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Chapter 1 - Introduction

An Eddy current engine dynamometer is a device designed to measure an engine's torque and rotational speed. It is able to achieve this by generating a controlled electromagnetic field within the dynamometer's outer casing. From these measurements, factors such as brake mean effective pressure (BMEP), specific fuel consumption (SFC), and overall thermal efficiency can be calculated. Furthermore, these constraints provide a fundamental insight into an engine's efficiency, fuel economy, and performance.

The main purpose of conducting the engine dynamometer test, is to establish the engines brake power (BP) output at differing rotational speeds, as well as measure the torque output to assess the engines load characteristics. Another objective was of conducting the test, was to determine how effectively the engine converts fuel energy into mechanical work (overall thermal efficiency).

Chapter 2 – Method



FIGURE 1 - SCHENCK WS230 DYNO LAYOUT

The engine dynamometer test is performed using a Schenck WS230 dyno. The Eddy current dynamometer is connected to a Honda D16 1600cc engine via a propshaft. The system utilises a wide range of sensors including recorder modules, exhaust extraction system and an inlet and outlet coolant tank for engine cooling. Furthermore, a fuel supply board is used to direct fuel through a filter, pump, and regulator to the engine. These engine sensors are used to monitor coolant levels, fuel flow, lambda values, and throttle position via an actuator box.

The inner core of the engine dynamometer spins freely, whereas the outer casing is exposed to an electromagnetic field which acts as a load and creates a resistance to slow the engine down. Additionally, a strain gauge stops the outer case from turning. The strain gauge will then send a signal between 0 and 10 volts to the computer system. Moreover, calibration arms, each measuring a precise 815.776mm

(dyno centre to the hook eye) are used to ensure accuracy. A mass is applied to one end of the calibration arms to determine torque output. (www.youtube.com, 2020)



FIGURE 2 - CONTROL ROOM LAYOUT

A sweep test is the primary testing procedure for collected data on the Honda D16 engine. It is essential that the system is set to the following; a ramp time of one second, a hold time of one second, and data logging every 50 RPM from 1000 to 5500 RPM. To add, the test gradually increases engine speed while maintaining full throttle. The objective of this testing method is that it reduces strain and prevents engine and dynamometer overheating. The throttle is controlled manually, and upon completion, the dyno returns to idle before closing the throttle to 0%. (www.youtube.com, 2020)

Chapter 3 – Spreadsheet Data

Calorific Value Of Fuel	Baro		Humidity	Ambient Temperature		Bore	Stroke	KW to BHP Times Factor	Distance	KW Calculation
J/Kg	Bar	mBar	%	Degrees Centigrade	Kelvin	mm	mm	N/a	M	N/a
43391000	1.0189	1018.9	46	27	300.15	75	90	1.340482574	0.815776	9549

Load	Dyno Speed	Fuel Flow Rate		Lambda	Corrected Power	Torque	BMEP	SFC	Overall Thermal Efficiency	Power		
Newtons	rpm	L/Min	Kg/Hr	Λ	KW	Nm	Kpa	Kg/kWh	%	BHP	KW	W
102.275	1000	0.0704	3.048	1.2658	8.794	83.433	655.285	0.349	23.786	11.712	8.737	8737.406
102.756	1050	0.0724	3.134	1.26783	9.277	83.826	658.367	0.340	24.400	12.356	9.217	9217.423
103.689	1100	0.0737	3.190	1.27344	9.808	84.587	664.345	0.327	25.339	13.062	9.744	9744.025
104.209	1150	0.0728	3.152	1.28476	10.305	85.011	667.676	0.308	26.953	13.724	10.238	10238.023
105.811	1200	0.0744	3.221	1.29181	10.918	86.318	677.941	0.297	27.943	14.541	10.847	10847.386
107.51	1250	0.07895	3.418	1.29729	11.556	87.704	688.826	0.298	27.870	15.390	11.481	11480.794
109.488	1300	0.079	3.420	1.29895	12.239	89.318	701.499	0.281	29.499	16.300	12.160	12159.701
111.797	1350	0.0796	3.446	1.29469	12.978	91.201	716.293	0.267	31.044	17.284	12.894	12893.682
114.268	1400	0.0835	3.615	1.2855	13.756	93.217	732.125	0.264	31.369	18.320	13.667	13666.764

