

Automotive Design
Engine Performance Characteristics
Vehicle Technology
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For Abi Summerfield

Contents

1.0	Introduction (Page 1)
2.0	Experimental Procedure (Page 2)
3.0	Results (Page 3)
4.0	Analysis (Page 4-6)
5.0	Discussion (Page 7)
6.0	Conclusion (Page 8)
7.0	Evaluation (Page 9)
8.0	Bibliography / References (Page 10)

1.0 Introduction

Introduction

The assignment brief was to identify at how a dyno works and how to collect data from it. Also to look at how to use the data collected, to identify other calculations relating to the car and what the equations are that tell us these.

After completion of the assignment a detailed understanding of the basics of a vehicle should be apparent.

A dyno or dynamometer is a machine used to measure the torque and rpm of an engine. As well as providing information about the characteristics of a car the dyno can also be used to test an engine. For instance it can be used to test emissions produced, to stress test it, to calibrate it, to diagnose a problem, to tune it and more.⁽¹⁾

⁽¹⁾ Author: Wikipedia . Title: Dynamometer

2.0 Experimental Procedure

Experimental Procedure

The dyno test was on a d16 engine from a 2003 1.6L Honda Civic. Before the test is performed, the torque arms are examined. Pressure is applied to attempt to move them but seemingly there was no movement. After this initial test weights on each arm were applied to mimic a torque loading.

Once the setup was complete individuals left the room and the ventilation was turned on to make sure there is no build-up of exhaust gasses. However, of course the room would be off limits while the test is being run. On reading the computer screen it became apparent that the graph showed tiny movements from then the torque arms were attempted to be rotated, showing how sensitive it is, and then large jumps in the graph from when the weights were put on.

The dyno is then started by pressing the ignition button, fuel controls and then start engine. Once it is running there are two knobs, one that acted like the throttle and another that was applying a resistant load on the engine, like going up an incline for instance. The engine had to achieve a certain rpm whilst putting on the resistance. When doing this it is important to take care as too much throttle would over rev the engine and alternatively too fast with the resistance the engine would stall. Once the revs reach the specific rpm the engine needs to be slowly brought back down to idle, but again, this is as delicate as building the revs up. If done too quickly the engine will stall.

After manual testing, a sweep test, where specific levels for throttle and rpms are set is performed, starting at 1500 rpm rising to 5500rpm. The dyno would rev up and then logs every 50 rpm until it reaches the maximum. After the test is complete, the data shows the Newton force for each stage of rpm.

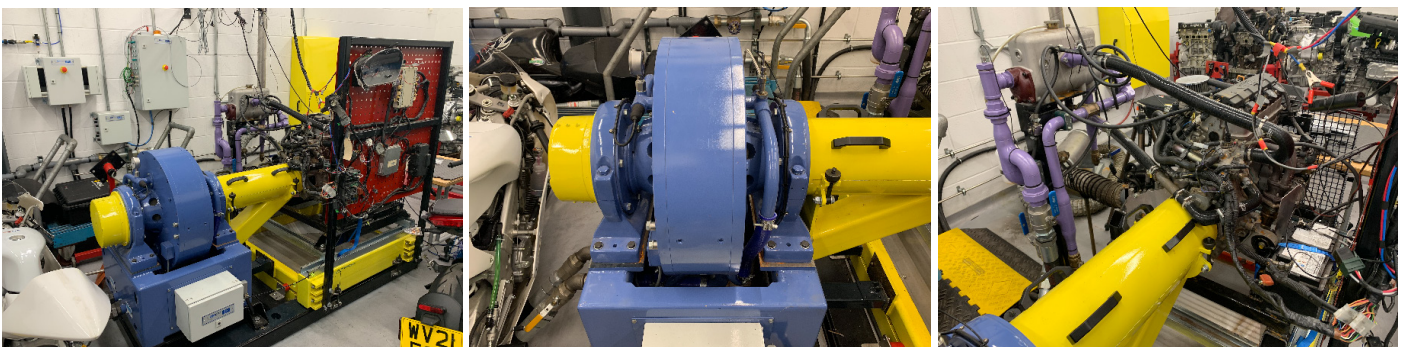


Table 3.1 data gathered from the dyno

3.0 Results

Results

The measurements units collected from the dyno are force in Newtons and engine speed in rpm. It is apparent that the rpm increases as the force increases. However the data shows that the force reaches a peak about halfway through and then drops back down again. This is because the engines torque (which will be identified later) has that same arc as it reaches its maximum at about 3000-3200 rpm for this engine.

