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Engine Performance Characteristics

Powertrain Technology (ACHA 4029)

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1. Introduction

Internal combustion engines (ICE's) work by converting stored chemical energy in fuels into mechanical rotational energy and the associated by-products, such as heat, noise and light, these by-products mean that they cannot be 100 percent efficient. The performance of these engines is usually evaluated based on brake power, fuel efficiency and torque, dependant on the desired application, understanding these how these parameters can vary with environment and engine speed is crucial to performance and optimisation.

One of the most effective ways to collect the data needed to calculate these parameters is using a dynamometer, allows a user to provide a controlled environment to test an engine whilst logging the data across a range of applied conditions.

This report analysis data obtained using a 1590cc Honda four-cylinder four stroke engine, on a Schenck WS230 Eddy-current dynamometer, raw data collected was processed in Microsoft Excel to calculate performance values, such as Brake power, Torque, Brake Mean Effective Pressure (BMEP), Specific Fuel Consumption (SFC) and overall Thermal Efficiency (OTE).

The primary aim of this report is to calculate and evaluate how key engine performance characteristics vary with engine speed, to observe trends between characteristics if any and understand the performance of the chosen engine.

(Honda Motor-Corporation, 1988a; SCHENCK, 2001)

2. Testing Equipment

There are two major components in running this test, the first being the powertrain in which this test used a Honda ICE, and an engine dynamometer to measure, record and log the data from the process whilst maintaining a controlled environment.

2.1 Honda D16 V-Tech Engine

A Honda 1590cc four-cylinder, four stroke engine, with a bore and stroke of 75mm x 90mm equipped with variable valve timing technology (V-TEC), this D16 engine upon leaving the factory produced approximately 78 KW (105 Horsepower) & 134 Nm of torque.

(Honda Motor-Corporation, 1988b, 1988a; Fall and UWTSD, 2020b)

2.2 Schenck WS230 Eddy-Current Dynamometer

The Schenck WS230 is an Eddy-Current type dynamometer (dyno), can read up to 10,000 Rpm well within the test range for the selected engine, an Eddy-Current dyno is a type of electromagnetic absorption dyno, that can apply a controlled resistive load to the engine this is done via electromagnetic induction, the resulting force pushing against the load can be quantified into the resulting torque and calculated to power. (SCHENCK, 2001)

There are two major parts of the dyno one is the inner rotor this is connected directly to the output shaft of the engine, so there are no drivetrain losses or scaling errors due to torque multiplication this also means that the rpm of the rotor and engine are the same.

There is also the static outer stator housing that is bolted to the ground this casing contains electromagnetic coils when a current is induced in these coils it generates a magnetic field, as the rotor starts to spin in this field it is subject to changing magnetic flux which in turn induces Eddy-Currents in the rotor which generates its own opposing magnetic field (Lenz's Law), these opposing forces can be controlled by varying the current within the stator housing, the resulting turning force is then measured by a strain gauge attached to the casing, the resulting voltage from this strain gauge can be translated into a torque.

Eddy-Current dynamometers produce a lot of heat due to this and require large amounts of cooling via a liquid cooled casing.

(Mayer and Varaksina, 2017; Fall and UWTSD, 2020a; da Mata *et al.*, 2023)

2.3 Strain Gauge

The strain gauge is crucial to the operation of a dynamometer the strain gauge used in the experiment was a Tedea Huntleigh 615 S type load cell (Figure 3), that can measure compressive and tensile forces, a common layout for a strain gauge is to use a thin metallic foil in a pattern on a flexible backing as external forces strain or compress the foil the geometry changes, the length can change and cross-sectional area can change all leading to changes within the resistivity.

(Nachazel Ted, 2020; RS-Components, 2026)

2.4 Wheatstone Bridge

Multiple strain gauges can be arranged into a bridge circuit that measures extremely small changes in resistance, this is known as a Wheatstone bridge (figure 2), in this set up an excitation voltage is applied across the whole circuit and the output is measured at two points in the centre of the bridge when there is no applied load to the circuit the output voltage is 0, so when a load is applied there is an imbalance of resistances in the bridge and a voltage is given at the output.

Equation 1 - Resistivity

$$R = \rho \frac{l}{A}$$

Equation 1: ρ = Resistivity, l = length, A = Cross-sectional Area

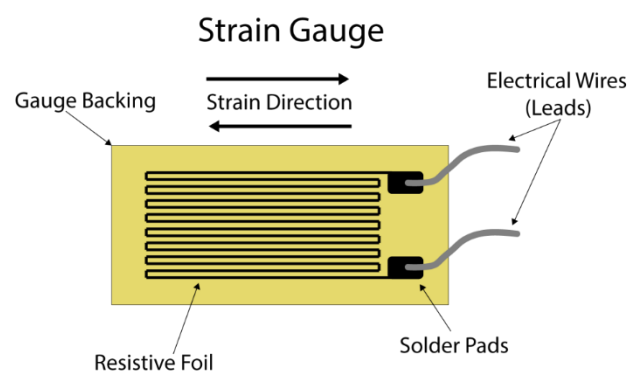


Figure 1- Diagram of a basic Strain Gauge (Nachazel Ted, 2020 michsci.com)

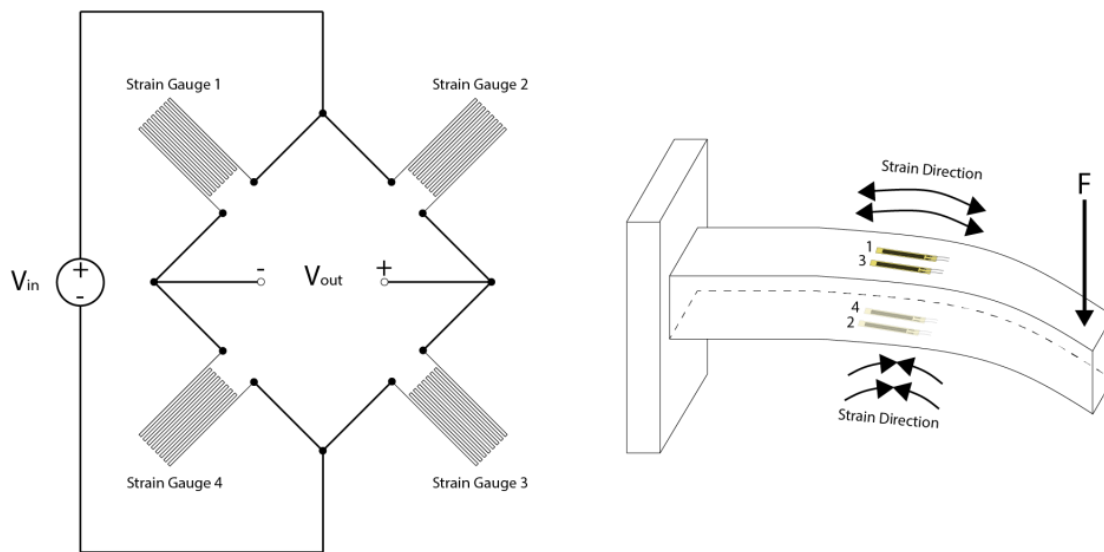


Figure 2- Wheatstone Bridge (Nachazel Ted, 2020 michsci.com)



Figure 3 - TedeA Huntleigh Model 615 S Type Load Cell (RS-Components, 2026)

3. Testing Methodology

The dynamometer has a variety of testing operations available, as described in 2.2 the engine is directly coupled to the dyno, the engine is self-contained within test area, with the ECU, ignition and fuel delivery system from the original engine mounted onto a wall plate, the throttle is actuated via an electronically controlled servo attached to the dynamometer which is controlled by a user of computer in the control room.

