Programme-	**B.Sc (Agriculture)**
Course -	**Farm Power and Machinery**
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Unit-	**2(Part-1)**
Topic-	Elementary knowledge about the engineering Terminology Calculations on piston displacement Compression ratio, HP and efficiencies of engines
Sub-Topic-	**TERMINOLOGY CONNECTED WITH ENGINE POWER BORE** **MEASUREMENT OF ENGINE POWER** **BRAKE DYNAMOMETER** **DRAWBAR DYNAMOMETER**

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TERMINOLOGY CONNECTED WITH ENGINE POWER BORE.

Bore: Bore is the diameter of the engine cylinder.

Stroke: It is the linear distance traveled by the piston from Top dead center (TDC) to Bottom dead center (BDC).

Stroke-Bore ratio: The ratio of length of stroke (L) and diameter of bore (D) of the cylinder is called stroke - bore ratio (L/D). In general, this ratio varies between1to1.45 and for tractor engines, this ratio is about 1.25.

Swept Volume: It is the volume (A x L) displaced by one stroke of the piston where A is the cross sectional area of piston and L is the length of stroke.

Compression Ratio. It is the ratio of the stroke of I.C. engine volume of the charge at the beginning of the compression stroke to that at the end of compression stroke, i.e. ratio of total cylinder volume to clearance volume.

$$\text{Compression ratio(r)} = \frac{Total\ cylinder\ volume}{Clearance\ volume} = \frac{V1}{V2}$$

$$= \frac{Swept\ volume + Clearance\ volume}{Clearance\ volume}$$

The compression ratio of diesel engine varies from 14:1 to 22:1 and that of carburetor type engine (spark ignition engine) varies between 4:1 to 8:1.

Power: It is the rate of doing work. It is expressed in "watt" in S.I. Unit.

Important conversions in S.I. Unit

1 kg = 9.8 neuton = 9.8 N

1 Nm = 1 Joule

1 Nm / s = 1 Joule / s = 1 watt

1 kg / cm² = 9.8 x 10 * N / m² = 9.8 x 104 Pascal (Pa) = 98 kPa.

1 Pascal = 1N / m^2

1 kg m / s - 9.8 Joules / s = 9.8 watt

1J/s += 0.10198 kg-m / s

1 Calorie = 4.186 Joules

1 Joule = 0.2889 Calorie

1 kW-h = 860 k. calories

1 kW - 1000 W = 102 kg.m / s

Indicated power (ip): It is the power generated in the engine cylinder and received by the piston. It is the power developed in the cylinder without friction or auxiliary unit,

In S.I, Unit.

Indicated power (ip),kW=$\frac{PLAn}{60X10^{12}}$X $\frac{x}{2}$ For 4 Stroke

Indicated power (ip),kW=$\frac{PLAn}{60X10^{12}}$X $\frac{x}{1}$ For 2 Stroke

Where,

P = mean effective pressure (mep), Pa (Pascal)

[1Pa 1N / m^2)

L= length of stroke, mm

A = cross sectional area of piston, mm^2

n = engine speed, rev / min.

x = number of cylinder

In metric unit.

Indicated power (ip), kW=$\frac{PLAn}{4500}$X $\frac{x}{2}$ For 4 Stroke

Indicated power (ip), kW=$\frac{PLAn}{4500}$X $\frac{x}{1}$ For 2 Stroke

Where,

P = mean effective pressure (mep), kg/cm^2

L= length of stroke, m

A = cross sectional area of piston, cm^2

n = engine speed, rev / min.

x = number of cylinder

Brake power (bp): It is the power delivered by the engine and is available at the end of the crankshaft.
Belt power: It is the power of the engine, measured at the end of a suitable belt, receiving drive from the pto shaft (power take off)
Drawbar power (db): It is the power of a tractor, measured at the end of the drawbar. It is the power, which is available for pulling loads at the drawbar,
Power take - off power (pto power): It is the power delivered by a tractor through its pto shaft. In general, the belt and pto power of a tractor will almost be the same.
Frictional power (p): It is the power required to run the engine at a given speed without producing any useful power. It represents the friction and pumping losses of an engine.

