MECHANICAL EFFICIENCY

This laboratory concerns itself with measurement of friction in a engine power unit.

The power available at the piston head is designated indicated power, Ip. The power produced at the flywheel or some other driver where the power may be measured is called brake power, Bp. There is a definite power loss between these two, composed of bearing and gear friction, pumping losses and some heat dissipation. The term that includes all of these losses is called friction power, Fp. Thus:

$$I_p = B_p + F_p \quad \textbf{(1)}$$

Friction power may be determined by measuring the power required to "motor" the power unit. Specially adapted equipment is required. A most desirable arrangement is to use an electric absorption dynamometer which may be wired to "motor" the unit being tested.

An alternate method is to determine friction by inference. If the number one injector is disconnected during the test, then for a four cylinder engine, with 3 cylinders firing (B_p is the Power measured at the dyno):

$$B_p(234) = I_p(234) - F_p(1234) \quad \textbf{(2)}$$

The output for a four cylinder engine, with all 4 cylinders firing (B_p is the Power measured at the dyno):

$$B_p(1234) = I_p(1234) - F_p(1234) \quad \textbf{(3)}$$

Therefore, the I_p for one cylinder may be determined by subtracting equation (2) from (3) giving:

$$\begin{aligned} B_p(1234) - B_p(234) &= [I_p(1234) - F_p(1234)] - [I_p(234) - F_p(1234)] \\ &= I_p(1) \end{aligned} \quad \textbf{(4)}$$

If the assumption is made that the power output of the engine is uniform, the total $I_p = 4*I_p(1)$, and the total Fp may be calculated from equation (1). This procedure is applicable for an engine of any number of cylinders.

Since Fp varies with engine speed, it is important that constant speed, wide-open-throttle tests be run with the load being varied to maintain constant speed.

Note: A major assumption is that the same amount of fuel is being injected into each cylinder at a particular rpm. Therefore the inference method only works when the engine is in the load control range and NOT WHEN OPERATING IN THE GOVERNOR CONTROL RANGE. Therefore, all data in the governor control range **MUST** be omitted when you determine the friction power by inference.

Once the Ip for a given engine has been determined it is possible to calculate the indicated mean effective pressure (IMEP) for that engine. The student should recognize, of course, that this value represents only the average working pressure existing in the cylinder during the cycle. Observation of a typical indicator diagram will show that both higher and lower pressures will exist at specific points in the cycle. In this lab we will only be concerned with power equations.

Engine mechanical efficiency (e_m.) is represented by the ratio of Bp to Ip, e_m. = Bp/Ip.

Procedure:

1) Place engine under load and operate until thoroughly warmed.
2) Starting at wide open throttle, no load, run a power test with all cylinders firing. Record Engine speed, Engine load, Fuel consumption and air flow. Repeat step (2) increasing load each time, and record all data for 10 speeds, between high idle and 1500 rpm.
3) Disconnect one injector run a power test with only 3 cylinders firing. Record Engine speed, Engine load, Fuel consumption and air flow. Use dynamometer load to achieve proper speed.
4) Reconnect the injector and run the engine for 5 minutes before shutting down.

Report of Friction Hp:

1) On one graph plot the brake power versus rpm/1000 observed with 4 cylinders firing (one curve) and 3 cylinders firing (second curve). **Remove all data points in the Governor control range**.
2) Use the trend line procedure in Excel to fit a separate second order curve (y=ao+a1*x+a2*x*x, where x=N/1000) to the 3 and 4 cylinder curves. The indicated power at any rpm can be calculated by

   IP= 4*[(Equation for 4 cylinders)-(Equation for 3 cylinders)]
3) For each engine test speed in the 4 cylinder tests (excluding data points in the governor control range) calculate for the engine:
   (a) Ip, Bp and Fp
   (b) IMEP, BMEP and FMEP
   (c) Mechanical Efficiency (M.E.)

   (Show a sample calculation for each calculation)
4) On a second graph plot curves of IMEP, BMEP and FMEP vs. engine rpm for the four cylinder tests, including all values in the governor control range.
5) List all factors that compose Fp in a diesel engine.
6) Why does the Fp change with rpm?
7) Plot a graph of actual air consumption for the four cylinder tests (one curve) and the three cylinder tests (second curve). Will the pumping losses be equal in the three and four cylinder tests. Explain the reasons for any differences in the air consumption between the two tests.

All Cylinder Tests

Run #	Dynamometer Load (lbs)	Engine Speed (rpm)	Fuel Flow (lb/min)	Airflow meter reading	Air Flow (Cfm)	Air Flow (lb/min)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						
19						
20						
21						
22						
23						
24						
25						
26						
27						
28						

3 Cylinder Tests

Run #	Dynamometer Load (lbs)	Engine Speed (rpm)	Fuel Flow (lb/min)	Airflow meter reading	Air Flow (Cfm)	Air Flow (lb/min)
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						
16						
17						
18						