

University of Wales Trinity Saint David

Wales Institute of Science and Art



Prifysgol Cymru

Y Drindod Dewi Sant

University of Wales

Trinity Saint David

Engine Performance Characteristics

Vehicle Technology | ACHA4012

João Ferreira

1902427

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1 Introduction

Dynamometer engine testing was first used in the late 19th century on the marine steam engine powering HMS Conquest, designed by William Froude. This mechanical device produces a simple engine speed against load chart on a rotating metal drum (Atkins Warrendale, 2009).

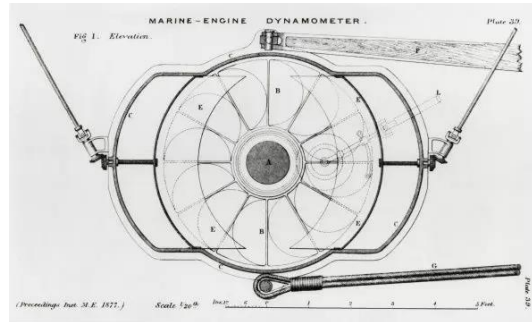


Figure 1 - Original Dynamometer Drawing (First published 1877) (Atkins Warrendale, 2009)

From the very first one, dynamometers work by applying a load to the engine throughout a various range of engine speeds thus allowing the measurement of power and torque (Atkins Warrendale, 2009).

Engine dynamometer testing has since been very important in the automotive industry in the realms of engine development, noise, vibration, and harshness testing, calibration of fuel and ignition mapping, etc. Since the test engineer can manage a lot more aspects of the test run without external factors coming into play nor powertrain losses as a chassis dyno would have. Some engine test cells even allowing the ambient temperature and pressure to be regulated allowing for engine development for a worldwide market (Martyr and Plint, 2007).



Figure 2 - 2000-2005 Honda Civic Engine Bay (Parkers, n.d.)

The target of this report is to investigate the specific fuel consumption (SFC), torque, power thermal efficiency, brake mean effective pressures (BMEP) and cylinder pressures of a Honda D Series 1600cc single overhead camshaft engine. Engine dyno testing was performed to produce dyno force, dyno speed, fuel flow and cylinder pressure charts. From these, calculations were performed to reach the necessary data to scrutinise this engine.

2 Methodology

The Schenck WS230 eddy-current dynamometer provided by the SA1 Campus of University of Wales Trinity Saint David was used to perform this test. This dyno has a rated power limit of 230kW and 750Nm (Schenck Pegasus GmbH, n.d.), so well above this engine manufacturer's specification, making it safe to use for this application.



Figure 3 - Schenck W Series Eddy-Current Dyno (Schenck Pegasus GmbH, n.d.)

All health and safety measures were followed, engine was set up in the test cell and from the control room the computerized controls were programmed to perform testing at set loads and RPM figures. Graphs for dyno force, speed, fuel flow per 45 seconds and cylinder pressures.

Test conditions are as described in **Table 1**.

