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Title of Report: Engine performance characteristics

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1. Introduction

Internal combustion engines (ICE) remain widely used within the automotive and motorsport industry, as they continue to evolve in terms of efficiency and performance. Hence the purpose of the experiment analysing its performance characteristics over a certain range of speeds and varying operating conditions. In this experiment a Honda civic 1.6 four-cylinder VTEC engine was used. Engine torque and speed were measured using a dynamometer allowing brake power to be calculated.

2. Methodology

An experimental investigation was organized to evaluate the performance characteristics of an internal combustion engine (ICE) over a variety of different speeds. In the experiment a Honda Civic 1.6L VTEC spark ignition engine was used, connected to an eddy current dynamometer via driveshaft. The specific dynamometer used within the experiment was a SCHENCK WS230, with a maximum operating speed of ten thousand rpm and a maximum load capacity of 230 kilowatts (SCHENK, 2001). Within the dynamometer resides an inner core that spins freely powered by the engine, and the outer casing is fed by current hence an electromagnetic field is produced applying load on the engine as it generated a resistive torque opposing engine rotation. This resistance provided a controllable load on to the engine (Fall, Engine Dynamometer Overview, 2020)

During the testing phase the engine operated over the range of approximately 1000 to 6000 rpm. At each speed interval the dynamometer load was adjusted to maintain a constant engine speed. The engine was enabled to reach a steady state condition before recording measurements. This procedure was uniform across the full range of operating speeds to accrue an accurate set of performance data.

Before the experiment starts inspect the engine and dynamometer to ensure proper operation, the fuel supply system was also verified to ensure consistent and uninterrupted flow of fuel throughout the test (Fall, Engine Dynamometer Overview, 2020). Ambient temperature, barometric pressure and humidity were also recorded as these parameters could have an influential impact on engine performance.

In engine dynamometer testing, there are 3 different ways to run tests. There is manual mode where resides two dials one, dynamometer and another engine, the engine controls rpm through the throttle box and the dynamometer controls the amount of current being induced to create the electromagnetic field opposing the engine rotation (Fall, Engine Dynamometer testing, 2020)

An alternative method of dynamometer testing is sequence testing where this method has interval steps ranging from 1-1000 steps, within the test manager software different parameters can be altered such as engine speed, load, and the duration at each step. With sequence testing it is automatically controlled after parameters have been set, this allows for consistent and repeatable testing conditions improving data accuracy. (Fall, Engine Dynamometer testing, 2020)

Lastly, the third type of testing is the p-curve test where parameter values can be predefined. During this test parameters such as starting speed, final speed can be altered, it can also log every measurement at each specified interval. The advantageous point of this type of test is that it allows the sensors sufficient time to stabilise and accurately measure the required parameter therefore producing an much more accurate reading. (Fall, Engine Dynamometer testing, 2020)

The first parameter that needs to be calculated within the results table is torque, measurement in newton meter (N/m), to calculate the torque utilize the formula $T = WR$ where W is engine load provided by dynamometer results R is the radius at which the load acts. Multiply the length of the arm which is 815.776mm converted into m which is 0.815776m then multiply it by the given loads.

Furthermore, the next value that needs to be calculated is power measured in kilowatts (kW). Power can be calculated by utilizing this formula: $\text{two} \times \text{PI} \times \text{NT} / 60$ the value from this get the power in watts to convert it into kilowatts divide it by one thousand, within the formula N is the engine speed (r/m) and T torque.

Next, after power has been calculated corrected power can be determined. Corrected power accounts for varying operating conditions such as ambient temperature, humidity and barometric pressure. To calculate corrected power utilize the formula given as: $1.01325 / \text{Pa} \times \text{Squarerooot of } \text{Ta} / 293$ where 1.01325 is the standard pressure in bar, Pa is the ambient pressure, Ta is ambient temperature.

