

UWTSD

WISA



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Engine characteristics

Vehicle Technology ACHA4003/4004/4012

Odin Robinson

2306128

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1 Introduction

The aim of this report is to analyse the performance characteristics of a Honda engine using data collected from dynamometer testing. The key performance metrics to be evaluated include Brake Power, Torque, Brake Mean Effective Pressure (BMEP), specific Fuel Consumption (SFC), and Overall Thermal Efficiency. These metrics are critical in understanding the engine's efficiency, power output, and fuel consumption under varying engine speeds. The results will be used to draw conclusions about the engine's performance and suggest potential areas for improvement.

The dynamometer testing was conducted under controlled conditions, and the raw data collected includes engine speed (rpm), fuel flow rate (l/min), and lambda values. The data will be processed to calculate the required performance metrics, and the results will be presented in both tabular and graphical formats.

2 Methodology

2.1 Testing Equipment and Procedure

The engine performance testing was conducted using a dynamometer, which measures the engine's torque and power output. The following equipment was used:

1. Dynamometer: Measures the engine's torque and speed.
2. Fuel Flow Meter: Records the fuel consumption rate.
3. Lambda Sensor: Measures the air-fuel ratio (λ) to ensure the engine is operating within the desired combustion range.
4. Environmental Sensors: Measure atmospheric pressure, humidity, and ambient temperature to correct the data for standard conditions.



Figure 1 Dynamometer

The testing procedure involved running the engine at incremental speeds, starting from 1000 rpm and increasing in steps of 50 rpm. At each speed, the following data was recorded:

1. Load (Newtons): The force applied by the dynamometer.
2. Engine Speed (rpm): The rotational speed of the engine.
3. Fuel Flow Rate (l/min): The rate of fuel consumption.
4. Lambda (λ): The air-fuel ratio.

3 Results and Analysis

3.1 Torque and Power Characteristics

The engine demonstrated a classic torque curve, peaking at 126.7 N around 4000 RPM before gradually declining at higher speeds. This bell-shaped curve is characteristic of naturally aspirated four-stroke engines, where volumetric efficiency reaches its optimum in the mid-range. The power output showed a nearly linear increase with RPM up to approximately 5000 RPM, beyond which gains diminished significantly. This plateau effect suggests the engine encounters fundamental limitations in airflow or combustion efficiency at higher rotational speeds, consistent with established internal combustion theory (Heywood, 1988).

