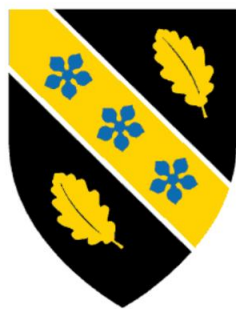


MODULE: POWERTRAIN TECHNOLOGY

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ASSIGNMENT 1

ENGINE PERFORMANCE CHARACTERISTICS



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(Tables not included as per Technical Report Guidelines)

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1 Introduction

This written report will cover an investigation into the performance and various other values, including torque and power upon testing the Honda 1.6L VTEC on an engine dynamometer. The data recorded and gathered will be used for analysis, discussion and the creation of graphical results. The dynamometer that was used for this investigation is the SCHENCK WS230 which is an eddy current dynamometer with a torque measurement accuracy of $\pm 0.2\%$ (SCHENCK PEGASUS GmbH, 2001).

The aims of this assignment are to gain a further understanding of how engine performance values can change when under different operating conditions such as increased load and to be able to use raw data to calculate and analyse other various numerical values.

The engine is a 1.6L Honda engine with dual overhead camshafts and variable valve timing. This engine is an inline 4 cylinder, that is usually transversely installed and has a compression ratio of 9.1:1 to 9.5:1 (Honda Motor Co. Ltd, 1987).

2 Raw data collected

Table 1 - Table showing ambient conditions

Baro	Humidity	Ambient temp
mBar	%	Deg C
1018.9	46	27

Table 2 - Table showing raw data

Load	Dyno Speed	Fuel Flow Rate
Newtons	rpm	l/min
102.275	1000	0.0704
102.756	1050	0.0724
103.689	1100	0.0737
104.209	1150	0.0728
105.811	1200	0.0744
107.51	1250	0.07895
109.488	1300	0.079
111.797	1350	0.0796
114.268	1400	0.0835
115.783	1450	0.0847
116.985	1500	0.08865
117.788	1550	0.0932
118.471	1600	0.0959
118.772	1650	0.09875
118.656	1700	0.10005
118.861	1750	0.10305
119.584	1800	0.1093
119.934	1850	0.11415
120.176	1900	0.11745
120.948	1950	0.12055
122.157	2000	0.12555
122.845	2050	0.12785
123.796	2100	0.1309
124.794	2150	0.13435
125.137	2200	0.1377
126.028	2250	0.14105
126.66	2300	0.14495
126.822	2350	0.14985
126.69	2400	0.1537
126.552	2450	0.15565

126.438	2500	0.1596
126.239	2550	0.1626
126.161	2600	0.16805
125.847	2650	0.17145
124.911	2700	0.17465
123.927	2750	0.1784
123.689	2800	0.18005
123.389	2850	0.1831
122.519	2900	0.1879
121.837	2950	0.19255
121.709	3000	0.199
121.123	3050	0.20605
121.124	3100	0.21005
120.851	3150	0.21605
120.596	3200	0.21795
120.84	3250	0.22305
121.633	3300	0.2255
122.181	3350	0.2285
122.933	3400	0.2342
123.475	3450	0.23605
123.428	3500	0.24195
124.205	3550	0.24545
124.066	3600	0.25505
123.967	3650	0.25755
123.815	3700	0.26445
123.767	3750	0.2651
123.509	3800	0.2693
122.672	3850	0.27375
122.157	3900	0.2759
121.184	3950	0.28285
120.004	4000	0.28455
118.734	4050	0.2871
117.442	4100	0.28895
116.5	4150	0.29305
115.931	4200	0.2949
115.034	4250	0.29715
114.391	4300	0.3022
114.016	4350	0.30605
113.871	4400	0.3092
113.985	4450	0.3099
113.306	4500	0.31445
113.074	4550	0.3171
112.195	4600	0.3194
111.061	4650	0.32055
109.973	4700	0.3207
108.654	4750	0.32485

107.076	4800	0.32455
105.24	4850	0.3257
103.632	4900	0.3277
102.335	4950	0.32845
101.106	5000	0.3287
99.3149	5050	0.32985
97.5815	5100	0.3297
95.8486	5150	0.33095
94.8033	5200	0.3338
93.0976	5250	0.3313
91.7886	5300	0.3324
90.5938	5350	0.3308
89.6374	5400	0.3388
88.9256	5450	0.3438
88.6474	5500	0.3488

3 Calculations

Please see the attached Excel spreadsheet file to view calculations performed to calculate results that are presented in Table 3 and Table 4. Additional, tables 1 and 2 can also be found within the Excel spreadsheet.