115.783	1450	0.0847	3.667	1.27818	14.436	94.453	741.832	0.256	32.453	19.226	14.343	14342.532
116.985	1500	0.08865	3.838	1.2795	15.089	95.434	749.533	0.256	32.409	20.095	14.991	14991.133
117.788	1550	0.0932	4.035	1.27766	15.699	96.089	754.678	0.259	32.073	20.908	15.597	15597.169
118.471	1600	0.0959	4.152	1.28235	16.299	96.646	759.054	0.256	32.362	21.707	16.194	16193.662
118.772	1650	0.09875	4.275	1.29028	16.851	96.891	760.983	0.255	32.493	22.443	16.742	16742.143
118.656	1700	0.10005	4.331	1.29942	17.345	96.797	760.240	0.251	33.010	23.100	17.233	17232.634
118.861	1750	0.10305	4.461	1.31053	17.886	96.964	761.553	0.251	33.049	23.821	17.770	17770.124
119.584	1800	0.1093	4.732	1.3149	18.509	97.554	766.185	0.257	32.244	24.650	18.389	18389.021
119.934	1850	0.11415	4.942	1.31849	19.079	97.839	768.428	0.261	31.825	25.409	18.955	18955.144
120.176	1900	0.11745	5.084	1.31892	19.634	98.037	769.978	0.261	31.831	26.148	19.507	19506.726
120.948	1950	0.12055	5.219	1.31484	20.280	98.666	774.925	0.259	32.033	27.009	20.149	20148.668
122.157	2000	0.12555	5.435	1.31653	21.008	99.653	782.671	0.260	31.861	27.978	20.872	20871.871
122.845	2050	0.12785	5.535	1.32098	21.654	100.214	787.079	0.257	32.251	28.839	21.514	21514.159
123.796	2100	0.1309	5.667	1.32287	22.354	100.990	793.172	0.255	32.517	29.771	22.210	22209.508
124.794	2150	0.13435	5.816	1.32164	23.071	101.804	799.566	0.254	32.698	30.726	22.922	22921.614
125.137	2200	0.1377	5.961	1.31652	23.672	102.084	801.764	0.253	32.734	31.527	23.519	23519.141
126.028	2250	0.14105	6.106	1.30465	24.383	102.811	807.473	0.252	32.916	32.473	24.225	24224.933
126.66	2300	0.14495	6.275	1.29646	25.050	103.326	811.522	0.252	32.906	33.361	24.887	24887.447

126.822	2350	0.14985	6.487	1.28229	25.627	103.458	812.560	0.255	32.564	34.130	25.461	25461.002
126.69	2400	0.1537	6.654	1.27304	26.145	103.351	811.714	0.256	32.390	34.820	25.976	25975.661
126.552	2450	0.15565	6.738	1.26984	26.661	103.238	810.830	0.254	32.615	35.507	26.488	26487.937
126.438	2500	0.1596	6.909	1.27446	27.180	103.145	810.100	0.256	32.427	36.199	27.004	27004.159
126.239	2550	0.1626	7.039	1.27876	27.680	102.983	808.825	0.256	32.415	36.864	27.501	27500.891
126.161	2600	0.16805	7.275	1.27634	28.205	102.919	808.325	0.260	31.959	37.564	28.023	28022.798
125.847	2650	0.17145	7.422	1.28027	28.676	102.663	806.313	0.261	31.848	38.191	28.491	28490.612
124.911	2700	0.17465	7.561	1.28371	29.000	101.899	800.316	0.262	31.617	38.622	28.812	28812.270
123.927	2750	0.1784	7.723	1.2812	29.304	101.097	794.011	0.265	31.278	39.028	29.115	29114.656
123.689	2800	0.18005	7.794	1.27448	29.780	100.903	792.487	0.263	31.494	39.661	29.587	29587.082
123.389	2850	0.1831	7.926	1.26036	30.238	100.658	790.564	0.264	31.446	40.271	30.042	30042.380
122.519	2900	0.1879	8.134	1.2531	30.552	99.948	784.990	0.268	30.960	40.689	30.354	30353.898
121.837	2950	0.19255	8.335	1.23943	30.905	99.392	780.621	0.271	30.562	41.160	30.705	30705.364
121.709	3000	0.199	8.615	1.22735	31.396	99.287	779.800	0.276	30.041	41.814	31.193	31192.988
121.123	3050	0.20605	8.920	1.2193	31.766	98.809	776.046	0.283	29.355	42.306	31.560	31560.181
121.124	3100	0.21005	9.093	1.20692	32.287	98.810	776.052	0.283	29.268	43.000	32.078	32077.826
120.851	3150	0.21605	9.353	1.19274	32.734	98.587	774.303	0.288	28.849	43.595	32.522	32521.744
120.596	3200	0.21795	9.435	1.18481	33.183	98.379	772.669	0.286	28.990	44.193	32.968	32968.251

