TORQUE

Following are the essentials of indicating instruments:

OPERATING TORQUE   CONTROLLING TORQUE   DAMPING TORQUE

1. **Operating torque/ deflection torque**
   a) Operating torque is required to move the moving system of the instrument.
   b) The operating torque causes the moving system to move from zero position when the instrument is connected to the circuit to measure the given electrical quantity.
   c) To calculate deflection torque, the equation is as follow:

   Torque, T= BINA

   Where, T = Torque in unit Newton Meter (Nm)

   B = Flux density in unit Tesla (T)@wb/m^2

   I = Current through coil in unit Ampere (A)

   N = Numbers of coil

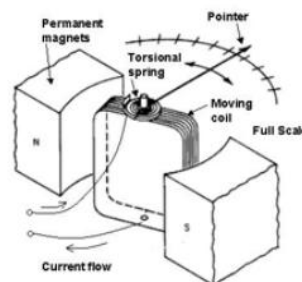   A = Cross-sectional area (Length in unit Meter(m) x Diameter of coil in unit Meter (m))

Figure 1 : PMMC

2. **Controlling torque**
   a) Controlling torque opposes the operating torque.
   b) It ensures that the deflection of the pointer is according to the magnitude of electrical quantity being measured.
   c) It also brings the pointer back to zero when the instrument is removed from the circuit.
   d) This torque is either obtained by **spring** or by **gravity**.
   e) In **spring control**, one or two phosphor bronze spiral hair-springs are attached to the moving spindle. The other end is attached to the frame.
   f) In **gravity control**, a small weight is attached to the moving system is such a way it tries to bring the pointer back to the zero position when it is deflected, due to gravity.

3. Damping torque

a) Controlling torque controls the deflection and tries to stop the pointer at its final position.
b) But due to inertia, the pointer oscillates around its final position before coming to rest.
c) Hence, damping torque is providing to avoid this oscillation and bring the pointer quickly to its final position.

3.1 Relationship between Critical Damping, Over Damping & Under Damping with Moving Coil needle

a) **Under damped case** : The pointer attached to moveable coil oscillates back and forth several times before coming to rest.
b) **Over damped case** : The pointer tends to approach the steady state position in a sluggish manner.
c) Critically damped case: The pointer moves up to its steady state position before oscillations. It is the ideal behaviour for a PMMC movement.
* in practice, however, the instrument is usually slightly under damped, causing the pointer to overshoot a little before coming to rest.

3.2 Common Damping System in Indicating Instrument

a) Air friction damping
A damping force is provided by the movement of an aluminium piston in the air chamber.
When the pointer deflects in the clockwise direction, the piston moves out of the chamber, and the pressure inside the chamber falls below the external value.
The difference between these two pressures acts on the piston and tries to arrest it movement.
Again when the piston moves into the chamber, the air inside it will be compressed, and this compression opposes the movement of the piston and damping occurs.

b) Liquid Damping
The liquid damping is similar to air friction damping. Mineral oil is used in place of air. The vane attached to the spindle is arranged to move in the damping oil. The liquid damping system is rarely used in commercial type instruments.

c) Eddy current Damping
Is the most efficient form of damping. The essential components in this type of damping are a permanent magnet and a light conducting the disc, usually aluminium.
When a sheet of conducting material moves in a magnetic field so as to cut through the line of force, eddy currents are set up in it and a force exists between these currents and the magnetic field, which is always in the direction opposing the motion.