Flow measurement

(Instrumental Technique)

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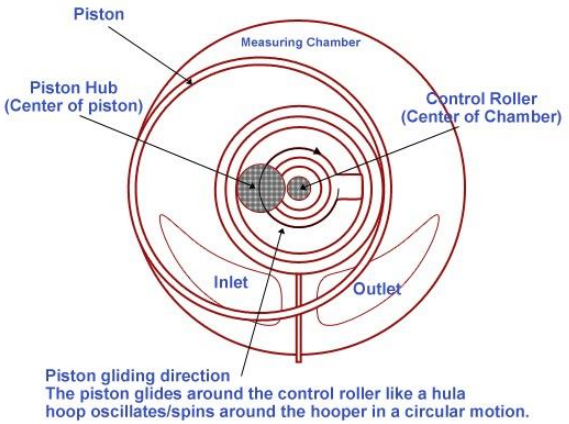
Flow Measurement is a quantification of bulk movement of fluid

1. Pressure based flow meters
2. **Mechanical Flow meters**
3. Optical Flow meters
4. Open Channel flow meters
5. Thermal mass flow meters
6. Vortex Flow meters
7. Sonar Flow meters
8. Electromagnetic flow meters
9. Laser Doppler flow meters

Mechanical flow meters

Principle: Positive displacement meter can be compared to a bucket and stop-clock. Amount of time required to fill a bucket gives the volumetric flow rate.



Rotary flow-meter

Oval gear flow-meter

Helical gear flow-meter

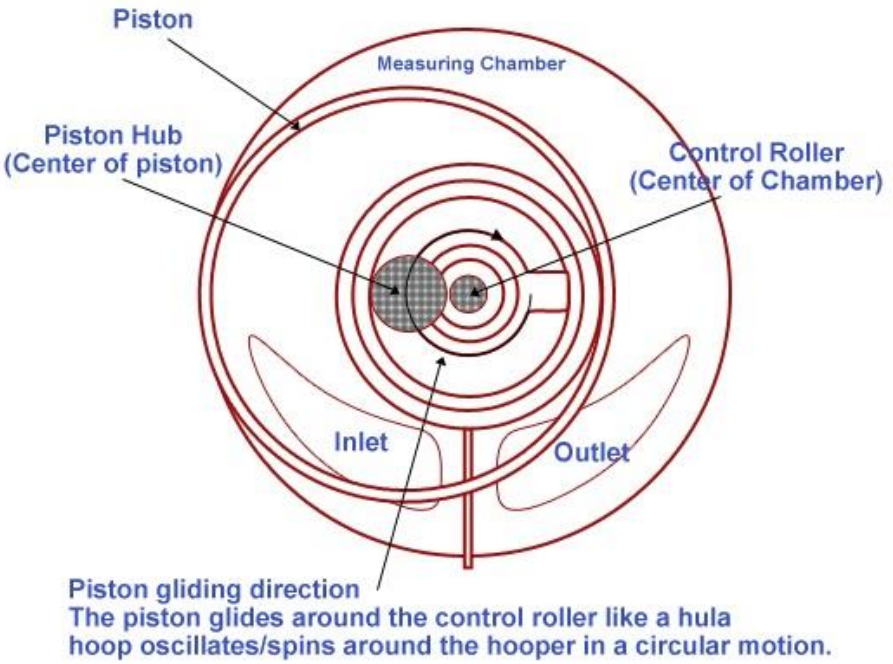
Nutating flow-meter

Paddle wheel flow-meter

Woltman flow-meter

Rotary flow meter

- Oscillating piston meters use a precision-machined chamber containing a cylindrical piston that oscillates as liquid flows.
- The piston's central shaft is constrained to run in a circular groove in the chamber, resulting in an off-center rotating motion as the liquid sequentially enters and exits compartments machined into the underside of the piston.
- Since the volume of the compartments are known, the amount of liquid metered per revolution can be calculated accurately.
- The position of the piston divides the chamber into compartments containing an exact volume. Liquid pressure drives the piston to oscillate and rotate on its center hub. The movements of the hub are sensed through the flow meter wall by a follower magnet.



- Each revolution of the piston hub is equivalent to a fixed volume of fluid, which is indicated as flow by an indicator/totalizer. Close clearances between the piston and the chamber ensure minimum liquid slip for highly accurate and repeatable flow measurement of each volume cycle.

Advantages:

- High accuracy and repeatability.
- Only one moving part to cause wear.
- Can be made of materials to ensure sanitary needs of food and beverage processing.

Disadvantages:

- Can only be used with relatively clean liquids.

Oval flow meter

- The oval gear PD meter uses two fine-toothed gears, one mounted horizontally, the other vertically, with gears meshing at the tip of the vertical gear and the center of the horizontal gear .
- The two rotors rotate opposite to each other, creating an entrapment in the crescent-shaped gap between the housing and the gear.
- These meters can be very accurate if slippage between the housing and the gears is kept small.
- If the process fluid viscosity is greater than 10 centipoise and the flow rate is above 20% of rated capacity, accuracy of 0.1% AR can be obtained.
- At lower flows and at lower viscosity, slippage increases and accuracy decreases to 0.5% AR or less.

