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Engine Performance Characteristics

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30/03/2025

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1 Introduction

In this report, several characteristics of an engine will be recorded and analysed after being put on an Eddy-Current Engine Dynamometer. These characteristics include Specific fuel consumption, Torque, Brake Power, BMEP and Overall thermal efficiency. From here the Specific fuel consumption, Brake Power and Torque were to be plotted on a graph against Engine speed and the reasons why these factors varied were discussed. The way the engine dynamometer works will also be reported, as well as the specifications of the Honda Civic Coupe CRX engine that was used during the experiment and how the test could have been improved.

2 Background

To measure Torque on the engine dynamometer, an engine is connected to the dynamometer via a drive shaft. The dynamometer used was a Schenck W230 (Technical Specification Eddy-Current Dynamometer W Series, 2001). There is an inner and outer core to the dynamometer. The engine connected drives the inner core, whilst the outer core is fed by a current which produces an electromagnetic field that puts a load on the engine to try slow the it down. This causes the outer case to try turn, which is prevented by a strain gauge. The strain gauge then sends a signal between 0 and 10 volts to the computer running the system. There are two torque arms on the dynamometer where a mass is hung from one side from a distance of 0.815776 meters. The outer casing will try turn a certain amount depending on the mass, and this then sends the exact voltage from the strain gauge. The computer running the system then converts the voltage into the amount of torque produced (Engine Dynamometer Overview - YouTube, 2020).



Figure 1 - The Schenck W-series Dynamometer

The engine used in the experiment was a Honda Civic Coupe CRX from 1988. The engine is water-cooled and has four cylinders. The engine has either dual overhead camshafts or single overhead camshafts. The bore of each piston is 75 millimetres, and the stroke of each piston is 90 millimetres. The displacement of the engine is 1590cc (Honda Civic Coupe CRX Chassis Maintenance and Repair 88, 1988).

The experiment started with the engine running at 1000 RPM. The engine speed was then increased in increments of 50 RPM up to 5500 RPM. The other factors noted during the experiment were the load on the engine, the fuel flow rate and the reading from the lambda sensor. With these values recorded the Torque, Power, BMEP, SFC and Overall thermal efficiency could be calculated in excel. The Brake Power, Torque and SFC could then be plotted against engine speed.