4 Methodology

Engine Dynamometer: SCHENCK WS230.

Specifications: Limited to 10,000 RPM - Maximum load = 230KW

Type: Eddy Current

Engine: Honda 1.6L VTEC

Configuration:

Dynamometer and Engine:

The dynamometer is located in the dynamometer room within the IQ building and has a control room from which the dynamometer and engine can be operated. The throttle of the engine is operated by an actuator that is controlled via the computer. The engine is connected to the dynamometer via a driveshaft that is bolted to the crankshaft and the other side of the driveshaft being connected to the dynamometer. This allows the rpm from the engine to be transferred to the dynamometer. On both the engine there is an engine speed sensor, fuel flow meter, coolant temp sensor and lambda sensor. The dynamometer has a coolant temperature sensor and an engine speed sensor. The extractor fan is directly positioned at the exhaust to maintain a safe working environment.

Dynamometer control room:

The dynamometer control room is situated within the dynamometer room. It has a large window to view the dynamometer and engine and to protect from direct noise and should anything go wrong, debris. Inside the control room there is the computer system from which the technician can operate the dynamometer and engine. There are also three monitors that each show valuable information and data. The screen in the middle screen is the screen that provides graphical representation of what is being monitored and recorded in real-time. The left screen is used for monitoring the outputs of each sensor such as lambda and fuel flow rate and various other sensor output data. The screen on the right is used to monitor the status of each actuator such as fuel pump, ignition and other actuators. From the control room, the dynamometer and engine can be controlled and each actuator can be controlled remotely from the computer system.

How does the dyno itself work?

The SCHENCK WS230 is an eddy current dynamometer meaning that the load on the engine is generated with the use of electromagnetic principles. The inner core is allowed to rotate with little resistance and is powered by the engine. When current is sent through the outer core, an electromagnetic field is created which is how this type of dynamometer applies a load to the engine, allowing it to produce and measure torque. In reaction to this, the forces are also exerted on the outer core. The rotation of the outer core is prevented by the strain gauge, which in turn measures this twisting force known as torque by sending a signal between 0V and 10V to the computer in the control room. This signal is then used by the system to calculate the amount of torque that is produced by the engine. It is worth noting that the dynamometer must be calibrated via two calibration arms that cancel each other out and are designed to exact specification. The electromagnetic force that creates a load on the engine is influenced by the amount of current delivered to the outer core, meaning that the more current is delivered, the stronger the load is and the harder the engine must work to maintain the rpm. While the dynamometer measures and records values such as torque and rpm, it also monitors and records the data received from the various sensors on the engine and dynamometer. The system is capable of monitoring over 2000 sensors at the same time. The SCHENCK WS230 can measure torque with an accuracy of $\pm 0.2\%$ (SCHENCK

PEGASUS GmbH, 2001). Additionally, the engine throttle and dynamometer load can be manually adjusted via the system or programmed before testing. The general correlation is, as the dynamometer load is increased, the engine rpm is slowed and the torque produced is increased due to the engine needing to work harder. Due to the amount of current being delivered to the outer core, a lot of heat is generated. This is regulated by coolant being delivered through an intake and outlet via the coolant tank that is located on the roof of the IQ building. The coolant temperature is maintained by the fans and radiators on the tank (UWTSD WISA Workshops, 2025).

Dynamometer test: Sweep Test

The data that was used for this assignment was taken from a sweep test that was uploaded to YouTube by UWTSD (UWTSD WISA Workshops, 2026).