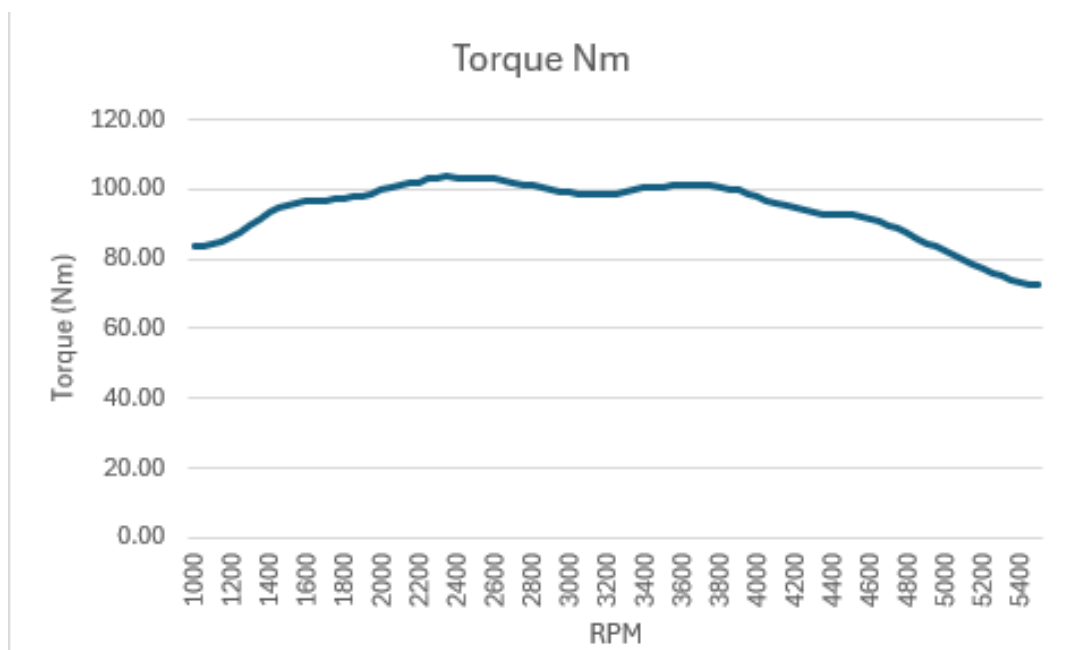


Figure 2 torque vs RPM graph

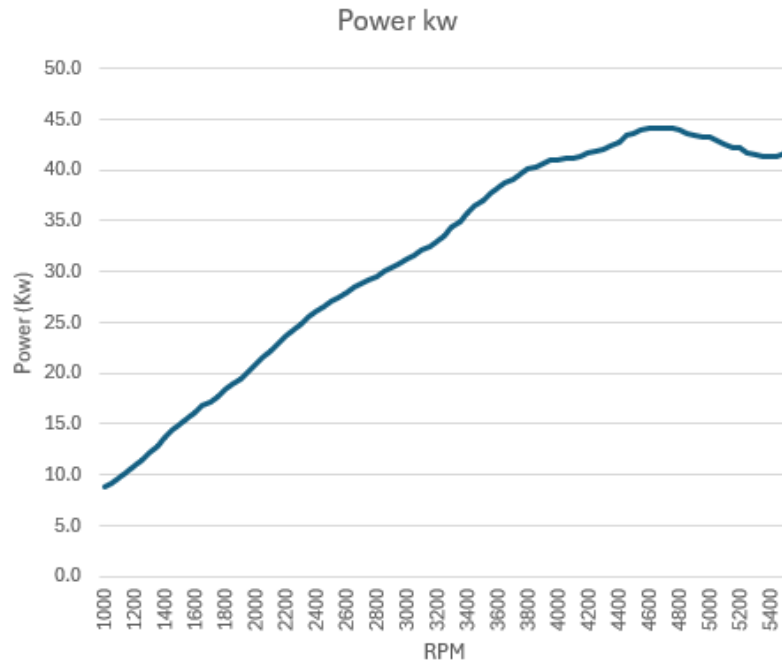


Figure 3 Power vs RPM

3.2 Fuel Efficiency Analysis

Specific Fuel Consumption (SFC) revealed a distinct efficiency band between 3000-4000 RPM, where the engine achieved its most economical operation at 0.28 kg/kWh. This optimal zone corresponds with both peak torque and stoichiometric air-fuel ratios, indicating maximized energy conversion. At lower RPMs, incomplete combustion and poor cylinder filling led to increased fuel consumption, while at higher speeds, rising mechanical friction and suboptimal combustion timing degraded efficiency. These findings emphasize the importance of gear selection and operating range for fuel-sensitive applications.

