



University of Wales Trinity Saint David
Wales Institute of Science and Art

Engine Performance Characteristics
ACHA 4003/4004/4012

Jake Davies
2205290
03/2024

Contents

Introduction	2
Testing equipment and Method	3
Testing Equipment	3
Method.....	4
Results From Test	5
Graphs From Calculations.....	7
Conclusion from test results	11
Evaluation.....	12
References.....	13

Introduction

The aim of the engine dynamometer test is to gather results to examine the condition of the engine. Troubleshooting issues such as overheating or figuring out why the engine is down on power. This test is also an effective way of figuring out if there are sensor issues and which sensors may be broken. This test is much safer than driving the car to figure out the problems as you can run this test in a controlled environment.

Testing equipment and Method

Testing Equipment

The dynamometer used is a SCHENK WS230 Eddie current w series from 2001. This machine works by a coil that excites a magnetic field through a cooling chamber then there is a gap of space which is filled with a toothed rotor with another cooling chamber on the other side of it. The air gap is a varied space as the teeth rotate around which induces a tension in the front of the cooling chambers. These currents that are generated are called Eddie currents. The dynamometer has a max RPM of 10000 and a minimum of 300. The load applied from this tries to slow the engine down, but this tries to turn the machine which is restricted by a gauge which is restricted from 0-10 volts. The machine is calibrated by calibration arms with a length of 815.776mm this means we can calculate what torque is applied through the centre of the dynamometer. Torque applied can be a varied amount.

The engine used for this test is a 1.6L VTEC Honda Engine from 2000/2001 D16 model. It runs lower power due to it being an imported engine. The sensors used on this engine are, coolant temperatures, flow meter, lambda sensor. The throttle is controlled by a throttle actuator box which is further controlled by the computer software. The engine is controlled by a drive shaft from the dynamometer which is bolted directly to the crank shaft. This means that the RPM of the engine will be directly proportional to the RPM of the dynamometer.

Method

For this test we operated the system manually, so the first thing to do is to start the engine and select manual mode on the software then you will control the dynamometer via a dial and the engine will also be controlled by another dial. The engine dial controls the RPM via the throttle box connected to the engine, and the dynamometer controls the amount of current needed to produce the magnetic field to try and slow the engine down therefore producing torque. The throttle dial is a direct input 0-100% whereas the dynamometer is 0-200%.

The next thing to do is gather data at different stages of RPM and trying to hold a constant RPM by using the torque to create a balance and repeat this in stages. The stages performed in the test were 1500, 2500, 3500, 4500, 5500. The software will then read all the data in between to give you the numbers needed for the calculations.

