

Our Organisation

Location:



Our offices are located in the industrial area of Kfar Saba, an expanding town 15km north of Tel Aviv and 30 minutes from Ben Gurion International Airport, close to the Route 6 highway placing us in a convenient position for access from all parts of the country, avoiding inner city congestion.



אינסטרומטריקס
הנדסה בע"מ



Flow Technology Theory

Bob Umpleby

Instrumetrics Engineering Ltd.



אינסטרומטריקס
הנדסה בע"מ

Flow Technology Theory



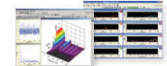
אינסטרומטריקס
הנדסה בע"מ



Our Business



A privately owned company established in 1976 to provide the Israeli market with sales, technical support and professional services in the fields of Sensing, Calibration, Monitoring & Signal Conditioning and Data Acquisition.



אינסטרומטריקס
הנדסה בע"מ

History

-18th Century, Daniel Bernouli – Conservation of Energy in Fluid Flows – the basis for many of the flow measuring instruments in use today



אינסטרומטריקס
הנדסה בע"מ

History

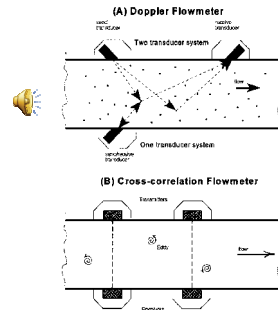
- Interest in measurement of water and air flow goes back to earliest recorded history



אינסטרומטריקס
הנדסה בע"מ

History

-19th Century, Christian Doppler – Doppler effect, used in Doppler Flow Meters



אינסטרומטריקס
הנדסה בע"מ

History



- Greek philosophers Aristotle and Archimedes studied fluid dynamics, pneumatics and aerodynamics
- Archimedes screw



אינסטרומטריקס
הנדסה בע"מ

Fluid Flow

- Flow rates of liquids expressed in volumetric or mass units:
 - l/min, m³/hr, gpm, gph, kg/hr, lb/hr
- Flow rates of gases and vapours usually expressed in volumetric units:
 - m³/hr, cc/min, scfm, scfh
- Flow rates of steam usually expressed in mass units:
 - kg/hr, lb/hr



אינסטרומטריקס
הנדסה בע"מ

History

- 19th Century, Osborne Reynolds – Reynold's Number – a single number used to describe fluid flow



$$Re = \frac{\rho V D}{\mu}$$



אינסטרומטריקס
הנדסה בע"מ

Characteristics of Fluid Flow

- Most important – is the fluid a liquid, gas or vapour
 - At certain temperatures and pressures most fluids can change phase between vapour, liquid or solid. E.g. Water can be heated to make steam or cooled to become ice. Gases can be condensed to liquids like liquid N₂ or liquid O₂.
- A number of physical properties influence flow meter selection
 - Pressure, velocity, density, viscosity, compressibility, electrical capacitance and conductivity, thermal conductivity, response to sonic impulses, light or mechanical vibration.
- Major factors affecting fluid flow are the properties of the fluid, Reynolds number (describes the type of flow) and compressibility of the fluid.



אינסטרומטריקס
הנדסה בע"מ

Fluid Flow

- Movement of liquids, gases or vapours in pipes, ducts, channels
- A fluid is a material that takes the shape of its container
[abc19387625a768e18f38d00b415a823.avi](#)
- All liquids and gases are fluids
- Need to measure fluid flow has generated a variety of instruments based on various scientific principles
- Often more convenient to measure flow using some other characteristic that varies with flow such as pressure drop caused by restriction in pipeline
- Two types of flow measurement are flow rate and total flow



אינסטרומטריקס
הנדסה בע"מ

Compressibility

- An incompressible fluid - very little change in volume when subject to change in pressure. Liquids are essentially incompressible.
- A compressible fluid – volume and density change when subject to change in pressure. Gases and vapours are compressible fluids.
- Flowing condition is the pressure and temperature of the gas or vapour at the point of measurement. Actual flow is the flowing volume at the temp and press at the point of measurement.
- Standard or Normal conditions are an accepted set of temp and press conditions used as a basis for measurement. This compensates for the compressibility of fluids. Standard or Normal conditions are used as units of measure.
- Gases measured at Actual conditions can be converted to Standard (Normal) conditions using the gas laws.