With the raw data the torque (Nm), the power (W), the corrected power (W) and the BMEP (Pa) can be identified.

Temperature	26 °C
Barometric Pressure	1010.67 mBar
Humidity	42.8 %
Torque arm	815.744 mm

Newton's Force	RPM		
130.037	1000	154.283	3650
130.61	1050	153.895	3700
131.485	1100	153.537	3750
132.641	1150	153.207	3800
133.729	1200	152.982	3850
135.143	1250	152.81	3900
136.396	1300	152.686	3950
137.723	1350	152.585	4000
139.186	1400	152.443	4050
140.496	1450	152.235	4100
141.522	1500	151.91	4150
142.271	1550	151.399	4200
143.07	1600	150.827	4250
143.631	1650	150.068	4300
143.895	1700	149.154	4350
143.984	1750	148.116	4400
143.769	1800	147.008	4450
143.411	1850	145.914	4500
143.045	1900	144.832	4550
142.816	1950	143.855	4600
142.873	2000	142.954	4650
143.19	2050	141.876	4700
143.772	2100	140.982	4750
144.551	2150	140.028	4800
145.344	2200	139.039	4850
146.106	2250	137.983	4900
146.954	2300	136.865	4950
147.835	2350	135.733	5000
148.72	2400	134.623	5050
149.675	2450	133.253	5100
150.825	2500	131.742	5150
152.138	2550	129.994	5200
153.556	2600	128.245	5250
155.005	2650	126.542	5300
156.482	2700	125.13	5350
157.786	2750	123.554	5400
158.838	2800	122.083	5450
159.646	2850	121.004	5500
160.156	2900		
160.53	2950		
160.755	3000		
160.772	3050		
160.64	3100		
160.269	3150		
159.847	3200		
159.295	3250		
158.657	3300		
158.007	3350		
157.267	3400		
156.714	3450		
156.031	3500		
155.394	3550		
154.841	3600		

4.0 Analysis

Analysis

Finding the Torque, Power, Corrected Power and BMEP

Before generating the equation to find the rest of the data, the units/format of other elements eg temperature and humidity needed changing in order to fit into the equations. The Honda handbook was checked to establish the diameter of the cylinder, the length of the stroke and the area of the cylinder as that could be something that needs to be used.

Temperature		26	°C	299	k	Diameter (d)	0.075	m
Barometric Pressure		1010.67	mBar	1.01067	Bar	Stroke (l)	0.09	m
Humidity		42.8	%			Area (A)	0.004418	m ²
Torque arm		815.744	mm	0.815744	m			

This provided the information required to find the equations for each of the other measurements like torque, power, corrected power and BMEP.

Torque

$$T = WR$$

Force
Radius of the Torque arm

Power

$$P = \frac{2\pi NT}{60}$$

Engine speed
Torque

Corrected Power

$$P_s = \left(\frac{1.01325}{P_a} \sqrt{\frac{T_a}{293}} \right) \times P$$

Ambient pressure
Ambient temperature

BMEP

$$BMEP = \frac{60 \times 2 \times BP}{L \times A \times N \times n}$$

Stroke
Area
Engine speed
Number of Cylinders

(2) Author: Honda Motor Company LTD .
Title: Honda Chassis Maintenance and Repairs