120.84	3250	0.22305	9.656	1.17378	33.770	98.578	774.233	0.288	28.828	44.975	33.551	33551.127
121.633	3300	0.2255	9.762	1.16118	34.514	99.225	779.314	0.285	29.144	45.966	34.291	34290.861
122.181	3350	0.2285	9.892	1.15104	35.195	99.672	782.825	0.283	29.329	46.873	34.967	34967.253
122.933	3400	0.2342	10.139	1.14117	35.940	100.286	787.643	0.284	29.221	47.865	35.708	35707.581
123.475	3450	0.23605	10.219	1.12669	36.630	100.728	791.115	0.281	29.548	48.783	36.392	36392.439
123.428	3500	0.24195	10.474	1.11975	37.146	100.690	790.814	0.284	29.234	49.472	36.906	36905.812
124.205	3550	0.24545	10.626	1.10622	37.914	101.323	795.793	0.282	29.413	50.494	37.669	37668.685
124.066	3600	0.25505	11.041	1.09697	38.405	101.210	794.902	0.289	28.672	51.148	38.156	38156.481
123.967	3650	0.25755	11.149	1.09401	38.907	101.129	794.268	0.288	28.765	51.817	38.656	38655.562
123.815	3700	0.26445	11.448	1.09659	39.392	101.005	793.294	0.293	28.363	52.463	39.137	39137.044
123.767	3750	0.2651	11.476	1.09808	39.909	100.966	792.986	0.289	28.665	53.151	39.651	39650.545
123.509	3800	0.2693	11.658	1.09907	40.357	100.756	791.333	0.291	28.535	53.747	40.095	40095.463
122.672	3850	0.27375	11.851	1.10533	40.611	100.073	785.971	0.294	28.248	54.085	40.348	40347.739
122.157	3900	0.2759	11.944	1.11704	40.965	99.653	782.671	0.293	28.272	54.558	40.700	40700.149
121.184	3950	0.28285	12.245	1.12259	41.160	98.859	776.437	0.299	27.709	54.817	40.894	40893.606
120.004	4000	0.28455	12.318	1.12461	41.275	97.896	768.876	0.300	27.620	54.971	41.008	41008.015
118.734	4050	0.2871	12.429	1.1222	41.349	96.860	760.739	0.303	27.424	55.069	41.081	41081.203
117.442	4100	0.28895	12.509	1.12394	41.404	95.806	752.461	0.304	27.284	55.142	41.136	41135.836

