Experiment No. 1

Name of the Experiment: Full Load Performance.

Objectives:
Understanding engine performance by plotting its characteristic "cardiograph" curves.

Conditions:
The test is conducted at full throttle with incremental increase in engine speed through gradual load reduction to maintain a steady state engine operation each time the speed changes.

Theory:
Torque and power are the most important characteristic of the engine. Therefore, it is very important to know how much a specified engine can develop (maximum power and torque). However, the speed at which these characteristics are obtained plays a key role in engine marketing. The lower the speed of maximum torque and power the more efficient is the engine, because in normal engine operation it is quite rear to reach speeds as high as 4000 rpm. Moreover, the difference between the speed of maximum torque and that of maximum power shows the operational range of the engine. The bigger the difference the larger the engine operational range. In automotive practice, engines of smaller operational range need gearboxes of a larger number of gear ratios. The width of the peak torque and peak power is one of the major objectives in engine design. Mechanical engineers struggle to broaden and level-out these peaks for a wider range of engine speeds.

Procedure:

1. Start the engine and allow to warm-up.
2. Increase the throttle opening and dynamometer load until the throttle is fully open and a minimum possible engine speed is obtained without engine laboring.
3. Adjust the secondary variables as follows (if possible):
   - Mixture strength optimized for maximum power.
   - Ignition timing optimized for maximum power.
   - Coolant and oil temperatures held constant.
4. Allow the engine conditions to stabilize then take the readings of:
   - Dynamometer load in [N].
   - Engine speed [rpm].
   - Time in [s] to consume 50 ml of fuel (to calculate the rate of fuel consumption).
   - Manometer reading in [mm H_2O] (to calculate the rate of air intake).
   - Exhaust temperature in [°C].
5. Take other sets of readings at successive lower loads by adjusting the dynamometer loads until a maximum engine speed is obtained.
6. During the test plot the control graph (Load vs speed curve).
7. Reduce the throttle opening and the load simultaneously until the idle speed is reached.
8. Wait to cool down and switch-off the engine.

Calculations:

$$\dot{m}_{a_{actual}} = \rho_a * Q_a$$

$$Q_a = 0.1123 * d^2 * \sqrt{h}$$

$$\dot{m}_{a_{theoretical}} = \rho_a * V_d * \frac{N}{x}$$

$$\eta_v = \frac{\dot{m}_{a_{actual}}}{\dot{m}_{a_{theoretical}}}$$

$$\dot{m}_{f_{actual}} = \rho_f * Q_f$$

$$Q_f = \frac{V_f}{t}$$

$$A/F = \frac{\dot{m}_{a_{actual}}}{\dot{m}_{f_{actual}}}$$

$$BP = \frac{2\pi}{60} * N * T$$

$$T = L * r$$

$$BP = \frac{bmep * V_d}{60} * \frac{N}{x}$$

$$bsfc = \frac{\dot{m}_{f_{actual}}}{BP}$$

Where

$\dot{m}_{a_{actual}}$ *is the air actual mass flowrate* $[kg/s]$

Q_a *is the air volumetric flowrate* $[lit/min]$

d *is the orifice diameter* $= 40\ mm$

h *is the manometer reading* $[mm\ H_2O]$

ρ_a *is the air density* $= 1.23\ [kg/m^3]$

$\dot{m}_{a_{theoretical}}$ *is air theoretical mass flowrate* $[kg/s]$

V_d *is engine displacement* $= 848\ cm^3$

N *is engine speed* $[rpm]$

$\frac{N}{x}$ *is the number of effective suction strokes*

$x = 2$ *for* $4-$*stroke engines*

η_v *is the engine volumetric efficiency.*

$\dot{m}_{f_{actual}}$ *is fuel actual mass flowrate* $[kg/s]$

Q_f *is the fuel volumetric flowrate* $[lit/min]$

ρ_f *is the fuel density* $= 710\ [kg/m^3]$

V_f *is the amount of fuel consumed* $= 50\ ml$

t *is the time to collect* v_f *in* $[s]$

T *is the engine torque* $[Nm]$

r *is the torque arm* $= 0.25\ m$

L *is the dynamometer load* $[N]$

BP *is the engine brake power* $[kW]$

$bmep$ *is the barke mean effective pressure* $[kPa]$

$bsfc$ is the brake specific fuel consumption $[kg/(kW.h)]$

Results:
Correct the readings of torque and power to the standard ambient conditions.
Discussion:

1. Derive the following expressions:
   - Air actual mass flowrate in (kg/s) in terms of manometer reading (mm H_2O).
   - Air theoretical mass flowrate (kg/s) in terms of engine speed (rpm).
   - Volumetric efficiency in terms of manometer reading (mm H_2O) and engine speed (rpm).
   - Fuel actual mass flowrate (kg/s) in terms of time to collect 50 ml fuel (s).
   - Air to fuel ratio in terms of time to collect 50 ml fuel (s) and manometer reading (mm H_2O).
   - bmep in (kPa) in terms of dynamometer load (N).
2. Plot the torque, BP, bmep, and bsfc against engine speed.
3. Plot AF ratio, η_v and T_{ex} against engine speed.
4. Discuss the graphs and how do you assess this engine.

Engine speed (N)	Load (L)	Time to consume 50 ml fuel (t)	Pressure drop across the orifice (h)	Exhaust temperature (T_{ex})
[rpm]	[N]	[s]	[mm H_2O]	[°C]
1000				
2000				
3000				
4000				
5000				
6000				