Indicated power (IP) :

It is the power produced inside the cylinder and calculated by finding the actual mean effective pressure.

$$IP = \frac{100 P_m L\, A\, n}{60}\ KW$$

where P_m = Mean effective Pressure in bar

L= Stroke Length in meters

A= Cross section area of cylinder bore in m^2

$A = \frac{\pi d^2}{4}$ where d= bore dia in meters

n=Number of cycles per min;

n = N for two stroke engine (N = rpm of engine)

$n = \frac{N}{2}$ *for four stroke engine*

Brake power (BP) :

It is the net power available calculated at the crank shaft is called *Brake Power.*

$$BP = \frac{2\pi NT}{60}\ KW$$

where N = Rpm of crank shaft

T= Engine torque (in KN-m) $=(W - S) \times R$

Where W= Load on brake drum, KN

S=Spring balance reading, R=Radius of the brake drum

Also FP =(IP - BP) KW

where FP=Power lost in friction

Efficiencies of engine :

(i) Mechanical Efficiency :

$$\eta_{mech} = \frac{BP}{IP} \times 100$$

(ii) Thermal Efficiency :

Indicated thermal efficiency

$$\eta_{indicated-thermal} = \frac{IP}{m_f \times CV}$$

where m_f = Mass of fuel burnt in Kg/sec

CV=Calorific value of fuel in KJ/Kg

Brake thermal efficiency

$$\eta_{brake-thermal} = \frac{BP}{m_f \times CV}$$

NOTE :