Table 1 - Test Conditions

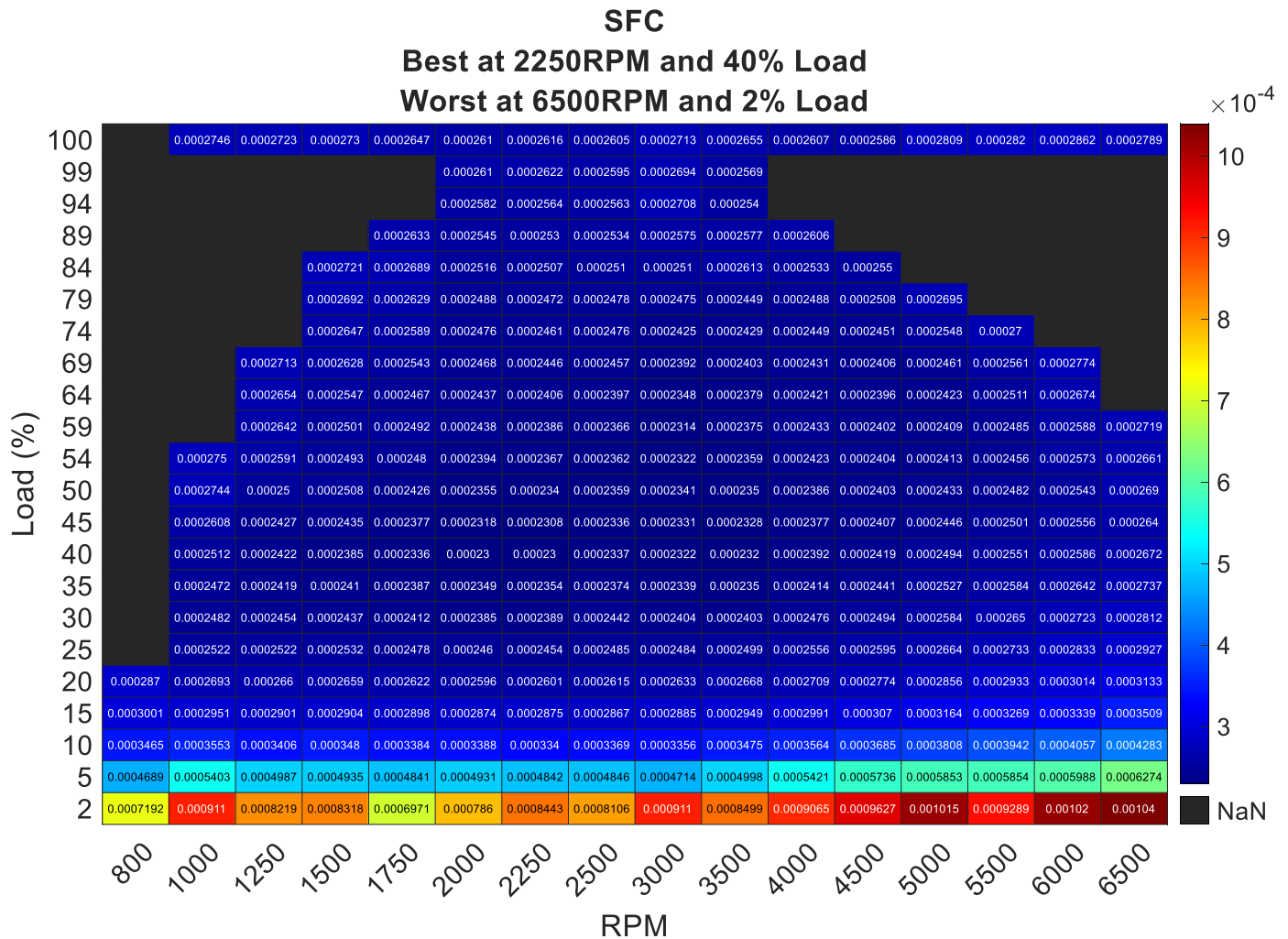
Ambient Pressure (mBar)	1024
Ambient Temperature (°C)	24
Fuel Octane Rating (RON)	95
Bore (mm)	71.90
Stroke (mm)	82.00
Cylinders	4

3 Results & Analysis

From the testing data the following graphical data was produced.