A crucial part is that the fuel return line is after the fuel flow meter so the fuel usage value is only what is being used in the system with the engine running, as opposed to what is moving through the whole system.

The engine is run and a load is produced against the engine by inducing the current in the stator the engine RPM and load are controlled by two dials turned by the operator in the control booth, the resultant force from this rotation loads the strain gauge giving a voltage between 0 -1, the parameters such as load, fuel flow, rpm and lambda are recorded during specified sections of the run.

The force in the load cell is programmed using calibration arms, these arms are a highly accurate set distance from the centre of the dynamometer a known mass is applied to this arm, this torque force can be calculated, by multiplying the force by distance, the length on the dyno used was 0.815, this is done numerous times for a variety of weights, the corresponding strain gauge voltage is stored and a force map can be built.

Equation 2 - Torque Calculation

$$\text{Torque (T)} = \text{Load (Newtons)} * \text{Lever Arm length (meters)}$$

For the experiment the lever arm length was 0.815 meters.

3.1 Test Types

The WS230 can do multiple types of tests the one that was likely used for the data acquisition in this test was the manual mode, where the tester manually controls the engine rpm and resistive load (current) to record data.

Another method is step testing, where a user can predefine desired parameters for engine behaviour through given test times and a test can be ran by the dyno computer independently which can allow for increased consistency and accuracy.

P-curve test is another type of test available on the dyno one being a step and one being a sweep test these tests can be much more useful for targeting specific areas of an engine giving a smaller resolution of data. (Fall and UWTSD, 2020b, 2020a)

4. Raw Data and Processed Data

Table 1 - Dynamometer Test Parameters

Baro mBar	Humidity %	Ambient temp Deg C	Length (m)	Engine Capacity L	Fuel Density	Calorific value of Fuel kj
1018.9	46	27	0.815776	1.59	0.75	43391

Table 2 - First 20 data points of collected data and processed data

Load Newtons	Dyno Speed rpm	Fuel Flow Rate l/min	Lambda Lambda		Torque N/m	Brake Power Kw	Corrected Power Kw	BMEP KPa	SFC Kg/KWh	OTE %
102.275	1000	0.0704	1.2658		83.43	8.74	8.79	659.41	0.360	23.02
102.756	1050	0.0724	1.26783		83.83	9.22	9.27	662.51	0.351	23.62
103.689	1100	0.0737	1.27344		84.59	9.74	9.80	668.52	0.338	24.53
104.209	1150	0.0728	1.28476		85.01	10.24	10.30	671.88	0.318	26.09
105.811	1200	0.0744	1.29181		86.32	10.85	10.91	682.20	0.307	27.05
107.51	1250	0.07895	1.29729		87.70	11.48	11.55	693.16	0.308	26.98
109.488	1300	0.079	1.29895		89.32	12.16	12.24	705.91	0.291	28.56
111.797	1350	0.0796	1.29469		91.20	12.89	12.97	720.80	0.276	30.05
114.268	1400	0.0835	1.2855		93.22	13.67	13.75	736.73	0.273	30.36
115.783	1450	0.0847	1.27818		94.45	14.34	14.43	746.50	0.264	31.41
116.985	1500	0.08865	1.2795		95.43	14.99	15.08	754.25	0.264	31.37
117.788	1550	0.0932	1.27766		96.09	15.60	15.69	759.42	0.267	31.05
118.471	1600	0.0959	1.28235		96.65	16.19	16.29	763.83	0.265	31.33
118.772	1650	0.09875	1.29028		96.89	16.74	16.85	765.77	0.264	31.45
118.656	1700	0.10005	1.29942		96.80	17.23	17.34	765.02	0.260	31.95
118.861	1750	0.10305	1.31053		96.96	17.77	17.88	766.34	0.259	31.99
119.584	1800	0.1093	1.3149		97.55	18.39	18.50	771.00	0.266	31.21
119.934	1850	0.11415	1.31849		97.84	18.95	19.07	773.26	0.269	30.81
120.176	1900	0.11745	1.31892		98.04	19.51	19.63	774.82	0.269	30.81
120.948	1950	0.12055	1.31484		98.67	20.15	20.27	779.80	0.268	31.01