3 Results

Table 1 - Results of the Honda Civic 1.6 on the engine dynamometer

Power(W)	Torque (Nm)	Power (kW)	BMEP(Pa)	SFC (kg/k	Overall Thermal Efficiency
8732.705329	83.4334904	8.732705329	1156810.559	0.00048	0.410318431
9212.464064	83.8258787	9.212464064	1281381.779	0.00047	0.444026736
9738.782998	84.5869977	9.738782998	1419092.851	0.00045	0.487458854
10232.51492	85.0112012	10.23251492	1558811.729	0.00043	0.544790426
10841.55014	86.3180743	10.84155014	1723399.914	0.00041	0.598419728
11474.61684	87.7040778	11.47461684	1900035.187	0.00041	0.631713741
12153.15936	89.3176827	12.15315936	2092887.977	0.00039	0.708186049
12886.74503	91.2013095	12.88674503	2304572.857	0.00037	0.790259048
13659.41121	93.217092	13.65941121	2533223.18	0.00037	0.846395911
14334.81584	94.4529926	14.33481584	2753426.948	0.00035	0.918960615
14983.06819	95.4335554	14.98306819	2977182.472	0.00036	0.959221369
15588.77768	96.0886235	15.58877768	3200790.135	0.00036	0.987652774
16184.94972	96.6457985	16.18494972	3430400.093	0.00036	1.034665993
16733.13564	96.8913471	16.73313564	3657418.977	0.00035	1.074023124
17223.36252	96.7967171	17.22336252	3878647.417	0.00035	1.12309079
17760.56372	96.9639511	17.76056372	4117259.431	0.00035	1.159475481
18379.12785	97.5537572	18.37912785	4382388.167	0.00036	1.170646333
18944.94568	97.8392788	18.94494568	4642784.556	0.00036	1.19098663
19496.23106	98.0366966	19.49623106	4907018.58	0.00036	1.225869891
20137.82768	98.6664756	20.13782768	5201884.078	0.00036	1.274248406
20860.64209	99.6527488	20.86064209	5526766.363	0.00036	1.312909225
21502.58452	100.214003	21.50258452	5839262.01	0.00036	1.369861524
22197.55929	100.989806	22.19755929	6175014.158	0.00035	1.425827136
22909.28225	101.803395	22.90928225	6524742.563	0.00035	1.479726216
23506.48744	102.083761	23.50648744	6850525.017	0.00035	1.519979071
24211.90047	102.810618	24.21190047	7216470.43	0.00035	1.574275522
24874.0577	103.326188	24.8740577	7578581.26	0.00035	1.616855202
25447.30398	103.458344	25.44730398	7921785.491	0.00035	1.636902761
25961.68615	103.350661	25.96168615	8253869.07	0.00036	1.661070237
26473.6861	103.238084	26.4736861	8591993.458	0.00035	1.705594466
26989.63081	103.145086	26.98963081	8938206.64	0.00035	1.728849043
27486.09503	102.982746	27.48609503	9284674.06	0.00035	1.759955226
28007.72208	102.919116	28.00772208	9646384.63	0.00036	1.768125685
28475.28364	102.662962	28.47528364	9996025.857	0.00036	1.791408791
28796.76929	101.899396	28.79676929	10299614.49	0.00036	1.798518946
29098.99219	101.096672	29.09899219	10600444.59	0.00037	1.797865171
29571.16451	100.902518	29.57116451	10968314.56	0.00037	1.839669474
30026.21722	100.657785	30.02621722	11335976.07	0.00037	1.865129423
30337.56773	99.9480597	30.33756773	11654461.06	0.00037	1.8553712
30688.84406	99.3917005	30.68884406	11992672.79	0.00038	1.852736302
31176.20629	99.2872812	31.17620629	12389619.23	0.00038	1.850075831
31543.20192	98.8092364	31.54320192	12744390.01	0.00039	1.829089709
32060.56828	98.8100522	32.06056828	13165772.55	0.00039	1.85359914
32504.24777	98.5873454	32.50424777	13563260.78	0.0004	1.852345703