(3) Author: Abi Summerfield . Title: Vehicle Technology

Table 4.1 data calculated from the dyno

Engine Speed (rpm)	Torque (N)	Torque (ftlb)	Power (W)	Power (BHP)	Power (Kw)	Corrected Power (W)	BMEP (Pa)
1000	106.0769025	78.23830822	11108.34726	14.8968599	11.10834726	11250.15405	848837.9867
1050	106.5443238	78.58306049	11715.16028	15.7106271	11.71516028	11864.71352	852578.3388
1100	107.2580998	79.10951465	12355.24614	16.56901487	12.35524614	12512.97059	858290.0458
1150	108.2010999	79.8050358	13030.41159	17.47444615	13.03041159	13196.75505	865836.0267
1200	109.0886294	80.45964395	13708.48147	18.38377242	13.70848147	13883.48102	872938.1263
1250	110.2420914	81.31039387	14430.65602	19.3522453	14.43065602	14614.8747	882168.2447
1300	111.2642186	82.06427623	15147.03025	20.31293966	15.14703025	15340.39401	890347.4091
1350	112.3467109	82.86268157	15882.64207	21.29943262	15.88264207	16085.3965	899009.6207
1400	113.5401444	83.74291292	16645.85456	22.32293947	16.64585456	16858.352	908559.5947
1450	114.608769	84.53109001	17402.61323	23.33779142	17.40261323	17624.77129	917110.836
1500	115.4457224	85.14839512	18134.17166	24.31884857	18.13417166	18365.66864	923808.2204
1550	116.0567146	85.59903988	18837.81764	25.26247369	18.83781764	19078.29721	928697.4416
1600	116.7084941	86.07976774	19554.69587	26.22384394	19.55469587	19804.32696	933913.046
1650	117.1661265	86.41730006	20244.85332	27.14938025	20.24485332	20503.29481	937575.0661
1700	117.3814829	86.5761388	20896.67224	28.02350266	20.89667224	21163.43471	939298.3697
1750	117.4540841	86.62968671	21524.58512	28.86556583	21.52458512	21799.36339	939879.3319
1800	117.2786991	86.5003294	22106.51398	29.6459621	22.10651398	22388.72103	938475.8839
1850	116.9866628	86.28493444	22664.00716	30.39358886	22.66400716	22953.33105	936138.9798
1900	116.6881005	86.06472619	23217.14368	31.13537314	23.21714368	23513.5288	933749.8544
1950	116.5012951	85.92694561	23789.97483	31.90356892	23.78997483	24093.67259	932255.0191
2000	116.5477925	85.96124034	24409.71258	32.73466883	24.40971258	24721.32178	932627.096
2050	116.8063834	86.15196716	25075.46852	33.62748147	25.07546852	25395.57661	934696.3658
2100	117.2811464	86.50213439	25791.47115	34.5876775	25.79147115	26120.71958	938495.4669
2150	117.9166109	86.97082901	26548.62704	35.60306214	26.54862704	26887.54116	943580.518
2200	118.5634959	87.44794689	27315.06857	36.63089931	27.31506857	27663.76693	948756.9564
2250	119.1850929	87.90641326	28082.32591	37.65983051	28.08232591	28440.81891	953731.0372
2300	119.8768438	88.41662255	28872.98957	38.72015077	28.87298957	29241.57601	959266.4972
2350	120.5955142	88.94668668	29677.52189	39.79906963	29.67752189	30056.37882	965017.3702
2400	121.3174477	89.47915746	30490.40019	40.88918086	30.49040019	30879.63415	970794.3538
2450	122.0964832	90.05374457	31325.48886	42.00907734	31.32548886	31725.38339	977028.274
2500	123.0345888	90.74565575	32210.38003	43.1957615	32.21038003	32621.57088	984535.0888
2550	124.1056607	91.53563783	33140.60171	44.44323619	33.14060171	33563.66758	993105.9131
2600	125.2623857	92.3887944	34105.36052	45.73702693	34.10536052	34540.74229	1002362.142
2650	126.4443987	93.26060249	35089.25015	47.05647308	35.08925015	35537.19205	1011820.729
2700	127.6492526	94.14925711	36091.97588	48.4011794	36.09197588	36552.71837	1021462.09
2750	128.7129828	94.93382422	37066.6781	49.70830476	37.0666781	37539.86343	1029974.166
2800	129.5711455	95.56677254	37992.24415	50.94953601	37.99224415	38477.24505	1036841.269
2850	130.2302666	96.05291536	38867.39265	52.12315475	38.86739265	39363.56551	1042115.623
2900	130.6462961	96.35976292	39675.61958	53.20702827	39.67561958	40182.1101	1045444.732
2950	130.9513843	96.58478447	40453.93085	54.25078336	40.45393085	40970.35712	1047886.079
3000	131.1349267	96.7201584	41197.25224	55.24761523	41.19725224	41723.1676	1049354.803
3050	131.1487944	96.73038665	41888.30237	56.17434868	41.88830237	42423.03953	1049465.774
3100	131.0411162	96.65096728	42540.04014	57.04836226	42.54004014	43083.09725	1048604.122
3150	130.7384751	96.42775072	43126.33847	57.8346182	43.12633847	43676.88013	1046182.358
3200	130.3942312	96.1738494	43695.52626	58.59792804	43.69552626	44253.33405	1043427.683
3250	129.9439405	95.84173203	44225.01729	59.30800249	44.22501729	44789.58445	1039824.412
3300	129.4234958	95.45787174	44725.5494	59.97924157	44.7255494	45296.50625	1035659.762
3350	128.8932622	95.0667915	45217.19736	60.63856655	45.21719736	45794.43048	1031416.78
3400	128.2896116	94.6215617	45677.15283	61.25539029	45.67715283	46260.25765	1026586.307
3450	127.8385052	94.28884267	46185.89852	61.93764418	46.18589852	46775.49787	1022976.509
3500	127.2813521	93.87790759	46651.05207	62.5614388	46.65105207	47246.58947	1018518.113
3550	126.7617231	93.49464897	47124.32095	63.19611649	47.12432095	47725.9	1014359.991