Results From Test

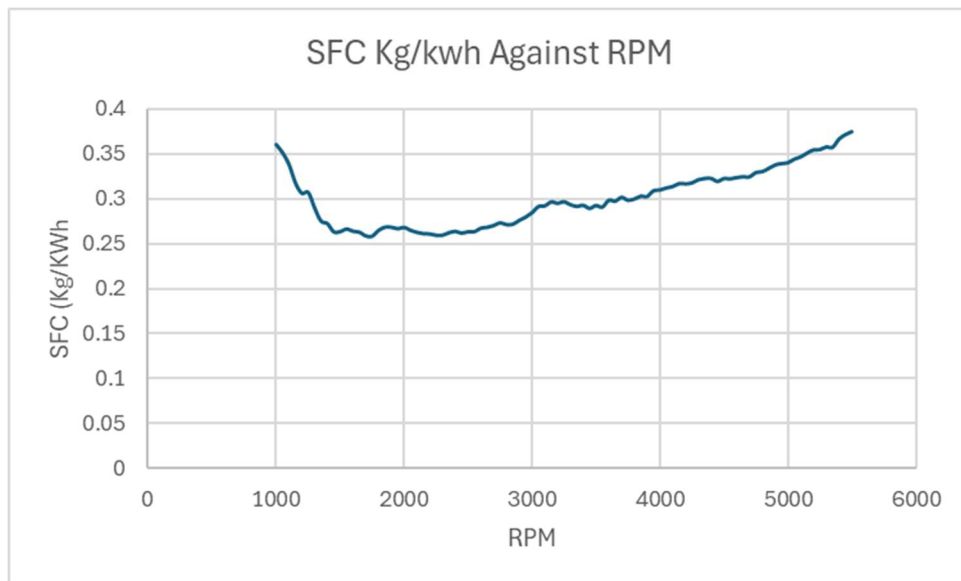
Load	Dyno Speed	Fuel Flow Rate	Lambda	Torque Nm	Power	Corrected power	SFC	Thermal Efficiency	BMEP
Newtons	rpm	l/min	Lambda		Kw	Kw	Kg/kwh	%	kPa
102.275	1000	0.0704	1.2658	83.4334904	8.737134683	8.791862712	0.360333197	21.81387136	1326.673112
102.756	1050	0.0724	1.26783	83.82587866	9.21713676	9.274871445	0.351271715	22.37658676	1332.912464
103.689	1100	0.0737	1.27344	84.58699766	9.74372265	9.804755786	0.338254218	23.23773539	1345.014992
104.209	1150	0.0728	1.28476	85.01120118	10.237705	10.30183236	0.31800168	24.71767445	1351.760238
105.811	1200	0.0744	1.29181	86.31807434	10.84704913	10.91499333	0.30673404	25.62565931	1372.540783
107.51	1250	0.07895	1.29729	87.70407776	11.48043693	11.55234857	0.307534869	25.55892945	1394.579577
109.488	1300	0.079	1.29895	89.31768269	12.15932362	12.23548769	0.290548288	27.05320368	1420.237455
111.797	1350	0.0796	1.29469	91.20130947	12.89328137	12.97404285	0.276089731	28.46995424	1450.18894
114.268	1400	0.0835	1.2855	93.21709197	13.66633946	13.75194325	0.273234112	28.76749888	1482.24183
115.783	1450	0.0847	1.27818	94.45299261	14.34208667	14.43192323	0.264102015	29.76221905	1501.893844
116.985	1500	0.08865	1.2795	95.43355536	14.99066782	15.08456699	0.264459033	29.72204039	1517.485739
117.788	1550	0.0932	1.27766	96.08862349	15.59668454	15.6943797	0.267229421	29.41390952	1527.901955
118.471	1600	0.0959	1.28235	96.6457985	16.19315896	16.29459035	0.264842497	29.67900578	1536.761576
118.772	1650	0.09875	1.29028	96.89134707	16.74162293	16.8464898	0.263778986	29.79866639	1540.666036
118.656	1700	0.10005	1.29942	96.79671706	17.23209846	17.3400376	0.259644766	30.27313871	1539.161327
118.861	1750	0.10305	1.31053	96.96395114	17.76957213	17.88087792	0.259341293	30.30856335	1541.820511
119.584	1800	0.1093	1.3149	97.55375718	18.38845001	18.50363235	0.265812674	29.57068818	1551.198997
119.934	1850	0.11415	1.31849	97.83927878	18.95455483	19.07328316	0.269316507	29.18596448	1555.739066
120.176	1900	0.11745	1.31892	98.03669658	19.50611983	19.62830308	0.269266782	29.19135423	1558.8782
120.948	1950	0.12055	1.31484	98.66647565	20.14804188	20.27424602	0.26756852	29.37663224	1568.892296
122.157	2000	0.12555	1.31653	99.65274883	20.87122291	21.00195695	0.269010646	29.21914851	1584.574992
