after this point. The value of power rises from 1000 to 6000 RPM and then drops after this point. The reason is because the torque is directly proportional to the force reading of the dynamometer and the power is proportional to the product of the torque and the RPM. The reasons of having these deviations from the factory torque Power figures, it might be attributed due to the air filter that was used on the engine, due to the silencer, due to the fuel and due to fuel and ignition systems.

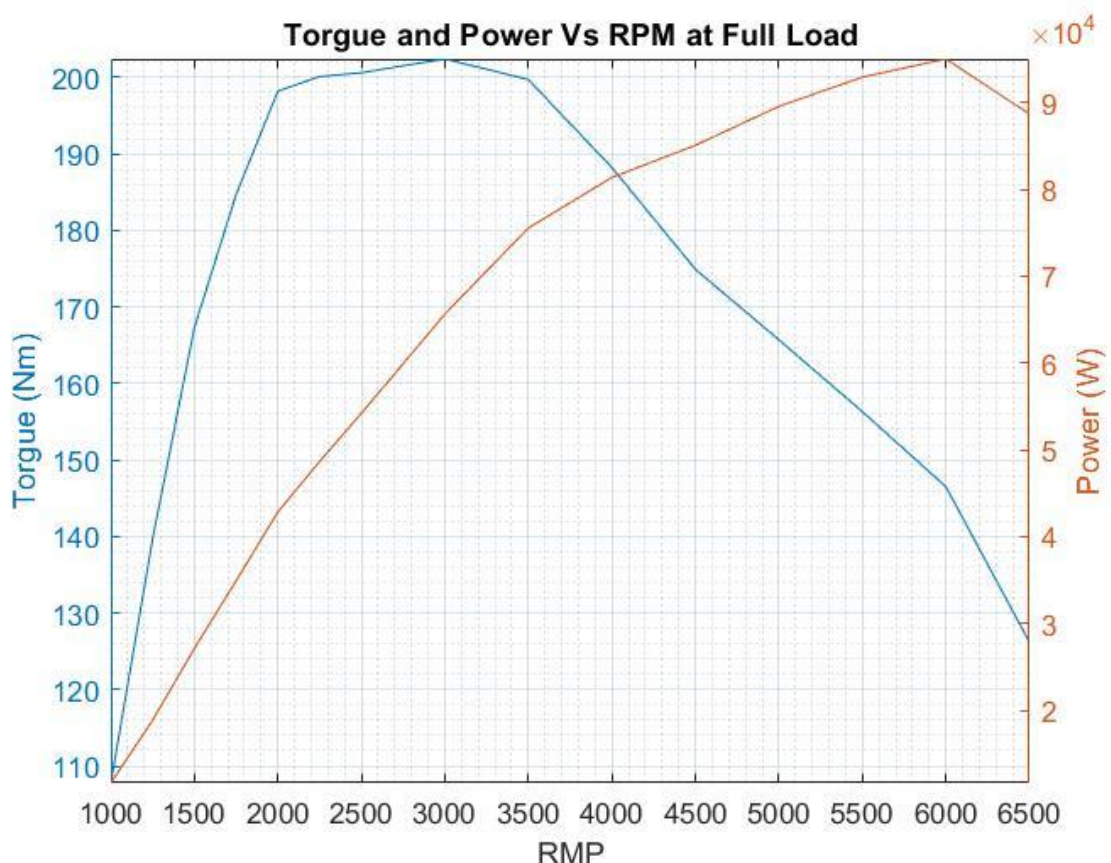


Figure 1 – Torque – Power Curves at Full Load

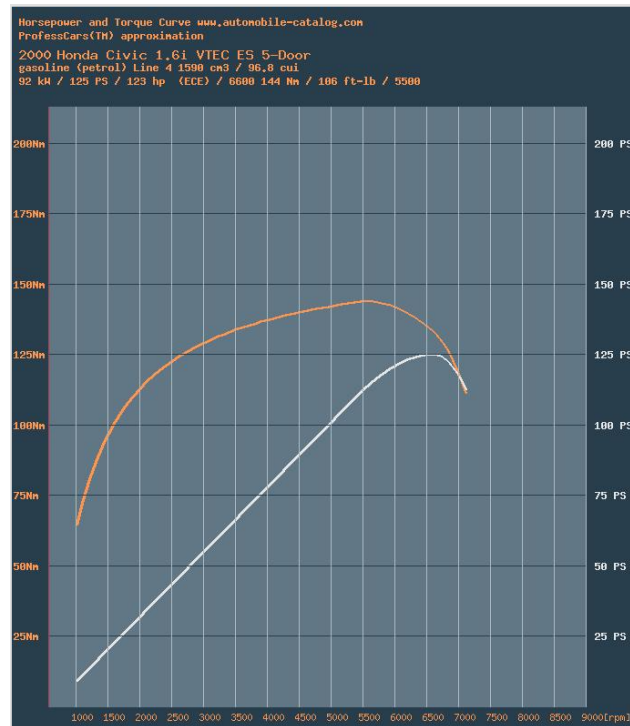


Figure 2 – Power – Torque Curves for Honda 1.6 Vtec Year 2000 - 2001 (automobile-catalog.com, 2022)

