Dynamometers

Defination:

➢ Dynamometer is a device which is used to measure the frictional resistance. By know ing frictional resistance we ca determine the torque transmi and hence the power of the engine.

Types of dynamometers:

1)Absorption dynamometer:

- ➢ **Prony brake dynamometer**
- ➢ **Rope brake dynamometer**
- ➢ **Hydraulic dynamometer**

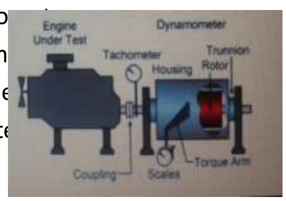
2) Transmission dynamometer:

- ➢ **Belt transmission dynamometer**
- ➢ **Epicyclic dynamometer**
- ➢ **Torsion dynamometer**

Absorption dynamometers:

- This dynamometers measure and absorb the power output of the engine to which they are coupled, the power absorbed is usually dissipated as heat by some means.
- Examples such dynamo

1. Prony brake dynamom
2. Rope brake dynamome
3. Hydraulic dynamomet



Prony brake dynamometer

Construction & Working :

- A simplest form of an Absorption type Dynamometer is a Prony Brake Dynamometer . It consists of Two wooden blocks around a Pulley fixed to the shaft of an engine , whose power is required to be measured . The blocks are clamped by means of Two Bolts and Nuts . A Helical Spring is provided between the nut and the upper block to adjust the Pressure on the Pulley to Control its Speed . The upper block has a long lever attached to it and carries a weight **W** at its outer end . A Counter Weight is placed at the other end of the lever which balances the Brake when Unloaded . Two stops S_1 and S_2 are provided to limit the motion of the Lever .

-In Prony Brake Dynamometer , when the Brake is to be put in operation , the long end of the lever is loaded with suitable weights W and the nuts are tightened until the engine shaft runs at a constant speed and the lever is in Horizontal Position . Under these conditions , the moment due to the weight W must balance the moment of the Frictional Resistance between the Blocks and Pulleys .

Let ,
W = Weight at the outer end of the lever in Newton ,
L = Horizontal Distance of the weight W from the Centre of the pulley in Meter ,
F = Frictional Resistance between the blocks and the pulley in Newton ,
R = Radius of the pulley in Meter ,
N = Speed of the Shaft in R.P.M.

We know that the Moment of the Friction Resistance or Torque on the Shaft ,

T = W * L = F * R N-m

Work done in One Revolution = Torque * Angle Turned in Radians
= **T * 2π** N-m

Work done per Minute = **T * 2πN** N-m

Brake Power of the Engine = B.P. = (Work done per minute) / (60)
= **(T * 2πN / 60)**
= **(W * L * 2πN / 60)** Watts

We can Calculate the brake power without knowing the value of coefficient of friction between blocks and pulley , the radius of pulley and the pressure exerted by tightening the nuts.

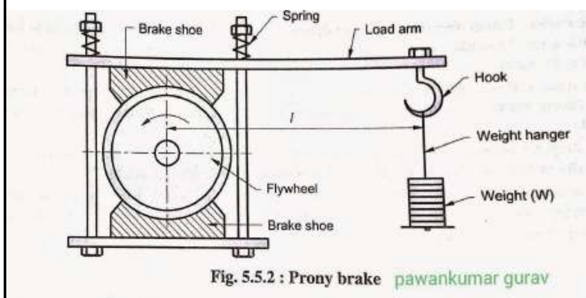


Fig. 5.5.2 : Prony brake

Rope brake dynamometer:

- Construction & Working :
- It is another form of Absorption type Dynamometer which is most commonly used for measuring the Brake Power of the Engine . It consists of one , two or more ropes wound around the flywheel or rim of a pulley fixed rigidly to the shaft of an engine . The upper end of the ropes is attached to a spring balance while the lower end of the ropes is kept in position by applying a dead weight .
- In the Operation of Brake , the engine is made to run at a constant speed . The Frictional Torque , due to the Rope , must be equal to the torque being Transmitted by the Engine .

Let ,
W = Dead Load in Newton ,
S = Spring Balance Reading in Newton ,
D = Diameter of the Wheel in Meter ,
d = Diameter of the Rope in Meter ,
N = Speed of the Engine Shaft in R.P.M.