Indicated power (ip) = brake power (bp) + friction power (fp)

ip= bp + fp

Mean effective pressure (mep): It is the average pressure during the power stroke minus the average pressure during other strokes. This pressure actually forces the piston down during the power stroke.
Volumetric efficiency: It is the ratio of actual weight of air introduced by the engine on the suction stroke to the theoretical weight ar air that should have been introduced by filling the piston displacement volume with air at atmospheric pressure and temperature.
Torque: A turning effect due to force applied on some point is called Torque (T).

T = F x r

Where F is the force and r is the distance of the force from the center of the shaft.
Piston displacement: It is the volume displaced by one stroke (L) of the piston. It is also known as swept volume.

Piston displacement = A x L

Where A is cross sectional area of piston and L is the length of stroke.
Displacement volume: It is the total swept volume of all pistons during power strokes occurring in one minute.

Displacement volume = A x L x n x $\frac{x}{2}$ [for 4 stroke engine)

Displacement volume = A x L x n x $\frac{x}{1}$ [for 2 stroke engine]

Where, A = cross - sectional area of piston.
L = stroke length.
n = speed, rev / min. , and
x = number of cylinders
Piston speed (Sp): It is the total length of travel of the piston in a cylinder in one minute.

Sp = 2 x L x n

Specific fuel consumption: It is the quantity of fuel consumed per kW - hr. in an engine.
Brake mean effective pressure (bmep): It is the average pressure, acting throughout the entire power strokes, which are necessary to produce brake power of the engine.

$$\text{bmep, Pascal (Pa)} = \frac{bp \times 60 \times 10^{12}}{L \times A \times n \times \frac{x}{2}}$$ For 4 Stroke Engine

$$\text{bmep, Pascal (Pa)} = \frac{bp \times 60 \times 10^{12}}{L \times A \times n \times \frac{x}{1}}$$ For 2 Stroke Engine

Where,

bp = brake power, kW
L = length of stroke, mm
A = cross - sectional area of piston, mm^2
n = speed, rev / min
x = number of cylinders.

Mechanical efficiency: It is the ratio of the brake power (bp) to indicted power (ip) and is expressed as:

$$\text{Mechanical efficiency } (\eta_{mech}) = \frac{bp}{ip} \times 100$$

Thermal efficiency (η_{ther}): It is the ratio of the output in the form of useful mechanical power to the power value of the fuel consumed.

$$\text{Thermal efficiency (percent)} = \frac{Brake\ power \times 100}{Power\ Value\ of\ Fuel}$$

Top dead center (TDC) and Bottom dead center (BDC). The piston, while moving in the cylinder occupies two extreme positions. The upper most position of the piston is called top dead center (TDC) and the lower most position is called bottom dead center (BDC).

MEASUREMENT OF ENGINE POWER:

The measurement of power of an engine is done by an instrument called dynamometer. Power is obtained by measuring force, time and distance. Dynamometer is usually classified as:

1. **Brake dynamometer or belt dynamometer:**
(a) Prony brake type
(b) Electrical type
(c) Hydraulic type

2. Drawbar dynamometer:
(a) Spring type
(b) Hydraulic type
(c) Strain gauge type

Brake dynamometer measures brake or belt power of the engine, whereas the drawer dynamometer measures the drawbar power of the engine.

BRAKE DYNAMOMETER:

- Prony brake dynamometer. The prony brake dynamo meter is used to determine the belt or brake power of an engine. It consists of a friction - band which fits on the belt pulley. There is an arm of 1 to 2 meter length, which rests on or supported by a suit able scale Brake blocks are fitted on a pulley which is connected to the crank shaft of the engine. The blocks are set to grip the pulley tightly by suitable screws. A counter poise balances the weight of the brake arm, which is connected through spring balance to a rigid support.