4.2 BMEP and Break Thermal Efficiency at full load

As it can be seen from Figure 3, the max BMEP at full load is 142Pa and occurs at 3000 RPM. The Break Thermal Efficiency is 0.333 and it occurs at 3500 RPM. This is because at this RMP, the fuel air mixture is optimum under the present set up of the engine. This is line with literature (Zammit, 1987).

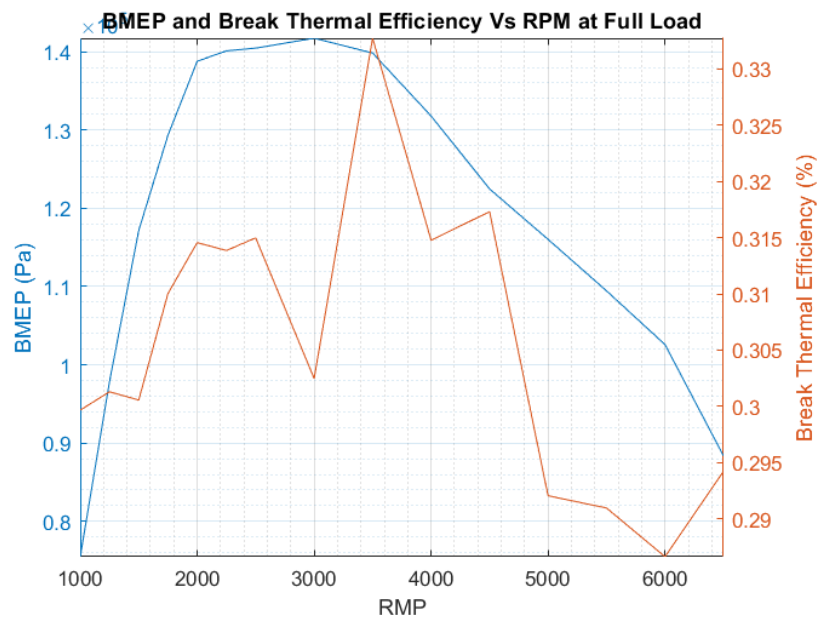


Figure 3 – BMEP and Break Thermal Efficiency Vs RPM at Full Load

4.3 Specific Fuel Consumption

Figure 4 shows with a colour scheme the specific fuel consumption of the engine as the load and the RPM change. From figure 4 it can be seen that the best SFC occurs at 2250 RPM when the load is 40% because this is the point where the engine gets full advantage of the fuel air mixture. The worst SFC occurs at 6500 RMP with 2% load because under the present setup of the engine and due to the high RPM, not adequate fresh air can enter the cylinders during the intake strokes.