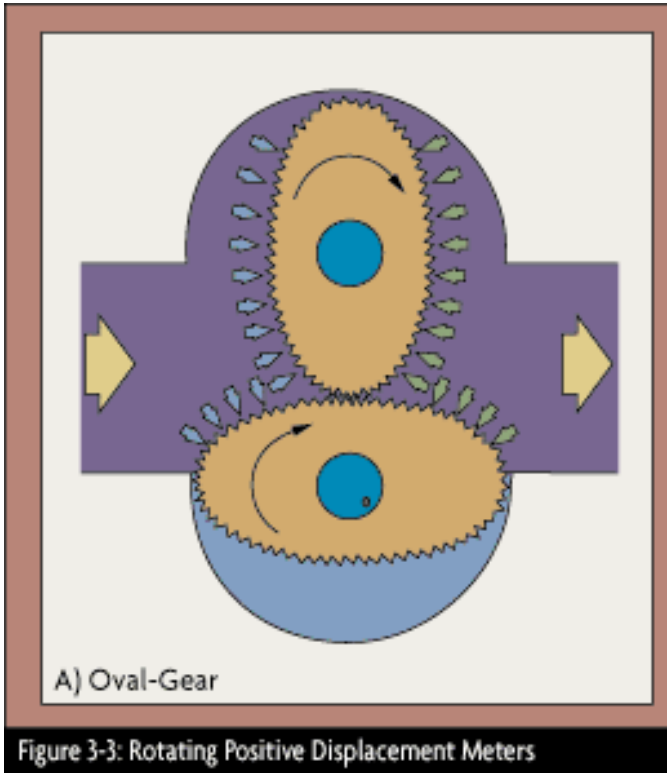


Figure 3-3: Rotating Positive Displacement Meters

- The lubricating characteristics of the process fluid also affect the turndown of an oval gear meter. With liquids that do not lubricate well, maximum rotor speed must be derated to limit wear.

Helical flow meter

- The helix meter is a positive displacement device that uses two radially pitched helical gears to continuously entrap the process fluid as it flows.

- The flow forces the helical gears to rotate in the plane of the pipeline. Optical or magnetic sensors are used to encode a pulse train proportional to the rotational speed of the helical gears.

- The forces required to make the helices rotate are relatively small and therefore, in comparison to other PD meters, the pressure drop is relatively low.

- Helical gear meters can measure the flow of highly viscous fluids (from 3 to 300,000 cP), making them ideal for extremely thick fluids such as glues and very viscous polymers.

Nutating disc meter

- Nutating disc meters are the most common PD meters. They are used as residential water meters around the world. As water flows through the metering chamber, it causes a disc to wobble (nutate), turning a spindle, which rotates a magnet. This magnet is coupled to a mechanical register or a pulse transmitter.

- Because the flow meter entraps a fixed quantity of fluid each time the spindle is rotated, the rate of flow is proportional to the rotational velocity of the spindle.

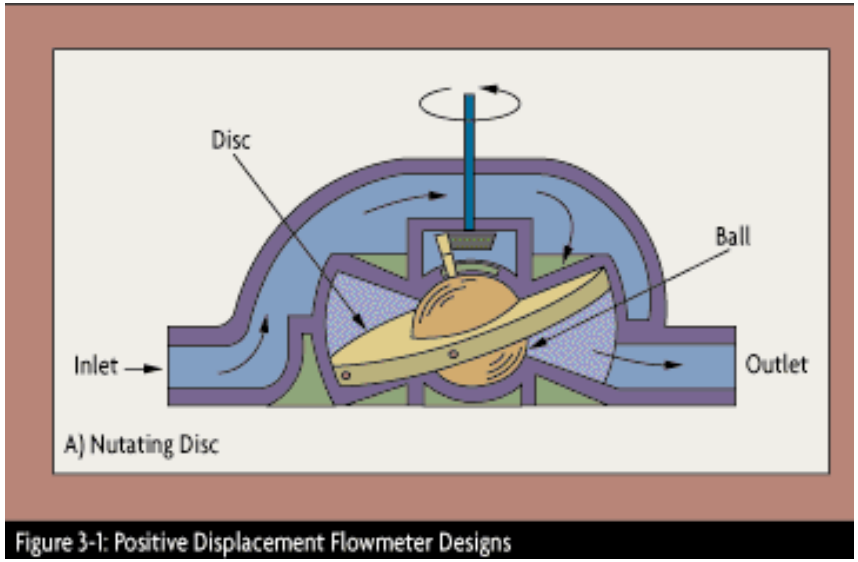


Figure 3-1: Positive Displacement Flowmeter Designs

- Because it must be nonmagnetic, the meter housing is usually made of bronze but can be made from plastic for corrosion resistance or cost savings. The wetted parts such as the disc and spindle are usually bronze, rubber, aluminum, neoprene, Buna-N, or a fluoroelastomer such as FKM.

- Nutating disc meters are designed for water service and the materials of which they are made must be checked for compatibility with other fluids. Meters with rubber discs give better accuracy than metal discs due to the better sealing they provide.

Woltman flow meter

- Invented by Reinhard Woltman in the 18th century, the turbine flow meter is an accurate and reliable flow meter for both liquids and gases.
- It consists of a multi-bladed rotor mounted at right angles to the flow and suspended in the fluid stream on a free-running bearing.
- The diameter of the rotor is very slightly less than the inside diameter of the metering chamber, and its speed of rotation is proportional to the volumetric flow rate.

- Turbine rotation can be detected by solid state devices (reluctance, inductance, capacitive and Hall-effect pick-ups) or by mechanical sensors (gear or magnetic drives).
- In the reluctance pick-up, the coil is a permanent magnet and the turbine blades are made of a material attracted to magnets. As each blade passes the coil, a voltage is generated
- In the inductance pick-up, the permanent magnet is embedded in the rotor, or the blades of the rotor are made of permanently magnetized material (Figure 3-8B). As each blade passes the coil, it generates a voltage pulse.

Thank you