

UWTSD

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Engine Performance Characteristics

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1-Introduction

Testing an engine's performance and evaluating the efficiency, power output, and durability is a crucial part of development. Using an engine dynamometer means that the engines can be tested in various environments under different operating conditions whilst all being controlled and accurately recorded. The information gathered from the use of an engine dynamometer can be used to optimize an engine's characteristics such as fuel efficiency, power, torque, longevity, and emission reduction. This experiment aims to analyze the performance of a 1.6 Honda D series engine similar to Figure 1 and to delve into what applications it is designed and tuned for.

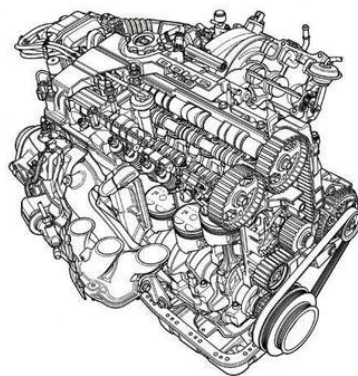


Figure 1- A Honda D series engine diagram (IPGParts, 2025).

2- Experimental Procedure

This Experiment was run on a Schenck WS230 Dynamometer from 2018, which is limited to 10,000 rpm and 230Kw (Dadt, 2001). The dyno operates via a core that is directly attached to the engine. The outer casing is an electromagnet, which applies a braking force to the core to apply a resistive force to the engine. The resultant of this force creates a reaction where the outer casing tries to turn, this is then measured by a strain gauge sending a signal between 0-10v to the control point. That is the only data taken from the dyno, everything else is either taken from the engine sensors or can be calculated. To calculate load from the 0-10v, there are calibration arms on either side of the dynamometer. These arms are designed to be exactly 815.776mm from pivot to hook eye. A mass is hung on one end, and the voltage off the strain gauge is recorded. Gathering information from different voltages' respective mass creates a picture of the amount of torque needed to cause a certain voltage reaction at the strain gauge. As the engine is run, this rotational force is what's recorded alongside the pressure needed to brake the engine.

To run the dyno, there is a control panel with two dials on, one for torque and one for power. Turning the power dial increases the throttle position and turning the torque dial increases the braking force on the drive shaft. The dyno can also be used in an automatic mode where the engine can be run in steps where each step can simulate various situations such as a gear change or acceleration and deceleration. These steps can be looped into one long continuous test where the engine's lifespan can be tested.

For this experiment, the dynamometer was set into a sweep test. A sweep test has a set starting and ending speed with set increments where data is taken. Unlike in a step test where the engine pauses to take the data. Because it is continuous, the data is marginally less accurate, however, this method does reduce the risk of overheating. For this experiment, the engine speed started at 1000 rpm and ended at 5500 rpm, with data being taken every 50 rpm.



Figure 2-shows the Schenck dynamometer attached to the Honda engine.

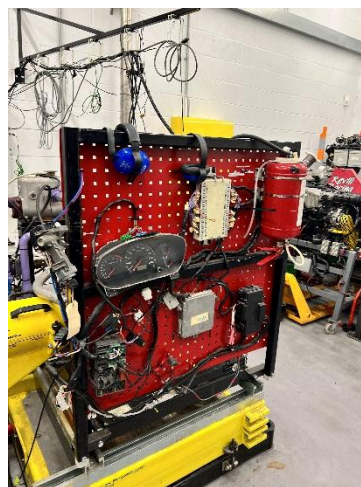


Figure 3- Shows the engine control panel with all original parts still attached.



Figure 4- Shows the engine side of the rig.

3- Raw Data

Table 0-1 The data that was taken off the engine Dynamometer at the time of test.