116.5	4150	0.29305	12.686	1.12233	41.573	95.038	746.426	0.307	27.012	55.367	41.304	41303.519
115.931	4200	0.2949	12.766	1.12179	41.868	94.574	742.780	0.307	27.034	55.760	41.597	41596.990
115.034	4250	0.29715	12.864	1.12456	42.039	93.842	737.033	0.308	26.938	55.987	41.767	41766.510
114.391	4300	0.3022	13.082	1.12278	42.295	93.317	732.913	0.311	26.650	56.329	42.022	42021.673
114.016	4350	0.30605	13.249	1.11943	42.647	93.012	730.511	0.313	26.533	56.798	42.371	42370.939
113.871	4400	0.3092	13.385	1.11986	43.082	92.893	729.582	0.313	26.531	57.377	42.803	42803.457
113.985	4450	0.3099	13.416	1.11873	43.616	92.986	730.312	0.310	26.799	58.087	43.333	43333.198
113.306	4500	0.31445	13.613	1.11563	43.843	92.432	725.962	0.313	26.549	58.390	43.559	43559.055
113.074	4550	0.3171	13.727	1.10953	44.239	92.243	724.475	0.312	26.565	58.918	43.953	43952.864
112.195	4600	0.3194	13.827	1.10569	44.378	91.526	718.843	0.314	26.456	59.102	44.090	44090.433
111.061	4650	0.32055	13.877	1.09782	44.407	90.601	711.578	0.315	26.378	59.141	44.119	44119.193
109.973	4700	0.3207	13.883	1.09558	44.444	89.713	704.607	0.314	26.388	59.191	44.157	44156.736
108.654	4750	0.32485	14.063	1.08827	44.379	88.637	696.156	0.319	26.013	59.104	44.091	44091.245
107.076	4800	0.32455	14.050	1.08396	44.194	87.350	686.046	0.320	25.929	58.858	43.908	43908.278
105.24	4850	0.3257	14.100	1.08221	43.889	85.852	674.282	0.323	25.659	58.452	43.605	43604.932
103.632	4900	0.3277	14.186	1.0846	43.664	84.540	663.980	0.327	25.371	58.152	43.381	43381.343
102.335	4950	0.32845	14.219	1.08823	43.557	83.482	655.670	0.329	25.252	58.010	43.276	43275.533
101.106	5000	0.3287	14.229	1.08687	43.469	82.480	647.795	0.329	25.181	57.892	43.188	43187.689

99.3149	5050	0.32985	14.279	1.0891	43.126	81.019	636.319	0.333	24.895	57.435	42.847	42846.842
97.5815	5100	0.3297	14.273	1.09185	42.793	79.605	625.213	0.336	24.714	56.992	42.516	42515.833
95.8486	5150	0.33095	14.327	1.09407	42.445	78.191	614.111	0.340	24.421	56.528	42.170	42170.236
94.8033	5200	0.3338	14.450	1.09346	42.390	77.338	607.413	0.343	24.181	56.455	42.115	42115.293
93.0976	5250	0.3313	14.342	1.08804	42.027	75.947	596.485	0.343	24.155	55.972	41.755	41755.224
91.7886	5300	0.3324	14.390	1.08339	41.831	74.879	588.098	0.346	23.962	55.711	41.560	41560.202
90.5938	5350	0.3308	14.320	1.08007	41.676	73.904	580.443	0.346	23.989	55.504	41.406	41406.192
89.6374	5400	0.3388	14.667	1.07895	41.621	73.124	574.315	0.355	23.392	55.432	41.352	41351.955
88.9256	5450	0.3438	14.883	1.07923	41.673	72.543	569.754	0.359	23.081	55.501	41.403	41403.432
88.6474	5500	0.3488	15.100	1.08366	41.924	72.316	567.972	0.363	22.887	55.835	41.653	41652.562

