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Engine Performance Characteristics

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1 Introduction

The experiment carried out in this paper is crucial for understanding the performance characteristics of an engine. Engineers must have a continuous understanding of how the engine is performing, as it is the most critical component of the entire vehicle. Without a properly functioning engine, there is no possibility of operating the vehicle. To conduct this experiment, an engine dynamometer was used.

The engine dynamometer works by directly connecting to the engine via a shaft, which is driven by the engine itself. As the engine operates, the shaft turns a magnet inside the drum of the dynamometer. An electrical current is then applied to the magnet, which generates a load on the engine. This load ensures that the engine produces accurate results across the entire RPM range. The recorded data is subsequently transferred to an Excel spreadsheet, where it is used to create tables and graphs that represent key performance metrics, including Brake Power, Torque, Specific Fuel Consumption (SFC), Brake Mean Effective Pressure (BMEP), and overall thermal efficiency. This data is invaluable for assessing the engine's efficiency and performance, providing valuable insights into its behaviour under various operating conditions.

2 Experimental Method

The experiment was conducted in the university's dynamometer room, utilizing the Schneck W230 dynamometer, which was connected to the Honda D16 1.6 engine. The step test procedure was used to carry out the experiment.

In the step test, the process begins at a set RPM, determined by the user. The user then selects the RPM increments by which the dynamometer will increase to meet the final RPM target. As the RPM gradually increases to the desired steps, the system pauses momentarily to allow for data recording.

For this particular experiment, the dynamometer was initially set at 1000 RPM and incrementally increased to 5500 RPM in 50 RPM steps. The data collected during the experiment includes RPM, load (in Newtons), fuel flow rate, and lambda (air-fuel ratio). With this information, key performance metrics such as power (in kilowatts), torque, specific fuel consumption (SFC), brake mean effective pressure (BMEP), and thermal efficiency can be accurately calculated. These results are vital for understanding how the engine is performing across different operating conditions. Moreover, they provide insight into any potential problem areas that may need to be further

3 Data Analysis

Below is the data collected from the tests. Figures 1 and 2 present the initial data table, which includes both the raw data gathered during the test and the calculated results for key performance metrics, including power in kilowatts (KW), torque in newton-meters (NM), specific fuel consumption (SFC), brake mean effective pressure (BMEP), and overall thermal efficiency. These figures provide a comprehensive overview of the engine's performance across the tested RPM range. The raw data in the table, such as RPM, load, fuel flow rate, and lambda, were used to calculate the metrics required, giving a detailed insight into the engine's efficiency and operational characteristics. By analysing both the collected and calculated data, engineers can assess how well the engine is performing under various conditions and identify areas for improvement. This data is crucial for optimizing engine design, enhancing fuel efficiency, and ensuring that the engine meets performance standards.