A sweep test is the most time effective test as it can be programmed to investigate specific rpm ranges in one “sweep”, without having to pause to take measurements. A downside to this is reduced accuracy as in other tests, the engine is held at certain rpms to record data at each increment. In this test, the technician can input when the engine must start, what rpm to hold the engine at before the test begins, the rpm range to target and the increments of which the data is recorded. In this case, 1000 rpm to 5500 rpm in increments of 50 rpm. The technician will also input when engine will go back to idle and turn off the ignition, fuel injectors and other actuators. During this test, measurements from all of the sensors on the dynamometer and engine, such as coolant temperature and lambda are also recorded.

What other tests can be carried out?

With the dynamometer used for this investigation, there are three more methods of testing that can be performed. These tests are step test, test sequencing and manual mode.

Step test:

The step test is similar to the sweep test in that it is a test that must be pre-programmed by a technician. The key difference with the step test is that instead of completing the test in a single “sweep” without pausing to take measurements, it instead pauses for half a second at each increment before increasing to the next increment. In this type of test, all steps and increments can be pre-programmed. All data from sensors on engine and dynamometer are monitored and recorded throughout. This type of test produces more accurate results as the sensors have more time to capture the data before the engine speed changes. However, while it produces more accurate results, a downside to this is that the engine is put under more strain. This is due to the engine being required to hold certain engine speeds for longer, producing more heat and therefore more strain.

Test sequencing:

Test sequencing is a test mode that is controlled by the computer and ran by the dynamometer. In this mode, the system will start the engine, run the test by reaching certain engine speeds and loads, monitoring and recording all of the data from the dynamometer and engine sensors and then stopping the engine and test. In this test, there are also many steps and sequences that can be pre-programmed into the system before starting the test.

Manual operation:

In addition to being able to pre-programme various engine dynamometer tests, the engine dynamometer can also be manually operated. Inside the control room, along with the computer, there are two adjustable dials that can be manually adjusted to alter the operating conditions of the engine. These two dials are labelled “Engine” and “Dynamometer”. The engine dial is used to control the engine speed via the throttle box and the dynamometer dial is used to control the amount of current that is sent through the outer core of the dynamometer, which in turn creates a stronger or weaker electromagnetic field, causing more or less resistance or load. This then in turn forces the engine to work harder or less hard to produce more or less torque.

5 Results

Table 3 - Table showing ambient conditions after calculations

Baro	Humidity	Ambient temp	Pressure	Temp
mBar	%	Deg C	kPa	kelvin
1018.9	46	27	101.89	300

