Department of MECHANICAL ENGINEERING THE UNIVERSITY OF UTAH

Spark Ignition Engine Lab

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1. Figures

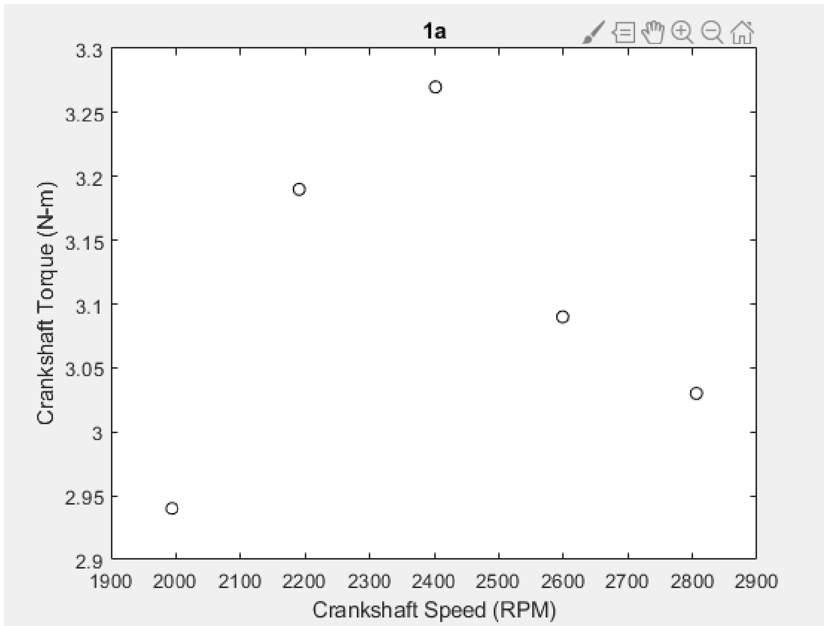

Figure 1a. Measured torque versus crankshaft speed for the spark ignition engine at fully open throttle.

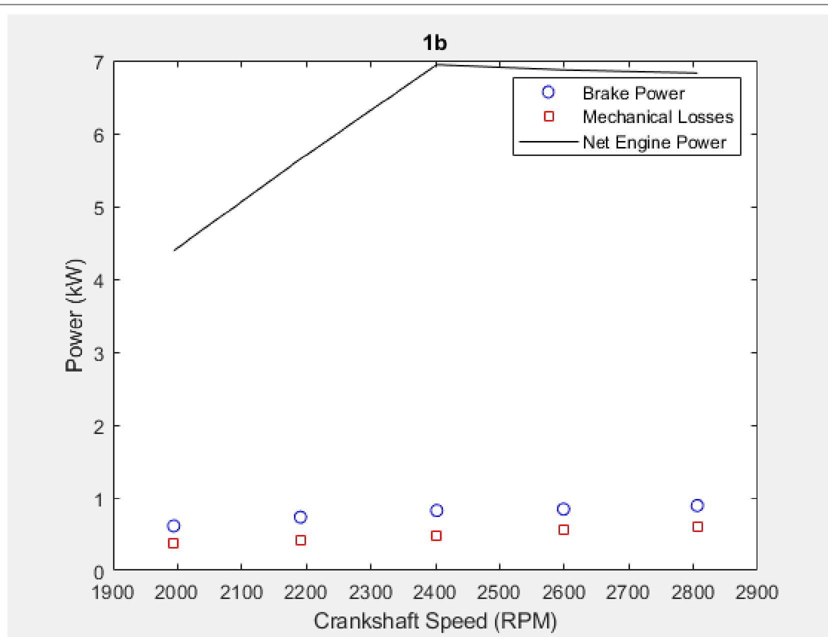

Figure 1b. Brake power and total power versus crankshaft speed for the spark ignition engine at full throttle. The markers indicate the experimental measurements. The black line represents the total theoretical power available, based on the Otto cycle using the air-standard model at the same conditions as those measured in the experiment.