122.845	2050	0.12785	1.32098	100.2140027	21.51349094	21.64824804	0.265760536	29.57648314	1593.499471
123.796	2100	0.1309	1.32287	100.9898057	22.20881822	22.34793074	0.263581451	29.82099838	1605.835488
124.794	2150	0.13435	1.32164	101.8039501	22.92090217	23.06447507	0.262123893	29.98682002	1618.781171
125.137	2200	0.1377	1.31652	102.0837613	23.51841027	23.66572587	0.261834352	30.01997998	1623.230439
126.028	2250	0.14105	1.30465	102.8106177	24.2241811	24.37591754	0.260390198	30.18647423	1634.788159
126.66	2300	0.14495	1.29646	103.3261882	24.88667418	25.04256037	0.260466578	30.1776223	1642.986227
126.822	2350	0.14985	1.28229	103.4583439	25.46021122	25.61968995	0.263205761	29.86356366	1645.08763
126.69	2400	0.1537	1.27304	103.3506614	25.9748543	26.13755667	0.264619225	29.70404738	1643.375376
126.552	2450	0.15565	1.26984	103.2380844	26.48711394	26.65302502	0.26279381	29.91037727	1641.585291
126.438	2500	0.1596	1.27446	103.1450859	27.00332034	27.17246486	0.264311686	29.73860947	1640.106526
126.239	2550	0.1626	1.27876	102.9827465	27.50003638	27.67229225	0.264416115	29.72686449	1637.525172
126.161	2600	0.16805	1.27634	102.9191159	28.02192801	28.19745293	0.268189117	29.3086539	1636.513385
125.847	2650	0.17145	1.28027	102.6629623	28.48972671	28.66818185	0.269122403	29.20701476	1632.440294
124.911	2700	0.17465	1.28371	101.8993959	28.81137543	28.99184532	0.271084849	28.99557851	1620.298852
123.927	2750	0.1784	1.2812	101.0966724	29.11375162	29.29611555	0.274029504	28.68399901	1607.534771
123.689	2800	0.18005	1.27448	100.9025177	29.58616343	29.77148648	0.272147983	28.88230851	1604.447524
123.389	2850	0.1831	1.26036	100.6577849	30.04144696	30.22962183	0.27256378	28.83824843	1600.556036
122.519	2900	0.1879	1.2531	99.94805974	30.35295539	30.5430815	0.276838472	28.39295407	1589.270721
121.837	2950	0.19255	1.23943	99.39170051	30.70440989	30.89673745	0.280442232	28.02809678	1580.424072
121.709	3000	0.199	1.22735	99.28728118	31.19201932	31.38740119	0.285305558	27.5503291	1578.763703
121.123	3050	0.20605	1.2193	98.80923645	31.55920109	31.75688292	0.291976074	26.92091136	1571.16233
121.124	3100	0.21005	1.20692	98.81005222	32.07682986	32.27775405	0.292841007	26.84139796	1571.175302