Table 4 - Table showing data after calculations

Load	Dyno Speed	Fuel Flow Rate	Lambda	Torque	Power	BMEP	SFC	Overall thermal efficiency	Power	Corrected Power
Newtons	rpm	l/min	Lambda	Nm	Kw	kPa	Kg/kWh	%	Watts	Kw
102.275	1000	0.0704	1.2658	83.35413	8.724398	645.14309	0.36312	22.84826	8724.398	8.779047
102.756	1050	0.0724	1.26783	83.74614	9.203701	714.615365	0.353988	23.43766	9203.701	9.261351
103.689	1100	0.0737	1.27344	84.50654	9.729519	791.415621	0.34087	24.33964	9729.519	9.790463
104.209	1150	0.0728	1.28476	84.93034	10.22278	869.335612	0.320461	25.88976	10222.78	10.28682
105.811	1200	0.0744	1.29181	86.23597	10.83124	961.124997	0.309106	26.8408	10831.24	10.89908
107.51	1250	0.07895	1.29729	87.62065	11.4637	1059.63294	0.309913	26.77091	11463.7	11.53551
109.488	1300	0.079	1.29895	89.23272	12.1416	1167.18525	0.292795	28.33604	12141.6	12.21765
111.797	1350	0.0796	1.29469	91.11456	12.87449	1285.24004	0.278225	29.81997	12874.49	12.95513
114.268	1400	0.0835	1.2855	93.12842	13.64642	1412.75632	0.275347	30.13162	13646.42	13.7319
115.783	1450	0.0847	1.27818	94.36315	14.32118	1535.56203	0.266144	31.17351	14321.18	14.41089
116.985	1500	0.08865	1.2795	95.34278	14.96882	1660.34852	0.266504	31.13143	14968.82	15.06258
117.788	1550	0.0932	1.27766	95.99722	15.57395	1785.05255	0.269296	30.80869	15573.95	15.6715
118.471	1600	0.0959	1.28235	96.55387	16.16955	1913.10401	0.26689	31.08635	16169.55	16.27084
118.772	1650	0.09875	1.29028	96.79918	16.71722	2039.71044	0.265819	31.21169	16717.22	16.82193
118.656	1700	0.10005	1.29942	96.70464	17.20698	2163.0876	0.261653	31.70866	17206.98	17.31476
118.861	1750	0.10305	1.31053	96.87172	17.74367	2296.15943	0.261347	31.74576	17743.67	17.85481
119.584	1800	0.1093	1.3149	97.46096	18.36164	2444.01939	0.267868	30.97289	18361.64	18.47666
119.934	1850	0.11415	1.31849	97.74621	18.92692	2589.24017	0.271399	30.56993	18926.92	19.04548
120.176	1900	0.11745	1.31892	97.94344	19.47769	2736.60117	0.271349	30.57558	19477.69	19.59969
120.948	1950	0.12055	1.31484	98.57262	20.11867	2901.04507	0.269638	30.76964	20118.67	20.24469
122.157	2000	0.12555	1.31653	99.55796	20.8408	3082.22907	0.271091	30.60469	20840.8	20.97134
122.845	2050	0.12785	1.32098	100.1187	21.48213	3256.50514	0.267816	30.97897	21482.13	21.61669
123.796	2100	0.1309	1.32287	100.8937	22.17644	3443.75117	0.26562	31.23508	22176.44	22.31535
124.794	2150	0.13435	1.32164	101.7071	22.88749	3638.79163	0.264151	31.40876	22887.49	23.03085
125.137	2200	0.1377	1.31652	101.9867	23.48413	3820.47764	0.263859	31.44349	23484.13	23.63123
126.028	2250	0.14105	1.30465	102.7128	24.18887	4024.56218	0.262404	31.61788	24188.87	24.34038
126.66	2300	0.14495	1.29646	103.2279	24.8504	4226.50821	0.262481	31.60861	24850.4	25.00606
126.822	2350	0.14985	1.28229	103.3599	25.4231	4417.9102	0.265241	31.27966	25423.1	25.58234