After, calculations for specific fuel consumption (SFC) is needed, in order to calculate SFC flow fuel rate in L/min must be converted in kg/h that can be done by using the fuel density

value which is given as 0.75 multiplying it original given values for flow fuel rate in L/min then multiplying it by 60 where 60 converts minutes into hours. Once the conversion is done specific fuel consumption can then be calculated by the following formula where Power is divided by the converted values for fuel flow rate per hour. As specific fuel consumption directly relates to overall thermal efficiency in an opposite manner which is the next parameter that is needed to be filled in is calculated by: $3.6 \text{ divided by (specific fuel consumption values * by 43) * 100}$ where 3.6 is the conversion factor between kWh and MJ, 43 is the estimated calorific value of petrol in mega joules per kg, overall thermal efficiency accounts for energy losses within the engine, including heat losses through frictional losses, exhaust gas and cooling system (UWTSD, 2026).

Lastly, the final parameter that needs to be calculated is brake mean effective pressure which is an average theoretical pressure acting on the piston during the power stroke, representing the engines capability to produce torque regardless of its displacement. A typical peak value for spark ignition engines is 7000kPa (UWTSD, 2026) brake mean effective pressure is calculated by the following formula $(4 \cdot P_i \cdot T) / (0.0016 \cdot 100000)$ where 0.0016 is the displacement of the engine in meters cubed and the value of 100000Pa is the conversion rate from 1 bar.

3. Results

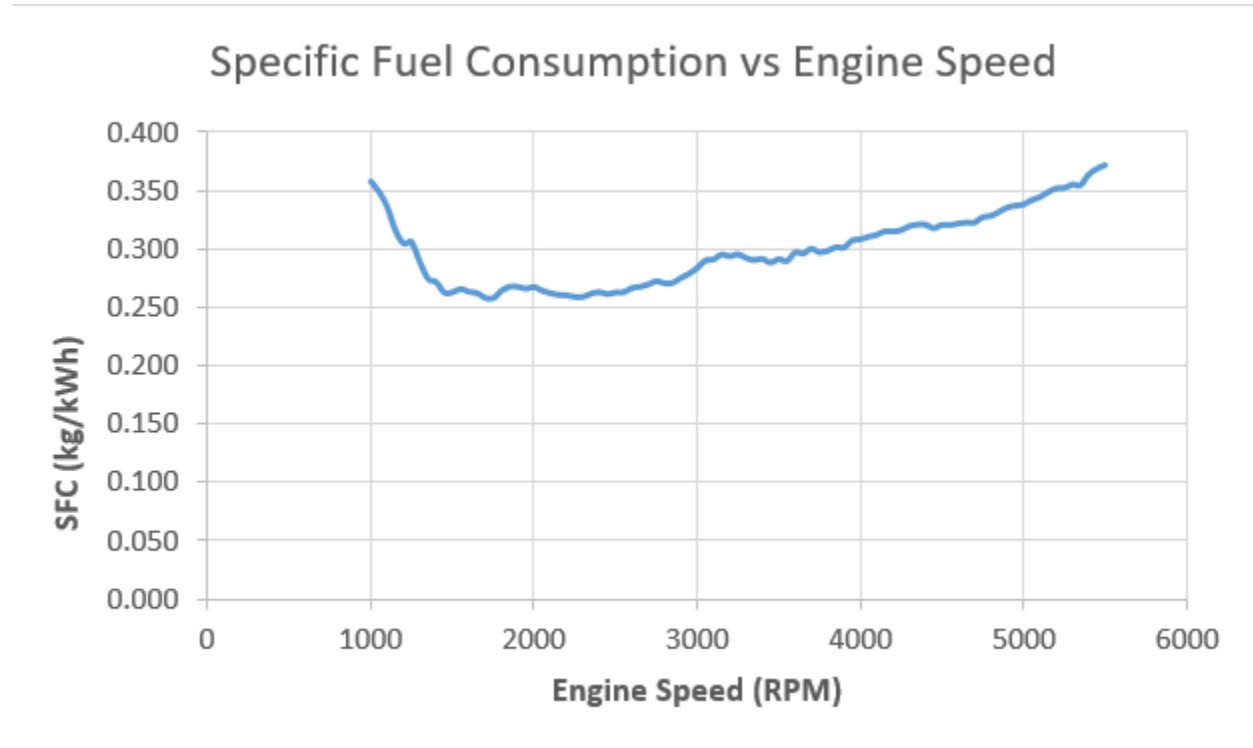


Figure 3.1 Portraying the correlation between specific fuel consumption against engine speeds.