3600	126.3106167	93.16192994	47617.98066	63.85813933	47.61798066	48225.86167	1010750.192
3650	125.8554316	92.8262026	48105.3574	64.51173638	48.1053574	48719.46016	1007107.755
3700	125.5389229	92.59275778	48641.69947	65.23099844	48.64169947	49262.64906	1004575.021
3750	125.2468865	92.37736282	49184.33733	65.95870346	49.18433733	49812.21411	1002238.117
3800	124.977691	92.17881439	49733.00615	66.69449632	49.73300615	50367.88713	1000083.987
3850	124.7941486	92.04344047	50313.38883	67.47281908	50.31338883	50955.67884	998615.2625
3900	124.6538406	91.93995462	50909.5067	68.27224353	50.9095067	51559.40663	997492.5041
3950	124.5526884	91.86534855	51520.35176	69.09141789	51.52035176	52178.04961	996683.0736
4000	124.4702982	91.80458069	52137.99661	69.91971111	52.13799661	52803.57918	996023.7794
4050	124.3544626	91.7191447	52740.59393	70.72782484	52.74059393	53413.86913	995096.851
4100	124.1847878	91.59399903	53318.86235	71.50331227	53.31886235	53999.5196	993739.0966
4150	123.919671	91.39845891	53853.87606	72.22079293	53.85387606	54541.36319	991617.6055
4200	123.5028259	91.09100968	54319.37986	72.84505725	54.31937986	55012.8095	988281.9686
4250	123.0362203	90.74685908	54758.37215	73.43376829	54.75837215	55457.40588	984548.1442
4300	122.4170706	90.2901977	55123.78832	73.92381	55.12378832	55827.48687	979593.6464
4350	121.6714806	89.74027872	55425.12328	74.32791554	55.42512328	56132.66861	973627.3605
4400	120.8247383	89.11575367	55672.04283	74.65904725	55.67204283	56382.74029	966851.6441
4450	119.920894	88.44911229	55883.48559	74.94260276	55.88348559	56596.88227	959618.9912
4500	119.02847	87.79089417	56090.84505	75.22068236	56.09084505	56806.88884	952477.7255
4550	118.145835	87.139896	56293.52324	75.49248416	56.29352324	57012.15438	945414.7919
4600	117.3488531	86.55207233	56528.21855	75.80722252	56.52821855	57249.84576	939037.2631
4650	116.6138678	86.00997496	56784.7569	76.15125353	56.7847569	57509.65902	933155.8368
4700	115.7344957	85.36138343	56962.53385	76.38966148	56.96253385	57689.70544	926119.0139
4750	115.0052206	84.82349769	57205.76306	76.71584426	57.20576306	57936.03966	920283.2813
4800	114.2270008	84.24951224	57416.75306	76.9987926	57.41675306	58149.72312	914055.8888
4850	113.42023	83.65446862	57605.09276	77.25136573	57.60509276	58340.46711	907600.028
4900	112.5588044	83.01911366	57756.9391	77.45499942	57.7569391	58494.25189	900706.8136
4950	111.6468026	82.34645566	57873.54783	77.61137767	57.87354783	58612.34923	893408.884
5000	110.7233804	81.66537439	57974.62638	77.74692916	57.97462638	58714.71813	886019.5671
5050	109.8179045	80.99752968	58075.52554	77.88224008	58.07552554	58816.90535	878773.8589
5100	108.7003352	80.17325288	58053.66968	77.85293026	58.05366968	58794.77048	869830.9577
5150	107.467746	79.26414176	57958.07965	77.72473915	57.95807965	58697.96017	859967.6557
5200	106.0418255	78.21243676	57744.30481	77.4380562	57.74430481	58481.45632	848557.2971
5250	104.6150893	77.1601301	57515.14929	77.13074696	57.51514929	58249.37545	837140.4109
5300	103.2258772	76.13549989	57291.87951	76.83133081	57.29187951	58023.25546	826023.7972
5350	102.0740467	75.28595329	57187.05509	76.69075592	57.18705509	57917.09287	816806.7341
5400	100.7884342	74.33773414	56994.51679	76.43255223	56.99451679	57722.09666	806519.1339
5450	99.58847475	73.45268948	56837.39975	76.22185028	56.83739975	57562.97391	796916.9385
5500	98.70828698	72.8034963	56851.89202	76.24128515	56.85189202	57577.65118	789873.5879