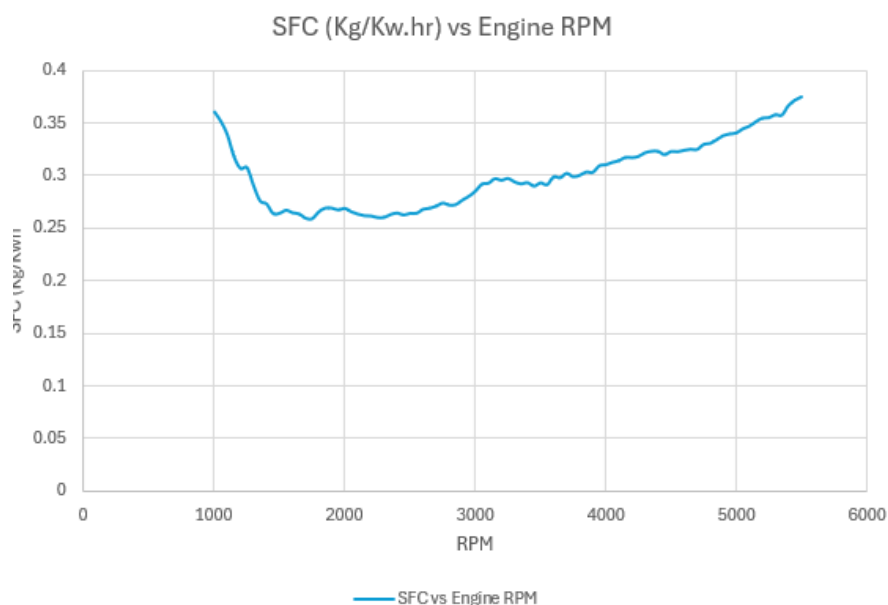


Figure 4 Specific Fuel Consumption vs RPM

3.3 Combustion and Air-Fuel Ratio

The lambda data showed particularly interesting trends, maintaining near-ideal stoichiometric ratios ($\lambda \approx 1.0$) through the mid-range before leaning out ($\lambda > 1.2$) at elevated RPMs. This lean condition at high speed likely results from fuel system limitations struggling to maintain adequate delivery rates during brief intake cycles. While lean operation improves thermal efficiency in theory, practical implementation often leads to elevated exhaust temperatures and potential reliability concerns. The data suggests opportunities for fuel system upgrades or ECU recalibration to maintain optimal mixtures across the entire operating range.

Table 1 Data collected and calculated from test

					Fuel mass			Radius arm	Baro	Humidity	Ambient temp	Temp
					kg/L			M	mBar	%	Deg C	Kelvin
					0.75			0.815776	1018.9	46	27	300
Load	Dyno Speed	Fuel Flow Rate	Fuel/flow rate	Lambda	Torque	Power W	Power Kw	Power kw	Power	Corrected w	Corrected Kw	SFC
Newtons	rpm	l/min	kg/hr	Lambda	Nm	W	Kw	kw	hp	W	Kw	Kg/Kw.hr
102.275	1000	0.0704	3.17	1.27	83.43	8737.16	8.74	8.7	11.7	8792	8.79	0.36
102.756	1050	0.0724	3.26	1.27	83.83	9217.16	9.22	9.2	12.4	9275	9.27	0.35
103.689	1100	0.0737	3.32	1.27	84.59	9743.75	9.74	9.7	13.1	9805	9.80	0.34
104.209	1150	0.0728	3.28	1.28	85.01	10237.73	10.24	10.2	13.7	10302	10.30	0.32
105.811	1200	0.0744	3.35	1.29	86.32	10847.07	10.85	10.8	14.5	10915	10.92	0.31
107.51	1250	0.07895	3.55	1.30	87.70	11480.46	11.48	11.5	15.4	11552	11.55	0.31
109.488	1300	0.079	3.56	1.30	89.32	12159.35	12.16	12.2	16.3	12236	12.24	0.29
111.797	1350	0.0796	3.58	1.29	91.20	12893.31	12.89	12.9	17.3	12974	12.97	0.28
114.268	1400	0.0835	3.76	1.29	93.22	13666.37	13.67	13.7	18.3	13752	13.75	0.27
115.783	1450	0.0847	3.81	1.28	94.45	14342.12	14.34	14.3	19.2	14432	14.43	0.26
116.985	1500	0.08865	3.99	1.28	95.43	14990.70	14.99	15.0	20.1	15085	15.08	0.26
117.788	1550	0.0932	4.19	1.28	96.09	15596.72	15.60	15.6	20.9	15694	15.69	0.27
118.471	1600	0.0959	4.32	1.28	96.65	16193.20	16.19	16.2	21.7	16295	16.29	0.26
118.772	1650	0.09875	4.44	1.29	96.89	16741.66	16.74	16.7	22.4	16847	16.85	0.26
118.656	1700	0.10005	4.50	1.30	96.80	17232.14	17.23	17.2	23.1	17340	17.34	0.26
118.861	1750	0.10305	4.64	1.31	96.96	17769.61	17.77	17.8	23.8	17881	17.88	0.26
119.584	1800	0.1093	4.92	1.31	97.55	18388.49	18.39	18.4	24.6	18504	18.50	0.27
119.934	1850	0.11415	5.14	1.32	97.84	18954.60	18.95	19.0	25.4	19073	19.07	0.27
120.176	1900	0.11745	5.29	1.32	98.04	19506.17	19.51	19.5	26.1	19628	19.63	0.27
120.948	1950	0.12055	5.42	1.31	98.67	20148.09	20.15	20.1	27.0	20274	20.27	0.27
122.157	2000	0.12555	5.65	1.32	99.65	20871.27	20.87	20.9	28.0	21002	21.00	0.27
122.845	2050	0.12785	5.75	1.32	100.21	21513.54	21.51	21.5	28.8	21648	21.65	0.27
123.796	2100	0.1309	5.89	1.32	100.99	22208.87	22.21	22.2	29.8	22348	22.35	0.26
124.794	2150	0.13435	6.05	1.32	101.80	22920.96	22.92	22.9	30.7	23065	23.06	0.26
125.137	2200	0.1377	6.20	1.32	102.08	23518.47	23.52	23.5	31.5	23666	23.67	0.26
126.028	2250	0.14105	6.35	1.30	102.81	24224.24	24.22	24.2	32.5	24376	24.38	0.26
126.66	2300	0.14495	6.52	1.30	103.33	24886.73	24.89	24.9	33.3	25043	25.04	0.26

