Numerical:

1. A six cylinder, four stroke IC engine develops 100 KW of brake power at 800 rpm. The stroke to bore ratio is 1.5. The indicated mean effective pressure is 8 bar and mechanical efficiency is 80 %. Determine the cylinder diameter and piston stroke of the engine.

   Solution:

   Data: i= 6, 4-stroke engine, N = 800 rpm, Hence n = 800/2 = 400 cycles/sec., L/D = 1.5, Hence L = 1.5 D, η_{mech} = 80 %

   Determine D = ? L = ?

   We have, η_{mech} = BP/IP

   IP = BP/ η_{mech}

   = 100/0.8

   = 125 kW

   We have, IP = $(iP_mLAn)/60000$

   $125 = (6\times8\times10^5\times1.5D\times\Pi\times D^2\times400)/(60000\times4)$

   Therefore, $D^3 = 0.00332$

   D = 0.149 m or 149 mm

   Hence, **L = 1.5D = 1.5×149 = 224 mm**

2. From a test on a four stroke petrol engine, the following data is available: engine speed 1000 rpm, net brake torque 70 N.m, indicative mean effective pressure 10 bar, stroke 150 mm, bore 100 mm, rate of fuel consumption 2.57 kg/h, CV of petrol 41000 kJ/kg. Calculate the indicated thermal efficiency, brake thermal efficiency and mechanical efficiency.

   Solution:

   Data: 4-stroke petrol engine, i = 1, N = 1000 rpm, Hence n = 1000/2 = 500 cycles/sec, T = 70 N.m, P_m = 10 bar = 10×10^5 N/m^2, L = 150 mm/0.15 m, D = 100 mm/0.1 m,

   Fuel consumption, m = 2.57 kg/h, CV = 41000 kJ/kg

   Calculate η_{mech}, η_{ind}, η_{brake}.

   We have, IP = $(iP_mLAn)/60000$

   $= (1\times10\times10^5\times0.15\times\Pi\times0.1^2\times500)/(60000\times4)$

   = 9.82 kW

   BP = $(2\Pi NT)/60000$

   $= (2\times\Pi\times1000\times70)/60000$

   = 7.33 kW

   $\eta_{mech} = (BP/IP)\times100$

$= (7.33/9.82)\times 100$

$\eta_{mech} = 74.64\ \%$

$\eta_{brake} = (BP\times 3600)/(m\times CV)$

$= (7.33\times 3600)/(2.57\times 41000)$

$\eta_{brake} = 25.04\ \%$

$\eta_{indicated} = (IP\times 3600)/(m\times CV)$

$= (9.82\times 3600)/(2.57\times 41000)$

$\eta_{indicated} = 33.55\ \%$

3. A four stroke diesel engine has a bore of 100 mm, stroke of 120 mm and piston speed of 10 m/s. The engine develops 20 kW power per liter of cylinder stroke volume. Brake thermal efficiency of the engine is 30 % with a fuel having calorific value of 40 MJ/kg and specific gravity of 0.90. Determine (i) rpm, (ii) BP, and (iii) engine fuel requirements in liters/h.

Solution:

Data: i=4, 4-stroke diesel engine, D = 100 mm/0.1 m, L = 120 mm/0.12 m, S = 10 m/s, Power, P = 20 kW/l, $\eta_{brake} = 30\ \%$, CV = 40 MJ/kg = 40000 kJ/kg, $\rho = 0.9$

Determine Speed, rpm = ?, BP = ? and Engine fuel requirement

We have, $S = (2LN)/60$

$N = (60\times S)/2L$

$= (60\times 10)/2\times 0.12$

$N = 2500$ rpm

Stroke Volume of the cylinder, $Vs = (4\times\Pi\times D^2\times L)/4$

$= (4\times\Pi\times 0.1^2\times 0.12)/4$

$= 0.003769\ m^3\times 1000$

$= 3.769$ l

Brake Power, BP = 20 kW×3.769

$BP = 75.38$ kW

$\eta_{brake} = (BP\times 3600)/(m\times CV)$

$0.30 = (75.38\times 3600)/(m\times 40000)$

Hence, m = 22.614 kg/h

$= 22.614/0.9$

$m = 25.13$ l/h

4. The power output of a six-cylinder four stroke diesel engine is given by a law which is $B_LN/20000$ KW, where B_L is the brake load in newton and N is the speed in rpm. The