אינסטרומטריקס
הנדסה בע"מ

Characteristics of Fluid Flow

- Reynolds Number
 - Ratio between inertial forces moving a fluid and viscous forces resisting that movement.
 - Describes the nature of the fluid flow.
 - Has no units.
 - Calculated from velocity or flow rate, density, viscosity and pipe ID
 - Reynolds numbers usually between 100 and 1,000,000

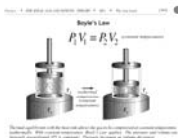
$$Re = \frac{\rho V D}{\mu}$$



אינסטרומטריקס
הנדסה בע"מ

Gas Laws

- The gas laws provide the basis for determining the volume of a gas at one set of pressure and temperature conditions when data from another set of conditions are known.



-Boyle's Law -

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

-Charles' Law -

- Gay-Lussac's Law -

$$\frac{P_1}{T_1} = \frac{P_2}{T_2} \quad P_1 T_2 = P_2 T_1$$



אינסטרומטריקס
הנדסה בע"מ

Reynolds Number and Flow Profiles

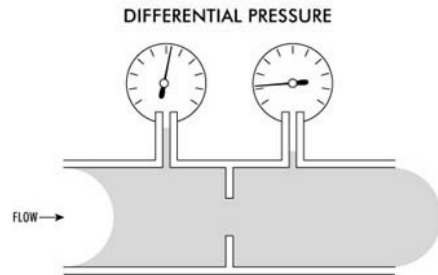
Laminar Stratified, parabolic profile Re = 0 to 2000	
Transitional Undefined profile Re = 2000 to 4000	
Turbulent Flattened profile Re = >4000	



אינסטרומטריקס
הנדסה בע"מ

Differential Pressure

Different geometries are used for different measurements, including the [orifice plate](#), [flow nozzle](#), [laminar flow element](#), [low-loss flow tube](#), [segmental wedge](#), [V-cone](#), and [Venturi tube](#).



Gas Laws

- Combined Gas Law -

$$\frac{P_1 \cdot V_1}{T_1} = \frac{P_2 \cdot V_2}{T_2}$$

Differential Pressure

-Differential pressure calculations for flow through the restriction are based on the Bernoulli equations.

- The basic flow equation for all fluid flow in pipes relates the flow rate to the area of flow and the square root of the pressure drop.

- In its simplest terms the equation can be written as:

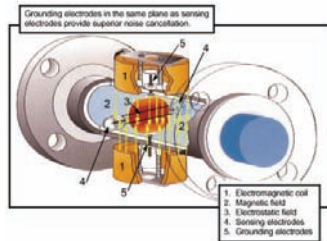
$$Q = k \cdot \sqrt{DP}$$

Flow Meter Types

- Differential Pressure
- Positive Displacement
- Turbine Meters
- Magnetic Flowmeters
- Vortex Shedding Flowmeters
- Ultrasonic Flowmeters
- Coriolis Meters
- Thermal Mass Meters
- Open Channel Flow

Magnetic Flow Meters

- A magnetic field is created across a section of by electromagnetic coils
- The flowing motion of a **conductive** fluid produces a measurable electric current (Faradays principle of electromagnetic induction)
- The current is proportional to the fluid velocity
- The voltage delivered to the electrodes represents an average of the flow cross section



Faraday's Formula:
E is proportional to $V \times B \times D$ where:

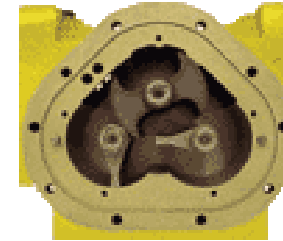
- E = The voltage generated in a conductor
- V = The velocity of the conductor
- B = The magnetic field strength
- D = The length of the conductor



אינסטרומטריקס
הנדסה בע"מ

Positive Displacement

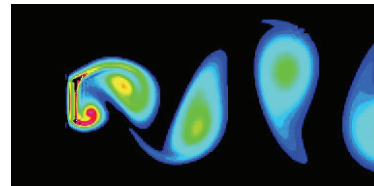
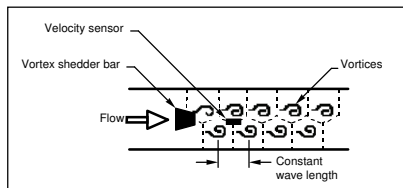
- Chambers in the flow stream alternately fill and empty with fluid
- They operate with rotating gears or oscillating pistons
- This will divide the volume being measured into segments that can be counted on a local totalizer or transmitted remotely.