Net Load on the Brake = **(W – S)** N

We know that Distance Moved in One Revolution = **π * (D + d)** m

Work done per Revolution = **(W – S) * π * (D + d)** N-m

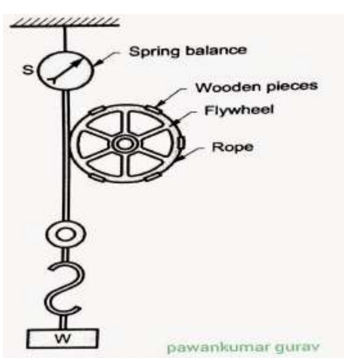
Work done per Minute = **(W – S) * π * (D + d) * N** N-m

Brake Power of the Engine = **B.P.** = (Work done per minute) / (60)

= **(W – S) * π * (D + d) * N / 60** Watts

If the Diameter of the Rope (**d**) is neglected , then Brake Power of the Engine,

B.P. = **(W – S) * (πDN/60)** Watts

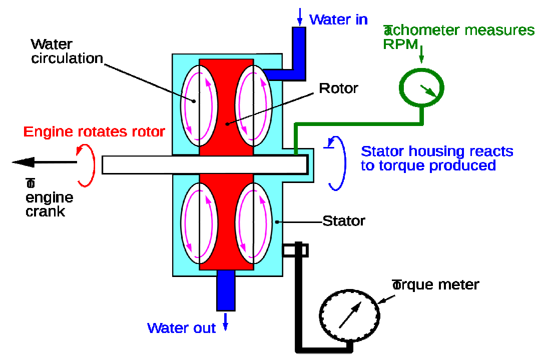


Rope brake friction dynamometer

Hydraulic dynamometer:

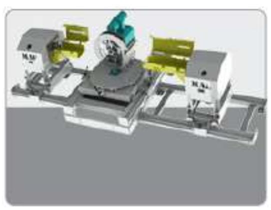
- It works on the principle of dissipating the power in fluid friction rather than in dry friction.
- It consists of an inner rotating member or impeller coupled to the output shaft of engine, this impeller rotates in a casing filled with fluid.
- The heat developed due to dissipation of power is carried away by a continuous supply of working fluid, usually water.
- The output can be controlled by regulating the sluice gates which can be moved in and out to partial or wholly obstructive flow of water between impeller and the casing.

HYDRAULIC DYNAMOMETER



Transmission Dynamometers :

- Power-measuring dynamometers may be **transmission dynamometers** or absorption dynamometers. The former utilize devices that measure torque, in terms of the elastic twist of the shaft or of a special torquemeter inserted between



1) Belt Transmission Dynamometer :

- It consists of endless or continuous belt run over the driving pulley.
- The driving pulley is rigidly fixed to the shaft of an engine whose power is to be transmitted.
- The intermediate pulleys rotates on a pin fixed to a lever having a fulcrum at the midpoint of the two pulley centers.
- A balancing weight is provided in the lever to initially keep it in equilibrium.
- The weight of suspended mass at one end of the lever balances the difference in tensions of tight and slack sides of the belt.

The weight of suspended mass at One end of the lever balances the difference in Tensions of Tight and Slack sides of the belt .

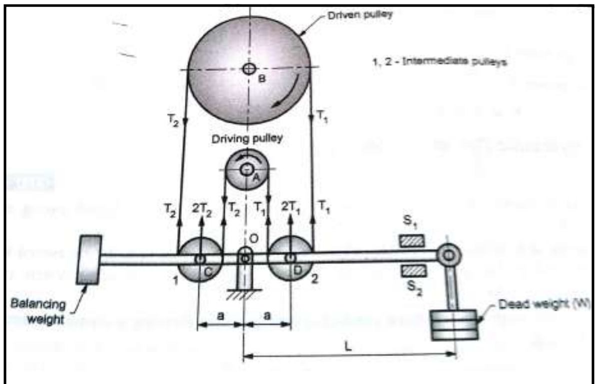
Therefore when the lever is in horizontal position , the total moment of all the forces about the fulcrum **O** should be Zero .