Complete Table 2 available in appendix

5. Graphical Results and Trends

5.1 Specific Fuel Consumption against engine speed

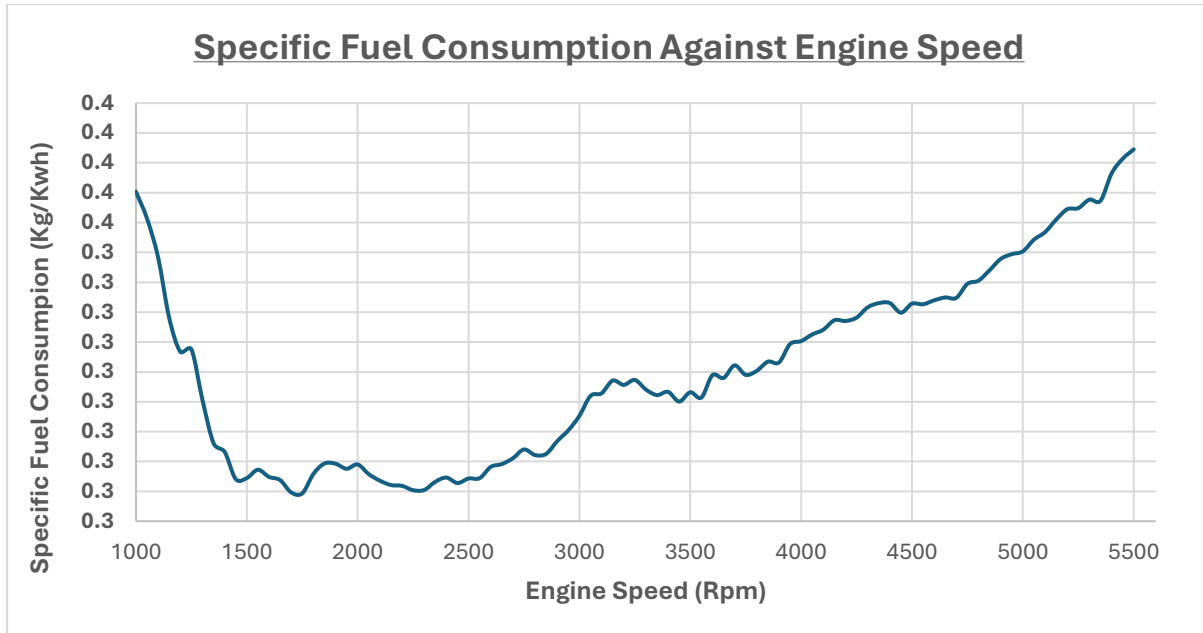


Figure 4 - A plot of specific fuel consumption against engine speed

The general trend shown in figure 4 is that the specific fuel consumption increases with engine speed from around 1500 RPM, between 1000 and 1500 RPM this decreases, this could be for a variety of reasons such as that on idle and transition the engine is programmed to run rich to assist with cooling whilst stationary or at low speeds.

Figure 5 contradicts this possibility as the graph shows the lambda is lean at this idle and transition RPM.

Another reason for this higher SFC at low rpm is that the engine is not very efficient at these low RPM's due to the pumping losses in the cylinders due to the throttle body being mostly closed, the cross sectional area that the airflow has to flow through is small meaning the engine has to work harder to pull air through, this could then lead into the low SFC part of the graph where the pumping losses are reduced and the engine becomes more efficient due to an increase in oil pressure and rotational inertia assisting the engine to keep moving.

The low range dip appears to be a common trend regardless of fuel or engine as seen in the Optimization of SI Engine Performance Operating with Low Octane Gasoline and Fuel Additives from Waste Experiment. (Ali, Koten and Alwan, 2022)

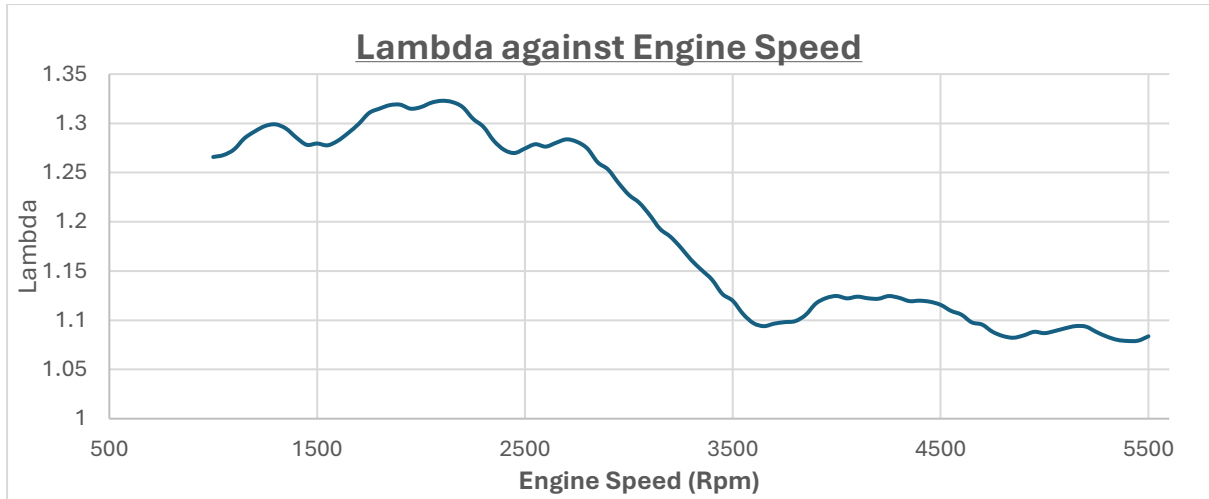


Figure 5 - Lambda Against RPM

Equation 3 - Specific Fuel Consumption

$$SFC (Kg/KWh) = \frac{(Fuel Flow Rate * 60) * Fuel Density}{Corrected Power}$$

Equation 4 - Corrected Power

$$Corrected Power (KW) = \frac{1.01325}{Ambient Pressure} * \sqrt{\frac{T_a}{293}} * Measured Brake Power$$

Corrected power is a crucial method as engine power can be affected significantly by atmospheric conditions using a correction factor on the raw data allows to compensate for these conditions, this also allows for a much more consistent comparisons between tests, correction factor can be done to a variety of standards such as SAE, STD, DIN and JIS.

All processed data in this experiment uses corrected power, the data was gathered at sea level meaning the correction factor had little influence in the results, figures 6 and 7 show how little the data was corrected from the raw data, showing that there was less than a 0.3 Kw correction of power at most. (Dynojet, 2025)

