



# ***Internal Combustion Engines***

## **Lecture-13**

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# Performance Parameters

- Power

- Indicated Power (IP)
- Brake Power (BP)
- Frictional Power (FP)

$$\mathbf{IP = BP + FP}$$

- Efficiency

- Thermal Efficiency [Power output / Energy supply per unit time]
- Mechanical Efficiency [BP / IP]
- Relative Efficiency [Brake thermal efficiency / Air standard efficiency]

- Specific Fuel Consumption [Fuel intake per unit time]

- Brake Specific Fuel Consumption [Specific fuel consumption per unit brake power]

- Speed

# Measurement of Power

## BRAKE POWER

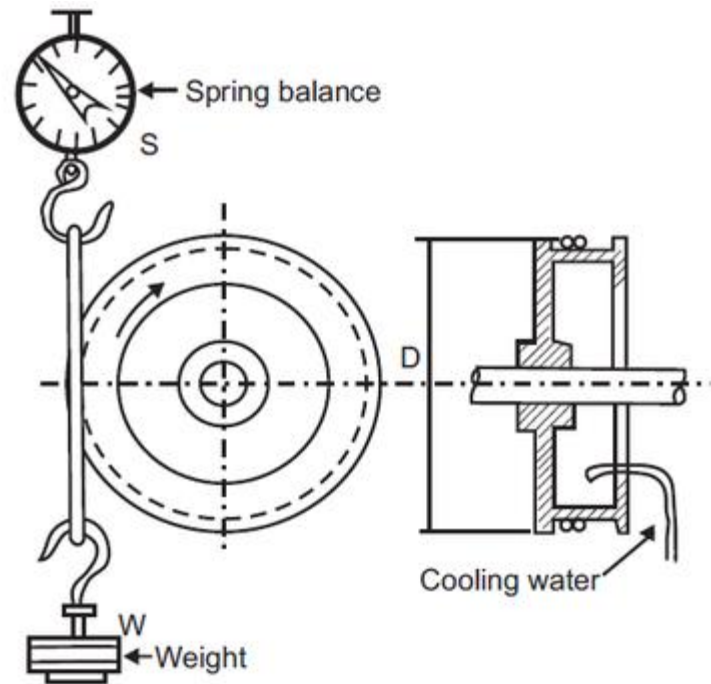
### Rope Brake Dynamometer:

Without rotation:  $W = S$

With rotation, Torque =  $T = (W-S)D/2$

Brake Power =  $2\pi NT$

N is the rotational speed (RPS)



## INDICATED POWER

The indicator diagram (P-V) can be drawn *in-situ* with the help of appropriate devices. Indicated power may be calculated from the diagram.



# Morse Test

This test carried out on multi cylinder I.C. engine.

First engine is allowed to run at constant speed and brake power of engine is measured when all cylinders are working and developing indicated power. (Considering Four cylinders)

$$I_1+I_2+I_3+I_4 = (BP)_{\text{engine}} +(F_1+F_2+F_3+F_4)$$

Where  $I_1$ ,  $I_2$ ,  $I_3$  and  $I_4$  – Indicated power of four cylinders

$(BP)_{\text{engine}}$  – Brake power of engine when all cylinders are working

$F_1$ ,  $F_2$ ,  $F_3$ ,  $F_4$  – Frictional power of all four cylinders

Then the first cylinder is cut off by short circuiting spark plug in case S.I. engine (or cutting fuel supply in case C.I. engine).

This causes the speed to drop due to non firing of first cylinder. It should be noted that although first cylinder is not producing power still it is moving up and down so its frictional power must be considered.

This speed is once again maintained to its original value by reducing load on the engine.



$$I_2 + I_3 + I_4 = (BP)_{2,3,4} + (F_1 + F_2 + F_3 + F_4)$$

Where  $(BP)_{2,3,4}$  – Brake power of 2,3 & 4 cylinders only.

Repeat the above procedure for remaining cylinders and calculate I.P. of the engine.

$$\text{Cylinder 2 is cut off} - I_1 + I_3 + I_4 = (BP)_{1,3,4} + (F_1 + F_2 + F_3 + F_4)$$

$$\text{Cylinder 3 is cut off} - I_1 + I_2 + I_4 = (BP)_{1,2,4} + (F_1 + F_2 + F_3 + F_4)$$

$$\text{Cylinder 4 is cut off} - I_1 + I_2 + I_3 = (BP)_{1,2,3} + (F_1 + F_2 + F_3 + F_4)$$

I.P. of cylinder 1 is calculated as ,

$$I_1 = (BP)_{\text{engine}} - (BP)_{2,3,4}$$

Similarly  $I_2, I_3$  and  $I_4$  is calculated as follows

$$I_2 = (BP)_{\text{engine}} - (BP)_{1,3,4}$$

$$I_3 = (BP)_{\text{engine}} - (BP)_{1,2,4}$$

$$I_4 = (BP)_{\text{engine}} - (BP)_{1,2,3}$$

Total Indicated power of engine = I.P.

$$IP = I_1 + I_2 + I_3 + I_4$$

Frictional power of engine

$$FP = IP - (BP)_{\text{engine}}$$



# Numerical problems can be found from:

- Solved problems from the book of V. Ganesan
- <http://ecoursesonline.iasri.res.in/mod/page/view.php?id=2464>
- <http://ecoursesonline.iasri.res.in/mod/resource/view.php?id=3799>
- [http://www.brainkart.com/article/Solved-Problems--Internal-Combustion-Engines\\_5658/](http://www.brainkart.com/article/Solved-Problems--Internal-Combustion-Engines_5658/)



**Thank You**