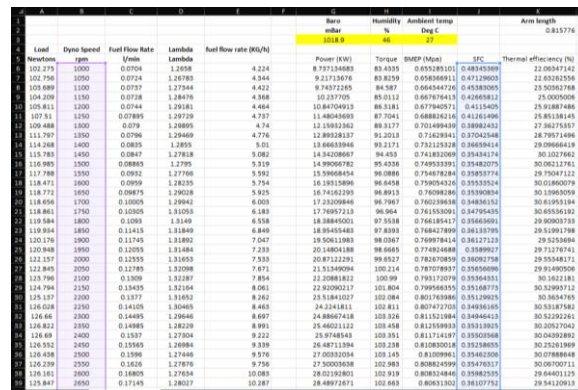


Figure 1

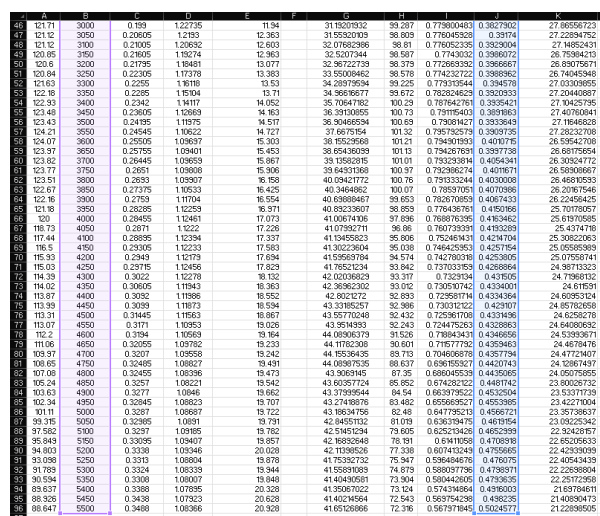


Figure 2

Figure 3 displays the graph showing Brake Power against RPM. As observed from the graph, the power curve increases steadily as the RPM rises, reflecting the engine's growing power output. The relationship between RPM and brake power remains fairly linear up to approximately 4700 RPM, at which point the engine reaches its peak power of 44.15 kW. Beyond this point, the power output does not continue to rise. Instead, the graph shows a noticeable drop in power, with the curve beginning to fall off around 4750 RPM. This decline in power after reaching the peak is a typical characteristic of many engines, where the engine's ability to produce additional power plateaus or even diminishes at higher RPMs. This behaviour is crucial for understanding the engine's performance limits, and it highlights the optimal operating range where maximum power can be achieved. Analysing the power curve allows engineers to identify the engine's peak efficiency and understand the RPM range in which the engine performs best. Additionally, it provides valuable insights into the engine's overall power delivery and helps in making informed decisions regarding performance improvements or adjustments.

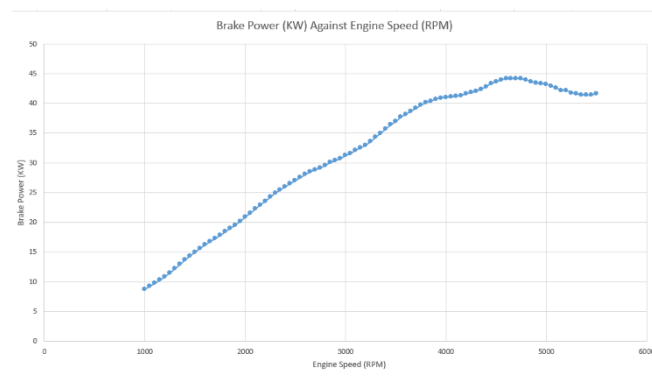


Figure 3

Figure 4 below illustrates the relationship between torque and RPM. The graph reveals that torque remains relatively constant across the range of RPM, which could be attributed to the fact that this is a relatively low-power engine. As a result, it doesn't produce significant amounts of torque or horsepower compared to higher-performance engines. According to the data collected the peak torque occurs around 2350 RPM, where it reaches 103.45 Nm. After this point, the torque level stabilizes and does not increase further, suggesting that the engine has reached its maximum efficiency in torque production for the given conditions. This behaviour is typical for engines with lower power outputs, where torque tends to plateau rather than continue rising at higher RPMs. Understanding this torque profile is important for evaluating the engine's performance, particularly its ability to provide consistent power across different RPM ranges. Additionally, this information can help identify the optimal operating range for the engine, where maximum torque is achieved, and highlight any potential limitations in its power delivery at higher speeds.

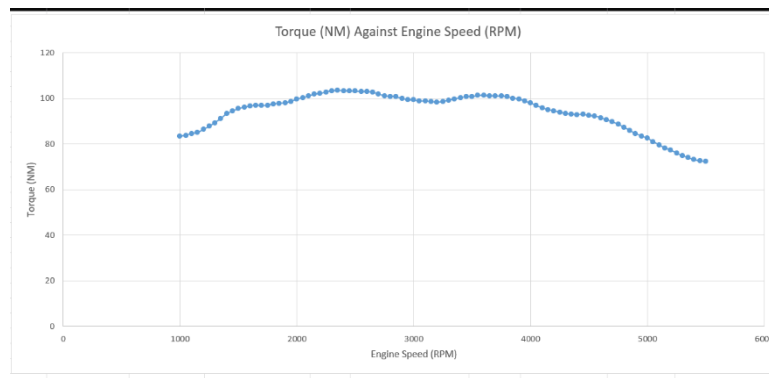
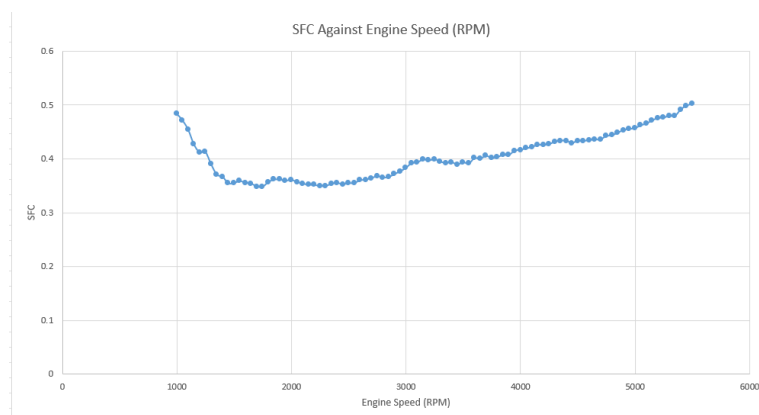
*Figure 4*