bore and stroke of the engine are 90 mm and 120 mm respectively. Fuel consumption is 5 cm^3/s and its density is 800 kg/m^3. Determine the following (i) the brake power (ii) the torque and (iii) the brake specific fuel consumption, if the brake load is 600 N and speed of engine is 2000 rpm.

Solution:

Note: Determination of Brake mean effective pressure (BMEP) is not required.

Data: $BP = (B_L N)/20000$, i = 6, 4-stroke diesel engine, D = 90 mm/0.09 m,

L = 120 mm /0.12 m, $V_f = 5\ cm^3/s = (5\times3600\times10^{-6})\ m^3/h$,

Hence $m = V_f \times \rho = (5\times3600\times10^{-6})\times800 = 14.4$ kg/h, B_L = 600 N, N = 2000 rpm.

Determine BP = ? T = ? Brake specific fuel consumption = ?

We have, $BP = (B_L N)/20000$

$= (600\times2000)/20000$

BP= 60 kW

We have, $BP = (2\Pi NT)/60000$

$60 = (2\times\Pi\times2000\times T)/60000$

Therefore, **T = 286.47 N.m**

Brake specific fuel consumption or Fuel consumption/BP = m/BP

$= 14.4/60$

= 0.24 kg/kWh

5. A four cylinder two stroke petrol engine with stroke to bore ratio of 1.2 develops 32 kW at 2500 rpm. The mean effective pressure on the piston is 8 bar and mechanical efficiency is 85 %. Determine (i) the diameter and stroke of each cylinder and (ii) the brake thermal efficiency, if the fuel consumption is 9 kg/h having calorific value of 44000 kJ/kg

Solution:

Data: i = 4, 2-stroke petrol engine, L/D = 1.2, Hence L = 1.2 D, BP = 32 kW,

N = 2500, Pm = 8 bar = $8\times10^5\ N/m^2$, η_{mech} = 85 %

Determine D = ?, L = ?, η_{brake} = ?

We have, $\eta_{mech} = BP/IP$

Hence, $IP = BP/\eta_{mech}$

$= 32/0.85$

$= 37.65$ kW

We have, $IP = (iP_m LAn)/60000$

$37.65 = (4\times8\times10^5\times1.2D\times\Pi\times D^2\times2500)/(60000\times4)$

Therefore $D^3 = 0.0002996\ m^3$

Hence, **D = 0.0669 m/66.9 mm**

L = 1.2D = 1.2×66.9

Hence, **L = 80.3 mm**

η_{brake} = [(BP×3600)/(m×CV)]×100

= [(32×3600)/(9×44000)] ×100

Hence, η_{brake} **= 29.1 %**

NOTE: Problem Numbers 6, 7 & 8 are ASSIGNMENT QUESTIONS. Do not solve in the class.

6. A four stroke cycle petrol engine has stroke volume of 9.7 liters. Its mean effective pressure is 600 kN/m^2 and rpm is 800. Find the indicative power of the engine.
7. Following results refer to a test on IC engine:
   Indicated power 42 kW, Frictional power 7 kW, Engine speed 1800 rpm, Specific fuel consumption per BP 0.30 kg/kWh and the calorific value of fuel 43000 kJ/kg. Calculate Mechanical efficiency, Brake thermal efficiency and Indicated thermal efficiency.
8. A four stroke cycle oil engine has the following data:
   Mean effective pressure 550 kPa, Swept volume 15L, Speed of the engine 6 revolutions per second, effective brake load 80 kg, effective brake radius 1 m, Fuel consumption 8 kg/h and calorific value of fuel 40 MJ/kg. Determine Indicated power, Brake power, Mechanical efficiency and Indicated thermal efficiency.

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