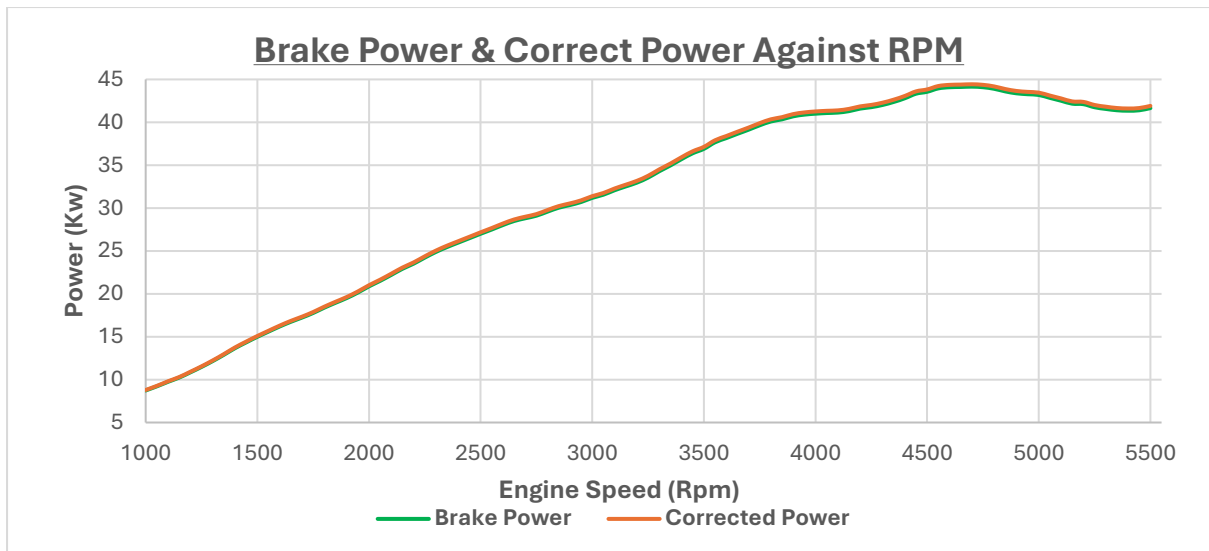


Figure 6 - A plot of Brake power and Corrected power over RPM

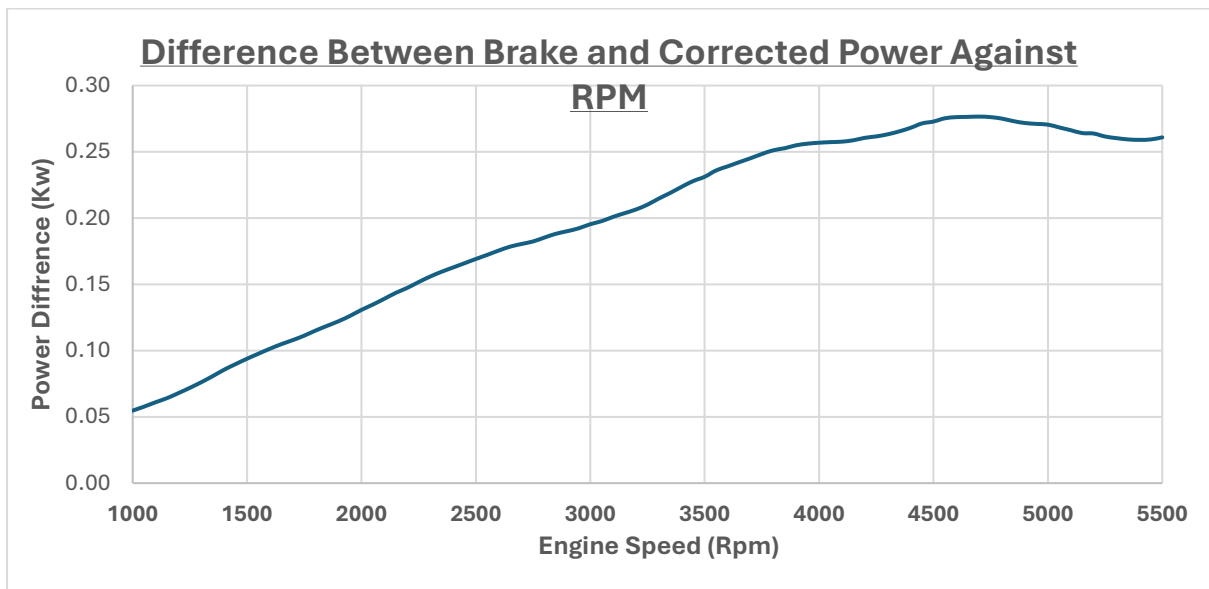


Figure 7- The difference in corrected power over RPM

5.2 Torque Against Engine Speed

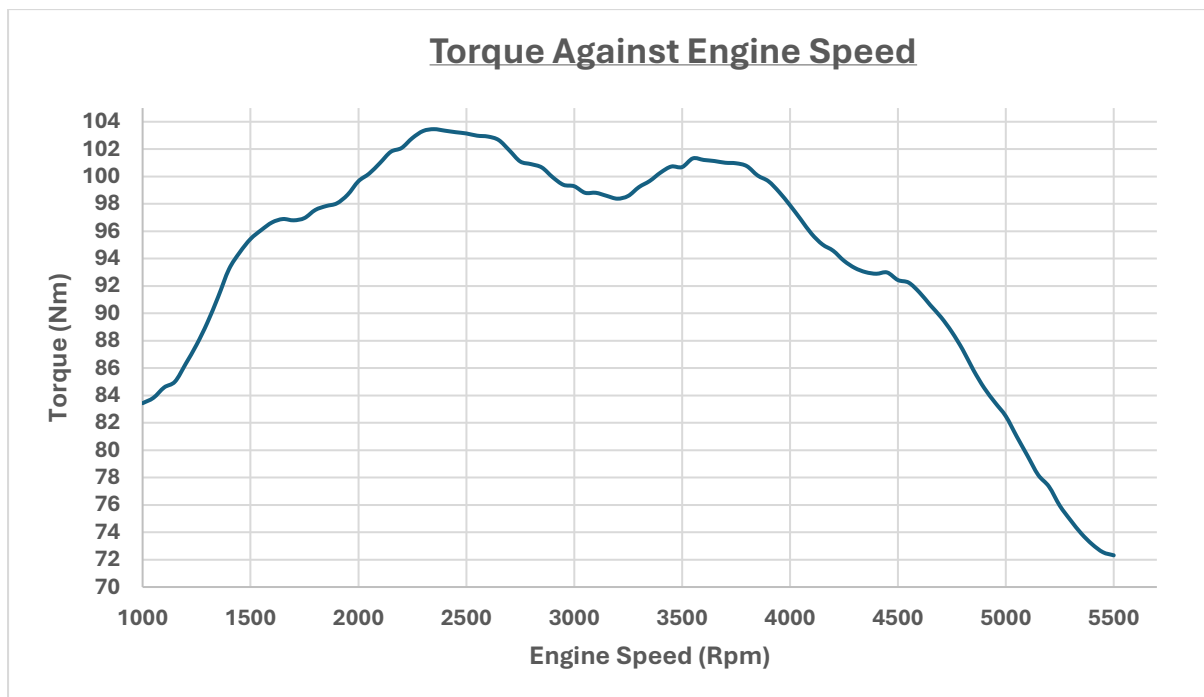


Figure 8 - Torque against RPM

Torque is the amount of instantaneous rotational force an engine can produce, it is closely linked to power output as power is a measure of how quickly that torque can be produced over time.

Equation 5 - Power Equation

$$Power (Kw) = Torque * RPM$$

The relationship between rpm and torque in this data set is that torque rapidly increases to a peak of around 103 Newton-meters, then has a gradual decline with a secondary peak and then a much more rapid drop with a small peak, these peaks could be caused by resonances in the inlet tract of the engine, where pulses of air are bouncing back towards the cylinder at the right time to force a little more air in the engine allowing for more power. (Mustafa *et al.*, 2020)

Another cause of these peaks could be due to the V-tec system changing the valve lift and duration allowing for a secondary torque peak due to increased volumetric efficiency in these areas of the rev range, however there is no obvious V-tec spike in Figure 9.

