

Study About Venturi Meter

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Abstract - Venturi meters are indispensable flow measurement devices used across a range of industries because of their accuracy and reliability. This paper comprehensively explores venturi meters, encompassing their working principle based on Bernoulli's theorem, distinct components, various types categorized by orientation and design, potential defects affecting performance, diverse applications ranging from water management to industrial processes, and a balanced discussion of their advantages and disadvantages. Proper selection, installation, and maintenance ensure the proper working of a venturi meter, which is an important aspect of accurate flow measurement.

Key Words: Venturi meter, types, component, Bernoulli's theorem, defects

INTRODUCTION

Flow measurement in many engineering applications requires accurate measurements. Among such devices, the venturi meter is a popular choice for measuring flow because it is known to be precise with relatively low-pressure loss.

Venturi Meter:- It is a device used for measuring the rate of flow of a flowing fluid through a pipe.

WORKING PRINCIPLE

Venturi meter operates based on Bernoulli's principle, which states that an increase in fluid velocity is accompanied by a decrease in pressure. The venturi meter design, with its converging section, throat, and diverging section, creates a controlled constriction in the flow path. As the fluid enters the converging section, its velocity increases, causing a pressure drop at the throat. This pressure difference between the inlet

and the throat is measured and correlated to the flow rate using Bernoulli's equation and the continuity equation.

COMPONENTS OF VENTURI METER

A Venturi meter comprises several key components:

- **Cylindrical Inlet Section:** For smooth and uniform flow entry.
- **Converging Conical Section:** Gradually reduces the diameter, accelerating the fluid.
- **Throat:** The narrowest section where velocity is maximum and pressure is minimum.
- **Diverging Conical Section:** Gradually increases the diameter, decelerating the fluid and recovering some pressure.
- **Pressure Taps:** Openings at the inlet and throat for pressure measurement.
- **Manometer:** Measures the pressure difference.

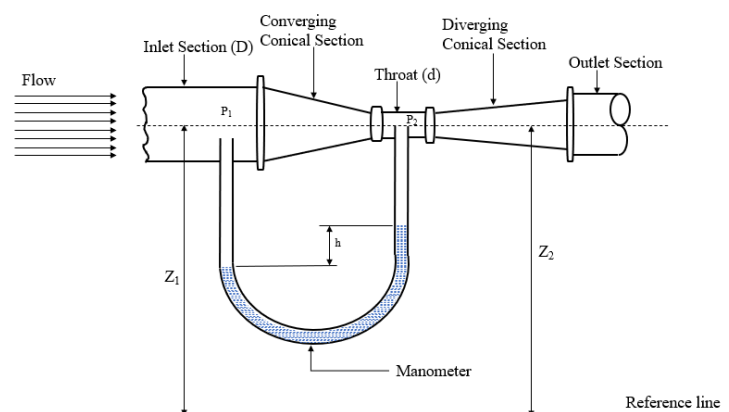


Fig.-1 Venturi Meter

Where, D = Diameter of inlet Section

d = Diameter of throat

P_1 = Pressure inlet for inlet section

P_2 = Pressure inlet for throat

Z_1 = Distance between inlet section and reference line

Z_2 = Distance between throat and reference line

h = difference of pressure head

TYPES OF VENTURI METER

- **Horizontal Venturi meter:** This is the most common type, where the venturi meter is installed horizontally in the pipeline. It's simple to construct and install.
- **Vertical Venturi meter:** In this type, the venturi meter is placed vertically. It's often used when the pipeline has a vertical orientation.
- **Inclined Venturi meter:** As the name suggests, the venturi meter is placed at an angle in the pipeline. This type is suitable for specific applications where neither horizontal nor vertical orientation is ideal.