(i) The mean effective pressure is given by

$$P_m = \frac{sa}{l} \, N/m^2$$

where a=Area of the indicator diagram, cm^2

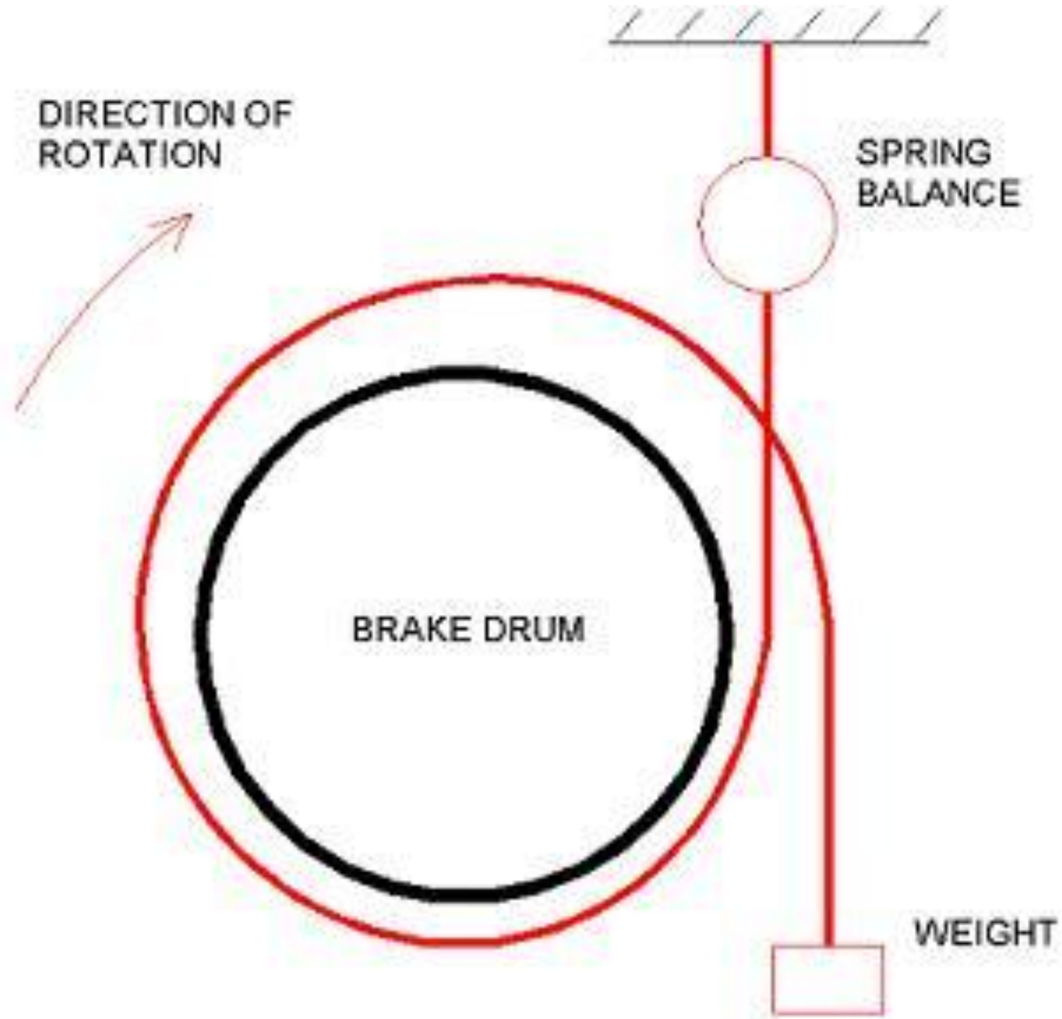
l = Base width of indicator diagram, cm

s= spring constant or spring value, $N/m^2 / cm$

(ii) If brake load is in kg, torque on brake drum

$$T = \frac{(9.81 \times W \times R)}{1000} \, KN\text{-}m$$

BRAKE DYNAMOMETER



PROBLEM 1

A single cylinder two stroke cycle I.C. Engine has a piston diameter 105 mm and stroke length 120 mm. The mean effective pressure is 6 bar. If the crank shaft speed is 1500 rpm. Calculate the indicated power of the engine.

Data : $N = 1500$ rpm, $d = 105$ mm $= 0.105$ m

$L = 120$ mm $= 0.12$ m, $P_m = 6$ bar,

Two stroke $\Rightarrow$ Number of cycles $n = N = 1500$

Solution :

Indicated power

$$IP = \frac{100 P_m L\, A\, n}{60}\ KW$$

$$IP = \frac{100 \times 6 \times 0.12 \times \left[\frac{\pi(0.105)^2}{4}\right] \times 1500}{60}\ KW$$

$\therefore IP = 15.586\ KW$

PROBLEM 2

On a single cylinder four stroke petrol engine, the following readings were taken:

Load on the brake drum	= 40 kg.
Spring balance reading	= 5 kg.
Diameter of the brake drum	= 120 cm.
Fuel consumption	= 3 kg/hour.
Calorific value of the fuel	= 42000 kJ/kg.
Engine Speed	= 500 rpm.

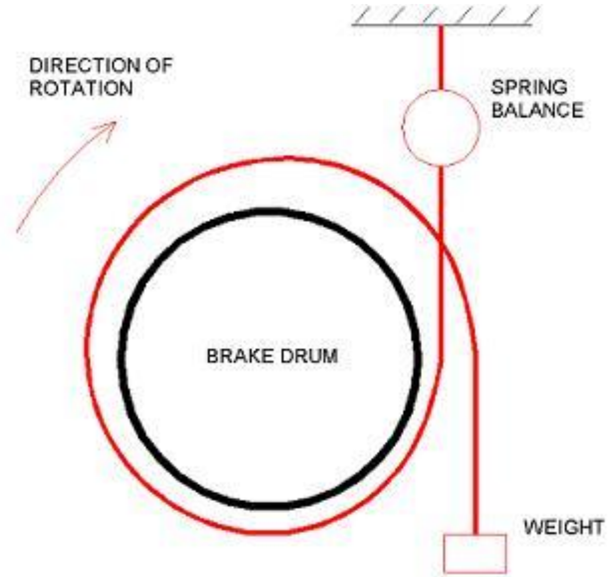
Find the brake thermal efficiency.