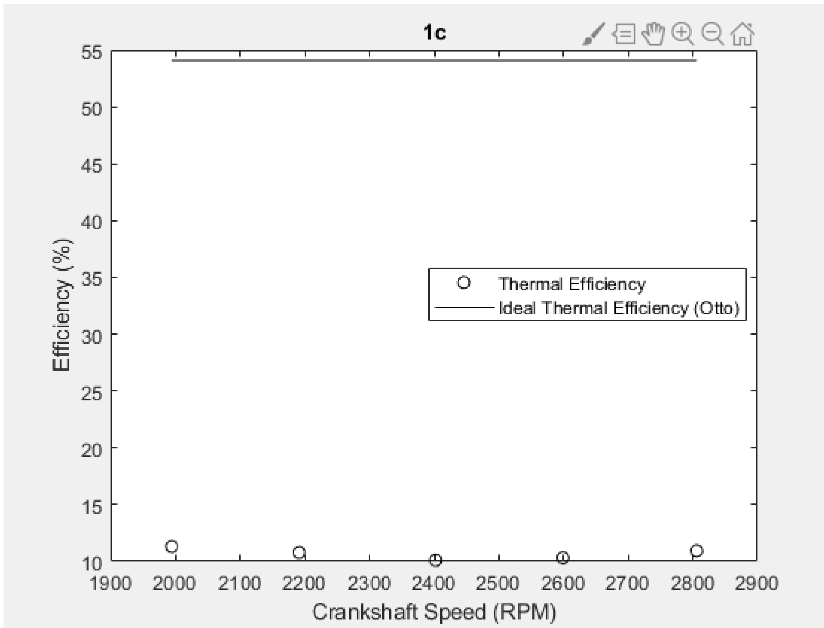

Figure 1c. Thermal efficiency versus crankshaft speed, comparing the measurements and theory. The theory is based on the Otto cycle using the air-standard model at the same conditions as those measured in the experiment.

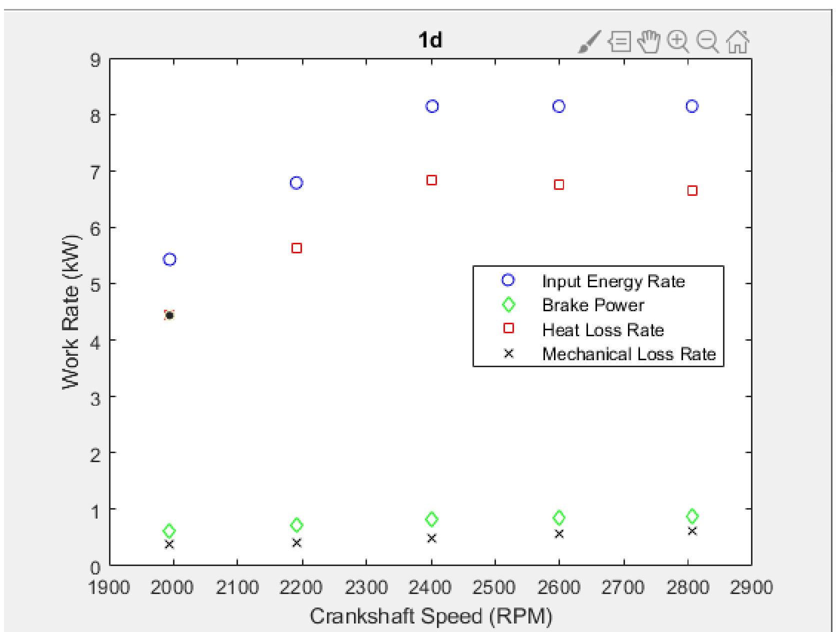

Figure 1d. Work rate terms in the energy balance of the engine versus crankshaft speed, as based on the experimental measurements.

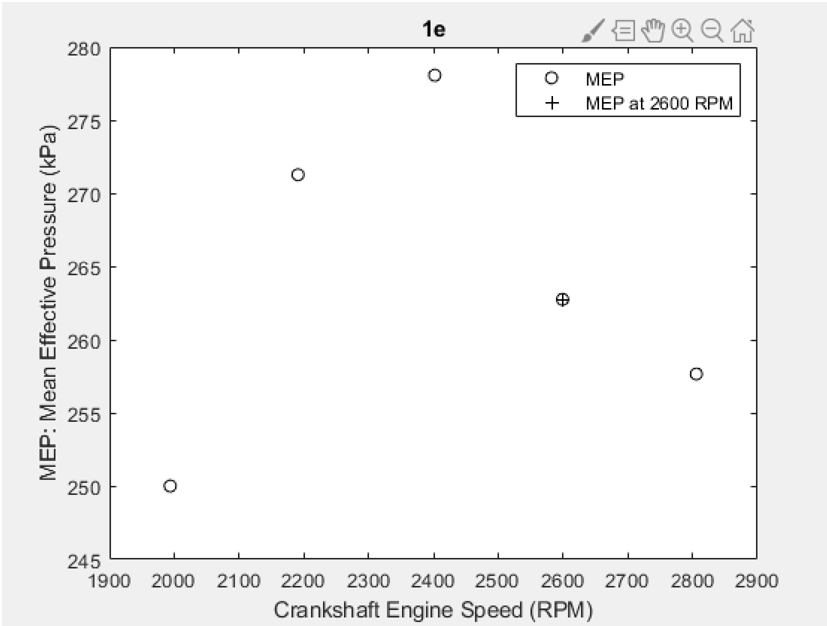

Figure 1e. Mean effective pressure acting on the piston head versus crankshaft speed, as based on the experimental measurements. Linear interpolation was not applied as a data point was taken at 2599 RPM. Besides, linear interpolation will not be accurate due to the trend displayed.