אינסטרומטריקס
הנדסה בע"מ

Vortex Shedding Flow Meters

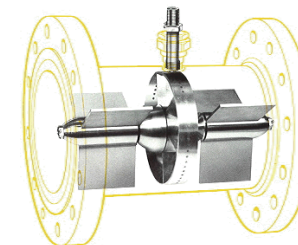
- Flow across a bluff body will alternately shed vortices on either side (the Von Karman effect). The frequency is proportional to the fluid velocity
- A change of pressure or temperature can be used to detect the vortex frequency



אינסטרומטריקס
הנדסה בע"מ

Turbine Meters

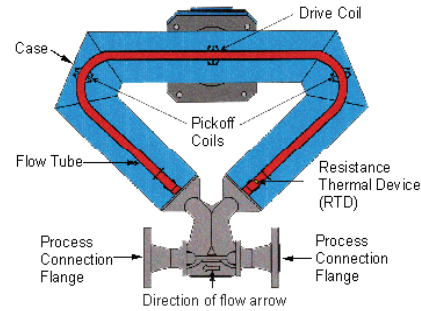
- Fluid passes through a free turning rotor
- Rotational velocity of the rotor blades is a measure of flow rate
- The velocity is detected by mechanical, magnetic, RF pick-offs



אינסטרומטריקס
הנדסה בע"מ

Coriolis Flow Meters

- These differ from other flowmeters because they have the ability to measure the mass of a fluid directly. Two semi-circular sections of tubing in line with the pipe are vibrated to their resonant frequency.
- As fluid passes through them a detectable secondary vibration is created due to the Coriolis (twisting) motion the fluid experiences



אינסטרומטריקס
הנדסה בע"מ

Ultrasonic Flow Meters

Transit Time Technique

◀ = Transducer is *both* the **transmitter and receiver**

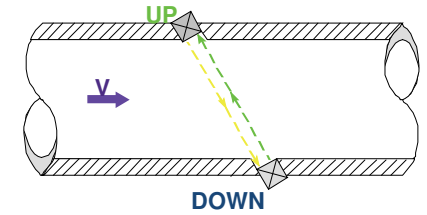
⚡ = Ultrasonic Pulses

t = Transit Times

- Upstream direction, t_{up}
- Downstream direction, t_{dn}

t_{up} = Ultrasound is *decelerated* by flow

t_{dn} = Ultrasound is *accelerated* by Flow



$$t_{up} > t_{dn}$$

$$\Delta t = t_{up} - t_{dn}$$

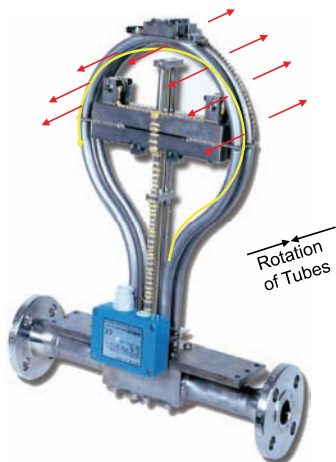
$$V = f(\Delta t)$$

$$Q = V \cdot A$$



אינסטרומטריקס
הנדסה בע"מ

Coriolis Flow Meters



As flow runs around the Omega tube perpendicular to the direction of oscillation, the Coriolis Force generated causes the measurement tubes to flex inwards or outwards, depending upon the direction of rotation



אינסטרומטריקס
הנדסה בע"מ

Ultrasonic Flow Meters

Transit Time Technique



אינסטרומטריקס
הנדסה בע"מ

Open Channel Meters

- Uses a restriction to create a head of liquid
- The height of the head is measured and used to determine the flow rate
- Common devices are weirs and Parshall flumes



Contracted Rectangular



Suppressed Rectangular



Cipolletti Contracted



Contracted Triangular or V-notch



אינסטרומטריקס
הנדסה בע"מ

Coriolis Flow Meters



אינסטרומטריקס
הנדסה בע"מ

Contact Me

Instrumetrics Engineering Ltd.

HaTaas 20

Beit HaPaamon, Unit 423

Kfar Saba 44425

Israel

Tel.: +972 9 7645820

Fax: +972 9 7645821

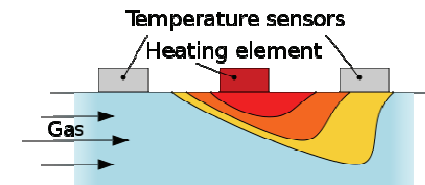
E-mail: bob@instrumetrics.com



אינסטרומטריקס
הנדסה בע"מ

Thermal Mass Meters

- Have two RTD temperature sensors and a heating element
- One of the sensors is heated (flow sensor) and the other measures (reference sensor) the gas temperature
- As gas flows by the flow sensor, the gas molecules carry heat away from the surface and the sensor cools down
- Power is applied to the heater to heat the flow sensor and maintain a constant temperature differential above the reference sensor
- The amount of electrical power required to maintain a constant temperature differential is directly proportional to the gas mass flow
- An alternative method uses a constant power input to the flow sensor and measures the changes in temperature difference



אינסטרומטריקס
הנדסה בע"מ