Figure 5 presents the results of Specific Fuel Consumption (SFC) plotted against RPM. This graph illustrates the fuel consumption over the entire rev range, providing specific data for each RPM step. While it's well-known that vehicles consume fuel during operation, this graph offers a detailed view of the fuel consumption at each RPM increment.

As observed in the lower RPM range, the engine consumes more fuel initially to overcome the load applied by the dynamometer. Once the engine has built up momentum, fuel consumption decreases. However, as the RPM increases further and more throttle is applied, fuel consumption begins to rise again. This increase is due to the engine requiring more fuel and air to produce additional power. The graph highlights how the engine's fuel efficiency varies with RPM, helping to pinpoint the points at which fuel consumption is optimized or becomes less efficient as power demands increase. Understanding this trend is important for evaluating the engine's overall performance and identifying areas for potential improvement in fuel efficiency.



4 Conclusion

In conclusion, the experiment conducted using the Schneck W230 dynamometer and the Honda D16 1.6 engine provided a comprehensive analysis of the engine's performance characteristics across a range of operating conditions. By using the step test procedure, important performance metrics such as brake power, torque, specific fuel consumption (SFC), brake mean effective pressure (BMEP), and thermal efficiency were recorded and analysed. The results highlighted several important aspects of the engine's behaviour, including the linear relationship between brake power and RPM up to 4700 RPM, the relatively constant torque across the RPM range, and the varying fuel consumption in relation to engine speed.

The data collected revealed that the engine's performance is typical of lower-powered engines, with peak power occurring at 4700 RPM and a plateau in torque production beyond 2350 RPM. Furthermore, the analysis of SFC showed the engine's fuel efficiency trends, indicating a decrease in fuel consumption as momentum builds, followed by an increase as power demands rise with higher RPMs.

These insights are invaluable for understanding the engine's operational limits, optimizing fuel efficiency, and identifying areas for potential performance improvements. Overall, the experiment reinforced the importance of thorough testing and data analysis in assessing engine performance, providing a foundation for further optimization in engine design and fuel management.

5 Evaluation

During this experiment, several aspects could have been improved. For data processing, MATLAB would have provided more advanced analysis compared to Excel, as it can handle a greater number of data points and generate more detailed, easily interpretable graphs. However, due to my limited confidence with MATLAB, Excel was the more accessible tool for this experiment.

If more time had been available with the engine on the dynamometer, the step test could have been extended, allowing for more precise data collection at each RPM increment. This would have led to more accurate results for post-processing. In real-world applications, manufacturers and racing teams typically conduct more exhaustive testing to gather every possible data point. It's not unusual to see Formula 1 teams working on the next season's engine in the middle of the current season. (Formula 1, 2020)

Furthermore, recording data at smaller RPM increments would have enhanced the accuracy of the results. However, due to time constraints during the university testing session, this approach was not feasible.

6 References

Formula 1. 2020 *Ferraris all-new 2021 engine delivering 'very promising' dyno figures, says Binotto*

[Online] Available at: <https://www.formula1.com/en/latest/article/ferraris-all-new-2021-engine-delivering-very-promising-dyno-figures-says.2ea6l0jR9lspOvxNTYgtRo> [Accessed 26th March 2025]