Within the graph above figure 3.1 shows specific fuel consumption against engine speed, initially at higher engine speeds specific fuel consumption is at its all time high, this could be due to the fact that during high rpms there is a rise in frictional losses and pumping losses in addition to this within the higher band of engine speed it is physically demanding requiring more fuel to sustain its production of its higher power outputs hence the reduced efficiency. Along the mid section of the graph portrays optimal engine operation this is where volumetric efficiency is maximized and combustion cycles are more complete, enabling the engine to produce greater power output much more efficiently. (Pilotgarage, 2025)

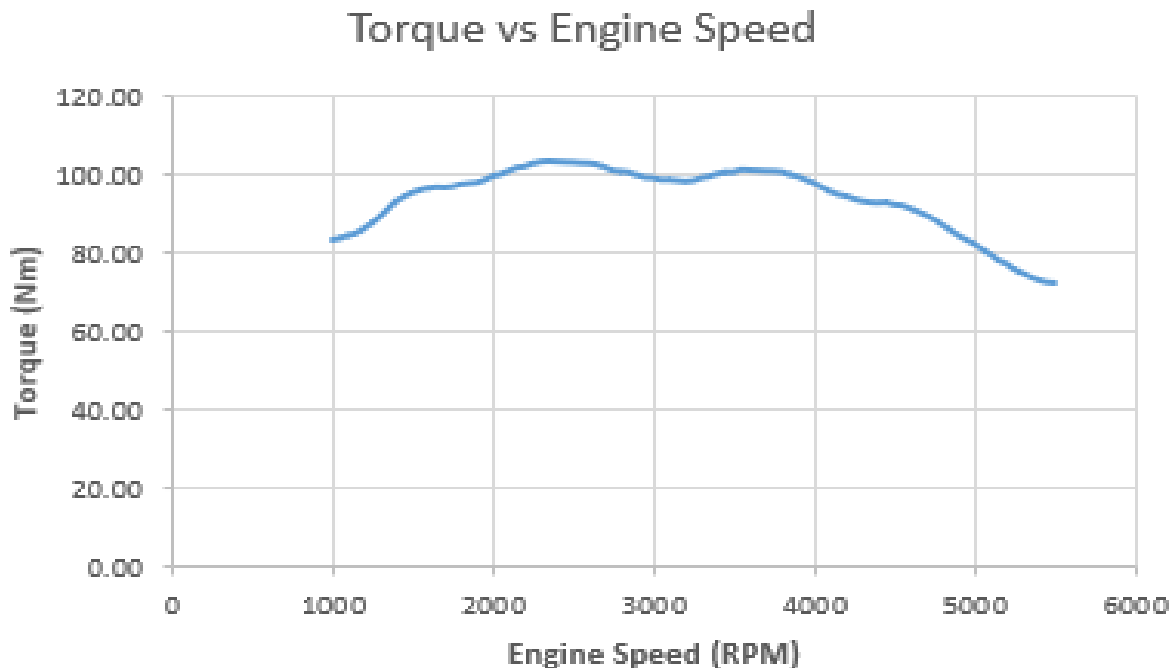


Figure 3.2 Shows the correlation between torque and engine speeds with varying rpms.

Within the midrange of the graph portrayed above in figure 3.2 depicts peak torque performance, there are various factors to why this could occur firstly the volumetric efficiency is optimally balanced where within the 2000-4000 rpms efficient scavenging effect is portrayed and backflow is also reduced during these stages. (UWTSD) In addition to this torque begins to decline when engine speed increases, the possible contribution to this factor is a decrease in volumetric efficiency where valves are closing much quicker therefore reducing time for complete filling cylinder. Within the initial stages the air intake speed is low, resulting in poor turbulence and less efficient combustion therefore minimal torque is produced.