2. Short Answer Questions

a) *State the value of the following energy ratios (in terms of a percentage) averaged over the entire range of engine speeds examined:*

i. W_dot_b/E_dot_in = 0.1069
ii. W_dot_f /E_dot_in = 0.0665
iii. Q_dot/E_dot_in = 0.8266

Discuss how the frictional/inertial loss compares to the miscellaneous heat lost to the surroundings, and how this affects the overall thermal efficiency of the engine. [2–4 sentences]

Based on the calculated ratios, the frictional/inertial loss is lower than that of the miscellaneous heat lost to the surroundings. The reason for this is because the factors that contribute to the heat loss to the surroundings is more than that of the frictional losses. Besides that, it is in the interest of the manufacturer of the engine to reduce the frictional/inertial losses in their engine while they have no control of the surroundings. However, neither of these losses affect the thermal efficiency of the engine as it is calculated using the brake power, not the losses.

b) *State the average mechanical efficiency of the engine (averaged over the range of crankshaft speeds measured), and compare this value with the typical mechanical efficiency of an electric motor having an equivalent power rating (1–2 hp)*

Average Mechanical Efficiency of the Engine = 0.6171
Minimum Nomial Efficiency of Electric Engine = 0.788
(Source: https://www.engineeringtoolbox.com/electrical-motor-efficiency-d_655.html)

Based on the Engineering Toolbox, an electric engine is more efficient than a spark ignition engine.

Write a statement that compares the calculated thermal efficiency with that of an ideal Otto cycle, by quantifying the discrepancy (e) with a percentage, as follows

$$\epsilon = \frac{\eta_{\mathrm{Otto}} - \eta_{\mathrm{th}}}{\eta_{\mathrm{Otto}}} \cdot 100$$

The discrepancy of the calculated thermal efficiency with that of the Otto cycle is high at 80.24%.

State three things that were neglected in the ideal model of the Otto cycle that might contribute to such a discrepancy.

The causes for such a high discrepancy are assuming that the system is ideal (internally reversible processes, air is an ideal gas, etc.), assuming a constant specific heat value, and excluding gases other than air such as CO and NOx.

c) *Based on your calculations for the mean effective pressure (MEP), estimate the average force acting on the piston head during the cycle when the engine is operating at 2600 RPM. State your answer in units of both N and lbs. Include this calculation in your Matlab code and have the code display the result to the screen. [1 sentence]*

Based on my calculations in MATLAB, the average force acting on the piston at 2600 RPM is 874.55 N (196.61 lbs).

d) *Carbon dioxide (CO2), a greenhouse gas, is released into the environment from the exhaust of spark ignition engines. A diagram of the carbon lifecycle is shown at the right, illustrating how auto emissions tend to alter the natural balance by creating excessive carbon dioxide in the atmosphere. Spend some time to research (using the internet, textbooks, or other sources) solutions for reducing CO2 gas emissions from combustion engines. For example, some technologies can help increase engine efficiency, thereby reducing CO2 emissions. State one operation or hardware modification that could be implemented to improve the efficiency of a spark ignition engine, such as turbo-charging, inner cooling, split-fire spark plugs, variable valve timing, etc. Explain how this modification works to improve engine efficiency and describe some of the challenges associated with implementing this modification in practice. Include your references. [4–6 sentences]*

One way to reduce carbon emissions is by replacing the spark ignition engine with an electrical engine. Instead of utilizing fuel which is the source of these carbon emissions, electric cars utilize rechargeable batteries to power an electric engine. Power is sourced from the grid and unlike fuel, it is emission free. Also, as proved in 2b), an electric engine is more efficient than that of a spark ignition engine. However, the challenges to implementing electric engines are that the driving range is limited, costs for maintenance is high, and charging stations are not readily available. That is why people turn to hybrid cars which run on both battery and gasoline.

Source: https://www.edfenergy.com/electric-cars/how-work, https://semiengineering.com/electric-cars-gain-traction-but-challenges-remain/