126.69	2400	0.1537	1.27304	103.2524	25.93699	4603.1103	0.266665	31.11258	25936.99	26.09946
126.552	2450	0.15565	1.26984	103.1399	26.4485	4791.6793	0.264826	31.32869	26448.5	26.61417
126.438	2500	0.1596	1.27446	103.047	26.96396	4984.75935	0.266356	31.14878	26963.96	27.13286
126.239	2550	0.1626	1.27876	102.8848	27.45995	5177.98119	0.266461	31.13648	27459.95	27.63195
126.161	2600	0.16805	1.27634	102.8212	27.98108	5379.70399	0.270263	30.69844	27981.08	28.15635
125.847	2650	0.17145	1.28027	102.5653	28.4482	5574.69584	0.271203	30.59198	28448.2	28.62639
124.911	2700	0.17465	1.28371	101.8025	28.76938	5744.00455	0.273181	30.37052	28769.38	28.94958
123.927	2750	0.1784	1.2812	101.0005	29.07131	5911.77485	0.276149	30.04416	29071.31	29.25341
123.689	2800	0.18005	1.27448	100.8065	29.54304	6116.93271	0.274252	30.25188	29543.04	29.72809
123.389	2850	0.1831	1.26036	100.562	29.99766	6321.9743	0.274671	30.20573	29997.66	30.18556
122.519	2900	0.1879	1.2531	99.85299	30.30871	6499.59058	0.278979	29.73932	30308.71	30.49856
121.837	2950	0.19255	1.23943	99.29716	30.65965	6688.2083	0.282611	29.35716	30659.65	30.8517
121.709	3000	0.199	1.22735	99.19284	31.14655	6909.58184	0.287512	28.85674	31146.55	31.34165
121.123	3050	0.20605	1.2193	98.71525	31.5132	7107.43439	0.294234	28.19747	31513.2	31.71059
121.124	3100	0.21005	1.20692	98.71606	32.03007	7342.43573	0.295105	28.11419	32030.07	32.2307
120.851	3150	0.21605	1.19274	98.49357	32.47333	7564.11142	0.299392	27.71168	32473.33	32.67674
120.596	3200	0.21795	1.18481	98.28574	32.91917	7789.67649	0.297934	27.84725	32919.17	33.12537
120.84	3250	0.22305	1.17378	98.4846	33.50118	8051.26276	0.299609	27.69161	33501.18	33.71102
121.633	3300	0.2255	1.16118	99.1309	34.23981	8355.37334	0.296366	27.99466	34239.81	34.45428
122.181	3350	0.2285	1.15104	99.57752	34.9152	8649.2779	0.294499	28.17206	34915.2	35.1339
122.933	3400	0.2342	1.14117	100.1904	35.65442	8964.22762	0.295587	28.06835	35654.42	35.87776
123.475	3450	0.23605	1.12669	100.6321	36.33826	9270.51341	0.292316	28.38249	36338.26	36.56588
123.428	3500	0.24195	1.11975	100.5938	36.85087	9537.53934	0.295454	28.08099	36850.87	37.0817
124.205	3550	0.24545	1.10622	101.2271	37.61261	9873.755	0.293658	28.25275	37612.61	37.84821
124.066	3600	0.25505	1.09697	101.1138	38.09968	10142.4843	0.301243	27.54142	38099.68	38.33833
123.967	3650	0.25755	1.09401	101.0331	38.59801	10417.8568	0.300268	27.63082	38598.01	38.83979
123.815	3700	0.26445	1.09659	100.9092	39.07878	10692.1064	0.304519	27.24506	39078.78	39.32356
123.767	3750	0.2651	1.09808	100.8701	39.59152	10978.7769	0.301315	27.53485	39591.52	39.83951
123.509	3800	0.2693	1.09907	100.6598	40.03577	11249.9958	0.302692	27.40957	40035.77	40.28655
122.672	3850	0.27375	1.10533	99.97768	40.28767	11469.7372	0.30577	27.13366	40287.67	40.54003
122.157	3900	0.2759	1.11704	99.55796	40.63956	11720.176	0.305503	27.15736	40639.56	40.89412
121.184	3950	0.28285	1.12259	98.76496	40.83273	11926.8577	0.311717	26.61598	40832.73	41.0885
120.004	4000	0.28455	1.12461	97.80326	40.94696	12111.6208	0.312715	26.53099	40946.96	41.20345
118.734	4050	0.2871	1.1222	96.76821	41.02004	12284.9023	0.314956	26.34227	41020.04	41.27699
117.442	4100	0.28895	1.12394	95.71523	41.0746	12453.1068	0.316564	26.20843	41074.6	41.33188
116.5	4150	0.29305	1.12233	94.9475	41.24203	12656.3559	0.319753	25.94709	41242.03	41.50036
115.931	4200	0.2949	1.12179	94.48377	41.53506	12899.8519	0.319501	25.96752	41535.06	41.79523
115.034	4250	0.29715	1.12456	93.75271	41.70433	13106.618	0.320632	25.87592	41704.33	41.96556
114.391	4300	0.3022	1.12278	93.22867	41.95911	13341.8277	0.324101	25.59895	41959.11	42.22194
114.016	4350	0.30605	1.11943	92.92304	42.30786	13609.1461	0.325525	25.48702	42307.86	42.57287
113.871	4400	0.3092	1.11986	92.80487	42.73973	13906.0904	0.325552	25.48488	42739.73	43.00745
113.985	4450	0.3099	1.11873	92.89778	43.26869	14238.1737	0.3223	25.74201	43268.69	43.53972
113.306	4500	0.31445	1.11563	92.34439	43.49421	14473.1978	0.325336	25.50176	43494.21	43.76665
113.074	4550	0.3171	1.10953	92.15531	43.88743	14766.3144	0.325139	25.51727	43887.43	44.16233

