Title: Performance Study of a Single Cylinder 4 Stroke Diesel Engine

Objective:

To conduct performance test on VCR Engine Test Rig to obtain characteristic curves at constant speed.

Theory

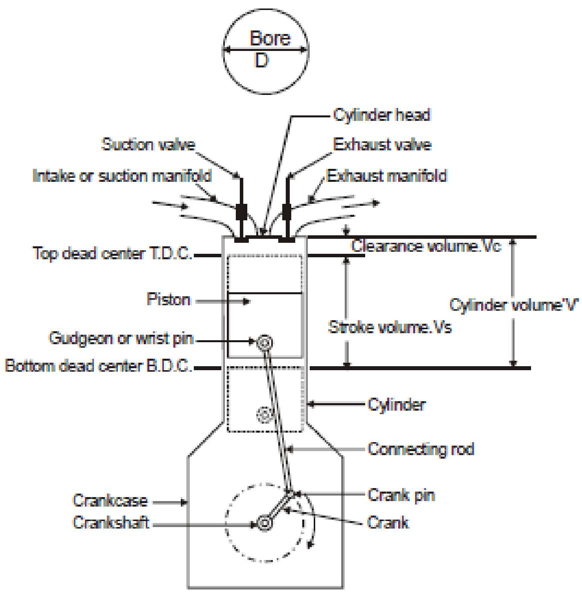
Four stroke cycle engine: In four-stroke cycle engine, the cycle of operation is completed in four strokes of the piston or two revolutions of the crankshaft. Each stroke consists of 180º of crankshaft rotation and hence a cycle consists of 720º of crankshaft rotation. The series of operation of an ideal four-stroke engine are as follows:

1. Suction or Induction stroke: The inlet valve is open, and the piston travels down the cylinder, drawing in a charge of air.

2. Compression stroke: Both valves are closed, and the piston travels up the cylinder. As the piston approaches top dead centre (TDC), ignition occurs. In the case of compression ignition engines, the fuel is injected towards the end of compression stroke.

3. Expansion or Power or Working stroke: Combustion propagates throughout the charge, raising the pressure and temperature, and forcing the piston down. At the end of the power stroke the exhaust valve opens, and the irreversible expansion of the exhaust gases is termed 'blow-down'.

4. Exhaust stroke: The exhaust valve remains open, and as the piston travels up the cylinder the remaining gases are expelled. At the end of the exhaust stroke, when the exhaust valve closes some exhaust gas residuals will be left; these will dilute the next charge.



Engine details:

Water cooled
VCR (Variable Compression Ratio)

Bore D = 87.5 mm
Stroke L = 110 mm

Combustion Parameters:

Specific gas constant = 1 $kJ/kg.K$

Air Density = 1.17 kg/m^3

Specific heat capacity of water = 4.18 kJ/KgK

Performance Parameters:

Orifice diameter = 20 mm
Pulses per revolution = 360
Fuel density = 830 kg/m^3
Fuel Pipe diameter = 12.40 mm

Orifice coefficient of discharge = 0.60
Dynamometer arm Length = 185 mm
Calorific value of fuel (CV) = 42000 kJ/kg

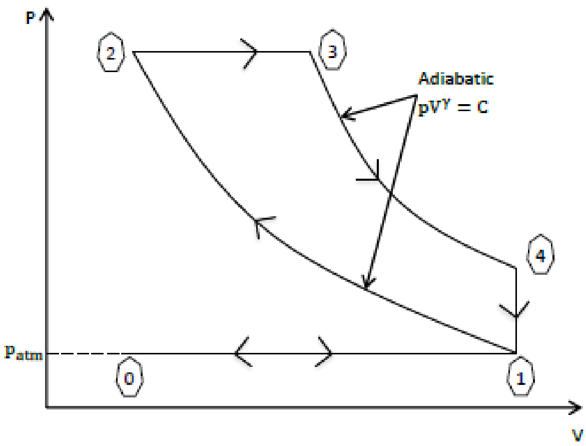
Formulas:

1. Brake Power

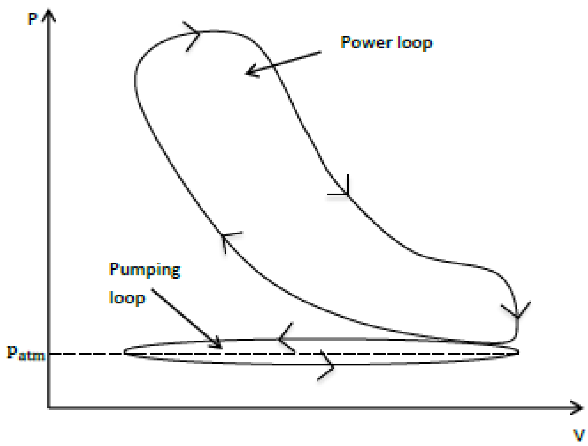
$$\text{BP} = \frac{2 \times \pi \times \text{N} \times \text{T}}{60 \times 1000}\, kW$$

$$\text{T} = \text{W} \times 9.81 \times \text{arm length}$$

Where, W = Engine load



Theoretical p-V diagram



Actual p-V diagram

2. Air flow rate

For air consumption measurement air box with orifice is used.