5.3 Brake Power against Engine Speed.

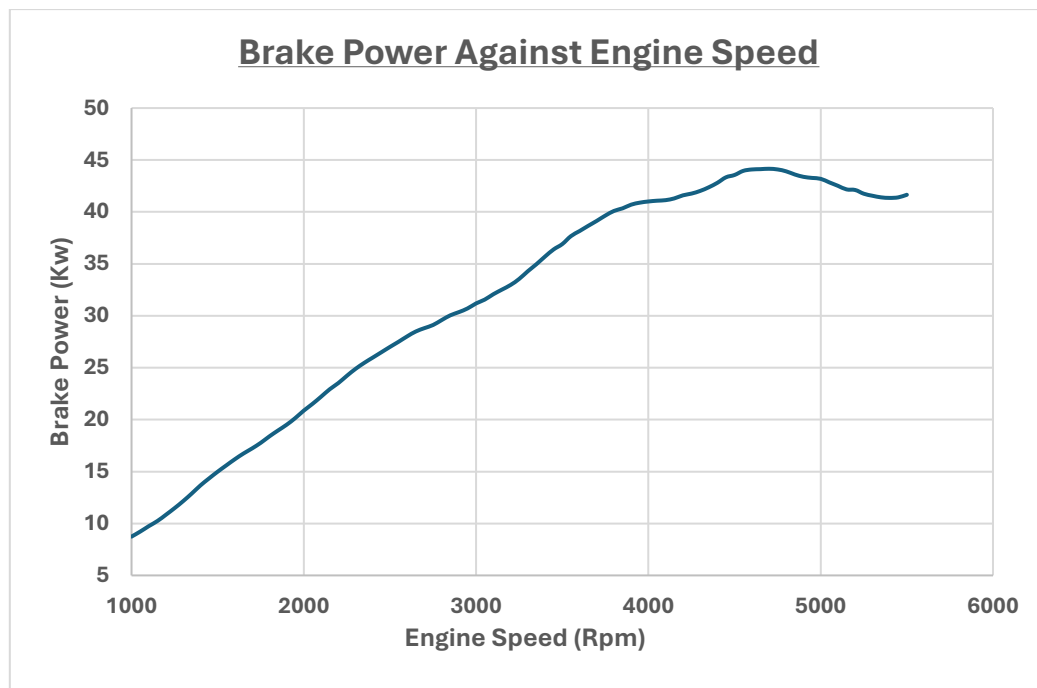


Figure 9 - Brake power Against Engine Speed

There is a rather linear positive correlation between engine speed and brake power until around the 4000 Rpm point where the power starts to flatten out and become less stable, over about 4750 Rpm the power starts to decline, there are a variety of reasons that can cause this drop such as internal friction, at this rpm the engine is moving the lubrication oil in and around the crankshaft much faster than before and the force to pump the oil can start to overcome the power produced by the engine.

Another issue could be that although the valve is open for the same crank duration, the real time the valve is open is much less than at a lower rpm, as the air the engine is trying to pump has a mass and inertia it gets to a point where it cannot accelerate into the cylinder fast enough meaning you can get less air into the cylinder which causes a drop in torque so even though the rpm is increasing the torque is decreasing and the power is a function of torque you can see this torque drop have an affect on power in figure 10.

Remedies to this engine can be a shorter stroke with a larger diameter bore, however a solution to improve the issue that can be applied to all existing vehicles is using an exhaust system that encourages scavenging effectively using the low pressure of the exhaust to increase the pressure differential between the inlet and the exhaust and cylinder resulting in more air being forced into the cylinder.(Rigneault *et al.*, 2014; Andy Harrison, 2026)

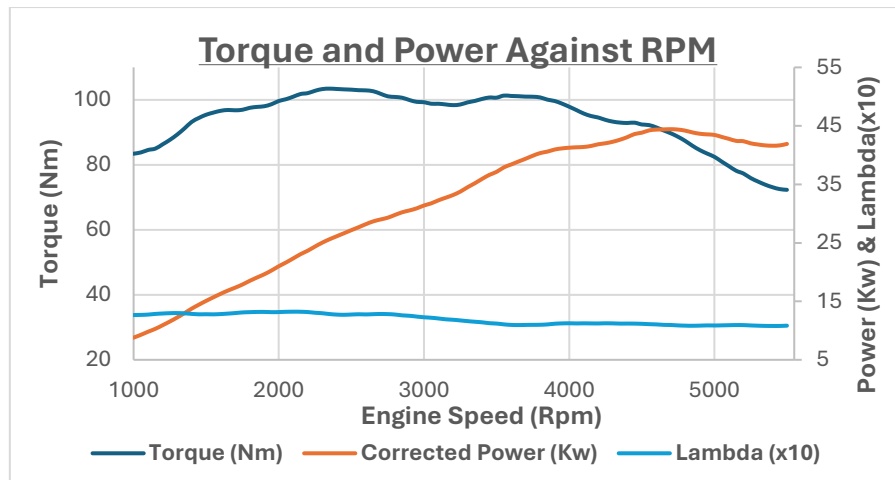


Figure 10 - Torque, power and Lambda (scaled)

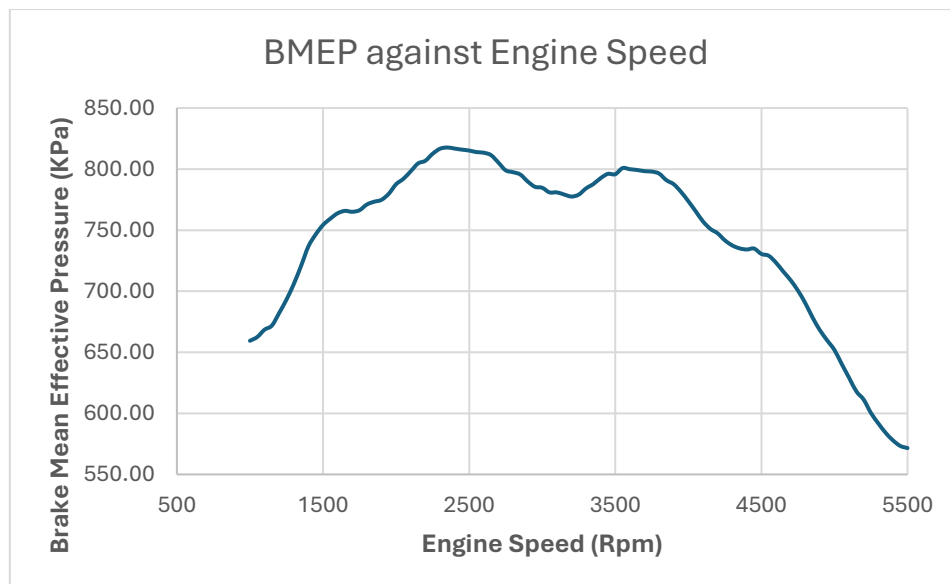


Figure 11- Brake Mean Effective Pressure Against Engine Speed

Figure 11 shows a plot of BMEP against RPM, this has a link to volumetric efficiency and supports the argument that the engine is not breathing so well at higher RPM, the graph shows that the engine theoretically is producing less average pressure on each piston through the stroke which means likely that there is less air entering the engine meaning the engine is less efficient and making less power.