112.195	4600	0.3194	1.10569	91.43893	44.02479	14975.3068	0.326475	25.41281	44024.79	44.30056
111.061	4650	0.32055	1.09782	90.51472	44.05351	15147.9564	0.327437	25.33816	44053.51	44.32946
109.973	4700	0.3207	1.09558	89.628	44.091	15323.8662	0.327312	25.34786	44091	44.36718
108.654	4750	0.32485	1.08827	88.55301	44.0256	15463.9166	0.33204	24.98692	44025.6	44.30137
107.076	4800	0.32455	1.08396	87.26694	43.84291	15561.8482	0.333115	24.90624	43842.91	44.11754
105.24	4850	0.3257	1.08221	85.7706	43.54002	15615.3196	0.336621	24.64683	43540.02	43.81274
103.632	4900	0.3277	1.0846	84.46008	43.31676	15695.4077	0.340434	24.3708	43316.76	43.58809
102.335	4950	0.32845	1.08823	83.40303	43.21111	15816.8922	0.342047	24.25585	43211.11	43.48177
101.106	5000	0.3287	1.08687	82.40139	43.12339	15944.2281	0.343004	24.1882	43123.39	43.39351
99.3149	5050	0.32985	1.0891	80.94164	42.78305	15976.5767	0.346942	23.91364	42783.05	43.05104
97.5815	5100	0.3297	1.09185	79.52892	42.45254	16010.1132	0.349484	23.73969	42452.54	42.71845
95.8486	5150	0.33095	1.09407	78.11661	42.10746	16035.6583	0.353684	23.45778	42107.46	42.37121
94.8033	5200	0.3338	1.09346	77.26469	42.0526	16170.2489	0.357196	23.2272	42052.6	42.31601
93.0976	5250	0.3313	1.08804	75.87454	41.69306	16186.1535	0.357577	23.20239	41693.06	41.95422
91.7886	5300	0.3324	1.08339	74.80771	41.49833	16263.9881	0.360448	23.01759	41498.33	41.75827
90.5938	5350	0.3308	1.08007	73.83395	41.34455	16356.5838	0.360047	23.04322	41344.55	41.60352
89.6374	5400	0.3388	1.07895	73.05448	41.29039	16487.8236	0.369238	22.46963	41290.39	41.54903
88.9256	5450	0.3438	1.07923	72.47436	41.34179	16661.2036	0.374222	22.17041	41341.79	41.60075
88.6474	5500	0.3488	1.08366	72.24763	41.59055	16915.2314	0.377393	21.98409	41590.55	41.85107