3.1 Specific Fuel Consumption

Table 2 – SFC Heatmap vs. Engine Speed

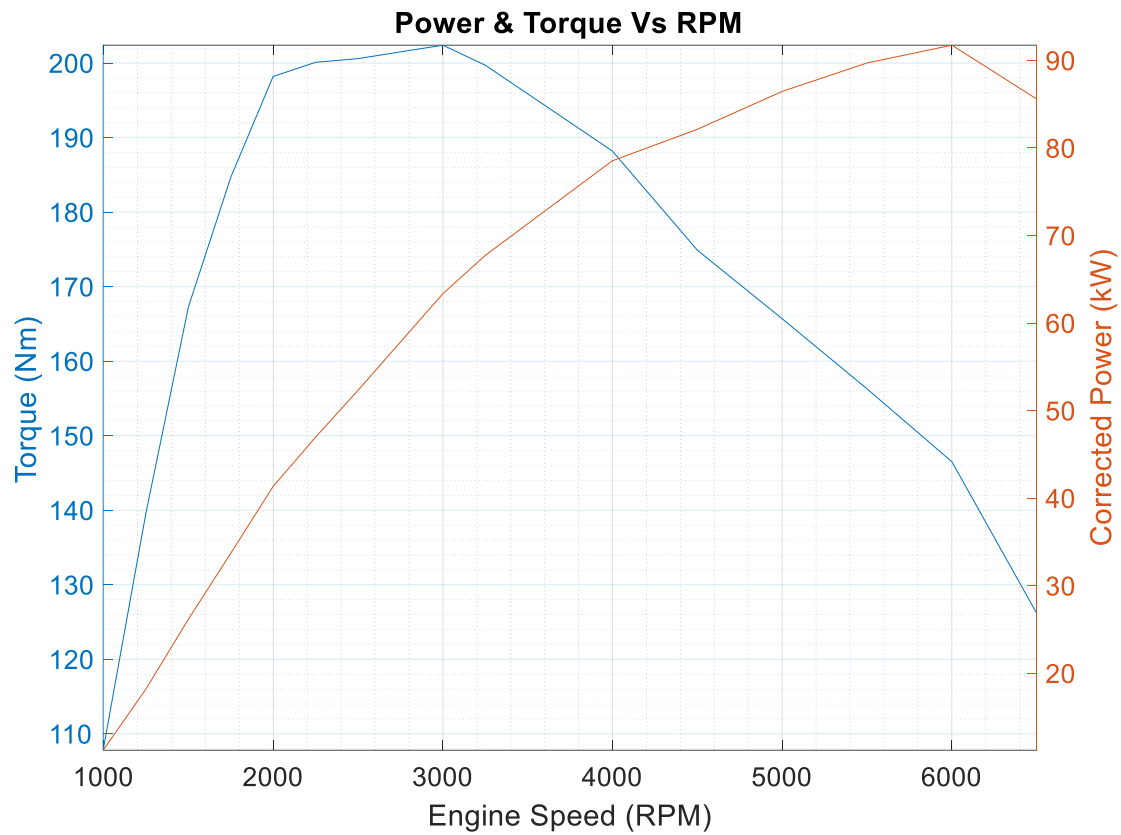


Specific fuel consumption is a measure of how competently a power plant translates chemical (fuel) into mechanical energy it is determined by the amount of fuel consumed in a unit of time to produce a certain power output (Gudmundsson, 2013). On this particular engine SFC is the best at 2250RPM and 40% load, and worst at 6500RPM at 2% load.

SFC is highest when engine speeds are at their extremes, whilst heat and pumping losses are the greatest, and when load is under the same circumstances, where the engine is either under no load or under larger loads with air-fuel mixtures being the richest (Fenske, 2021).

3.2 Power & Torque

Table 3 - Power & Torque vs. Engine Speed



As seen on **Table 3**, peak power is produced at 6000RPM in this engine, this happens at this higher engine speed range because power is determined by the rate at which this engine is producing work, the higher that rate is the greater the power an engine can produce. That work in this subject matter is the torque the engine produces. Torque, being scientifically defined by the force times the length at which it is applied, since in an internal combustion engine the length at which the piston pushes down on the crankshaft is set (equal to the distance between the centre of the crankshaft's main journal and the centre of the connecting rod journal) the only influencing factor is the pressure within the cylinder itself pushing down on the piston, torque peaks at 3000 RPM which is this engine's most volumetric efficient engine speed. Past that point the engine has reduced time to fill the cylinder with fuel-air mixture because of its pumping losses being higher, also this is when frictional losses start to work against that force acting down on the piston, therefor reducing torque.