DEFECTS IN VENTURI METER

Venturi meters are generally reliable flow measurement devices, but they can experience certain defects that affect their accuracy and performance. Here are some common issues:

- **Wear and Tear:**
 - a) **Erosion:** The throat of the venturi meter, where the fluid velocity is highest, is susceptible to erosion, especially if the fluid contains abrasive particles. This wear can alter the dimensions of the throat, affecting the pressure differential and the accuracy of flow measurement.
 - b) **Corrosion:** Certain fluids can corrode the venturi meter material, leading to deterioration and potential leaks.

- **Blockage and Fouling:**

- a) **Sediment Buildup:** In fluids carrying sediment or debris, these materials can accumulate in the venturi meter, particularly in the converging section or the throat. This buildup can obstruct the flow and alter the pressure readings.
- b) **Scaling:** Hard water or fluids with dissolved minerals can cause scaling or deposits to form on the venturi meter walls, affecting the flow area and pressure measurements.

- **Formation of Vapor Bubbles:** If the pressure in the throat drops too low, it can lead to cavitation, where vapor bubbles form in the liquid. Cavitation can cause damage to the venturi meter due to the implosion of these bubbles and can also introduce inaccuracies in the flow measurement.

- **Installation Issues:**

- a) **Upstream Disturbances:** Venturi meters require a straight section of pipe upstream to ensure a uniform flow profile. If there are flow disturbances like bends or valves too close to the venturi meter, it can affect the accuracy of the readings.
- b) **Incorrect Placement:** Improper installation, such as misalignment or incorrect positioning of the pressure taps, can lead to inaccurate measurements.

- **Pressure Tap Issues:**

- a) **Blockage:** The pressure taps used to measure the pressure difference can become blocked by debris or sediment, leading to incorrect readings.
 - b) **Leaks:** Leaks in the pressure tap connections or tubing can affect the pressure measurements and introduce errors.
- **Dimensional Inaccuracies:** Manufacturing defects, such as deviations from the designed dimensions of the venturi meter, can affect its performance.

ADDRESSING VENTURI METER DEFECTS

- **Regular Inspection:** Regular visual inspections can help identify issues like wear, blockage, or damage.
- **Cleaning:** Periodic cleaning of the venturi meter and pressure taps can remove sediment, scale, or debris.
- **Maintenance:** Proper maintenance, including lubrication and checking for leaks, can ensure the longevity of the venturi meter.
- **Calibration:** Regular calibration ensures the accuracy of the flow measurements.
- **Material Selection:** Choosing appropriate materials for the venturi meter based on the fluid being measured can minimize corrosion and wear.
- **Proper Installation:** Following recommended installation guidelines, including providing sufficient straight pipe upstream, can prevent flow disturbances.

APPLICATION OF VENTURI METER

Venturi meters find significant applications in various production fields due to their ability to accurately measure flow rates, which is crucial for process control, optimization, and efficiency. Here are some key applications in production:

- **Chemical Processing:**

- a) **Precise Flow Measurement:** In chemical plants, venturi meters are used to measure the flow rates of various liquids and gases involved in chemical reactions and processes. This ensures accurate proportions of reactants, proper mixing, and consistent product quality.
- b) **Process Control:** Venturi meters provide real-time flow rate data, enabling operators to monitor and control chemical processes effectively. This helps maintain desired reaction rates, optimize yields, and prevent deviations from set parameters.
- c) **Dosing and Mixing:** In processes requiring precise dosing or mixing of different fluids, venturi meters

ensure accurate flow rates, leading to consistent product formulations and quality.

- **Pharmaceutical Industry:**

- a) **Accurate Flow Measurement:** Venturi meters are critical in pharmaceutical production for measuring the flow rates of liquids and gases used in various stages, such as synthesis, formulation, and filling. This ensures precise ingredient proportions and dosage accuracy.
- b) **Process Control:** They help control critical parameters like mixing speeds, reaction times, and filtration rates by providing real-time flow data. This ensures consistent product quality and adherence to strict regulatory standards.
- c) **Sterile Fluid Handling:** Venturi meters can be used in sterile environments to measure the flow of purified water, gases, or other fluids used in pharmaceutical manufacturing, maintaining sterility and preventing contamination.