Data : ***W = 40 kg, S = 5 kg,***

Dia of brake drum 2R = 120 cm

$\Rightarrow$ Radius of brake drum

R = 60cm = 0.6 m



Mass of fuel consumed $3 kg / hr$

$$\Rightarrow m_f = \frac{3}{60 \times 60} = 8.333 \times 10^{-4} kg / \sec$$

Calorific value of fuel

$$CV = 42000 \; KJ / Kg$$

Speed of engine N=500 rpm

Solution :

Torque on the brake drum

$$T = \frac{9.81 \times (W - S) \times R}{1000} \; KN - m$$

$$T = \frac{9.81 \times (40-5) \times 0.6}{1000} = 0.206 \; KN - m$$

$$\text{Brake power } BP = \frac{2\pi NT}{60} \; KW$$

$$BP = \frac{2\pi \times 500 \times 0.206}{60} = 10.787 \; KW$$

Brake thermal efficiency

$$\eta_{brake-thermal} = \frac{BP}{m_f \times CV} = \frac{10.787}{8.333 \times 10^{-4} \times 42000}$$

$$\eta_{brake-thermal} = 0.3082 = 30.82\%$$

PROBLEM 3

A gas engine working on a four stroke cycle has a cylinder of 250 mm diameter, length of stroke 450 mm, and is running at 180 rpm. Its mechanical efficiency is 80% when the mean effective pressure is 0.65 Mpa.

Find 1. Indicated power, 2. Brake power and 3. Friction power.

Data :

Dia of cylinder bore d = 250 mm = 0.25 m

Stroke length L=450 mm=0.45 m

SPeed N= 180 rpm, $\eta_{Mech} = 0.8$

$P_m = 0.65 Mpa = 0.65 \times 10^6 \, Pa$

$\Rightarrow 650 KPa = 6.5 bar$

Speed of engine N=180 rpm

4-stroke $\Rightarrow$ n= $N/2 = 180/2 = 90 cycles / \min$

Solution :

Indicated power

$$IP = \frac{100 P_m L A n}{60} KW$$

$$IP = \frac{100 \times 6.5 \times 0.45 \times \left[\frac{\pi (0.25)^2}{4}\right] \times 90}{60} KW$$

$$\therefore IP = 21.54 \ KW$$

Also mechanical efficiency

$$\eta_{mech} = \frac{BP}{IP} \Rightarrow BP = IP \times \eta_{mech}$$

$$\therefore \text{Brake power } BP = 21.54 \times 0.8 = \mathbf{17.23\ KW}$$

Hence Power lost in friction

$$FP = (IP - BP) = (21.54 - 17.23) = \mathbf{4.31\ KW}$$

PROBLEM 4

During the test on a 4-stroke diesel engine, the following readings were taken when running at full load.

Area of the indicator diagram=3 cm^2

Length of indicator diagram =5 cm

Spring constant = 100 $N/cm^2/cm$

Engine crankshaft speed =500 rpm.

Diameter of the cylinder =150 mm

Stroke of the piston= 200 mm

Determine the indicated power of the engine.

Data :

Dia of cylinder bore d = 150 mm = 0.15 m

Stroke length L=200 mm=0.2 m

SPeed N= 500 rpm,

4 stroke $\Rightarrow$ Number of cycles n= $\frac{N}{2} = \frac{500}{2} = 250$

Spring constant $s = 100 \text{N/cm}^2/\text{cm}$

Area of indicator diagram=a=3 cm^2

length of indicator diagram $l = 5cm$

Solution :

Mean effective pressure

$$P_m = \frac{s \times a}{l} = \frac{100 \times 3}{5} = 60\ N / cm^2$$

$$\Rightarrow P_m = \frac{60\ N}{(10^{-2})^2} = 60 \times 10^4\ N / m^2 = 600 KPa = 6 bar$$

$$IP = \frac{100 P_m L\ A\ n}{60}\ KW$$

$$IP = \frac{100 \times 6 \times 0.2 \times \left[\frac{\pi (0.15)^2}{4}\right] \times 250}{60}\ KW$$

$$\therefore IP = 8.83\ KW$$

PROBLEM 5

The following observations were made during a trial on a 4-stroke diesel engine:

Cylinder diameter	=25cm
Stroke of piston	=1.6 times the bore
Crankshaft speed	=250 rpm
Brake load	=70 kg
Brake drum diameter	=2m
Mean effective Pressure	=6 bar
Diesel consumption	=0.1 litre/min
Specific gravity of diesel	=0.78
Calorific value of diesel	=43900 KJ/Kg

Determine (i) BP (ii) IP (iii) FP (iv) η_{mech} (v) $\eta_{I\text{-}thermal}$ (vi) $\eta_{B\text{-}thermal}$

Data :