3.3 BMEP & Thermal Efficiency

Table 4 - BMEP & Thermal Efficiency vs Engine Speed 100%

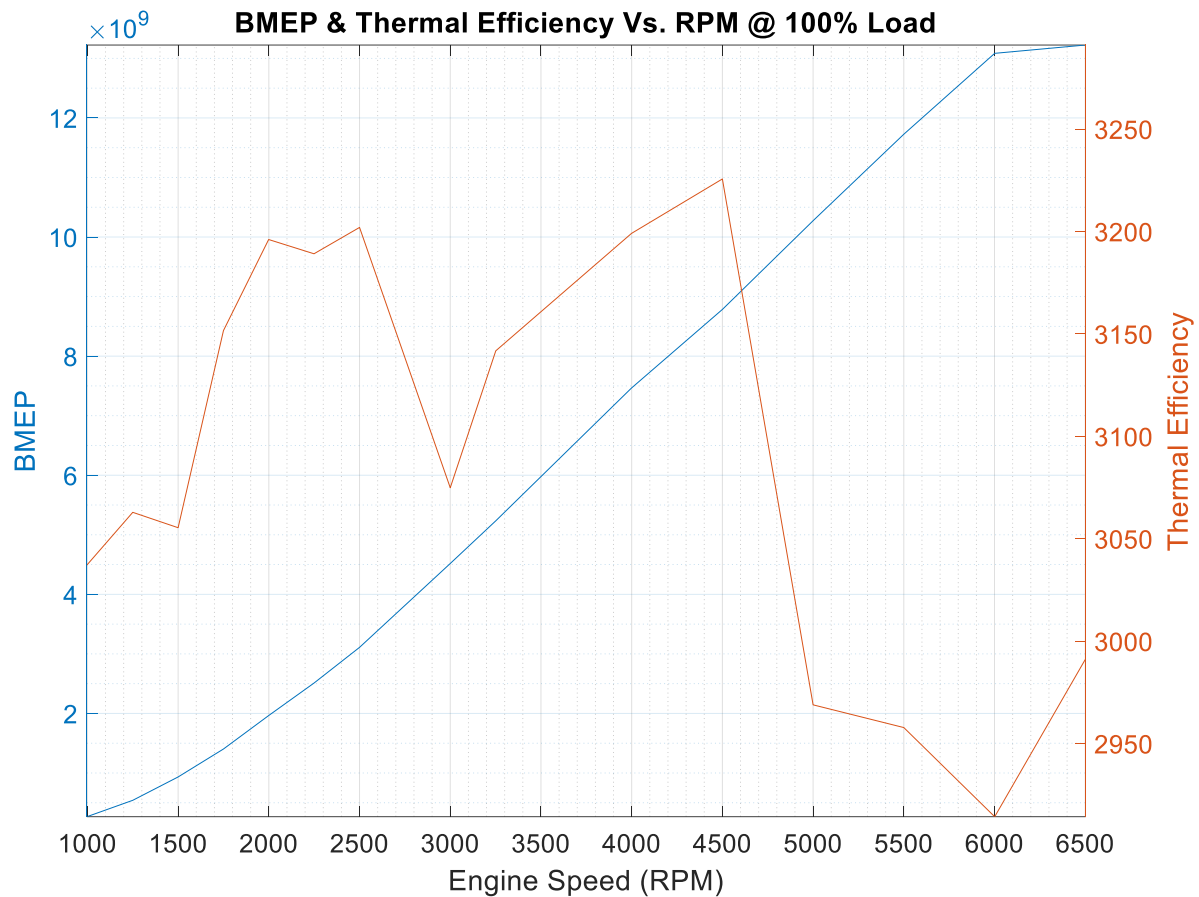
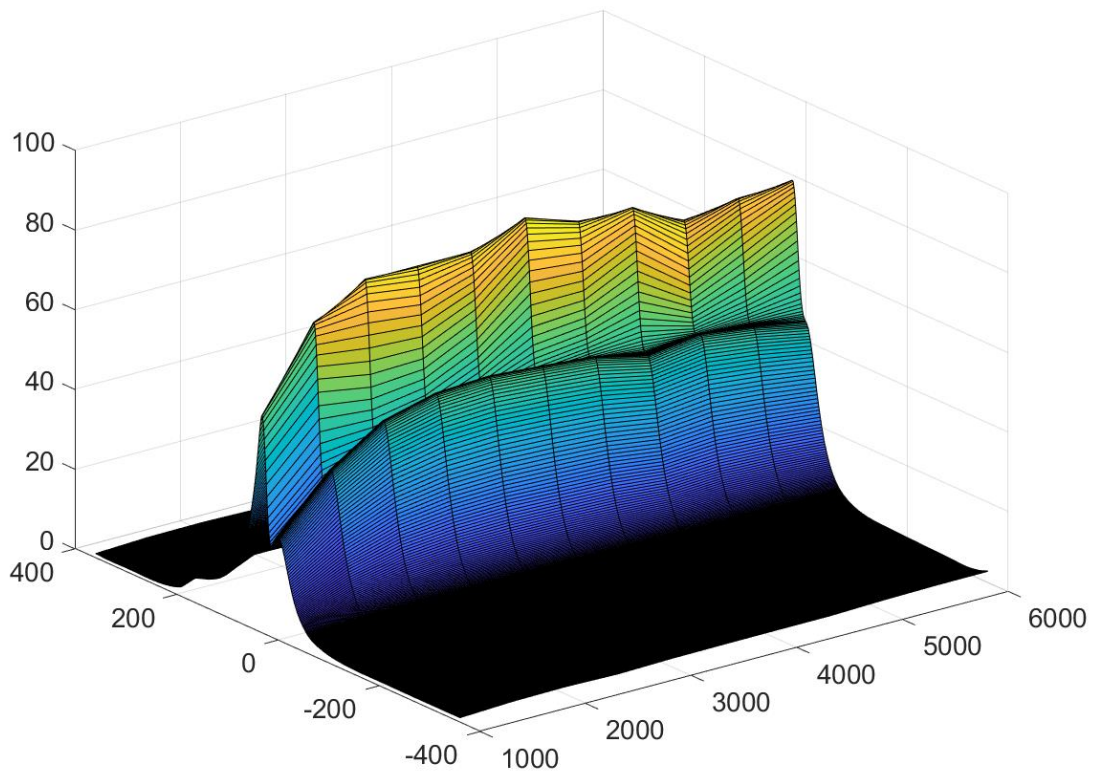