(figure 1)

(figure2)

120.851	3150	0.21605	1.19274	98.58734538	32.5207344	32.72443913	0.297094473	26.45711287	1567.634048
120.596	3200	0.21795	1.18481	98.3793225	32.96722739	33.17372889	0.295648103	26.58654644	1564.326283
120.84	3250	0.22305	1.17378	98.57837184	33.55008462	33.76023704	0.29730982	26.4379495	1567.49136
121.633	3300	0.2255	1.16118	99.22528221	34.28979594	34.50458179	0.294091378	26.72727799	1577.77786
122.181	3350	0.2285	1.15104	99.67232746	34.96616677	35.18518931	0.292239439	26.89665031	1584.886311
122.933	3400	0.2342	1.14117	100.285791	35.70647182	35.93013151	0.293319272	26.79763238	1594.640974
123.475	3450	0.23605	1.12669	100.7279416	36.39130855	36.61925795	0.290072781	27.09755109	1601.671596
123.428	3500	0.24195	1.11975	100.6896001	36.90466594	37.13583092	0.293187192	26.80970457	1601.06193
124.205	3550	0.24545	1.10622	101.3234581	37.6675154	37.90345875	0.291404805	26.97368704	1611.140883
124.066	3600	0.25505	1.09697	101.2100652	38.15529568	38.39429441	0.298931135	26.29455782	1609.337827
123.967	3650	0.25755	1.09401	101.1293034	38.65436099	38.89648578	0.297963936	26.37991065	1608.053636
123.815	3700	0.26445	1.09659	101.0053054	39.13582815	39.38096878	0.302182764	26.01161596	1606.081949
123.767	3750	0.2651	1.09808	100.9661482	39.64931368	39.8976707	0.299002418	26.28828914	1605.459311
123.509	3800	0.2693	1.09907	100.755678	40.09421772	40.34536155	0.300369102	26.16867703	1602.112631
122.672	3850	0.27375	1.10533	100.0728735	40.3464862	40.5992102	0.30342339	25.90526064	1591.25538
122.157	3900	0.2759	1.11704	99.65274883	40.69888467	40.95381604	0.303158562	25.92789049	1584.574992
121.184	3950	0.28285	1.12259	98.85899878	40.89233607	41.14847919	0.309324919	25.41102097	1571.953599
120.004	4000	0.28455	1.12461	97.8963831	41.00674106	41.2636008	0.310315866	25.32987475	1556.64708
118.734	4050	0.2871	1.1222	96.86034758	41.07992711	41.33724527	0.312538969	25.14970228	1540.173114
117.442	4100	0.28895	1.12394	95.80636499	41.13455823	41.39221859	0.314135131	25.02191331	1523.413773
116.5	4150	0.29305	1.12233	95.037904	41.30223604	41.56094671	0.317299076	24.77240747	1511.1945
115.931	4200	0.2949	1.12179	94.57372746	41.59569784	41.8562467	0.31704945	24.79191182	1503.813645
115.034	4250	0.29715	1.12456	93.84197638	41.76521234	42.02682302	0.318171802	24.70445831	1492.178096
114.391	4300	0.3022	1.12278	93.31743242	42.02036829	42.28357722	0.321614227	24.44003203	1483.83734
114.016	4350	0.30605	1.11943	93.01151642	42.36962302	42.63501963	0.323026707	24.33316452	1478.97298
113.871	4400	0.3092	1.11986	92.8932289	42.8021272	43.07023295	0.323053744	24.33112806	1477.092094
113.985	4450	0.3099	1.11873	92.98622736	43.33185257	43.60327643	0.319826883	24.57661448	1478.570859
113.306	4500	0.31445	1.11563	92.43231546	43.55770248	43.83054103	0.322839957	24.34724026	1469.763125
113.074	4550	0.3171	1.10953	92.24305542	43.9514993	44.22680453	0.322643703	24.36204993	1466.753708
112.195	4600	0.3194	1.10569	91.52598832	44.08906379	44.3652307	0.323969915	24.26232084	1455.351648
111.061	4650	0.32055	1.09782	90.60089834	44.11782308	44.39417013	0.32492442	24.19104726	1440.641823
109.973	4700	0.3207	1.09558	89.71333405	44.15536435	44.43194656	0.324800085	24.20030777	1426.528693
108.654	4750	0.32485	1.08827	88.6373255	44.08987535	44.36604735	0.329491827	23.85571162	1409.419118
107.076	4800	0.32455	1.08396	87.35003098	43.9069145	44.18194046	0.33055927	23.77867667	1388.949891
105.24	4850	0.3257	1.08221	85.85226624	43.60357724	43.87670314	0.334038315	23.53101919	1365.133985
103.632	4900	0.3277	1.0846	84.54049843	43.37999544	43.65172086	0.337821733	23.2674847	1344.275609
102.335	4950	0.32845	1.08823	83.48243696	43.27418876	43.54525143	0.339422773	23.15773315	1327.451409
101.106	5000	0.3287	1.08687	82.47984826	43.18634756	43.45686	0.340372038	23.09314848	1311.50928
99.3149	5050	0.32985	1.0891	81.01871186	42.84551132	43.11388881	0.344280008	22.83101493	1288.2758
97.5815	5100	0.3297	1.09185	79.60464574	42.51451294	42.78081712	0.346802633	22.66494332	1265.790782
95.8486	5150	0.33095	1.09407	78.19098751	42.16892648	42.43306596	0.350970397	22.39579771	1243.312251
94.8033	5200	0.3338	1.09346	77.33825686	42.11398526	42.3777806	0.354454617	22.17565135	1229.753009
93.0976	5250	0.3313	1.08804	75.94678774	41.75392732	42.01546731	0.354833611	22.15196576	1207.627306
91.7886	5300	0.3324	1.08339	74.87893695	41.55891089	41.81922933	0.357682345	21.97553814	1190.647446
90.5938	5350	0.3308	1.08007	73.90424779	41.40490581	41.66425958	0.35728464	21.99999978	1175.148947
89.6374	5400	0.3388	1.07895	73.12403962	41.35067022	41.60968427	0.366405087	21.4523823	1162.742883
88.9256	5450	0.3438	1.07923	72.54337027	41.40214564	41.66148212	0.371350207	21.16670966	1153.509679
88.6474	5500	0.3488	1.08366	72.31642138	41.65126866	41.91216561	0.37449747	20.98882537	1149.900973

