MEASUREMENT OF FORCE

The mechanical quantity which changes or tends to change the motion or shape of a body to which it is applied is called force. Force is a basic engineering parameter, the measurement of which can be done in many ways as follows:

- Directmethods
- Indirectmethods

- Directmethods

  It involves a direct comparison with a known gravitational force on a standard mass, say by a balance.

- Indirectmethods

  It involves the measurement of effect of force on a body, such as acceleration of a body of known mass subjected to force.

Devices to measureForce

- Scale andbalances
  a. Equal armbalance
  b. Unequal armbalance
  c. Pendulumscale
- Elastic force meter (Provingring)
- Loadcells
  a. Strain gauge loadcell
  b. Hydraulic loadcell
  c. Pneumatic loadcell

Scale and balances

a. Equal armbalance

An equal arm balance works on the principle of moment

comparison. The beam of the equal arm balance is in equilibrium position when,

Clockwise rotating moment = Anti-clockwise rotating moment

$$M_2L_2 = M_1L_1$$

That is, the unknown force is balanced against the known gravitational force.

Description

The main parts of the arrangement are a follows:

- A beam whose centre is pivoted and rests on the fulcrum of a knife edge. Either side of the beam is equal in length with respect to thefulcrum
- A pointer is attached to the center of the beam. This pointer will point vertically downwards when the beam is inequilibrium.
- A Provision to place masses at either end of thebeam.

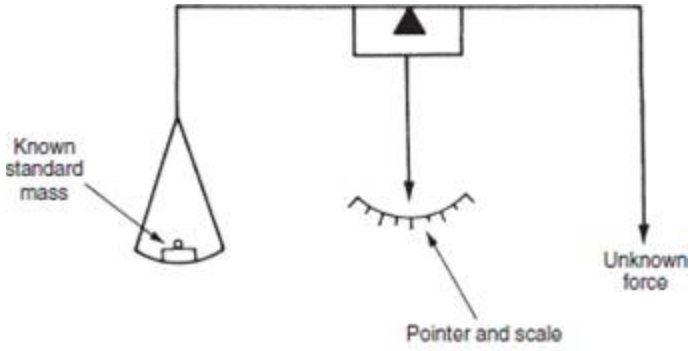

Fig 5.1 Equal Arm Balance

Operation

- A known standard mass (m_1) is placed at one end of the beam and an unknown mass (m_2) is placed at its other end.
- Equilibrium conditionexistswhen, clockwise rotating moment = Anti- clockwise rotatingmoment
- Moreover at a given location, the earth's attraction will act equally on both the masses (m1 and m2) and hence at equilibrium condition. W1=W2. That is, the unknown force

(weight) will be equal to the known force(weight).

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b. Unequal armbalance

An unequal arm balance works on the principle of moment comparison. The beam of the unequal arm balance is in

equilibrium position when, Clockwise rotating

moment = Anti-clockwise rotating moment

$$F \times L_2 = F_x \times L_1$$

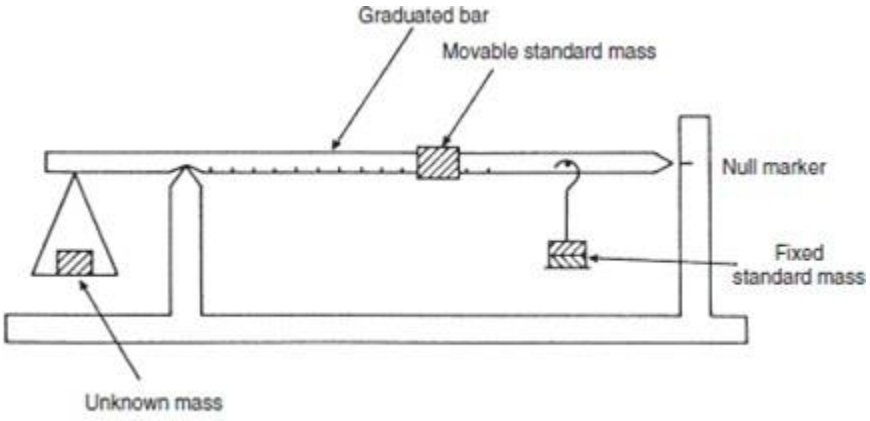

Fig 5.2 Unequal Arm Balance

Description

The main parts of the arrangements are as follows:

- A graduated beam pivoted to a knife edge"Y"
- A leveling pointer is attached to thebeam
- A known mass "m" is attached to the right side of the beam. This creates an unknown force "F". This mass "m" can slide on the right side of thebeam.
- Provisions are made to apply an unknown force "F_x" on the left side of the beam.

Operation

- An unknown force "Fx" is applied on the left side of the beam through knife edge "Z" asshown
- Now the position of mass "m" on the right side of the beam is adjusted until the leveling pointer reads null balance position.

When the leveling pointer is in null balance position, the beam is inequilibrium.

Clock wise rotating moment = Anti-clock wise rotating moment

$$F_x.L_1 = F.\ L_2$$

$$F_x = Mg.L2/L_1$$

- Thus the unknown force "F_x" is proportional to the distance "L_2" of the mass "m" from the knife edge"Y"
- The right hand side of the beam which is graduated is calibrated to get a direct measure of"F_x"

c. Pendulum Scale(Multi-leverType)

It is a moment comparison device. The unknown force is converted to torque which is then balanced by the torque of a fixed standard mass arranged as a pendulum.

Description

- The scale's frames carry support ribbons. These support ribbons are attached to the sectors. The loading ribbons are attached to the sectors and the load rod a shown. The load rod is inturn attached to the weighingplatform.
- The two sectors are connected on either side of an equalizer beam. The sectors carry counter weighs. To the centerof

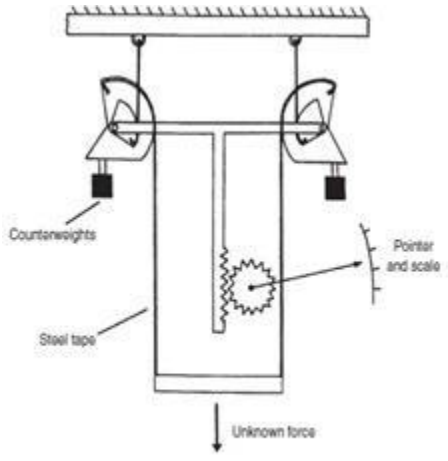

Fig 5.3 Pendulum Scale

the equalizer beam is attached a rack and pinion arrangement.

- A pointer is attached to the pinion which sweeps over a weight (force) calibratedscale.

Operation

- The unknown force is applied to the load rod. Due to this force, the loading tapes are pulled downwards. Hence the loading tapes rotate thesectors.
- As the sectors rotate about the pivots, it moves the counter weights outwards, This movements increases the counter weight effective moment until the torque produced by the force applied to the load rod and the moment produced by the counter weight balance each other, thereby establishing anequilibrium.
- During the process of establishing equilibrium, the equalizer beam would be displaced downwards. As the rack is attached to the equalizer beam, the rack also is displaced downwards rotating thepinion.
- As the pointer is attached to the pinion, the rotation of the pinion makes the pointer to assume a new position on the scale. The scale is calibrated to read the weight directly. Thus the force applied on the load rod ismeasured.