6 Conclusion

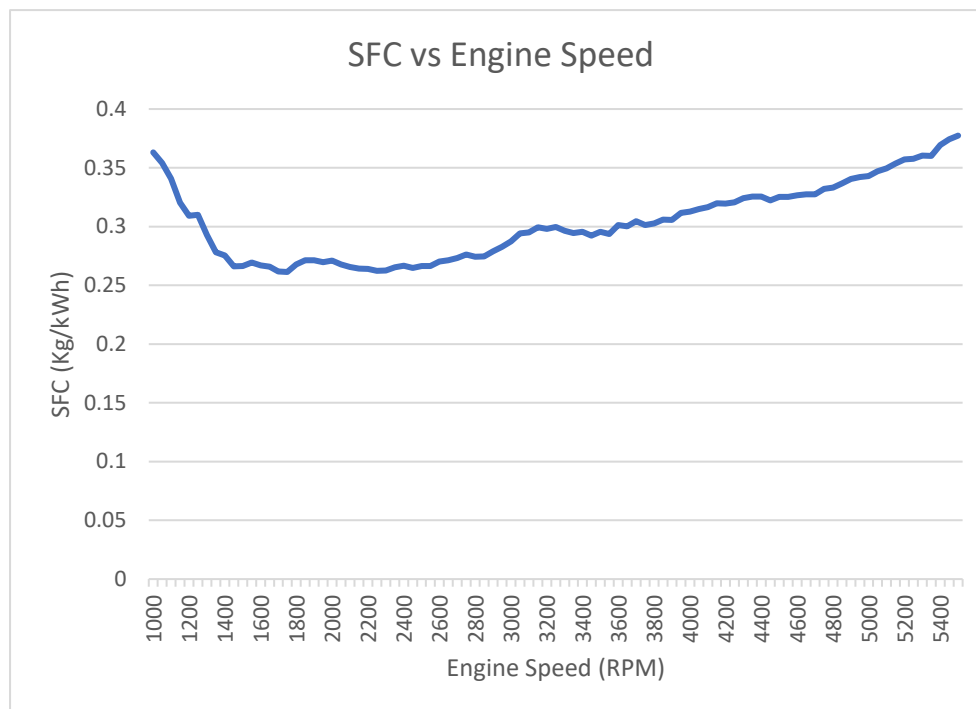
SFC Against Engine Speed

The graph below shows the engine rpm increasing from 1000 rpm to 5500 rpm and the measured SFC in Kg/kWh. SFC stands for Specific Fuel Consumption and is the measurement of how much fuel is consumed to produce a unit of power, in this case kWh (V A W Hillier and Calex Uk, 2014).

Why does SFC vary with engine speed?

Specific fuel consumption varies with engine speed because as the trend shows, the higher the engine speed, the higher the amount of fuel being consumed. This means that the harder the engine is working, the less efficient it is. The initial high fuel consumption can be explained by the additional effort required from the engine to gain momentum as the rpm increases.

Figure 1 - Graph showing SFC vs Engine speed



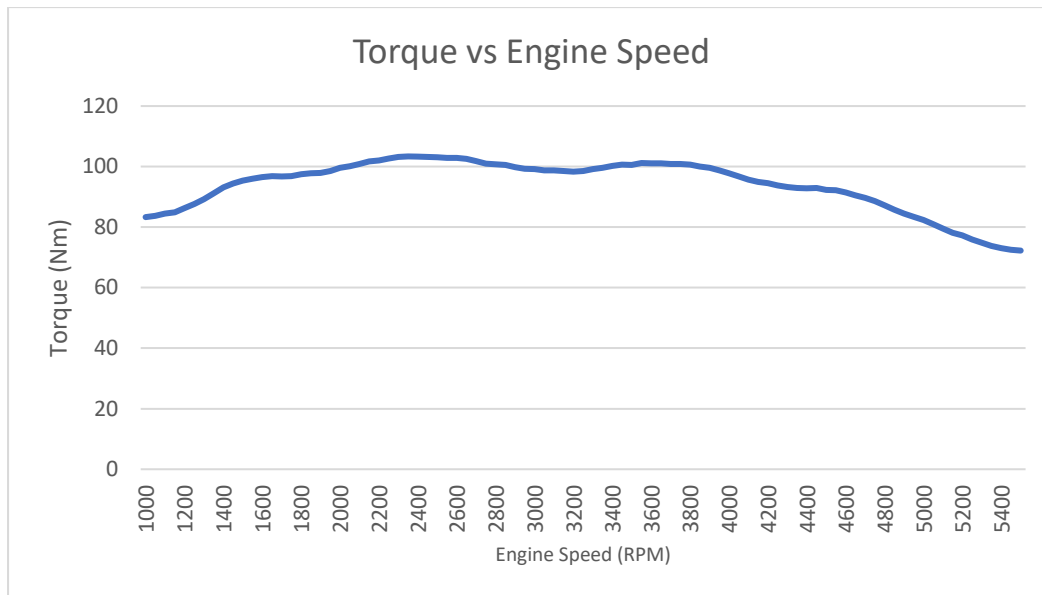
Torque Against Engine Speed

The graph below shows torque against engine speed. It shows the torque increase to a maximum of 103.36 Nm at 2350 rpm before a small drop in torque being produced between 2650 rpm and 3500 rpm before continuing to drop off from 3850 to 5500 rpm.