32950.51441	98.3793225	32.95051441	13967723.06	0.0004	1.886963927
33533.07615	98.5783718	33.53307615	14436775.22	0.0004	1.909592217
34272.41247	99.2252822	34.27241247	14982078.01	0.00039	1.973053579
34948.44042	99.6723275	34.94844042	15509080.33	0.00039	2.024722312
35688.37016	100.285791	35.68837016	16073818.87	0.00039	2.059978141
36372.85971	100.727942	36.37285971	16623022.05	0.00039	2.122985185
36885.95685	100.6896	36.88595685	17101828.09	0.00039	2.130063519
37648.41957	101.323458	37.64841957	17704698.74	0.00039	2.187391582
38135.95257	101.210065	38.13595257	18186559.08	0.0004	2.159931325
38634.76487	101.129303	38.63476487	18680331.38	0.0004	2.195285789
39115.98795	101.005305	39.11598795	19172090.31	0.00041	2.191599079
39629.21317	100.966148	39.62921317	19686121.24	0.0004	2.243971023
40073.89166	100.755678	40.07389166	20172445.67	0.0004	2.258825902
40326.03225	100.072873	40.32603225	20566465.47	0.00041	2.250157571
40678.25207	99.6527488	40.67825207	21015529.1	0.00041	2.271793952
40871.6054	98.8589988	40.8716054	21386131.39	0.00042	2.237089109
40985.95239	97.8963831	40.98595239	21717431.52	0.00042	2.236184051
41059.10134	96.8603476	41.05910134	22028143.71	0.00042	2.224240581
41113.70476	95.806365	41.11370476	22329752.42	0.00042	2.215881849
41281.29757	95.037904	41.28129757	22694199.83	0.00043	2.202728784
41574.61059	94.5737275	41.57461059	23130814.13	0.00043	2.220126296
41744.03916	93.8419764	41.74403916	23501567.92	0.00043	2.221310538
41999.06575	93.3174324	41.99906575	23923324.09	0.00043	2.210959935
42348.14342	93.0115164	42.34814342	24402654.47	0.00043	2.219588366
42780.42835	92.8932289	42.78042835	24935107.42	0.00043	2.242058011
43309.88516	92.9862274	43.30988516	25530568.26	0.00043	2.292707023
43535.62058	92.4323155	43.53562058	25951991.57	0.00043	2.283147414
43929.21776	92.2430554	43.92921776	26477580.97	0.00043	2.305190234
44066.71251	91.5259883	44.06671251	26852326.68	0.00043	2.302939166
44095.45722	90.6008983	44.09545722	27161905.96	0.00044	2.29767179
44132.97946	89.713334	44.13297946	27477330.93	0.00044	2.300507267
44067.52366	88.6373255	44.06752366	27728456.43	0.00044	2.264386176
43884.65556	87.350031	43.88465556	27904058.24	0.00044	2.247707775
43581.47209	85.8522662	43.58147209	27999938.18	0.00045	2.208930775
43358.00363	84.5404984	43.35800363	28143544.66	0.00045	2.172992296
43252.25059	83.482437	43.25225059	28361379.27	0.00046	2.157467329
43164.45392	82.4798483	43.16445392	28589706.28	0.00046	2.147083186
42823.79047	81.0187119	42.82379047	28647710.67	0.00046	2.105958436
42492.9599	79.6046457	42.4929599	28707845.34	0.00047	2.074488793
42147.54864	78.1909875	42.14754864	28753650.38	0.00047	2.033191703
42092.63527	77.3382569	42.09263527	28994985.65	0.00048	2.010582847
41732.75986	75.9467877	41.73275986	29023504.3	0.00048	1.991264035
41537.84229	74.878937	41.53784229	29163070.04	0.00048	1.966178416
41383.91529	73.9042478	41.38391529	29329104.08	0.00048	1.96107284
41329.70719	73.1240396	41.32970719	29564431.11	0.00049	1.909753561
41381.15651	72.5433703	41.38115651	29875319.92	0.0005	1.88666785
41630.15324	72.3164214	41.63015324	30330818.99	0.0005	1.882069323