Load N	Dyno Speed rpm	Fuel Flow Rate l/min	Lambda Lambda
102.275	1000	0.0704	1.2658
102.756	1050	0.0724	1.26783
103.689	1100	0.0737	1.27344
104.209	1150	0.0728	1.28476
105.811	1200	0.0744	1.29181
107.51	1250	0.07895	1.29729
109.488	1300	0.079	1.29895
111.797	1350	0.0796	1.29469
114.268	1400	0.0835	1.2855
115.783	1450	0.0847	1.27818
116.985	1500	0.08865	1.2795
117.788	1550	0.0932	1.27766
118.471	1600	0.0959	1.28235
118.772	1650	0.09875	1.29028
118.656	1700	0.10005	1.29942
118.861	1750	0.10305	1.31053
119.584	1800	0.1093	1.3149
119.934	1850	0.11415	1.31849
120.176	1900	0.11745	1.31892
120.948	1950	0.12055	1.31484
122.157	2000	0.12555	1.31653

Table 0-2 The atmospheric data given

Baro mBar	Humidity %	Ambient temp Deg C
1018.9	46	27

Table 0-1 Cylinder Data.

stroke	bore	number of cylinders
0.09	0.075	2

4- Calculated Data

Table 0-1 Calculated Data on excel, showing data from 1000-2000 rpm only.

Engine Speed	Power	Fuel Flow rate				Corrected Power	Torque	BMEP	SFC	Overall Thermal Efficiency
rad/s	Kw	cc/s				Kw	nm	Bar	KG/Kwh	%
104.720	8.737	1.17E-06				8.792	83.433	6.594	0.360	21.814
109.956	9.217	1.21E-06				9.275	83.826	6.625	0.351	22.377
115.192	9.744	1.23E-06				9.805	84.587	6.685	0.338	23.238
120.428	10.238	1.21E-06				10.302	85.011	6.719	0.318	24.718
125.664	10.847	1.24E-06				10.915	86.318	6.822	0.307	25.626
130.900	11.480	1.32E-06				11.552	87.704	6.932	0.308	25.559
136.136	12.159	1.32E-06				12.235	89.318	7.059	0.291	27.053
141.372	12.893	1.33E-06				12.974	91.201	7.208	0.276	28.470
146.608	13.666	1.39E-06				13.752	93.217	7.367	0.273	28.767
151.844	14.342	1.41E-06				14.432	94.453	7.465	0.264	29.762
157.080	14.991	1.48E-06				15.085	95.434	7.542	0.264	29.722
162.316	15.597	1.55E-06				15.694	96.089	7.594	0.267	29.414
167.552	16.193	1.60E-06				16.295	96.646	7.638	0.265	29.679
172.788	16.742	1.65E-06				16.846	96.891	7.658	0.264	29.799
178.024	17.232	1.67E-06				17.340	96.797	7.650	0.260	30.273
183.260	17.770	1.72E-06				17.881	96.964	7.663	0.259	30.309
188.496	18.388	1.82E-06				18.504	97.554	7.710	0.266	29.571
193.732	18.955	1.90E-06				19.073	97.839	7.733	0.269	29.186
198.968	19.506	1.96E-06				19.628	98.037	7.748	0.269	29.191
204.204	20.148	2.01E-06				20.274	98.666	7.798	0.268	29.377
209.440	20.871	2.09E-06				21.002	99.653	7.876	0.269	29.219

Table 0-3 shows the area of a cylinder

area M ²
0.00418

Table 0-2 Shows the Calorific Value of Petrol.