  For measuring brake power, the engine is first started with no load and its revolution is measured by a tachometer. The load is then increased in stages by tightening the screws. At each stage, the speed and force registered by spring balance is recorded properly. Beyond a certain limit, it is found that additional load reduces the speed of the engine to such an extent that the engine seems to be stopped. After this stage, no further load is applied and Brake power is calculated as follows:

Let

l = length of brake arm, m

r = radius of the flywheel, m

w = load registered on the balance, kg. , and

f = total frictional force round the rim of the pulley, kg.

Taking moments about the center of the pulley,

F X r = w x l

Work done against frictional force in one revolution of the pulley:

Work = 2 π.r.f kg-m

Work done per minute = 2. π.r.f.n. kg.m [n is speed, rev / min.]

From equations (I) Work = 2.π.w.l.n. kg-m

In S.I. unit:

$$\text{Power, W} = \frac{2.\pi.w.l.n \text{ X } 9.8}{60} \text{ Joules / sec.}$$

$$\text{Power, kW} = \frac{2.\pi.w.l.n \text{ X } 9.8}{60 \text{ X } 1000} \text{ kW}$$

In metric unit

$$\text{Brake horse power (bhp)} = \frac{2.\pi.w.l.n}{4500}$$

- Electrical dynamometer. The electrical dynamometer consists of a generating unit, a resistance unit and a control board. The generator is installed on heavy iron support. The engine to be tested is mounted by the side of the generator and its crankshaft is connected directly to the armature. The pressure on the scale is created by the electromagnetic action between the field and the armature. As the armature rotates, the electromagnetic field tends to cause the field frame rotate with the armature. The pulling force makes the frame rotate to a certain amount by adjusting the electromagnetic field. The stronger the current supplied to the field winding, the greater is the load on the engine. It is very accurate and precise instrument but its installation cost is considerably high.
- Hydraulic dynamometer. In this type of dynamometer, the energy the engine is converted into heat by a set of rotating cups, turning next to a set of stationary vanes. The clearance between two sets of vane is adjustable which controls the load to be applied. Heat is carried away through the water circulating round it.

DRAWBAR DYNAMOMETER:

- **Spring dynamometer:** It consists of a heavy spiral spring or an elliptical spring to absorb the pull. The tension or the compression of the spring actuates a needle on a dial, giving direct reading of load. The spring elongates under tension and shortens under compression. Such a dynamometer is suitable for approximate mate measurement of force because the needle of the dial fluctuates very much with rapid variation of load in agricultural fields.
- **Hydraulic dynamometer:** It consists of a cylinder and a piston, connected to a pressure gauge. The cylinder filled with hydraulic oil is placed between the tractor and the load. The drawbar pull causes an increase in oil pressure which is indicated by a pressure

gauge. The gauge is calibrated in such a way that it giver direct reading in ka. Momentary deflections in the pull are dampened out with the use of hydraulic oil. Overloads do not seriously affect the unit. It is simple, sensitive and accurate device for measuring drawbar pull.

- **Strain gauge dynamometer:** The operation of an electrical strain gauge is based on the principle that if a piece of fine wire is subjected to strain, there will be change in its length and resistance. If such wire is bonded to some structural member and if the structural member is subjected to some strain, the wire would also experience a like strain and in turn, it changes the electrical resistance strain gauge is a fine piece of resistance wire, mounted on an insulating medium and cemented to a particular place on the test piece. Change in the dimension of the test piece causes compression or tension of the strain gauge. This changes electrical resistance of the unit. The change in the resistance is proportional to strain in the wire. Since the strain gauge is rigidly fixed on the test piece, the change in the resistance of the wire is proportional to strain in the test piece. The change in resistance is read and recorded by strain indicators or other suitable electric recorder. This is very precise and accurate device but the recording instruments are very costly.

Reference Books		
1.	Elements of Agricultural engineering	Sahay .J.
2.	Principles of Agricultural Engineering	Michel A.M. & Ojha T.P.,
3.	Tractors and their Power Units	E.L. Barger, J.B. Lijedahl, W.M. Carleton, E.G. Mokibben