FIGURE 3 - DYNAMOMETER TEST RESULTS TABLE

Chapter 4 – Graphical Results

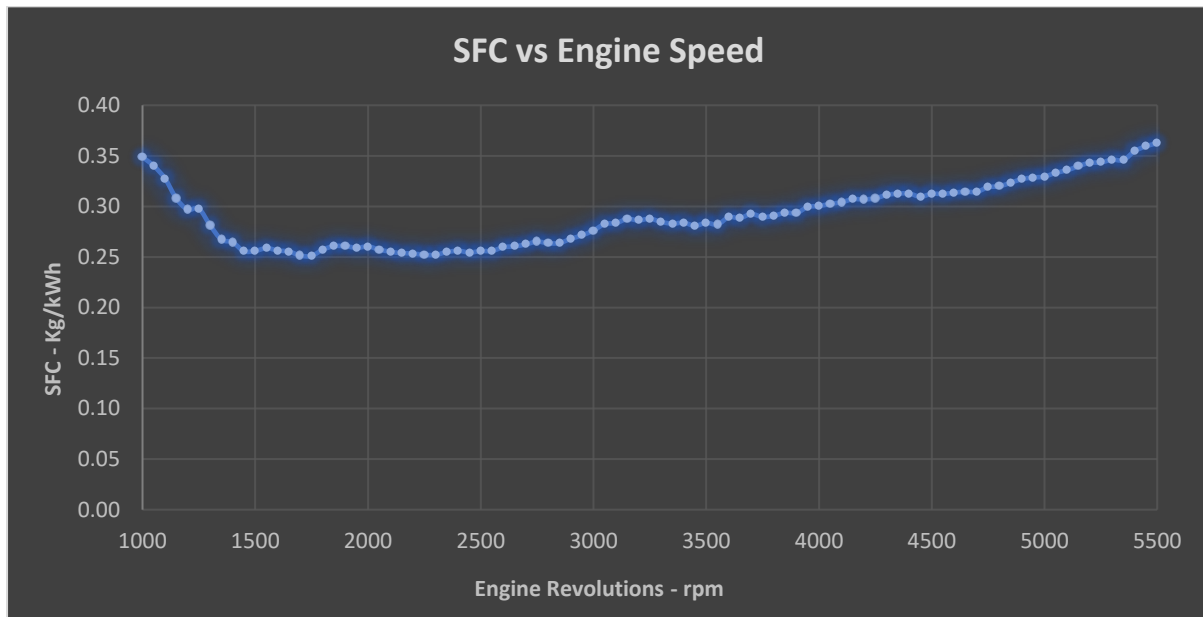


FIGURE 4 - SFC VS ENGINE SPEED GRAPH

At the start, between 1000 and 1500 rpm, The Specific Fuel Consumption (SFC) drops significantly from 0.349 kg/kWh to approximately 0.26 kg/kWh, demonstrating a significant improvement in engine efficiency. This Suggests that the Honda engine achieves a greater efficiency as the RPM elevates in this range, consuming less fuel per unit of power generated. This is possible due to the engine reaching an optimised heat cycle as it warms up, meaning that internal friction reduces, contributing to better fuel efficiency.

Furthermore, between 1500 and 4000 rpm, the SFC curve is relatively consistent, with low values around 0.25–0.29 kg/kWh. This would indicate that this value range is the most fuel-efficient. This smooth mid-range zone makes it ideal for cruising speeds with a primary concentration on fuel efficiency.

SFC starts to climb gradually, reaching approximately 0.29–0.30 kg/kWh between 2800–4000 rpm. However, beyond 4000 rpm, the SFC has a notable rise to around 0.36 kg/kWh by 5500 rpm. The graph conveys that the efficiency drops considerably due to mechanical losses and the fuel demand increases faster than power output, making high-RPM applications much less fuel-efficient than mid-range speeds. (www.sciencedirect.com, 2022)