$$A_f = C_d \times \frac{\pi \times d^2}{4} \times \sqrt{2gH\frac{\rho_w}{\rho_a}} \times \rho_a \times 3600 kg/Hr$$

Where,

C_d=Coefficient of discharge of orifice

d=Orifice diameter (m)

ρ_w=Density of water kg/m^3

H=Pressure drop across orifice meter (m of water)

ρ_a=Density of air at working condition(kg/m^3)

g =Acceleration due to gravity= 9.81 m/s^2

3. Volumetric efficiency

$$\eta_v = \frac{A_f}{Theoretical\ flow\ rate\ (A_{ft})}$$

$$A_{ft} = \frac{\pi \times D^2}{4} \times L \times \frac{N(rpm)}{n} \times 60 \times \text{no. of cylinders} \times \rho_a$$

where, n= 2 for 4-stroke engine

4. Brake thermal efficiency

$$\eta_{bth} = \frac{BP}{m_f \times C.V.}$$

where,

m_f= Mass flow rate of fuel (kg/s)

$C.V$ = Calorific value of fuel

5. Brake mean effective pressure

$$BMEP(bar) = \frac{BP \times 60}{A \times L \times \left(\frac{N}{n}\right) \times (No.of\ cylinder) \times 100}$$

where, A= Area of piston (m^2)

6. Brake specific fuel consumption

$$\text{BSFC} = \frac{\text{Fuel flow in kg/hr}}{\text{BP}}$$

7. Heat balance(kJ/hr)
   a) Heat supplied by fuel= Fuel flow × C.V.
   b) Heat equivalent to useful work = BP × 3600

c) Heat in jacket cooling water = F3× C_{pw} ×(T2-T1)

d) Heat in exhaust (Calculate C_{pex} value):

$$C_{pex} = \frac{F4 \times C_{pw} \times (T4 - T3)}{(F1 + F2) \times (T5 - T6)} kJ.K/kg$$

Where,

C_{pex}=Specific heat of exhaust gas (kJ/kg.K)

C_{pw}=Specific heat of water (kJ/kg.K)

$F1$ =Fuel consumption (kg/hr)

$F2$ =Air consumption (kg/hr)

F3= Jacket water flow rate(kg/hr)

$F4$ =Calorimeter water flow (kg/hr)

T3 =Calorimeter water inlet temperature (K)

T4=Calorimeter water outlet temperature (K)

T5=Exhaust gas to calorimeter inlet temperature (K)

T6=Exhaust gas to calorimeter outlet temperature (K)

$$Heat\ in\ exhaust \left(\frac{kJ}{h}\right) = (F1 + F2) \times Cpex \times (T5 - Tamb)$$

$$Heat\ in\ exhaust\ (\%) = \frac{Heat\ in\ exhaust \times 100}{Heat\ supplied\ by\ fuel}$$

8. Heat to radiation and unaccounted (%) = Heat supplied by fuel (100%) – {Heat equivalent to useful work (%) + Heat in jacket cooling water (%) + Heat to exhaust (%)}

<u>Data Sheet</u>

Performance of a Single Cylinder 4 Stroke Diesel Engine

Date of Experiment:

Name: Roll No.

Engine performance: Observations							Compression ratio =				
Speed (RPM)	Load (kg)	Air flow (mmwc)	Fuel flow (cc/min)	Jacket water (LPH)	Calorimeter water (LPH)	Engine water in (ºC) T1	Engine water out (ºC) T2	Cal water in (ºC) T3	Cal. water out (ºC) T4	Ex. Temp. cal. in (ºC) T5	Ex. Temp. cal. out (ºC) T6

Engine performance: Observations							Compression ratio =				
Speed (RPM)	Load (kg)	Air flow (mmwc)	Fuel flow (cc/min)	Jacket water (LPH)	Calorimeter water (LPH)	Engine water in (ºC) T1	Engine water out (ºC) T2	Cal wat. in (ºC) T3	Cal. water out (ºC) T4	Ex. Temp. cal. in (ºC) T5	Ex. Temp. cal. out (ºC) T6

Observation and report

Record-

Engine Load
Speed
CR
Fuel consumption
Coolant flow rate
Pressure drop across orifice meter
Temperature of coolant in and out
Exhaust, air/ambient and necessary parameters

Calculate-

Values of BP (kW)
BMEP (Bar)
BSFC (kg/kW.h)
Brake thermal efficiency (%)
Volumetric efficiency (%)
Air flow (kg/h)
Fuel flow (kg/h)
Air fuel ratio
Heat equivalent to work (%)
Heat by jacket cooling water (%)
Heat by exhaust (%)
Unaccounted heat (%)

Report-

A line diagram of test set up
Discussion of result

Plots-

1. BP vs load
2. Fuel flow vs load
3. BSFC vs load
4. Brake thermal efficiency vs load
5. Volumetric efficiency vs load
6. Exhaust temp vs load
7. Heat balance (work, jacket cooling and exhaust gas) vs load

Procedure

1. Run the computer programme: "Enginesoft".
2. Turn on the engine.
3. Set compression ratio to 18.
4. Select "Engine Model" open "Configure" in view in computer programme. Check configuration values & system constants with the values displayed on engine setup panel.
5. Record readings corresponding to an initial load value.
6. Increase the load and take consecutive reading.
7. Set compression ratio to 14 and repeat steps 4to 6.
8. Turn off the engine.