Why does torque vary with engine speed?

Torque varies with engine speed because as the engine speed increases, the torque increases initially until it reaches peak torque where the engine's volumetric efficiency is at its highest. After this, as the engine speed increases and the torque starts to drop off as it has passed the rpm range where the engine is capable of producing the maximum torque. (V A W Hillier and Calex Uk, 2014)

Figure 2 - Graph showing Torque vs Engine speed



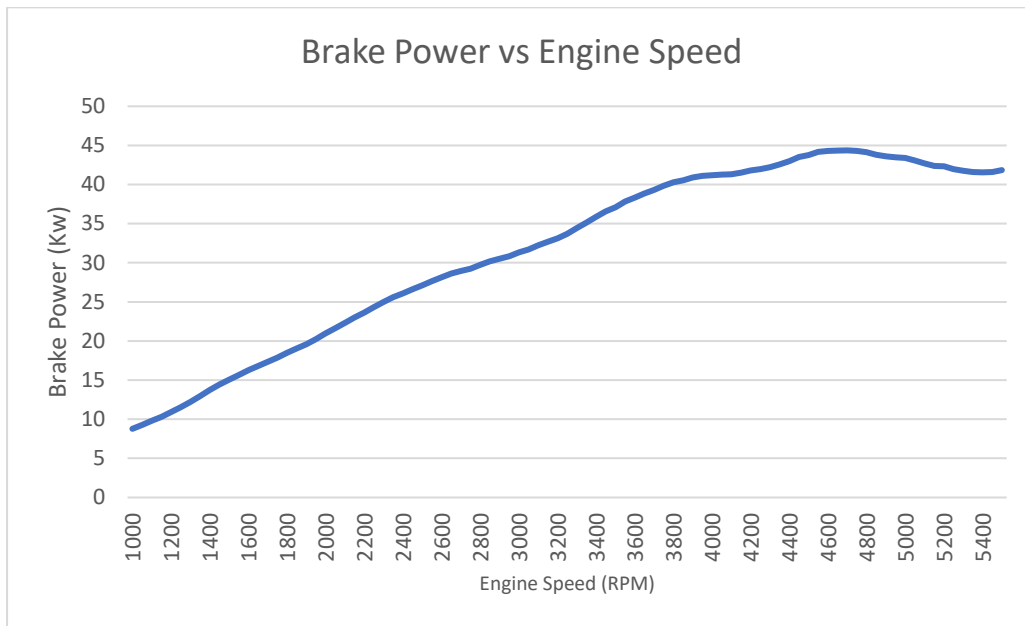
Brake Power Against Engine Speed

The graph below shows brake power against engine speed using the corrected power values as seen in table 4 for the brake power value. The graph shows that as the rpm increases from 1000 rpm to 4700 rpm, the brake power steadily increases before slightly declining and levelling out.

Why does brake power vary with engine speed?

Brake power varies with engine speed because more brake power is being produced as the engine speed increases. As brake power is reliant on power and torque (V A W Hillier and Callex UK, 2014), this explains why the brake power drops off towards the end, because less torque is being produced at higher engine speeds.

Figure 3 - Graph showing Brake Power vs Engine speed



7 Evaluation

Limitations to this investigation:

Unfortunately, this test was not performed in person as at the time of this assignment, the Dynamometer was not in working condition. Due to this, the results from this test were provided via Microsoft Teams.

How could the investigation have been improved?

As previously mentioned, at the time of this assignment, the dynamometer was not in working condition and the test was conducted at a previous date. One way that this investigation could have been improved is by being able to conduct the test at the time of the assignment. This would allow for the ambient conditions such as temperature to be more recent, giving different results. For example, if the air was cooler, it would be more dense, creating more power during the combustion stroke. Another way this investigation could have been improved is by performing the test more than once to compare each set of results to check for accuracy and identify any measurement errors.

8 Reference List

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