The torque (ftlb), power (BHP) and power (Kw) was identified on top of the mandatory calculations.

For the torque it was changed by multiplying Nm by 0.7375621493 which is the conversion from Nm to ftlb.

For the power the torque (ftlb) was multiplied by Engine speed and the divided by 5252 as that is where torque and horsepower cross.

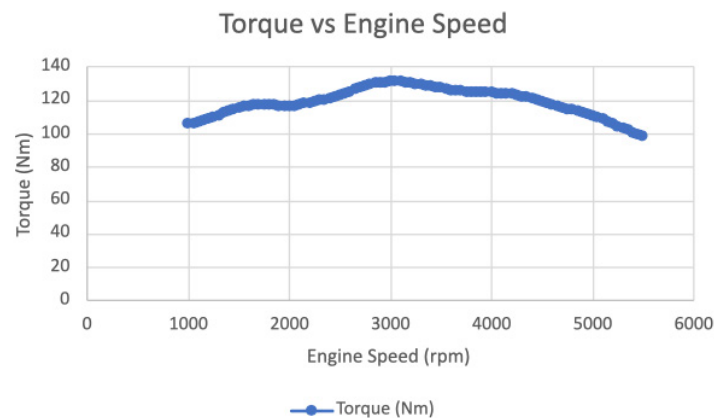
Finally for the power in Kw it was calculated by dividing power (W) by 1000.

5.0 Discussion

Plotting the data and Discussing it

Torque and Engine speed

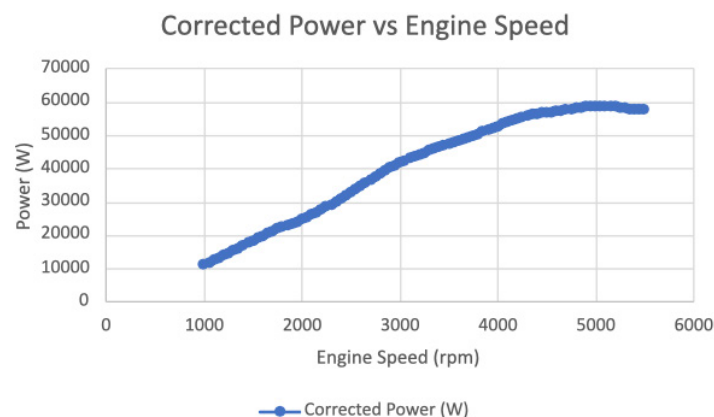
Looking at the graph made by the data for torque and engine speed you can see that the torque curve has a slight dip in it before reaching maximum torque at about the halfway point in the rpm. The dip is probably due to over fuelling because of larger injectors. The reason for the drop off after the halfway point is most likely due to the engine not being able to breath fast enough. This means the exhaust valve can get rid of the gasses fast enough to get the intake in. ⁽⁴⁾



