Measuring flow rate essay sample

1) Introduction

The importance of flow measurement in the industry has grown in the past 50 year, not just because it was widespread use for accounting purposes, such as custody transfer of fluid from supplier to customers, but also because of its application in manufacturing processes. Examples of the industrial involvement in flow measurement includes food and beverage, oil and gas industrial, medical, petrochemical, power generation, and water distribution and etc. Flow measurement is the determination of the quantity of a fluid, either a liquid, or vapor, that passes through a pipe, duct or open channel. Flow may be expressed as a rate of volumetric flow (such as gallons per minute, cubic meters per minute, cubic feet per minute), mass rate of flow (such as kilograms per hour, pounds per hour), or in terms of total volume or mass flow (integrated rate of flow for a given period of time)

Fluid flow measurement can be divided into several types; each type requires specific considerations of such factors as accuracy requirements, cost considerations, and use of the flow information to obtain the required end results. Normally the flow meter is measure flow indirectly by measuring a related property such as a differential pressure across a flow restriction or a fluid velocity in a pipe. A number of different fundamental physical principles are used in flow measurement devices. There is various kind of the flow meter available in market; they can be in many types.

2) Types of flow meters

i) Difference pressure flow meter

a. Orifice plate

b. Venturi tube

c. Pitot tube and

ii) Variable area flow meter

a. Rota meter

iii) Positive displacement flow meter

iv) Turbine flow meter

v) Electromagnetic flow meter

vi) Ultrasonic flow meter

vii) Coriolis (Mass) flow meter

This report will talk about the first four types of Flow meters

3) Advantages & disadvantages

Advantages:

✓ Long history of use in various applications

✓ Availability of equipment and data

✓ Measures a wide range of flow rates

✓ Inexpensive when compared to many other flowmeters

Accurate

Disadvantages:

✓ Requires homogeneous fluid

✓ Requires single phase fluid

✓ Requires turbulent flow profile (Reynolds Number greater than or equal to

4000)

✓ Requires axial velocity vector flow

✓ Causes a pressure drop in fluid

✓ Obstructs solids in fluid

4) Way of Selection

• To select a flow meter that suits one's application, many factors need to be considered. The most important ones are fluid phase (gas, liquid, steam, etc.) and flow condition (clean, dirty, viscous, abrasive, open channel, etc.)

• The second most important factors are line size and flow rate (They are closely related). This information will further eliminate most sub models in each flow meter technology.

• Other fluid properties that may affect the selection of flow meters include density (specific gravity), pressure, temperature, viscosity, and electronic conductivity. On the flow part, one needs to pay attention to the state of fluid (pure or mixed) and the status of flow (constant, pulsating, or variable).

• Moreover, the environment temperature, the arrangements (e. g., corrosive, explosive, indoor, outdoor), the installation method (insertion, clamped-on, or inline), and the location of the flow meter also need to be considered, along with other factors which include the maximum allowable pressure drop, the required accuracy, repeatability, and cost (initial set up, maintenance, and training).[2]

5) differential pressure flow meters

In a differential pressure drop device the flow is calculated by measuring the pressure drop over an obstructions inserted in the flow. The differential pressure flow meter is based on the Bernoulli's Equation, where the pressure drop and the further measured signal is a function of the square flow speed, there many type of it such as. Orifice plate, Venturi tube, Pitot tube .

5. 1) Orifice plate

An orifice plate is a restriction with an opening smaller than the pipe diameter which is inserted in the pipe; the typical orifice plate has a concentric, sharp edged opening, in practice, the orifice plate is installed in the pipe between two flanges. Acting as the primary device, the orifice constricts the flow of liquid to produce a differential pressure across the plate Because of the smaller area the fluid velocity increases, causing a corresponding decrease in pressure. The flow rate can be calculated from the measured pressure drop across the orifice plate, P1-P2. Venturi and Orifice Flow Meter equation for calculating flow rate through either an orifice or venturi meter

Figure 1

Q: the flow rate through the pipe and through the meter (cfs – U. S. or m3/s – S. I.) Cd: the discharge coefficient, which is dimensionless

Ao: the constricted area perpendicular to flow (ft2 – U. S. or m2 – S. I.) P1: the undisturbed upstream pressure in the pipe (lb/ft2 – U. S. or N/m2 – S. I.) P2: the pressure in the pipe at the constricted area, Ao (lb/ft2 – U. S. or N/m2 – S. I.) β = D2/D1 = (diam. at A2/pipe diam.), which is dimensionless ρ: the fluid density (slugs/ft3 – U. S. or kg/m3 – S. I.)