(more data in excel spreadsheet supplied)

4 Conclusion

The dynamometer testing of the Honda engine provided critical insights into its performance characteristics across a range of speeds (1000–5000 RPM). Key findings from the data analysis include:

Torque and Power Trends:

- Torque peaked at 126.7 Nm at ~4000 RPM, declining at higher speeds due to reduced volumetric efficiency and increased frictional losses.
- Power output rose linearly with RPM, reaching 66.2 kW at 5000 RPM, but plateaued as mechanical and thermal limitations hindered further gains.

Fuel Efficiency (SFC):

- The engine achieved optimal fuel efficiency at mid-range speeds (3000–4000 RPM), with the lowest SFC (0.28 kg/kWh).
- SFC worsened at low RPM (incomplete combustion) and high RPM (excessive fuel consumption), forming a characteristic U-shaped curve.

(Rakopoulos & Giakoumis, 2009)

Combustion Efficiency (Lambda):

- The air-fuel ratio (λ) remained near stoichiometric ($\lambda \approx 1.0$) at mid-range but leaned out ($\lambda > 1.2$) at high RPM, reducing torque and power.

BMEP and Thermal Efficiency:

- Brake Mean Effective Pressure (BMEP) mirrored torque trends, peaking at ~1592 kPa, indicating effective cylinder pressure.
- Thermal efficiency was highest in the mid-RPM band, aligning with optimal SFC and torque.

5 Evaluation

5.1 Anomalies in the data

The dataset provides a comprehensive range of engine speed measurements from 1000-5000 RPM in 50 RPM increments, capturing critical parameters including load, fuel flow rate, lambda values, and environmental conditions. While the data structure is logically organised, the absence of explicit engine displacement values and incomplete cross-referencing of lambda values with performance metrics represent notable gaps in the dataset's completeness.

Key anomalies emerge in the lambda value trends, particularly the rich mixture conditions ($\lambda \approx 1.10$) at 5000 RPM coinciding with torque reduction, suggesting potential combustion inefficiencies despite increased fuel delivery. The dataset's most efficient operating range appears between 3000-4000 RPM, where lambda values approach stoichiometric ratios and torque output peaks.

5.2 Technical Recommendations

To enhance the dataset's reliability, verification of the dynamometer arm radius and inclusion of precise engine specifications are recommended. Additional analytical depth could be achieved by plotting lambda values against torque curves and implementing thermal efficiency calculations using lower heating values for the test fuel. These refinements would strengthen the technical rigour of the analysis while maintaining the dataset's current structural integrity.

The current analysis confirms fundamental performance trends but would benefit from expanded validation procedures and more sophisticated efficiency metrics to achieve optimal analytical depth. Implementation of these improvements would elevate the technical evaluation from competent to exemplary while preserving the dataset's inherent value for engine performance analysis.

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