Thermodynamics (ESC-S202)

Lecture- 11 & 12
Work and Heat Transfer

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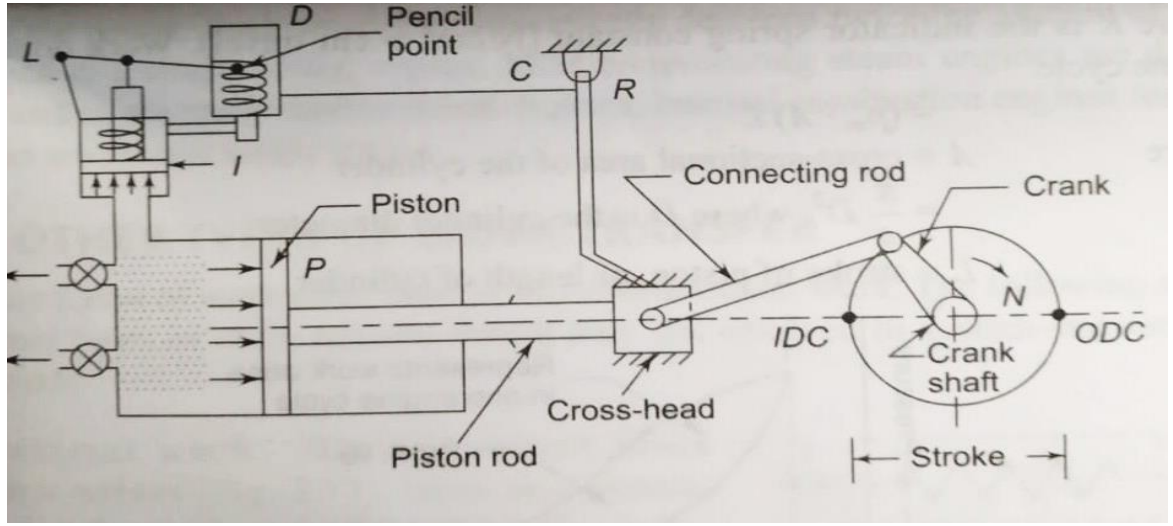
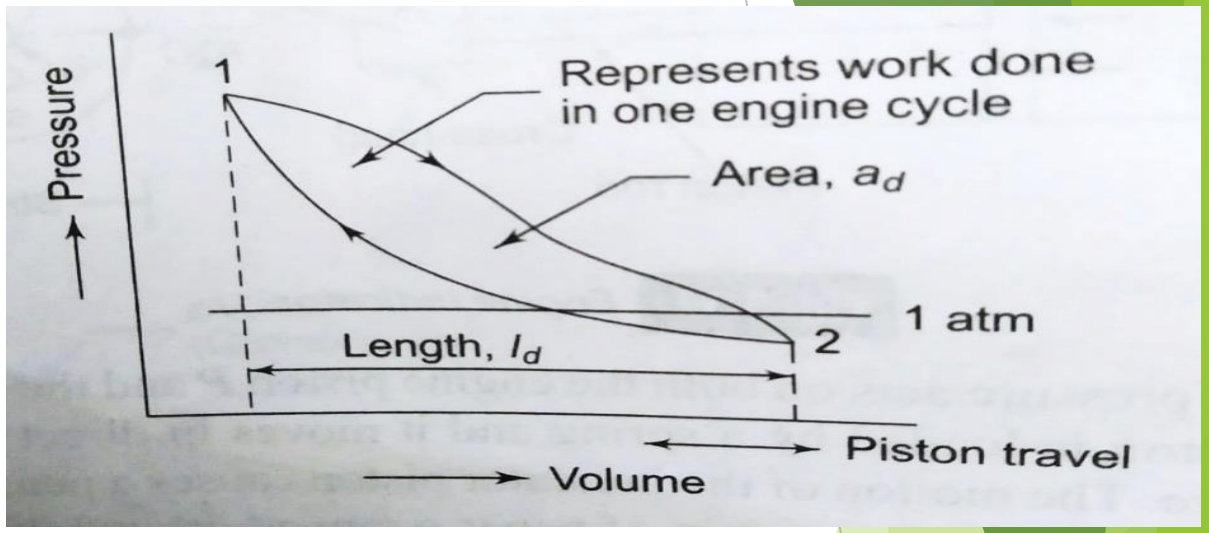
Indicator Diagram

- An indicator diagram is a trace made by reciprocating pressure gauge called the indicator, attached to the cylinder of a reciprocating engine. This represents the work done in one engine cycle.





- The area of the indicator diagram represents the magnitude of the net work done by the system in on engine cycle.

$$p_m = \frac{a_d}{l_d} \times K$$

- The mean effective pressure (m.e.p.) p_m is defined in the following way:

$$p_m = \frac{a_d}{l_d} \times K$$

Where K is indicator spring constant ($\frac{N}{cm^2} \times cm\ travel$)

- Work done in one engine cycle= $(p_m . A)L$

  A= cross-sectional area of the cylinder

$$A = \frac{\pi}{4} D^2$$

Where D is the cylinder diameter.

L= stroke of piston or length of cylinder.

Indicated Power-

- The power developed inside the cylinder of the engine is called indicated power(IP).
- Let N be the revolutions per minute (rpm) of the crankshaft.
- In a four stroke cycle, the engine cycle is completed in four stroke of the piston or in two revolutions of the crankshaft.
- In a two stroke cycle, the engine cycle is completed in two stroke of the piston or in one revolutions of the crankshaft.

- For a two stroke engine

Work done in one minute=$p_m ALN$

- For a four stroke engine

Work done in one minute=$p_m AL\frac{N}{2}$

$$IP = \frac{p_m AL\left(N \text{ or } \frac{N}{2}\right)n}{60} \text{kW}$$

Where

p_m is in kPa and n is the number of cylinders in the engine.

Brake Power

- The power available at the crankshaft is always less than the Indicated power due to the friction etc. , and is called the brake power or shaft power.

$$BP = T\omega$$

Where

- T is the torque transmitted to the crankshaft.
- ω is the angular velocity of the crankshaft in radian/sec.

$$BP = \frac{2\pi TN}{60}$$

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

Above expression is used for calculating mechanical efficiency.

Q.1 A single-cylinder, double-acting, reciprocating water pump has an indicator diagram which is a rectangle 0.075 m long and 0.05 m high. The indicator spring constant is 147 MPa per m. The pump runs at 50 rpm. The pump cylinder diameter is 0.15 m and the piston stroke is 0.20 m. Find the rate in kW at which the piston does work on the water.

Q.2 A single-cylinder, single-acting, 4 stroke engine of 0.15 m bore develops an indicated power of 4 kW when running at 216 rpm. Calculate the area of the indicator diagram that would be obtained with an indicator having a spring constant of 25 × 106 N/m3. The length of the indicator diagram is 0.1 times the length of the stroke of the engine.