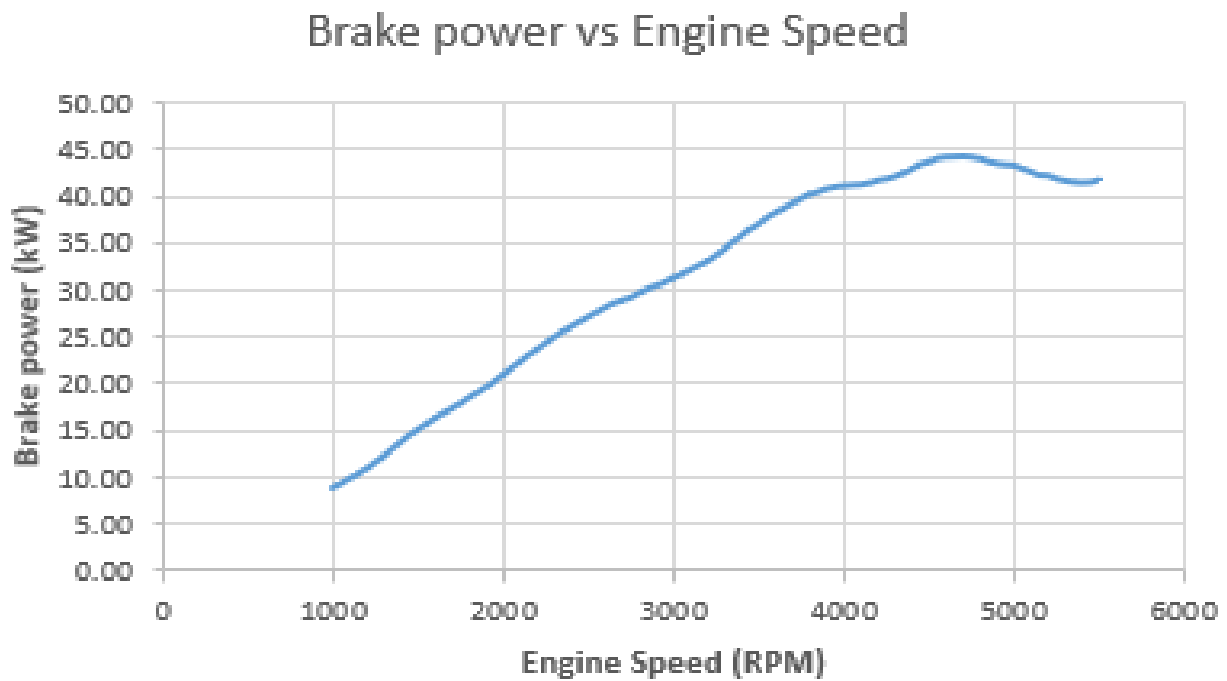


Figure 3.3 A graph showing brake power against engine speeds.

The figure above 3.3 shows brake power going against engine speeds. At lower engine speeds shows relatively low brake power as brake power is dependent on both torque and speed low engine speed restricts overall power output. Though as the engine speed increases brake power significantly increases within the mid region volumetric efficiency is optimized and combustion is more effective, allowing the engine to generate a higher torque while also operating at higher speeds. As engine speed continues to reach the higher band a slight divot within torque can be depicted and at a certain point brake power stabilizes then eventually declines.

4. Conclusion

Overall, the dynamometer testing demonstrated a typical performance characteristic of a naturally aspirated SI engine. In conclusion, overall results portrayed that the engine best achieves a balance of performance and efficiency at the mid-region band 2000-4000 rpm where fuel consumption is low and torque output is high. Within the lower region of engine speeds depicts a horrendous image in terms of engine operations it's the most less efficient due to poorer combustion and lower volumetric efficiency.

5. Evaluation

Due to the malfunction of the dynamometer, the experimental investigation could not be physically carried out. As a result of this the analysis was based on previously recorded data rather than data collected firsthand. While this limited the opportunity to engage face to face with the machine and familiarise within the dynamometer cell, the theoretical understanding of engine performance calculations, data processing and result interpretation is still developed.

6. References

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