Equation 6 - Brake Mean Effective Pressure

$$\text{Brake Mean Effective Pressure} = \frac{(\text{Torque} * 4\pi)}{\text{Engine Capacity (m}^3\text{)}}$$

5.4 Other Notable Data Plots

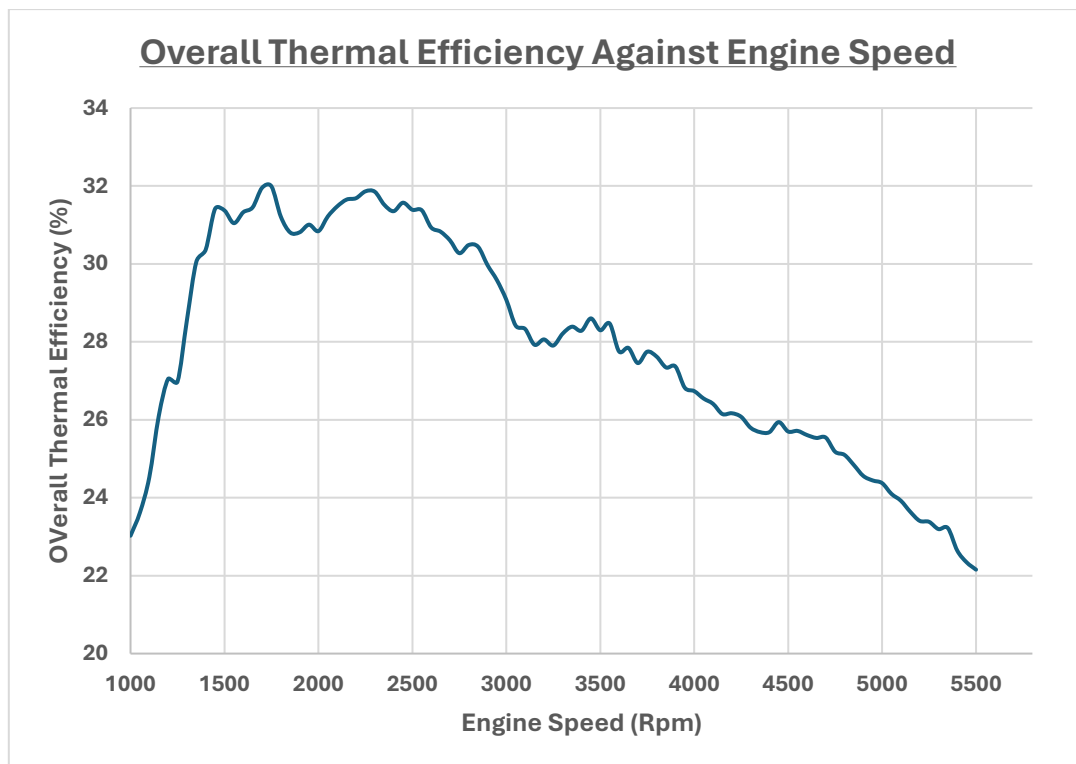


Figure 12 - Overall Thermal Efficiency Against Engine Speed

A relationship to figure 12 is that the engine is less thermally efficient at high rpm, where the lambda is at its richest value and the most power is made, where thermal energy is a byproduct of internal combustion there is clearly more heat energy being made at the same time.

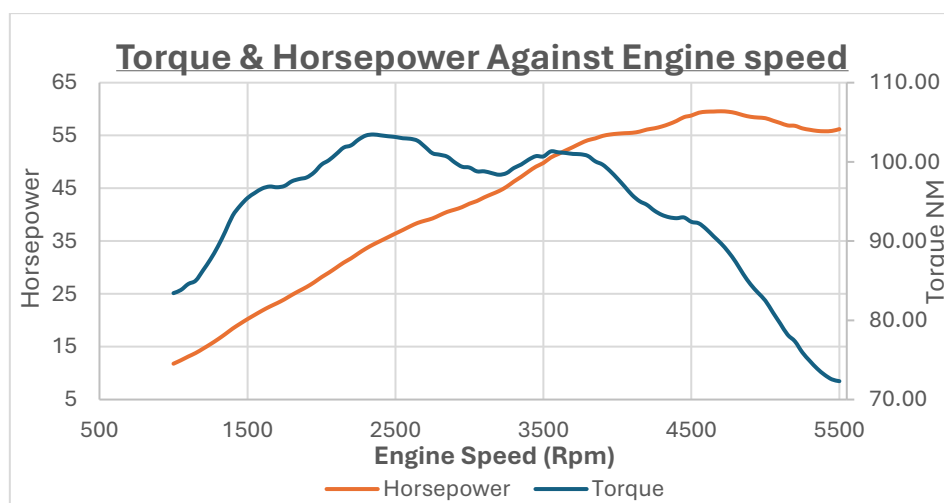


Figure 13- Torque and Horsepower Against Engine Speed

6. Conclusion

The main takeaway in this experiment is to understand that there are a considerable number of variables that influence an ICE's performance and that they all compound and affect each other, and that it is not just a simple case of adjusting air – fuel ratios.

One standout is that the engine is very far from working at its optimum or in its factory form, when leaving the factory the engine made approximately 78 KW or 105 Horse power, however when tested the engine only produced at peak 44.43 KW or 59.58 Horsepower, as seen in figure 5 the lambda value is well above the ideal value of 1 at best it is still 1.078, this factor very much could be the cause of the lack of power, the cause of the lean mixture in the engine could be due to the engine, running a non-standard airbox and running an unknown pod filter directly on the throttle body, this could cause the incorrect amount of air to enter the system for many factors such as turbulence.

The engine also does not use the OEM full length exhaust system which will impact scavenging and pulse lengths.

(Honda Motor-Corporation, 1988a, 1988b; Al-Arkawazi, 2019; Fall and UWTSD, 2020a)

7. Evaluation

An evaluation of this investigation could not be given due to the Dynamometer being out of service when gathering data for this experiment, however the data used is from this specific engine, dynamometer, location and test controller to reduce all variables, an improvement to the experiment could be to actually undertake the experiment and possibly use a higher revving engine such as 600cc sports bike engine to allow for a greater RPM range.