$$\Sigma M_o = 0$$
$$(2 * T_1 * a) - (2 * T_2 * a) = W * L$$
$$(2 * T_1 * a) = W * L + (2 * T_2 * a)$$
$$2 * a * (T_1 - T_2) = W * L$$
$$(T_1 - T_2) = (W * L) / (2 * a)$$

Power of Engine $P = (T_1 - T_2) * v$

where v = Belt speed in **(πDN/60)** m/sec

$$P = (T_1 - T_2) * (\pi DN/60)$$



Belt Transmission Dynamometer

2) Epicyclic Train Dynamometer :

- Epicyclic train dynamometer which measures power while it is being transmitted from driving to the driven shaft.
- It consist of simple epicyclic gear train.
- The pinion is free to rotate on a pin fixed to the lever arm.
- The lever is pivoted about common axis of the driving and driven shaft.
- When the dynamometer is in operation, two tangential forces acts at the end of pinion.

Since these Efforts act in the Upward Direction , therefore total upward force on the lever acting through the axis of the pinion is **2F** . This force tends to rotate the lever about its Fulcrum and it is balanced by a Dead weight **W** at the end of the lever . The stops S_1 & S_2 are provided to control the movement of the lever .

For equilibrium of the lever , taking moment about the Fulcrum **E** ,

2F * a = W * L

let , **R** = Pitch circle radius of the spur gear in meter ,

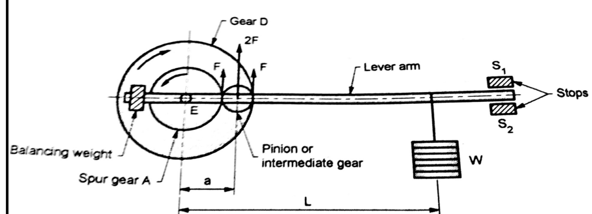
N = Speed of the engine shaft in R.P.M.

Torque Transmitted by Engine **T = F * R**

= (W * L / 2 * a) * R

Power Transmitted by Engine **P = T * ω**

= (W * L / 2 * a) * R * (2πN/60)



3) Torsion Dynamometer :

- When power is transmitted along a shaft, the driving end twists through a small angle relative to the driven end.
- Torque transmitted is directly proportional to the angle of twist.
- Therefore, a torsion dynamometer works on the principle of angle of twist.
- Torsion dynamometers can measures large powers as in case of power transmitted along the angle of twist in radians is given by,

By Torsion Equation ,

T/J =C*Ө / l

where, **Ө** = Angle of twist in radian ,

J = Polar moment of inertia of the shaft For a Solid shaft of Diameter **D** , the polar moment of inertia

J = (π/32) * (D)^4

For a Hollow Shaft of external diameter **D** and internal Diameter **d** ,the polar moment of inertia ,

J = (π/32) * [(D)^4– (d)^4]

From the above Torsion Equation,

T = C*Ө*J / l = k*Ө

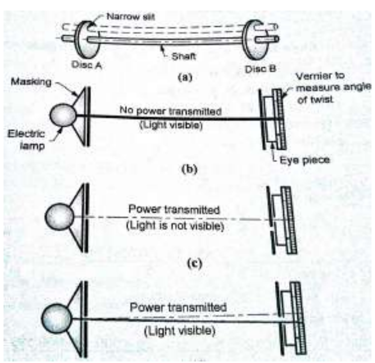
where, **k = C*J / l** is a constant for a particular shaft . Thus ,the Torque Acting on the shaft is Proportional to the Angle of Twist . This means that if the angle of twist is measured by some means , then the Torque and hence the Power Transmitted may be determined .

Power Transmitted **P = T * (2πN/60) Watts**

Quartz torque dynamometer.

4) Bevis-Gibson flash light torsion dynamometer :

- It consists of two discs A and B fixed on shaft at convenient distance.
- A radial narrow slit is made in each of the two discs.
- Behind disc A powerful electric lamp is fixed on the bearing of shaft.
- To the right of the disc B an eye-piece is fitted on shaft bearing.
- When torque or power is transmitted through the shaft, it twists so that disc B lags behind the disc A.



……..**THANK YOU**…….