cv petrol kj/kg
45800

5- Analysis

5.1- Torque With Engine Speed

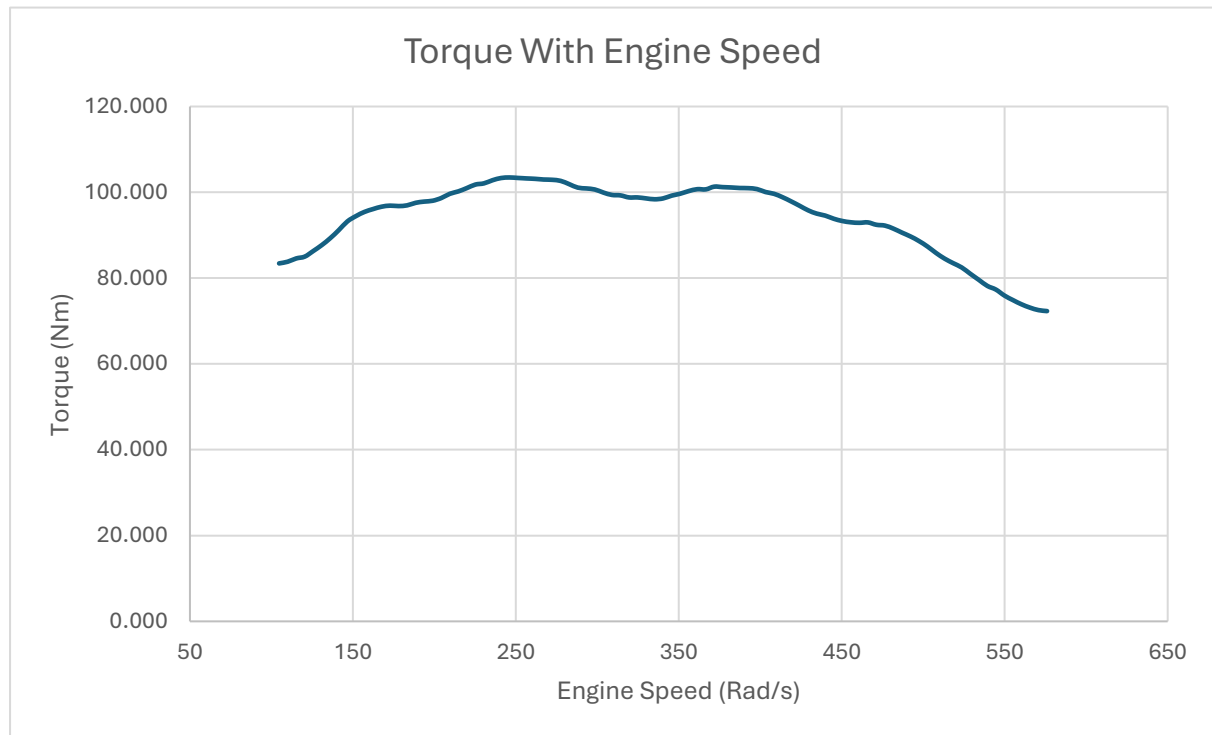


Figure 5- Shows the correlation of Torque in the engine with engine speed in rad/s

Engines are designed specifically for each application. Some engines are designed to have a longer stroke; this causes the piston to move faster, pulling air in faster at low speeds. More air in the cylinder at the time of combustion results in the air-fuel mixture burning more completely.

This engine has been designed to achieve peak torque during mid-engine-speed. At low rpm, the air to fuel mixture is not fully optimized for torque, this is due to there being more time for the air to be pulled into the chamber, leading to a slightly leaner mixture (Gellert, 2024). As the engine speed increases, the volumetric efficiency improves, this is due to the valves operating at optimal timing, allowing the desired stoichiometric ratio to be met. When peak stoichiometric values are met, the pressure in combustion will be greater, thus creating more force in the combustion chamber. As the engine accelerates, the torque starts to drop off due to the decrease of time the valves are open. As the engine speed increases, there is also an increase of temperature and frictional forces acting upon the engine, which will reduce the torque output. Peak torque was 103.5nm, which was reached at 2350 rpm or 246 rad/s as seen in figure 5. At 3850 rpm or 403 rad/s, the drop off of force starts; this is due to the engine now rotating at a speed that negatively affects the volumetric efficiency and where frictional losses start to increase.