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9. Appendix

8.1 Equations Used

Equation 7 - Resistivity

$$R = \rho \frac{l}{A}$$

Equation 8 - Torque Calculation

$$\text{Torque (T)} = \text{Load (Newtons)} * \text{Lever Arm length (meters)}$$

Equation 9 - Specific Fuel Consumption

$$SFC (Kg/KWh) = \frac{(\text{Fuel Flow Rate} * 60) * \text{Fuel Density}}{\text{Corrected Power}}$$

Equation 10 - Corrected Power

$$\text{Corrected Power (KW)} = \frac{1.01325}{\text{Ambient Pressure}} * \sqrt{\frac{T_a}{293}} * \text{Measured Brake Power}$$

Equation 11 - Power Equation

$$\text{Power (Kw)} = \text{Torque} * \text{RPM}$$

Equation 12 - Brake Mean Effective Pressure

$$\text{Brake Mean Effective Pressure} = \frac{(\text{Torque} * 4\pi)}{\text{Engine Capacity (m}^3\text{)}}$$

Equation 13 - Overall Thermal efficiency

$$\text{Overall Thermal Efficiency} = \frac{\text{Corrected Power}}{\frac{\text{Fuel Flow Rate}}{(60 * \text{Fuel Density} * \text{calorific value of fuel})} * 100}$$

8.2 Full Raw and Processed Data Set

Table 3 - Full Raw and Processed Data Set

Load Newtons	Dyno Speed rpm	Fuel Flow Rate l/min	Lambda Lambda		Torque N/m	Brake Power Kw	Corrected Power Kw	BMEP KPa	SFC Kg/KWh	OTE %
102.275	1000	0.0704	1.2658		83.43	8.74	8.79	659.41	0.360	23.02
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103.689	1100	0.0737	1.27344		84.59	9.74	9.80	668.52	0.338	24.53
104.209	1150	0.0728	1.28476		85.01	10.24	10.30	671.88	0.318	26.09
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107.51	1250	0.07895	1.29729		87.70	11.48	11.55	693.16	0.308	26.98
109.488	1300	0.079	1.29895		89.32	12.16	12.24	705.91	0.291	28.56
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118.772	1650	0.09875	1.29028		96.89	16.74	16.85	765.77	0.264	31.45
118.656	1700	0.10005	1.29942		96.80	17.23	17.34	765.02	0.260	31.95
118.861	1750	0.10305	1.31053		96.96	17.77	17.88	766.34	0.259	31.99
119.584	1800	0.1093	1.3149		97.55	18.39	18.50	771.00	0.266	31.21
119.934	1850	0.11415	1.31849		97.84	18.95	19.07	773.26	0.269	30.81
120.176	1900	0.11745	1.31892		98.04	19.51	19.63	774.82	0.269	30.81
120.948	1950	0.12055	1.31484		98.67	20.15	20.27	779.80	0.268	31.01

122.15 7	2000	0.12555	1.3165 3
122.84 5	2050	0.12785	1.3209 8
123.79 6	2100	0.1309	1.3228 7
124.79 4	2150	0.13435	1.3216 4
125.13 7	2200	0.1377	1.3165 2
126.02 8	2250	0.14105	1.3046 5
126.66	2300	0.14495	1.2964 6
126.82 2	2350	0.14985	1.2822 9
126.69	2400	0.1537	1.2730 4
126.55 2	2450	0.15565	1.2698 4
126.43 8	2500	0.1596	1.2744 6
126.23 9	2550	0.1626	1.2787 6
126.16 1	2600	0.16805	1.2763 4
125.84 7	2650	0.17145	1.2802 7
124.91 1	2700	0.17465	1.2837 1
123.92 7	2750	0.1784	1.2812
123.68 9	2800	0.18005	1.2744 8
123.38 9	2850	0.1831	1.2603 6
122.51 9	2900	0.1879	1.2531
121.83 7	2950	0.19255	1.2394 3
121.70 9	3000	0.199	1.2273 5
121.12 3	3050	0.20605	1.2193
121.12 4	3100	0.21005	1.2069 2
120.85 1	3150	0.21605	1.1927 4
120.59 6	3200	0.21795	1.1848 1

99.65	20.87	21.00	787.5 9	0.269	30.8 4
100.2 1	21.51	21.65	792.0 3	0.266	31.2 2
100.9 9	22.21	22.35	798.1 6	0.264	31.4 8
101.8 0	22.92	23.06	804.6 0	0.262	31.6 5
102.0 8	23.52	23.67	806.8 1	0.262	31.6 9
102.8 1	24.22	24.38	812.5 5	0.260	31.8 6
103.3 3	24.89	25.04	816.6 3	0.260	31.8 5
103.4 6	25.46	25.62	817.6 7	0.263	31.5 2
103.3 5	25.97	26.14	816.8 2	0.265	31.3 5
103.2 4	26.49	26.65	815.9 3	0.263	31.5 7
103.1 5	27.00	27.17	815.1 9	0.264	31.3 9
102.9 8	27.50	27.67	813.9 1	0.264	31.3 8
102.9 2	28.02	28.20	813.4 1	0.268	30.9 4
102.6 6	28.49	28.67	811.3 8	0.269	30.8 3
101.9 0	28.81	28.99	805.3 5	0.271	30.6 1
101.1 0	29.11	29.30	799.0 1	0.274	30.2 8
100.9 0	29.59	29.77	797.4 7	0.272	30.4 9
100.6 6	30.04	30.23	795.5 4	0.273	30.4 4
99.95	30.35	30.54	789.9 3	0.277	29.9 7
99.39	30.70	30.90	785.5 3	0.280	29.5 8
99.29	31.19	31.39	784.7 0	0.285	29.0 8
98.81	31.56	31.76	780.9 3	0.292	28.4 2
98.81	32.08	32.28	780.9 3	0.293	28.3 3
98.59	32.52	32.72	779.1 7	0.297	27.9 3
98.38	32.97	33.17	777.5 3	0.296	28.0 6

120.84	3250	0.22305	1.1737 8
121.63 3	3300	0.2255	1.1611 8
122.18 1	3350	0.2285	1.1510 4
122.93 3	3400	0.2342	1.1411 7
123.47 5	3450	0.23605	1.1266 9
123.42 8	3500	0.24195	1.1197 5
124.20 5	3550	0.24545	1.1062 2
124.06 6	3600	0.25505	1.0969 7
123.96 7	3650	0.25755	1.0940 1
123.81 5	3700	0.26445	1.0965 9
123.76 7	3750	0.2651	1.0980 8
123.50 9	3800	0.2693	1.0990 7
122.67 2	3850	0.27375	1.1053 3
122.15 7	3900	0.2759	1.1170 4
121.18 4	3950	0.28285	1.1225 9
120.00 4	4000	0.28455	1.1246 1
118.73 4	4050	0.2871	1.1222
117.44 2	4100	0.28895	1.1239 4
116.5	4150	0.29305	1.1223 3
115.93 1	4200	0.2949	1.1217 9
115.03 4	4250	0.29715	1.1245 6
114.39 1	4300	0.3022	1.1227 8
114.01 6	4350	0.30605	1.1194 3
113.87 1	4400	0.3092	1.1198 6
113.98 5	4450	0.3099	1.1187 3