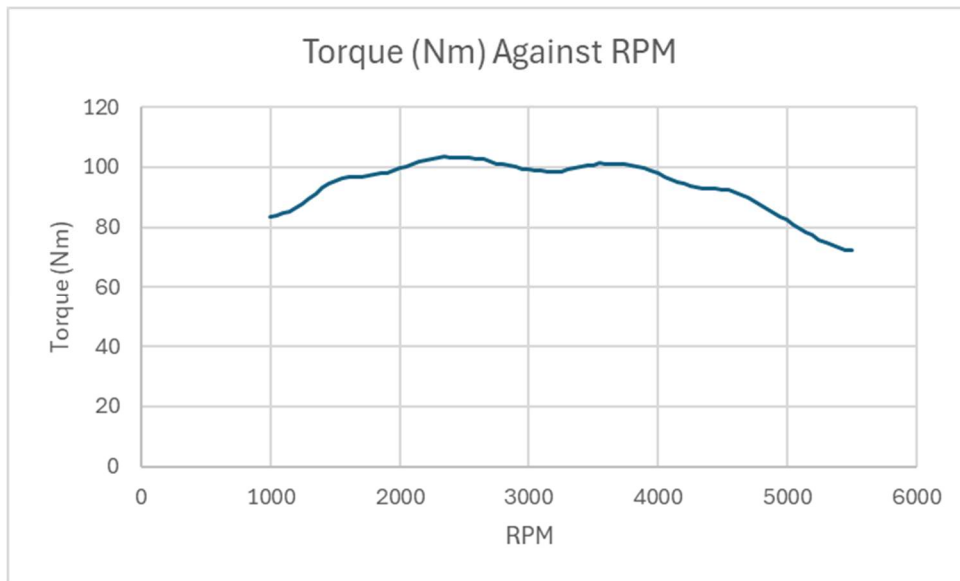
Graphs From Calculations



(Figure 3)

This graph shows the effect of Specific fuel consumption (SFC) at various RPM.