- **Oil and Gas Industry:**

- a) **Pipeline Flow Measurement:** Venturi meters are used to measure the flow rates of oil and gas in pipelines, helping to monitor production rates, optimize transportation, and ensure efficient distribution.
- b) **Process Control in Refineries:** In refineries, venturi meters are used to measure the flow of various fluids involved in refining processes, ensuring accurate process control and product quality.
- c) **Allocation Measurement:** They can be used to measure the flow of oil and gas from different wells or fields, enabling accurate allocation of resources and revenue.

- **Manufacturing Processes:**

- a) **Fluid Flow in Machinery:** Venturi meters can be integrated into various manufacturing machines and equipment to measure the flow rates of coolants, lubricants, or other fluids essential for their operation.

This ensures proper functioning and prevents equipment damage.

- b) **Process Monitoring:** They can be used to monitor the flow of fluids in various manufacturing processes, such as metal processing, plastics manufacturing, or textile production, ensuring consistent quality and efficient production.

- **Water and Wastewater Treatment:**

- a) **Flow Measurement in Treatment Plants:** Venturi meters are used to measure the flow rates of water and wastewater in treatment plants, helping to monitor treatment efficiency, optimize chemical dosing, and ensure compliance with environmental regulations.
- b) **Distribution Network Monitoring:** They can be used to measure the flow of water in distribution networks, helping to manage water resources effectively and detect leaks or other issues.

ADVANTAGES OF VENTURIMETERS

- **High Accuracy:** Venturi meters offer high accuracy in flow measurement compared to other devices like orifice plates. This is due to their gradual converging and diverging sections, which minimize energy losses and flow disturbances.
- **Low Pressure Loss:** They have a lower permanent pressure loss compared to orifice plates. The gradual design allows for better pressure recovery, reducing the overall energy loss in the system.
- **Wide Range of Flow Rates:** Venturi meters can measure a wide range of flow rates, making them suitable for various applications.
- **Versatility in Orientation:** They can be installed in any orientation – horizontal, vertical, or inclined – depending on the requirements of the application.
- **Less Susceptible to Clogging:** The smooth and gradual design makes them less prone to clogging or blockage by debris or sediment in the fluid. This is

especially advantageous in applications involving dirty or viscous fluids.

- **Predictable Performance:** The performance of a venturi meter can be accurately predicted due to its well-defined geometry and the principles of fluid mechanics governing its operation.

DISADVANTAGES OF VENTURI METERS

- **High Initial Cost:** The initial cost of a venturi meter can be higher compared to other flow measurement devices, especially for larger sizes.
- **Larger Size and Space Requirements:** Venturi meters are generally larger in size and require more space for installation compared to orifice plates. This can be a limitation in applications where space is restricted.
- **Difficult to Install and Maintain:** Installation of a venturi meter can be more complex and may require specialized tools and expertise. Maintenance can also be challenging due to their size and construction.
- **Not Suitable for Small Diameter Pipes:** Venturi meters are generally not suitable for pipes with very small diameters due to practical limitations in manufacturing and pressure measurement.
- **Sensitive to Upstream Disturbances:** The accuracy of a venturi meter can be affected by flow disturbances caused by bends, valves, or other obstructions upstream. Therefore, a straight section of pipe is required upstream of the venturi meter for accurate measurements.
- **Material Limitations:** The material of the venturi meter needs to be compatible with the fluid being measured to avoid corrosion or degradation. This can limit the choice of materials and increase costs in some cases.

CONCLUSION

Venturi meters are valuable tools for accurate flow measurement across various applications. Their robust design, based on established fluid dynamics principles, ensures reliable performance. However, understanding potential defects and limitations is crucial. Proper selection, installation, regular maintenance, and calibration are essential for maximizing accuracy and longevity. The choice of venturi meter type should be based on the specific application requirements, considering factors like fluid properties, flow rate range, space constraints, and cost. By addressing these considerations, venturi meters can continue to play a vital role in diverse engineering and industrial settings.

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