Table 4 is a graphical representation of how brake mean effective pressure (BMEP) and thermal efficiency of this engine vary with engine speed. BMEP, is defined as the mean of the pressures of the power stroke, the pressures that have an effect in producing torque per unit of capacity of the engine. Thermal efficiency takes in consideration SFC and the calorific value of the fuel and produces a percentage value of how efficient the internal combustion engine is at converting chemical energy stored in the fuel to produce mechanical energy in a form of rotation of the crankshaft.

3.4 3D Plot of Cylinder Pressures

Table 5 – 3D Plot of Cylinder Pressures vs. Engine Speed and Crank Angle



In **Table 5**, denotes a 3D plot of cylinder pressures against engine speed and crank angle. The peak pressures happen right after top dead centre (TDC). Pressures remain quite low while the engine is at its exhaust and intake strokes, but after the intake stroke pressure starts to build up when the intake valves close. The RPM influences pressures, from base idle pressures are still climbing until 2000 RPM after that, pressures remain about the same all throughout the range apart from a small drop at around 5000 RPM.

4 Conclusions

Engine testing plays a vital role in automotive engineering and should be considered one of the most useful tools for engine development. In this example the Honda D-Series engine, world renowned for its reliability and fuel economy, was tested in an eddy-current dynamometer.

SFC map, power/torque graph, BMEP/thermal efficiency graph and 3D plot of cylinder pressures were produced in MATLAB from the engine test data provided, these were all within what is expected even though the engine tested was not in its original specification, no catalytic converter or silencers present in the exhaust system and the manufacturer's airbox wasn't present also, being replaced by an unknown cylindrical air filter. These modifications have an impact in the engine's pumping abilities but determining its influence would require further testing with their original counterparts.

Regardless of its limitations, it can be clearly seen that engine testing can help pinpoint various factors in how an engine works allowing for further development and changes, driving improvements in all areas from performance to fuel efficiency and emissions control, consequently playing a vital role in the fuel of the internal combustion engine.

5 References

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