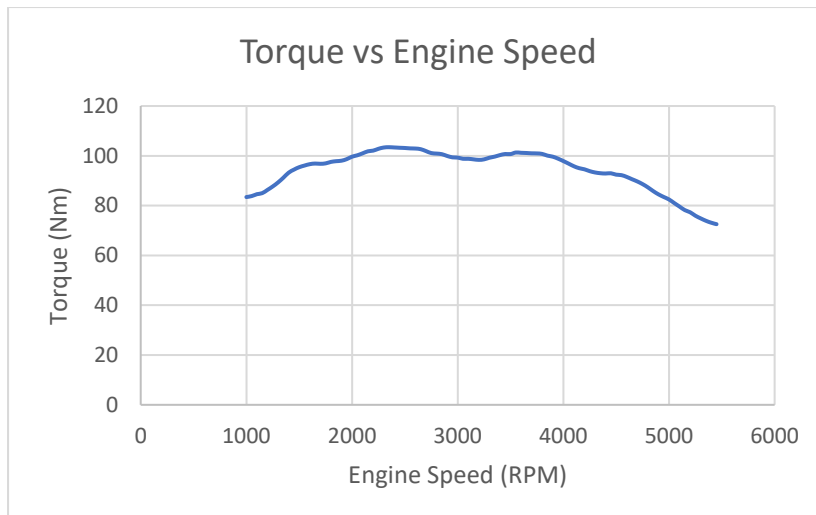


Figure 2 - Graph of Torque against Engine Speed

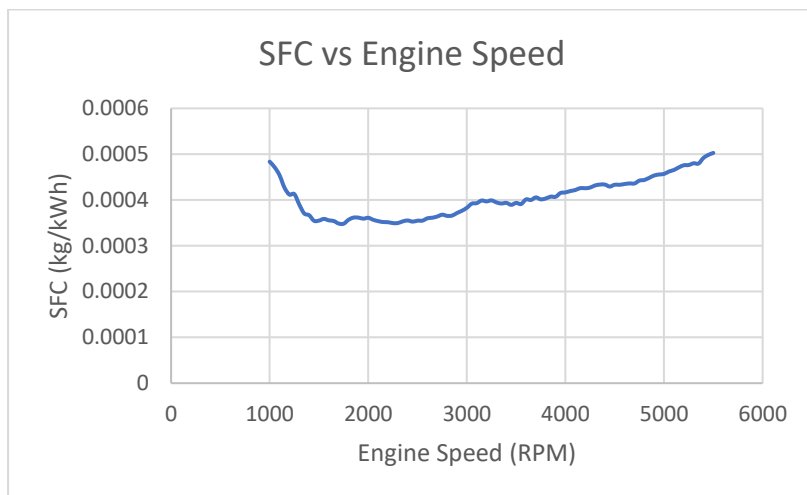


Figure 3 - Graph of SFC against Engine Speed

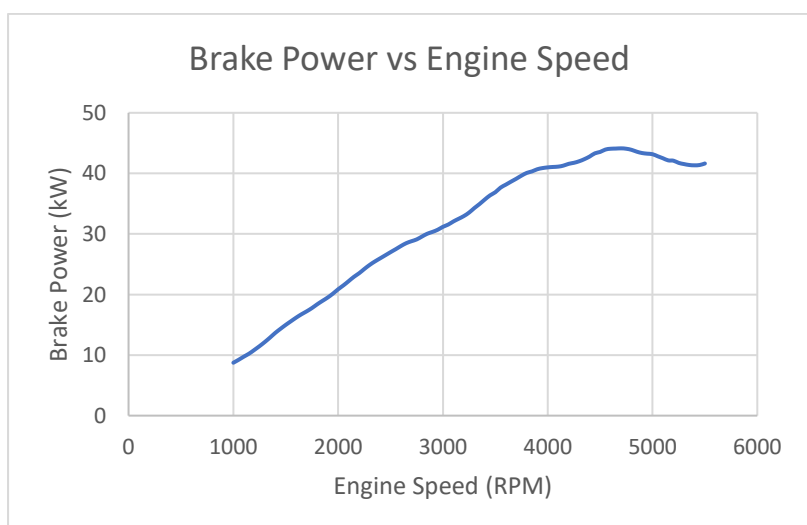


Figure 4 - Graph of Brake Power against Engine Speed

4 Analysis

As seen in table 1, the peak value for power was 44.13kW at 4700 RPM, peak Torque was 103.46 Nm at 2350 RPM, peak BMEP was 30.33 MPa at 5500 RPM, peak SFC was 0.0005 kg/kWh between 5450 RPM and 5500 RPM. The peak overall thermal efficiency was at 4550 RPM.

In terms of torque varying with engine speed, up to 2350 RPM the load acting on the engine is increasing at a constant rate. After this point, the load on the engine begins to decrease but not by a huge amount so the torque remains constant as the load remains fairly constant up until around 4000 RPM which can be seen in figure 2. As the engine speed reaches higher values, such as 5000 RPM, there is less force acting against the engine meaning that less torque is being produced. Also, as the RPM increases there is a higher mean effective pressure within the cylinder. In addition to this, as the engine speed increases, the amount of degrees that the ignition fires before top dead centre also increases. This means that the piston is not getting hit at the point where the most force will be. This means the torque will not be as great compared to lower RPM's (Powertrain 25, 2025).

In terms of SFC varying with engine speed, as the engine speed increases the SFC increases. This is true apart from at the very beginning of the test where the SFC is similar to the end of the test at the higher RPM's. Also, as the torque decreases is where the SFC begins to increase. As the engine has 4 cylinders, air is taken in twice per revolution. As the engine speed increases the rate at which air is taken in also increases. This means the work done per second increases which means the power increases, as seen in figure 4. This means that as the engine speed increases, the SFC will increase at a proportionate rate.

In terms of Brake power increasing with engine speed, as the engine speed increases the power of the engine increases, as seen in figure 4. There are several factors that contribute towards this. As seen in table 1, as the mean effective pressure increases the power in the engine increases. As the mean effective pressure increases, the amount of mechanical work that can be done also increases. The performance of the engine increases as well as the power. However, as the engine speed reaches the rev limit the power of the engine begins to decrease. As seen in figure 2, the torque begins to decrease at an increased rate at a similar RPM to the brake power starting to decrease which can be seen in figure 4. This means there is less work being done by the engine leading to a slight decrease in power.

5 Conclusion

In conclusion, as seen in figure 2, 3 and 4, different aspects of the engine respond differently in accordance with the speed of the engine. The torque of the engine remains steady in the mid-range of the rev range, the brake power increases at a proportionate rate up until the limits of the engine speed and the SFC on the most part also increases as the engine speed increases.

One way the experiment could have been improved is if the test had been performed more than once with a mean value taken for the engine load, fuel flow rate and lambda readings. However, with the small increasing increments in engine speed this should eliminate a lot of error in not needing to repeat the test. The calculation for thermal efficiency could have also been more accurate, as several factors were not considered such as valve timing and throttle position. One other factor that could've improved accuracy is changing the air filter to one that initially came with the original car the CRX engine was taken from, rather than a lawn mower.

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