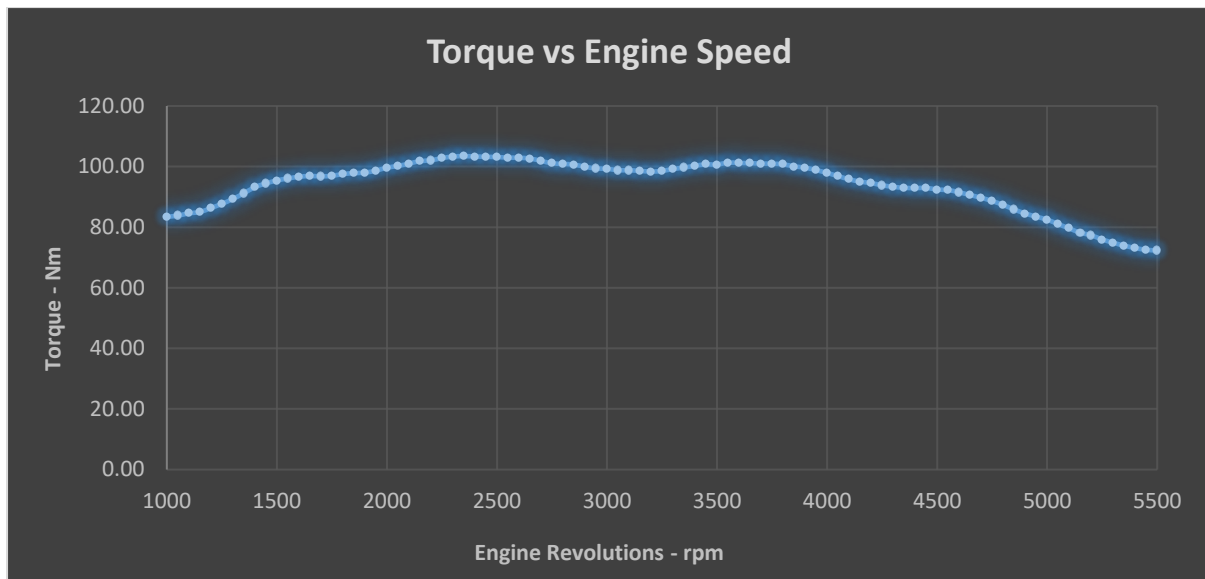


FIGURE 5 - TORQUE VS ENGINE SPEED GRAPH

Straight away at 1000 rpm, the engine is able to produce approximately 83 Nm and steadily increases to around 100 Nm by 2000 rpm. This low-range torque is crucial for low-speed power delivery, making it perfect for city driving or towing applications.

Additionally, between 2000-3000 rpm, the engine maintains peak torque of 103 Nm. This highlights that it's the most effective operating range. Furthermore, in this range, the engine delivers its highest pulling power, making it ideal for applications that demand strong acceleration. This Optimal balance between power and efficiency makes the 2000–3000 RPM range the sweet spot for this engine, ensuring smooth operation and improved fuel economy. To add, between 3000 and 4000rpm there is a slight fluctuation, meaning that torque remains relatively stable up to 4000 rpm.

However, beyond this point of 4000 rpm, the torque begins to decline noticeably, marking a loss in efficiency, falling below 70 Nm at 5500 rpm. This suggests that at high engine speeds, efficiency decreases, and the engine struggles to sustain its power output. This can be down to factors such as mechanical losses and increased friction. (TrueGeometry, 2024)

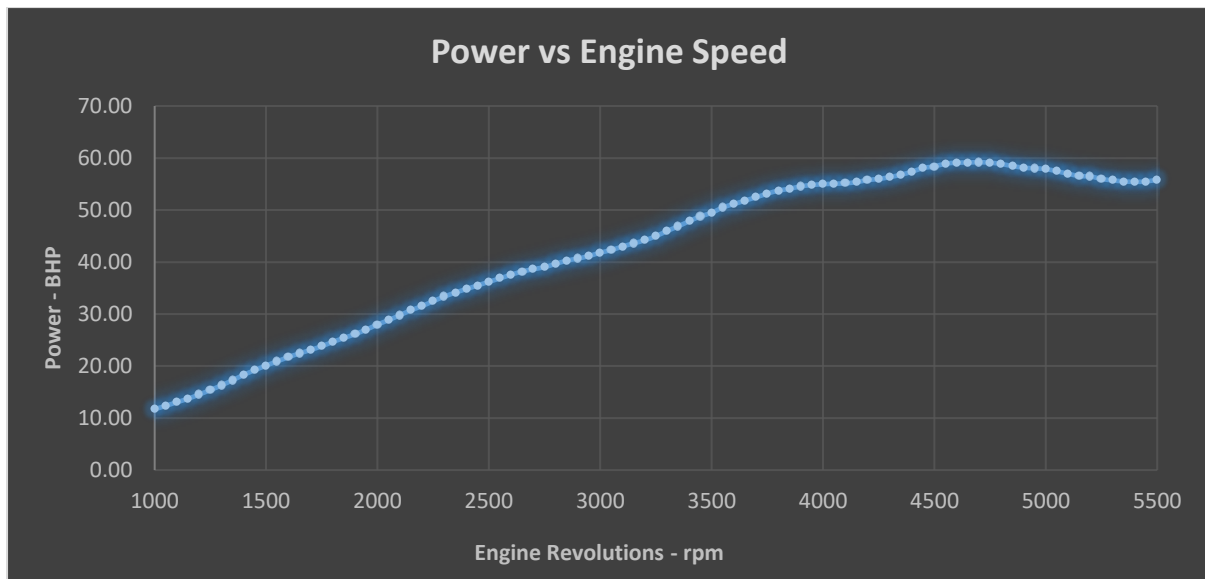


FIGURE 6 - POWER VS ENGINE SPEED GRAPH

The Power vs Engine Speed graph illustrates how power output varies with engine revolutions per minute (rpm).