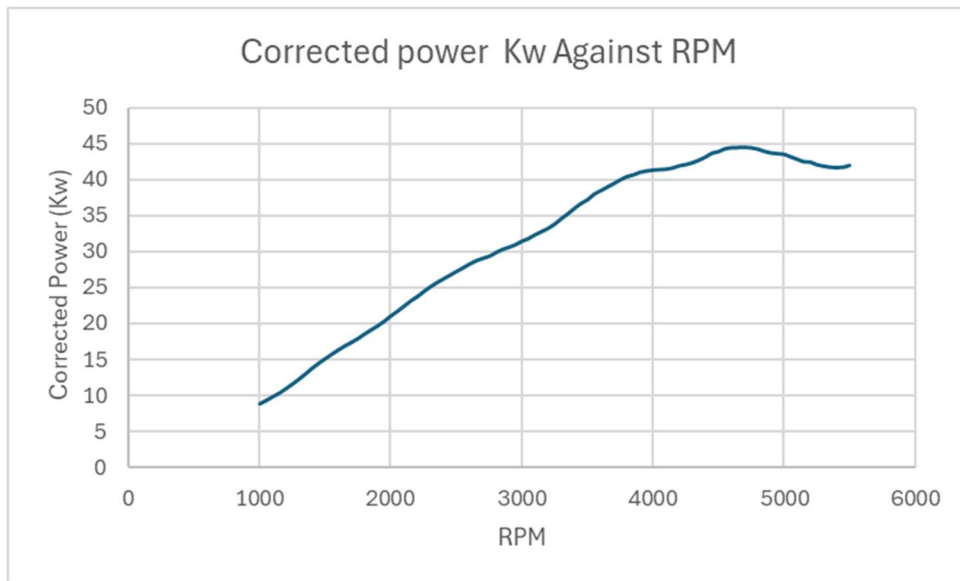
As RPM increases it needs more power to overcome the friction force of the piston against the bore meaning more fuel needs to be combusted to provide that power. In this graph it reaches its lowest around 2000 rpm this suggests that this is the least amount of friction at this speed. As the rpm increases it needs more power to stay at that rpm or keep increasing so more fuel must be combusted to maintain the increase in rpm hence there being a higher SFC. Atmospheric conditions will also alter SFC as when at higher altitudes oxygen is less dense therefore making combustion reactions less efficient using more fuel to extract more fuel.



(figure 4)

This graph shows torque amounts at different RPM.

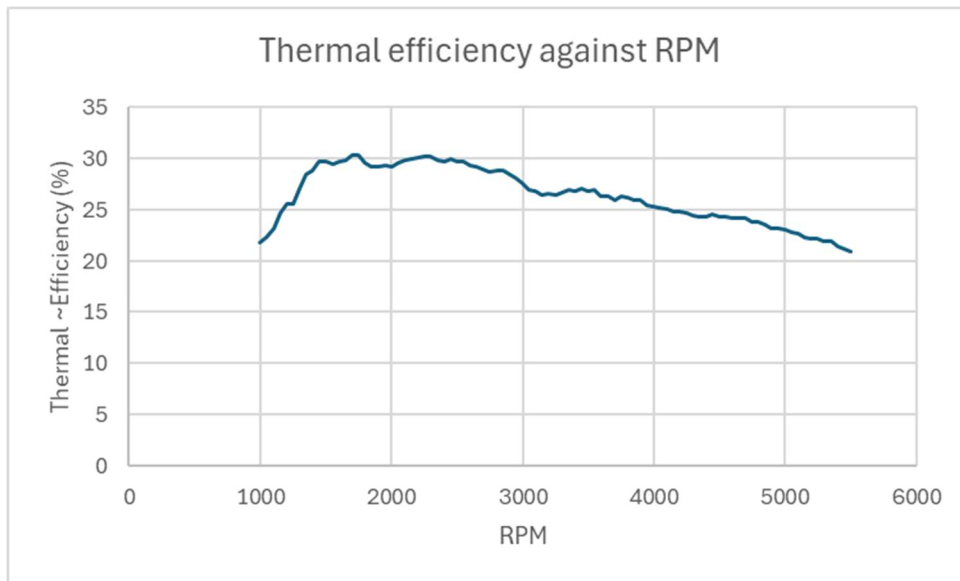
Torque represents how strong an engine is which translates to its acceleration. This graph demonstrates the peak power band of this engine which is at about 2500 RPM. As the rpm increases the amount of torque that the engine is producing decreases, this is opposed by power as power gradually increases as the rpm increases. Torque varies due to many factors such as air intake, how much octane is in the fuel, and cylinder pressures. More efficient cylinder pressures would result in an increase in peak amounts of torque. Higher octane fuel allows for a more efficient and powerful combustion also resulting in an increased amount of torque. (3)



(figure 5)

This graph shows Corrected power at various RPM.