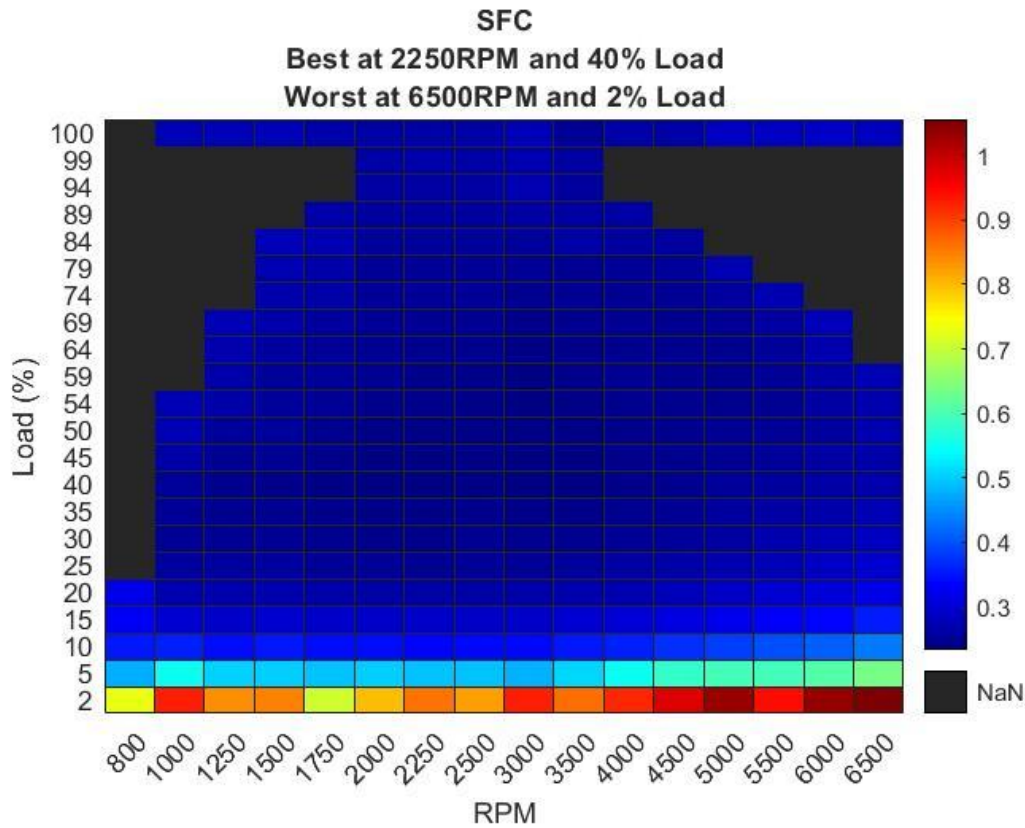


Figure 4 – Specific Fuel Consumption at Full Load Vs RPMs

4.4 Real cylinder pressure

Figure 5 shows the fluctuation of the real cylinder pressures at various RMP as the cylinder moves from the intake stroke (-360° to -180°), to compression stroke (-180° to 0°), then to power stroke (0° to 180°) and finally to the exhaust stroke (180° to 360°). Ideally the maximum compression which occurs at the end of the compression stroke (0°), should have been the same for all the RPM. At low RPM the maximum compression drops and after 2000 RPM the maximum pressure in the cylinder is more or less the same. The maximum compression though occurs at 3500 RPM. The reason of having lower pressure at low RPM might be due to deterioration of the cylinders, the piston and the compression rings.

Looking closely in Figure 5 and especially in the real pressure readings provided, the ignition occurs when the crank shaft angle is between 8° to 12° in to the power stroke. Because the ignition does not occur right after the compression stroke, the pressure in the cylinder reduces and this results in a reduced engine performance.

Also, at high RPM at the beginning of the intake stroke the pressure in the cylinder is higher which this signifies that not all the exhaust gases managed to escape from the cylinder. This does not allow enough fresh air to enter the cylinder and results in a non-optimum combustion. This is the reason why the performance of the engine drops at high RPM.