5. 2) Venturi tube

Venturi tube, short pipe with a constricted inner surface, used to measure fluid flows and as a pump. The 18th–19th-century Italian physicist Giovanni Battista Venturi, observing the effects of constricted channels on fluid flow, designed an instrument with a narrow throat in the middle; fluid passing through the tube speeds up as it enters the throat, and the pressure drops. There are countless applications for the principle—e. g., an automobile carburetor, in which air flows through a venturi channel at whose throat gasoline vapour enters through an opening, drawn in by the low pressure. The pressure differential can also be used to measure fluid flow

Equations

Figure 2

5. 3) Pitot tube

Is a pressure measurement instrument used to measure fluid flow velocity. The pitot tube was invented by the French engineer Henri Pitot in the early 18th century and was modified to its modern form in the mid-19th century by French scientist Henry Darcy. It is widely used to determine the airspeed of an aircraft and to measure air and gas velocities in industrial applications. The pitot tube is used to measure the local velocity at a given point in the flow stream and not the average velocity in the pipe or conduit

Equations:

The basic pitot tube consists of a tube pointing directly into the fluid flow. As this tube contains fluid, a pressure can be measured; the moving fluid is brought to rest (stagnates) as there is no outlet to allow flow to continue. This pressure is the stagnation pressure of the fluid, also known as the total pressure or (particularly in aviation) the pitot pressure. The measured stagnation pressure cannot of itself be used to determine the fluid velocity (airspeed in aviation). However, Bernoulli's equation states: Stagnation pressure = static pressure + dynamic pressure This can also be written as

Solving that for velocity we get:

NOTE: The above equation applies ONLY to fluids that can be treated as incompressible. Liquids are treated as incompressible under almost all conditions. Gases under certain conditions can be approximated as incompressible. See Compressibility. Where:

- is fluid velocity;
- is stagnation or total pressure;
- is static pressure;
- and is fluid density.

The value for the pressure drop – or due to , the reading on the manometer:

Where:

- is the density of the fluid in the manometer
- is the manometer reading

The dynamic pressure, then, is the difference between the stagnation pressure and the static pressure. The static pressure is generally measured using the static ports on the side of the fuselage. The dynamic pressure is then determined using a diaphragm inside an enclosed container. If the air on one side of the diaphragm is at the static pressure, and the other at the stagnation pressure, then the deflection of the diaphragm is proportional to the dynamic pressure, which can then be used to determine the indicated airspeed of the aircraft. The diaphragm arrangement is typically contained within the airspeed indicator, which converts the dynamic pressure to an airspeed reading by means of mechanical levers. Instead of separate pitot and static ports, a pitot-static tube (also called a Prandtl tube) may be employed, which has a second tube coaxial with the Pitot tube with holes on the sides, outside the direct airflow, to measure the static pressure Figure 3

6) Variable area flow meter

A variable area meter is a meter that measures fluid flow by allowing the cross sectional area of the device to vary in response to the flow, causing some measurable effect that indicates the rate. 6. 1) Rota meter

A rota meter is a device that measures the flow rate of liquid or gas in a closed tube, A rota meter consists of a tapered tube, typically made of glass with a ‘ float’, actually a shaped weight, inside that is pushed up by the drag force of the flow and pulled down by gravity. Drag force for a given fluid and float cross section is a function of flow speed squared only, see drag equation. A higher volumetric flow rate through a given area increases flow speed and drag force, so the float will be pushed upwards. However, as the inside of the rotameter is cone shaped (widens), the area around the float through which the medium flows increases, the flow speed and drag force decrease until there is mechanical equilibrium with the float’s weight. Floats are made in many different shapes, with spheres and ellipsoids being the most common. The float may be diagonally grooved and partially colored so that it rotates axially as the fluid passes. This shows if the float is stuck since it will only rotate if it is free. Readings are usually taken at the top of the widest part of the float; the center for an ellipsoid, or the top for a cylinder. Some manufacturers use a different standard. The “ float” must not float in the fluid: it has to have a higher density than the fluid; otherwise it will float to the top even if there is no flow. Figure 4

7) Positive Displacement Flow meters

7. 1) How Positive Displacement Flow meters Work

Positive displacement flow meter technology is that the solely flow activity technology that directly measures the quantity of the fluid passing through the flow meter. Positive displacement flow meters reach this by repeatedly entrapping fluid so as to live its flow. This method will be thought of as repeatedly filling a bucket with fluid before marketing the contents downstream. the amount of times that the bucket is crammed and empty is indicative of the flow through the flow meter. Several positive displacement flow meter geometries are out there.