The trend in this graph is that when rpm increases power being output from the engine increases as well until it reaches its peak at 4600rpm. Power is how fast the engine can generate the torque (5); this means that at peak power is where the engine will generate an amount of torque at the quickest rate. Fuel injection efficiency and spark timing has a big effect on power and can ultimately increase or decrease the power of an engine. Inefficient combustion also affects power as that's what causes the pistons to move therefore turning the crank shaft and the driveshaft. Exhaust designs can affect how the engine is performing as they may not allow for efficient air flow out of the engine. Valve timing influences power as the valves allow air and fuel into the piston chamber to be combusted, poor valve timing can result in not enough oxygen being let into the chamber therefore not efficiently burning the fuel. Gear ratios will also affect power of an engine as having gears too long or too short can take away the engines ability to achieve an optimal power curve throughout the rpm range. (5)



(figure 6)

This graph shows the effect of thermal efficiency at various RPM.

Thermal efficiency is the net work output compared to the heat input (6), this means that the energy conversion is either very efficient or not very efficient. A healthy petrol engine will operate at around 25-30% and if an engine is not in good condition that percentage can drop considerably. This graph shows that throughout most of the rpm it is operating between and healthy range, but it has lows that drop considerably below the desired amount. This is a result of the operating conditions of the engine not being in good health, but this is a common factor when it comes to the condition of an older engine.

Conclusion from test results

In conclusion this test has demonstrated the effect of how many different factors can affect an engines performance, such as efficient combustion of fuel being very important to make sure that the engine is extracting as much as possible of what it is burning to result in the correct amount of power. it has also shown that many different factors have very different affects at different rpms such as torque and power following different trends as the rpm increased.

Evaluation

The test could have been improved by repeating it multiple times and finding a mean result for all the data collected to make it a fairer test. Letting the engine warm up before the test would be an improvement as engines don't run properly if they are cold, potentially increasing the efficiency and having better more accurate results. My own performance could have been improved by having more experience with the equipment as it was my first time experiencing that so more experience and understanding how it works would have helped me perform the test to a higher standard.

References

(1)

Physics Forums: Science Discussion, Homework Help, Articles. (2014). Relation between SFC vs RPM in diesel engine? [online] Available at: <https://www.physicsforums.com/threads/relation-between-sfc-vs-rpm-in-diesel-engine.750380/> [Accessed 17 Mar. 2024].

(2)

Chudzinski, M. (2023). What Is Torque? Why It's Important for Cars and How It Works. [online] MotorTrend. Available at: <https://www.motortrend.com/features/what-is-torque-in-cars/>.

(3)

www.exro.com. (n.d.). Torque and Speed Relationship: The Fundamental Challenge of E-Mobility. [online] Available at: <https://www.exro.com/industry-insights/torque-and-speed-relationship-the-fundamental-challenge-of-e-mobility>.

(4)

Motor Vehicle Maintenance & Repair Stack Exchange. (n.d.). Engine power specification at different rpm? [online] Available at: <https://mechanics.stackexchange.com/questions/7922/engine-power-specification-at-different-rpm>.

(5)

Muscad, O. (2022). Torque vs RPM: How RPM Impacts Torque Output. [online] DATAMYTE. Available at: <https://datamyte.com/blog/torque-vs-rpm/>.

(6)

Physics LibreTexts. (2020). 6.2: Engines and Thermal Efficiency. [online] Available at: https://phys.libretexts.org/Courses/University_of_California_Davis/Physics_9B_Fall_2020_Taufour/06%3A_Applications_of_Thermodynamics/6.02%3A_Engines_and_Thermal_Efficiency.