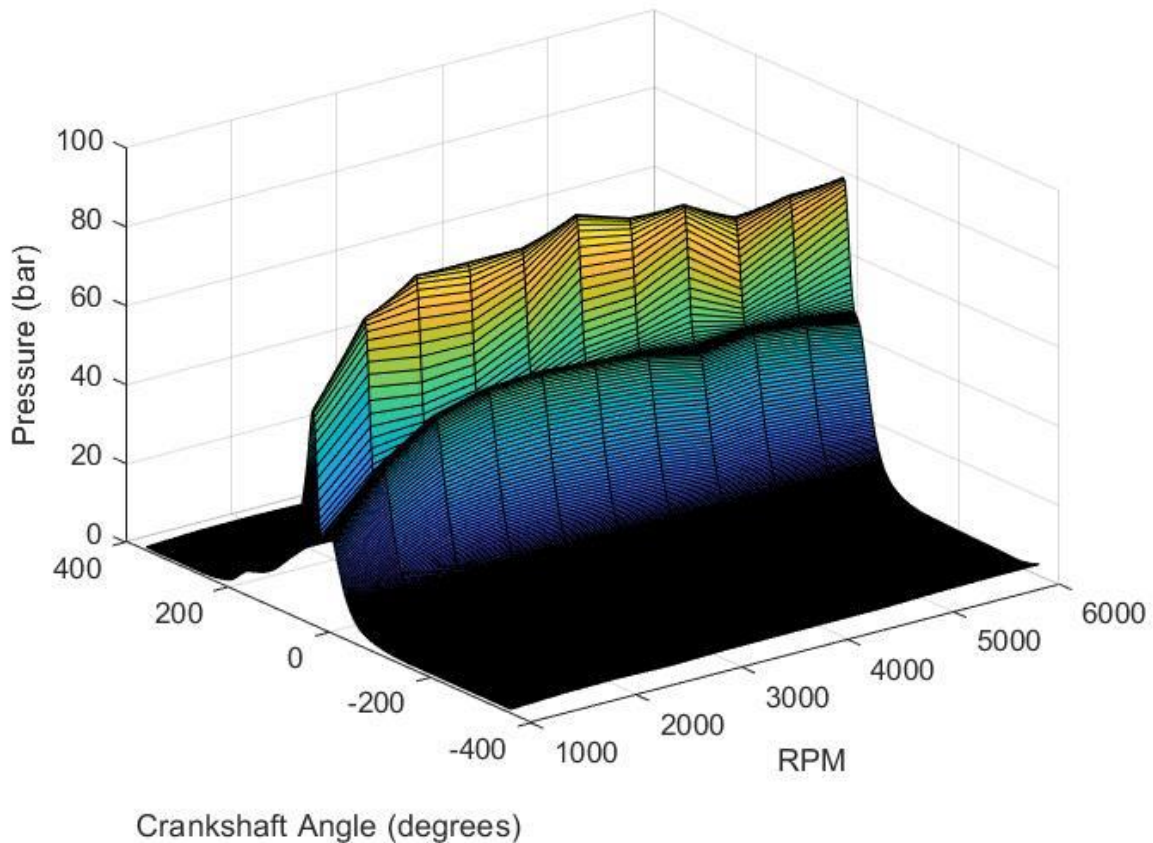


Figure 5– Rear cylinder pressure as the crankshaft angle changes Vs RPMs

5 Discussion and Conclusions

More accurate result could have been obtained if a P-Curve Step test was performed.

From the analysis of the dynamometer data provided for the Honda 1.6 Vtec engine (200 – 2001) the following observations/comments can be made:

1. The engine performs more or less as per the factory torque – Power Curves even though results showed that this engine has more torque at 3000 RPM.
2. The ignition in the cylinders it occurs when the crankshaft angle is between 8 to 12 degrees. If the ignition was happening just after the end of the compression cycle better performance could have been obtained.
3. Some of the exhaust gases do not escape from the cylinder as the RPM rise which this affects the optimum fuel air mixture.

4. At low RPM the pressure of the fuel air mixture at the end of the compression cycle is lower than that at higher RPM. This signifies that the cylinder, the piston rings or the piston might have some deterioration.
5. It has to be pointed out that the value of dynamometer arm which was used in the calculations was the one given in the dyno data (800mm). This value is slightly lower than the value of dynamometer arm (815.716mm) that was shown on the video (UWTSD WISA WORKSHOPS, 2020a). This definitely affected the results.
6. The calorific Value of the fuel and its specific gravity were obtained after research. These values might not be so accurate. In order to have accurate results these values should have been obtained after analysis of the fuel used.
7. The power, the torque the SFC, the BMEP are affected by the fuel air mixture strength, the compression ratio, the engine speed, the throttle opening, the valve timing, the ignition timing, the fuel used, the dimension of the engine, the combustion chamber design, the inlet charge temperature and cylinder temperature. (Zammit, 1987) Some of the above factors cannot be changed for a specific engine but some can be altered in order to obtain optimum performance of the engine. With the guidance of the initial results and considering the above observations, alterations can be made to the engine parameters and with the use of P-Curve step dynamometer tests optimum performance of this engine can be obtained.

6 References

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APPENDIX A

DYNO WORKSHEET

DYNO WORKSHEET

1. Calculate the torque:

$$T = W \times R$$

Where:

W= load on dyno (N)

R= arm length (m)

T = torque (Nm)

2. Calculate Power

$$P = \frac{2\pi NT}{60}$$

Where:

N = engine speed (RPM)

T = torque (Nm)

P = power (W)

4. Correct Power for Temperature and Pressure (re-arrange for P_s)

$$\frac{P_s}{P} = \frac{1.01325}{P_a} \times \sqrt{\frac{T_a}{293}}$$

Where:

P_s = corrected Power (W)

P = measured power (W)

P_a = ambient pressure (bar)

T_a = ambient temperature in Kelvin (K)

5. Calculate the piston area for the engine.

$$A = \frac{\pi d^2}{4}$$

Where:

d = bore (m)

A = area (m²)

6. Calculate Break Mean Effective Pressure (re-arranging for BMEP):

$$P_s = \frac{BMEP \times L \times A \times n \times N}{60 \times 2}$$

Where:

L = stroke (m)

A = Area (m²)

n = number of cylinders

N = engine speed in (RPM)

P_s = corrected Power (W)

BMEP = Brake Mean Effective Pressure (Pa)

8. Calculate Specific Fuel Consumption research the specific gravity of fuel used.

$$SFC = \frac{V \times SG \times 3600}{t \times 1000 \times P_s}$$

Where:

V=volume of flow (CC)

t = time (s)

SG = specific gravity of fuel

P_s = corrected Power (kW)

SFC = Specific Fuel Consumption (kg/kWh)

9. Calculate Break Thermal Efficiency, you will need to research the calorific value of the fuel used

$$\eta_T = \frac{3600 \times 1000}{SFC \times CV}$$

Where:

SFC = Specific Fuel Consumption (kg/kWh)

CV = calorific value of fuel (J/kg)

η_T = Break Thermal Efficiency (%)