5.2- SFC With Engine Speed

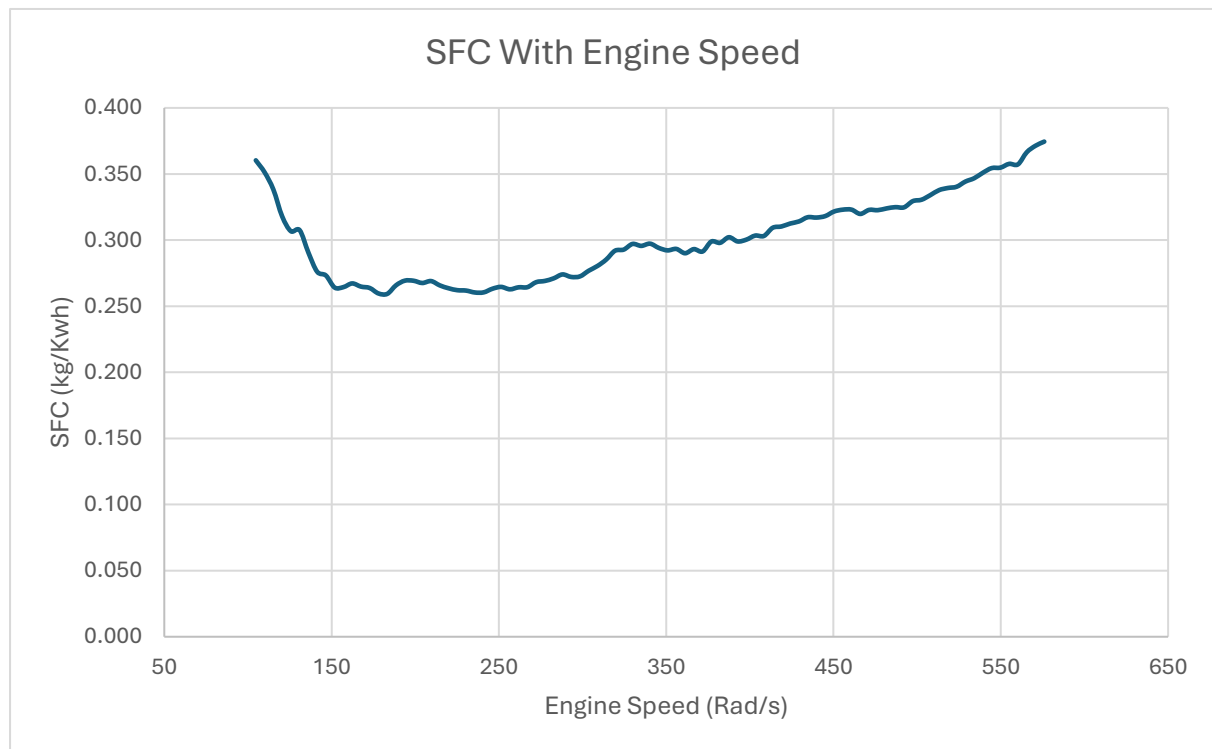


Figure 6 Shows the relationship with SFC and Engine Speed.

At minimal engine speeds, the engine will use more fuel, this is due to incomplete combustion as well as poor air to fuel mixing. This leads to an initial SFC above 0.35 kg/kWh, which isn't met again until just under 550 rad/s. The middle section of the graph is where it's at its lowest. This low area is due to it being the most fuel efficient area. This also corresponds with figure 5 as it is when the engine is producing the most torque. This area is where the efficiency of combustion and volumetric efficiency are maximised. As the engine speed increases, so does the fuel usage. This is due to the engine rotating faster and needing a richer air to fuel ratio to prevent knocking and overheating. Excess fuel in the combustion chamber absorbs heat as it vaporizes, this is known as evaporative cooling (Law, 2018). A richer mixture burns at a lower temperature than a 14.7:1 ratio, the risk of knocking is reduced due to the fuel being less likely to detonate prematurely in the cooler conditions. This engine has been tuned for daily use at mid range engine speeds with low fuel consumption. Looking at this graph, it is apparent that to maximize fuel efficiency, low engine speeds, such as in traffic, or high engine speeds, such as on a motorway, should be avoided.