98.58	33.55	33.76	779.1 0	0.297	27.9 1
99.23	34.29	34.50	784.2 1	0.294	28.2 1
99.67	34.97	35.19	787.7 5	0.292	28.3 9
100.2 9	35.71	35.93	792.6 0	0.293	28.2 9
100.7 3	36.39	36.62	796.0 9	0.290	28.6 0
100.6 9	36.90	37.14	795.7 9	0.293	28.3 0
101.3 2	37.67	37.90	800.8 0	0.291	28.4 7
101.2 1	38.16	38.39	799.9 0	0.299	27.7 5
101.1 3	38.65	38.90	799.2 6	0.298	27.8 4
101.0 1	39.14	39.38	798.2 8	0.302	27.4 6
100.9 7	39.65	39.90	797.9 7	0.299	27.7 5
100.7 6	40.09	40.35	796.3 1	0.300	27.6 2
100.0 7	40.35	40.60	790.9 1	0.303	27.3 4
99.65	40.70	40.95	787.5 9	0.303	27.3 7
98.86	40.89	41.15	781.3 2	0.309	26.8 2
97.90	41.01	41.26	773.7 1	0.310	26.7 4
96.86	41.08	41.34	765.5 2	0.313	26.5 5
95.81	41.13	41.39	757.1 9	0.314	26.4 1
95.04	41.30	41.56	751.1 2	0.317	26.1 5
94.57	41.60	41.86	747.4 5	0.317	26.1 7
93.84	41.77	42.03	741.6 7	0.318	26.0 8
93.32	42.02	42.28	737.5 2	0.322	25.8 0
93.01	42.37	42.64	735.1 1	0.323	25.6 8
92.89	42.80	43.07	734.1 7	0.323	25.6 8
92.99	43.33	43.60	734.9 1	0.320	25.9 4

113.30 6	4500	0.31445	1.1156 3
113.07 4	4550	0.3171	1.1095 3
112.19 5	4600	0.3194	1.1056 9
111.06 1	4650	0.32055	1.0978 2
109.97 3	4700	0.3207	1.0955 8
108.65 4	4750	0.32485	1.0882 7
107.07 6	4800	0.32455	1.0839 6
105.24	4850	0.3257	1.0822 1
103.63 2	4900	0.3277	1.0846
102.33 5	4950	0.32845	1.0882 3
101.10 6	5000	0.3287	1.0868 7
99.314 9	5050	0.32985	1.0891
97.581 5	5100	0.3297	1.0918 5
95.848 6	5150	0.33095	1.0940 7
94.803 3	5200	0.3338	1.0934 6
93.097 6	5250	0.3313	1.0880 4
91.788 6	5300	0.3324	1.0833 9
90.593 8	5350	0.3308	1.0800 7
89.637 4	5400	0.3388	1.0789 5
88.925 6	5450	0.3438	1.0792 3
88.647 4	5500	0.3488	1.0836 6

92.43	43.56	43.83	730.5 3	0.323	25.7 0
92.24	43.95	44.23	729.0 3	0.323	25.7 1
91.53	44.09	44.37	723.3 6	0.324	25.6 1
90.60	44.12	44.39	716.0 5	0.325	25.5 3
89.71	44.16	44.43	709.0 4	0.325	25.5 4
88.64	44.09	44.37	700.5 3	0.329	25.1 8
87.35	43.91	44.18	690.3 6	0.331	25.1 0
85.85	43.60	43.88	678.5 2	0.334	24.8 4
84.54	43.38	43.65	668.1 6	0.338	24.5 6
83.48	43.27	43.55	659.7 9	0.339	24.4 4
82.48	43.19	43.46	651.8 7	0.340	24.3 8
81.02	42.85	43.11	640.3 2	0.344	24.1 0
79.60	42.51	42.78	629.1 5	0.347	23.9 2
78.19	42.17	42.43	617.9 7	0.351	23.6 4
77.34	42.11	42.38	611.2 3	0.354	23.4 1
75.95	41.75	42.02	600.2 4	0.355	23.3 8
74.88	41.56	41.82	591.8 0	0.358	23.2 0
73.90	41.40	41.66	584.0 9	0.357	23.2 2
73.12	41.35	41.61	577.9 3	0.366	22.6 4
72.54	41.40	41.66	573.3 4	0.371	22.3 4
72.32	41.65	41.91	571.5 4	0.374	22.1 5

8.3 Helper Calculations

Table 4 - Helper Calculations

Helpers		
Lambda	Difference	Corrected
scaled	Power	Horsepower
12.658	0.05	11.79
12.6783	0.06	12.44
12.7344	0.06	13.15
12.8476	0.06	13.81
12.9181	0.07	14.64
12.9729	0.07	15.49
12.9895	0.08	16.41
12.9469	0.08	17.40
12.855	0.09	18.44
12.7818	0.09	19.35
12.795	0.09	20.23
12.7766	0.10	21.05
12.8235	0.10	21.85
12.9028	0.10	22.59
12.9942	0.11	23.25
13.1053	0.11	23.98
13.149	0.12	24.81
13.1849	0.12	25.58
13.1892	0.12	26.32
13.1484	0.13	27.19
13.1653	0.13	28.16
13.2098	0.13	29.03
13.2287	0.14	29.97
13.2164	0.14	30.93
13.1652	0.15	31.74
13.0465	0.15	32.69
12.9646	0.16	33.58
12.8229	0.16	34.36
12.7304	0.16	35.05
12.6984	0.17	35.74
12.7446	0.17	36.44
12.7876	0.17	37.11
12.7634	0.18	37.81
12.8027	0.18	38.44
12.8371	0.18	38.88

12.812	0.18	39.29
12.7448	0.19	39.92
12.6036	0.19	40.54
12.531	0.19	40.96
12.3943	0.19	41.43
12.2735	0.20	42.09
12.193	0.20	42.59
12.0692	0.20	43.29
11.9274	0.20	43.88
11.8481	0.21	44.49
11.7378	0.21	45.27
11.6118	0.21	46.27
11.5104	0.22	47.18
11.4117	0.22	48.18
11.2669	0.23	49.11
11.1975	0.23	49.80
11.0622	0.24	50.83
10.9697	0.24	51.49
10.9401	0.24	52.16
10.9659	0.25	52.81
10.9808	0.25	53.50
10.9907	0.25	54.10
11.0533	0.25	54.44
11.1704	0.25	54.92
11.2259	0.26	55.18
11.2461	0.26	55.34
11.222	0.26	55.43
11.2394	0.26	55.51
11.2233	0.26	55.73
11.2179	0.26	56.13
11.2456	0.26	56.36
11.2278	0.26	56.70
11.1943	0.27	57.17
11.1986	0.27	57.76
11.1873	0.27	58.47
11.1563	0.27	58.78
11.0953	0.28	59.31
11.0569	0.28	59.49
10.9782	0.28	59.53
10.9558	0.28	59.58
10.8827	0.28	59.50
10.8396	0.28	59.25
10.8221	0.27	58.84
10.846	0.27	58.54
10.8823	0.27	58.40

10.8687	0.27	58.28
10.891	0.27	57.82
10.9185	0.27	57.37
10.9407	0.26	56.90
10.9346	0.26	56.83
10.8804	0.26	56.34
10.8339	0.26	56.08
10.8007	0.26	55.87
10.7895	0.26	55.80
10.7923	0.26	55.87
10.8366	0.26	56.21