Dia of cylinder bore d = 25 cm = 0.25 m

Stroke length $L=1.6\times d=1.6\times 0.25=\boldsymbol{0.4\ m}$

Speed N= 250 rpm , Calorific value CV = $43900 KJ/Kg$

4 stroke $\Rightarrow$ Number of cycles $n=\frac{N}{2}=\frac{250}{2}=125$

$P_m=6bar$, W=70 kg, 2R=2 meters $\Leftarrow$ R= 1meter

Given volume of fuel=***0.1 litre / min***$=0.1\times 10^{-3} m^3/\min$

(As 1 m^3 = 1000litres)

Mass of fuel used per second

$$m_f=\frac{Volume(\ m^3/min)\times density\ of\ fuel}{60}$$

$$m_f=\frac{0.1\times 10^{-3}\times(0.78\times 1000)}{60}=1.3\times 10^{-3} kg/\sec$$

$(\because$ *Density of diesel*

$=$ *specific gravity of diesel* $\times$ *density of water* $(=1000\ kg/m^3)$

Solution :

(i) Indicated power :

$$IP = \frac{100 P_m L\, A\, n}{60}\ KW$$

$$IP = \frac{100 \times 6 \times 0.4 \times \left[\frac{\pi (0.25)^2}{4}\right] \times 125}{60}\ KW$$

$$\therefore IP = 24.54\ KW$$

(ii) Brake power :

$$BP = \frac{2\pi NT}{60}\ KW$$

$$BP = \frac{2\pi \times 250 \times \left(\frac{9.81 \times 70 \times 1}{1000}\right)}{60}\ KW$$

$$\therefore BP = 17.98\ KW$$

(iii) Frictional power :

$$FP = (IP - BP) = (24.54 - 17.98)$$

$$\therefore FP = 6.56\ KW$$

(iv) Mechanical efficiency :

$$\eta_{mech} = \frac{BP}{IP} \times 100 = \frac{17.98}{24.54} \times 100 = 73.3\%$$

(v) Brake Thermal efficiency :

$$\eta_{B-thermal} = \frac{BP}{m_f \times CV} \times 100$$

$$\eta_{B-thermal} = \frac{17.98}{(1.3 \times 10^{-3}) \times 43900} \times 100 = 31.5\%$$

(vi) Indicated Thermal efficiency :

$$\eta_{I-thermal} = \frac{IP}{m_f \times CV} \times 100$$

$$\eta_{I-thermal} = \frac{24.54}{(1.3 \times 10^{-3}) \times 43900} \times 100 = 43\%$$

PROBLEM 6

Find the indicated power of a four stroke petrol engine if the average piston speed is 70 m/min. The mean effective pressure is 5.5 bar. The diameter of the piston is 150 mm.

Note:

As the piston travels a distance of '2L' in one revolution of the crank shaft,

Piston speed=2LN m/min where

L=stroke length of piston in meters

N=Rpm of crank shaft

Here, given 2LN=70 m/min.

Hence LN=35 m/min

As it is a 4 stroke engine, n=N/2

Hence Ln=17.5 m/min

Solution :

Indicated power :

$$IP = \frac{100 P_m A(Ln)}{60} \, KW$$

$$IP = \frac{100 \times 5.5 \times \left[\frac{\pi(0.15)^2}{4}\right] \times 17.5}{60} \, KW$$

$$\therefore IP = 2.835 \; KW$$

PROBLEM 7

A 4-stroke single cylinder I C engine of 250 mm cylinder diameter and 400 mm stroke runs at a piston speed of 8m/sec. If the engine develops 50 KW indicated power, find its mean effective pressure and the crank shaft speed.

Note:

As the piston travels a distance of '2L' in one revolution of the crank shaft,

Piston speed=2LN m/min where

L=stroke length of piston in meters

N=Rpm of crank shaft

Here, given 2LN=8m/sec.

i.e. 2x0.4xN=8 m/sec

Hence N=10 rps=600 rpm.

Solution :

Indicated power :

$$IP = \frac{100 P_m LAn}{60} KW$$

$$50 = \frac{100 \times P_m \times 0.4 \times \left[\frac{\pi(0.25)^2}{4}\right] \times \left(\frac{600}{2}\right)}{60} KW$$

$$\therefore P_m = 5.09 \ bar$$