5.3- Engine Power With Engine Speed

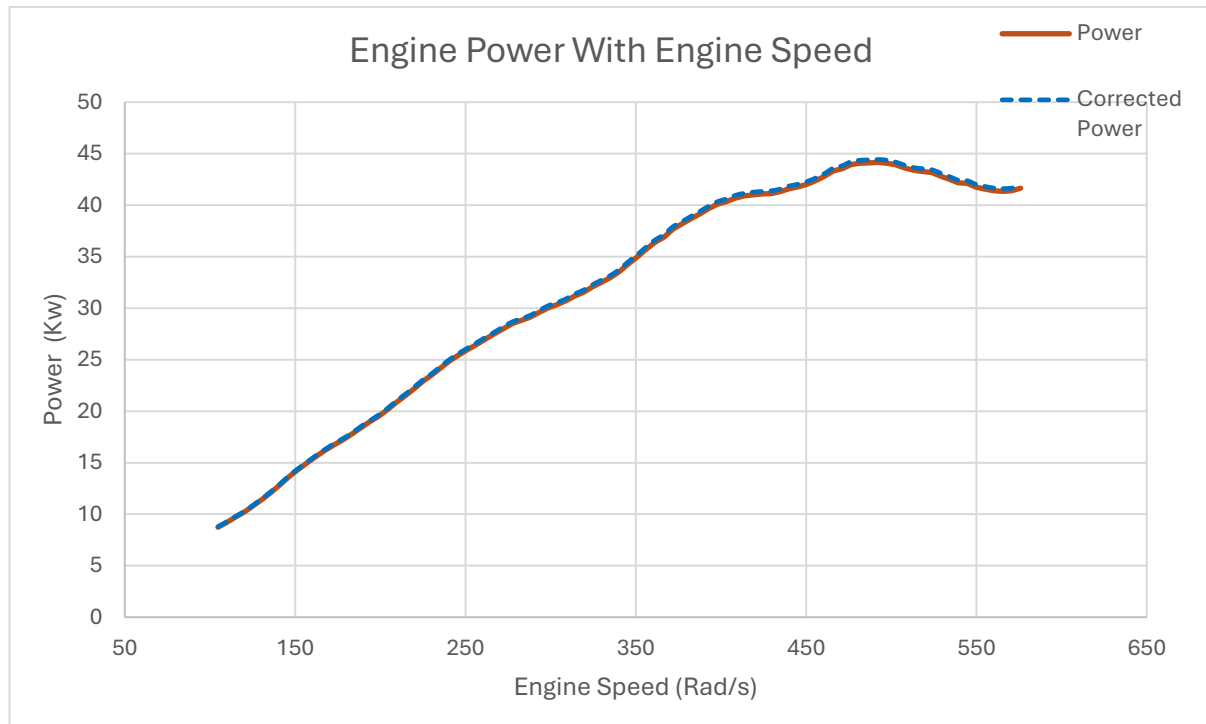


Figure 7 Shows engine power alongside corrected power against engine speed.

Figure 7 shows the relationship between power and engine speed. Corrected power is also shown; corrected powers minimal difference from power shows that atmospheric conditions had a minimal effect on performance. This dynamometer result shows that there is a very linear increase in power output with an increase in engine speed. After roughly 475 rad/s, the power begins to decline because of factors such as an increase in internal friction and a reduction in volumetric efficiency. This trend aligns with the torque graph in figure 5, where peak torque was found in the mid-range before dropping off in the higher speeds. This engine peaks at 44.36 kW at 4600 rpm.

6- Conclusion

The results provided by the Schenck WS230 Dynamometer have provided valuable insights into the key characteristics in defining an engines performance and efficiency.

The engine demonstrated a peak torque of 103 Nm at 2350rpm, this result aligns with its design for mid range efficiency as opposed to higher performance levels. The power output increased linearly until approximately 4600 rpm, where internal friction and a decreasing volumetric efficiency started to take a toll on power. The SFE was lowest in the midrange, which further reinforces the belief that this engine has been tuned for everyday urban driving.

7- Further Work

To improve this experiment and to get more accurate results, the use of a higher tech engine dynamometer would be ideal. There are many types of engine dynos, such as water brake, Eddy Current, and AC dynos. Water Brake dynos are suited towards continuous high load testing such as diesel engines. EC dynos are better suited to medium to high speed applications. EC dynos also have rapid load adjustments, so they are suited to performance tuning, however, they are less effective at low speeds. Finally, an AC dyno's ideal application is for use in advanced R&D for engine mapping as well as in automotive manufacturers' labs. One downside to an AC dyno is the cost of the dyno as well as the cost of running one. (Power Test, 2019).

Resolving the current issue with the engine dynamometer, which restricted the experiment from taking place due to the braking force being permanently large and stopping the core from spinning. Taking own data would improve accuracy as well as being able to compare with data used in this report to gain an understanding on how the engine behaves now as opposed to how it was when the data was recorded.

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