At 1000 rpm, the power starts at about 11 BHP and increases gradually as engine speed rises. From 1000 to 4000 rpm, the power output follows a consistent upward linear trend, reaching approximately 55 BHP. This range represents the engine's optimal power range, where increasing rpm allows for more energy conversion, resulting in a higher power output.

Between 4000 and 4500 rpm, power continues to rise linearly but at a slower rate, peaking at around 60 BHP. This represents the maximum power output range, where the engine reaches its peak efficiency in converting fuel into mechanical power.

Beyond 4500 rpm, power output starts to decline slightly. By 5500 rpm, the power has decreased to just 55 BHP. This drop indicates the onset of mechanical and thermal inefficiencies, where factors like increased friction and heat buildup limit further power generation. (Hill, 2008)

Chapter 5 – Conclusion

The lambda values observed at different RPM levels indicate changes in the air-fuel ratio throughout the engine's operating range. To start, at 1000 RPM, Lambda is equal to 1.2658, representing a lean mixture. Furthermore, by 2000 RPM Lambda peaks at 1.32287 suggesting an even leaner mixture. From 2000 to 5500 RPM Lambda decreases, with a final reading of 1.08366, meaning the mixture becomes richer. This happens because as engine speed increases, more fuel is injected to maintain power. The Ideal Lambda value for gasoline engines is 1.0, where the air-fuel ratio is 14.7:1, indicating the optimal balance. However, for performance applications, slightly richer mixtures run between <1.0 , while leaner mixtures >1.0 . (ranwhenparked.net, 2024)

At 1000 rpm, the Brake Mean effective pressure (BMEP) is 655.285 KPa, which highlights that the engine is operating at a fairly low speed with enough air-fuel mixture delivery for effective combustion. By 2600 rpm, the BMEP peaks at 808.325 KPa, indicating the optimal balance between intake, combustion efficiency, and power output, allowing the engine to take in and burn more air-fuel mixture per cycle. At 5500 rpm, the BMEP decreases to 567.972 KPa. This drop is due to increased frictional losses, reduced volumetric efficiency, and incomplete combustion.

The thermal efficiency is 24% at 1000 rpm, which is fairly low because at low engine speeds, the air-fuel mixture may not be fully atomized. To add, by 1750 rpm, the thermal efficiency peaks at 33%. This is because; at this speed, volumetric efficiency is high whereas frictional losses remain relatively low. At 5500 rpm, the thermal efficiency drops to 23%. The primary reasons for this decline include increased frictional and pumping losses, excessive heat transfer losses, and reduced combustion efficiency.

Finally, the corrected power was slightly higher than the actual power measured on the dyno. This could be due to conditions such as atmosphere, temperature, pressure, and humidity. These factors are extremely important and can adjust the measured power to a standardised baseline. Overall, the corrected power provides a true comparison but may slightly understate the raw dyno-measured output due to these adjustments.

Chapter 6 – Evaluation

To my disappointment, I and many others were unable to conduct the engine dynamometer experiment as planned due to a malfunction with the dynamometer, resulting in it being out of action. While this was setback, the assignment still provided multiple valuable learning opportunities.

Furthermore, despite being unable to gather real-time data, I feel that I gained considerable experience in terms of performing vital calculations, as it allowed me to conduct a critical analysis on the engine's performance. To add, the calculations included computing key parameters such as power, torque, and efficiency. This made it possible for me to create graphs for comparing and contrasting expected results. These skills will be highly beneficial for future applications in engine testing and performance evaluation.

Finally, If I were to conduct this test again in the future, I would highly consider modifying the engine's inlet plenum and exhaust manifold. Since I already have baseline data, implementing these alterations would make it possible for me to analyse how the improved airflow changes affect power, torque, and efficiency. This would provide deeper insights into the impact of intake and exhaust modifications on engine performance.

Overall, while the test could not be performed as intended, the assignment was still engaging and a fantastic educational experience.

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