Graph 5.1 This is Torque and Engine Speed

Corrected power and Engine speed

Looking at this graph for brake power and engine speed you can see again that the power drops off however this time its at high rpm and this is due to the engine being designed this way. However there are many ways to change this, for example intake, camshaft, airflow and more. However before the end the curve isn't much of a curve as it is fairly straight going up with the rpm. ⁽⁵⁾



Graph 5.2 This is Corrected Power and Engine Speed

⁽⁴⁾ Author: Mechanical Engineering . Title: Why Does the Torque Curve Drop Off at Low RPM in a Typical Piston Engine?

⁽⁵⁾ Author: Why increases? . Title: Why does the power output peak and then drop as engine speed increases?

6.0 Conclusion

Conclusion

The graphs demonstrate how the manufacturers of these engines purposefully engineer them to produce the power and torque to aid performance for the job of day-to-day driving. The torque drops off at about the halfway mark, this will most likely be to give the driver the most torque before the gear change (or the average gear change as on a normal road you would be changing at around 3000 rpm). This can of course be modified to produce maximum torque at a higher rpm for high performance vehicles.

Like the torque being manipulated to work best in midrange rpm, the power is made to drop off at high rpm to protect the engine from over revving. This of course can be changed for high performance cars to squeeze that extra bit of power output, however it also runs the risk of damaging the engine. The engine wants to produce more power as the engine speed goes up, unlike dropping off in the middle, as with the torque, otherwise all of the energy from the engine would not be used.

7.0 Evaluation

Evaluation

I am pleased with how the dyno went. I think we achieved the goal of understanding how to run the dyno test and how to collect the data from it. I went from not having a clue how to use a dyno or collect data and now I feel comfortable that I understand how to do it. I think what I also can take away from this is an understanding of what measurements are, for instance what torque, power, corrected power and BMEP actually are and what they mean. With an understanding of this it meant I could see why the graphs are the shape they are.

I think the execution of performing the dyno test was good as it was done safely and nothing was damaged in the process. However we did stall the engine a few times when testing it our selves which really shook it around and that won't of been good for it, so of course next time well try to make sure not to do that.

I think another thing to take into consideration is that the test has been done lots of time meaning the engine is not at its peak of performance. This means that the results we go where probably not the same as when that d16 engine rolled off the factory line. This is not something that effects our test however if you were testing two engines against each other and going for total accuracy you would need to take this into account.

Referencing

⁽¹⁾ Author: Wikipedia . Title: Dynamometer - Website Title: Wikipedia . En.wikipedia.org .
URL: <https://en.wikipedia.org/wiki/Dynamometer>

Their references came from:

(Winther, J. B. (1975). Dynamometer Handbook of Basic Theory and Applications. Cleveland, Ohio: Eaton Corporation.

Martyr, A.; Plint, M. (2007). Engine Testing - Theory and Practice (Fourth ed.). Oxford, UK: ELSEVIER. ISBN 978-0-08-096949-7.)

⁽²⁾ Author: Honda Motor Company LTD . Title: Honda Chassis Maintenance and Repairs

⁽³⁾ Author: Abi Summerfield . Title: Vehicle Technology

⁽⁴⁾ Author: Mechanical Engineering . Title: Why Does the Torque Curve Drop Off at Low RPM in a Typical Piston Engine? . Website Title: Physics Forums | Science Articles, Homework Help, Discussion . URL: <https://www.physicsforums.com/threads/why-does-the-torque-curve-drop-off-at-low-rpm-in-a-typical-piston-engine.244434/>

⁽⁵⁾ Author: Why increases? . Title: Why does the power output peak and then drop as engine speed increases? . Website Title: Motor Vehicle Maintenance & Repair Stack Exchange . URL: <https://mechanics.stackexchange.com/questions/18681/why-does-the-power-output-peak-and-then-drop-as-engine-speed-increases>