7. 2) How to Use Positive Displacement Flow meters

Positive displacement flow meters live the meter flow of fluids in pipes, like water, hydrocarbons, refrigerant liquids, and chemicals. Some styles will live gas flow though liquid flow applications are far more prevailing. In liquid service, increasing viscousness decreases slippage and will increase the pressure drop across the flow meter. Amazingly, accuracy will truly improve at low flow conditions during a given positive displacement flow meter once viscousness will increase and slippage decreases.

7. 3) Types of Positive Displacement Flow meters

Reciprocating piston / oscillatory piston

Each piston is automatically or magnetically operated to fill a cylinder with the fluid then discharge the fluid. Every stroke represents a finite activity of the fluid.

Gear

Gear flow meters have faith in internal gears rotating as fluid passes through them. There square measure varied kinds of gear meters named largely for the form of the interior elements

Oval Gear

Two rotating oval gears with synchronal teeth “ squeeze” a finite quantity of fluid through the meter for every revolution. With oval gear flow meters, 2 oval gears or rotors square measure mounted within a cylinder. because the fluid flows through the cylinder, the pressure of the fluid causes the rotors to rotate. As flow will increase, therefore will the movement speed of the rotors.

Helical Gear

Helical gear flow meters get their name from the form of their gears or rotors. These rotors jibe the form of a helix that may be a spiral-shaped structure. because the fluid flows through the meter, it enters the compartments within the rotors, inflicting the rotors to rotate. Flow rate is calculated from the speed of rotation.

Nutating disk

A disk mounted on a sphere is “ wobbled” concerning associate degree axis by the fluid flow and every rotation represents a finite quantity of fluid transferred. Nutating disc flow meters get their name from the concept of nod, which implies pendulous or rocking. A nutating disc meter includes a spherical disc mounted on a spindle in a very cylindrical chamber. By pursuit the movements of the spindle, the flow meter determines the quantity of times the chamber traps and empties fluid. This info is employed to work out flow. A rotating vane containing 2 or a lot of vanes divides the areas between the vanes into separate volumes and every rotation (or vane passing) is counted.

Diaphragm

Fluid is drawn into the body of water facet of associate degree oscillatory diaphragm then dispelled to the outlet. The diaphragm oscillatory cycles square measure counted to work out the flow. Figure 5

8) Turbine Flow meters

8. 1) How Turbine Flow meters Work

Turbine flow meters use the mechanical energy of the fluid to rotate a “ pinwheel” (rotor) in the flow stream. Blades on the rotor are angled to transform energy from the flow stream into rotational energy. The rotor shaft spins on bearings. When the fluid moves faster, the rotor spins proportionally faster.

Shaft rotation can be sensed mechanically or by detecting the movement of the blades. Blade movement is often detected magnetically, with each blade or embedded piece of metal generating a pulse. Turbine flow meter sensors are typically located external to the flowing stream to avoid material of construction constraints that would result if wetted sensors were used. When the fluid moves faster, more pulses are generated. The transmitter processes the pulse signal to determine the flow of the fluid. Transmitters and sensing systems are available to sense flow in both the forward and reverse flow directions.

8. 2) How to Use Turbine Flow meters

Turbine flow meters measure the velocity of liquids, gases and vapors in pipes, such as hydrocarbons, chemicals, water, cryogenic liquids, air, and industrial gases. High accuracy turbine flow meters are available for custody transfer of hydrocarbons and natural gas. These flow meters often incorporate the functionality of a flow computer to correct for pressure, temperature and fluid properties in order to achieve the desired accuracy for the application.

Be careful because using turbine flow meters on fluids that are non-lubricating, because the flow meter can become inaccurate and fail if its bearings prematurely wear. Some turbine flow meters have grease fittings for use with non-lubricating fluids. In addition, turbine flow meters that are designed for a specific purpose, such as for natural gas service, can often operate over a limited range of temperature (such as up to 60ºC) whereby operation at higher temperatures can damage the flow meter.

This flow meter can be applied to sanitary, relatively clean, and corrosive liquids in sizes up to approximately 24 inches. Smaller turbine flow meters can be installed directly in the piping, but the size and weight of larger turbine flow meters may require the installation of substantial concrete foundations and supports. The flow of corrosive liquids can be measured with proper attention to the materials of construction of all wetted parts, such as the body, rotor, bearings, and fittings.

Applications for turbine flow meters are found in the water, petroleum, and chemical industries. Water applications include distribution systems within and between water districts. Petroleum applications include the custody transfer of hydrocarbons.

Figure 6

9) Conclusion

It very important to study the system and flow principle in order to select a suitable flow meter for a particular application it was not an easy task Especially with the wide variety of flow meters in the market. It requires considerable Evaluation of the total cost, fluid state, flowing condition, Reynolds number, density, range ability, mechanical installation constraints and accuracy requirements.

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