Sensors & Transducers

Anemometer

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Introduction

- An **anemometer** is an instrument used to measure the speed or velocity of gases either in a contained flow, such as airflow in a duct, or in unconfined flows, such as atmospheric wind.
- To determine the velocity, an anemometer detects change in some physical property of the fluid or the effect of the fluid on a mechanical device inserted into the flow.

- The hot wire anemometer is the most popular kind of constant-temperature anemometers.
- It consists of an electrically heated, fine-wire element (0.00016 inch in diameter and 0.05 inch long) supported by needles at its ends.
- While hot wire anemometers are best suited for clean gases at low velocities, venturi meters can also be considered for some liquid (including slurry) flow applications.

Types of anemometers

- There is a wide range of anemometers models for directly measuring wind and air velocity.
- The four most popular anemometer models are:
  - Vane Anemometers,
  - Thermal Anemometers,
  - Thermal Anemometers with Velocity / Temperature Profiling
  - Cup Anemometers.
- Anemometers are usually classified as constant-temperature, or constant-power anemometers.

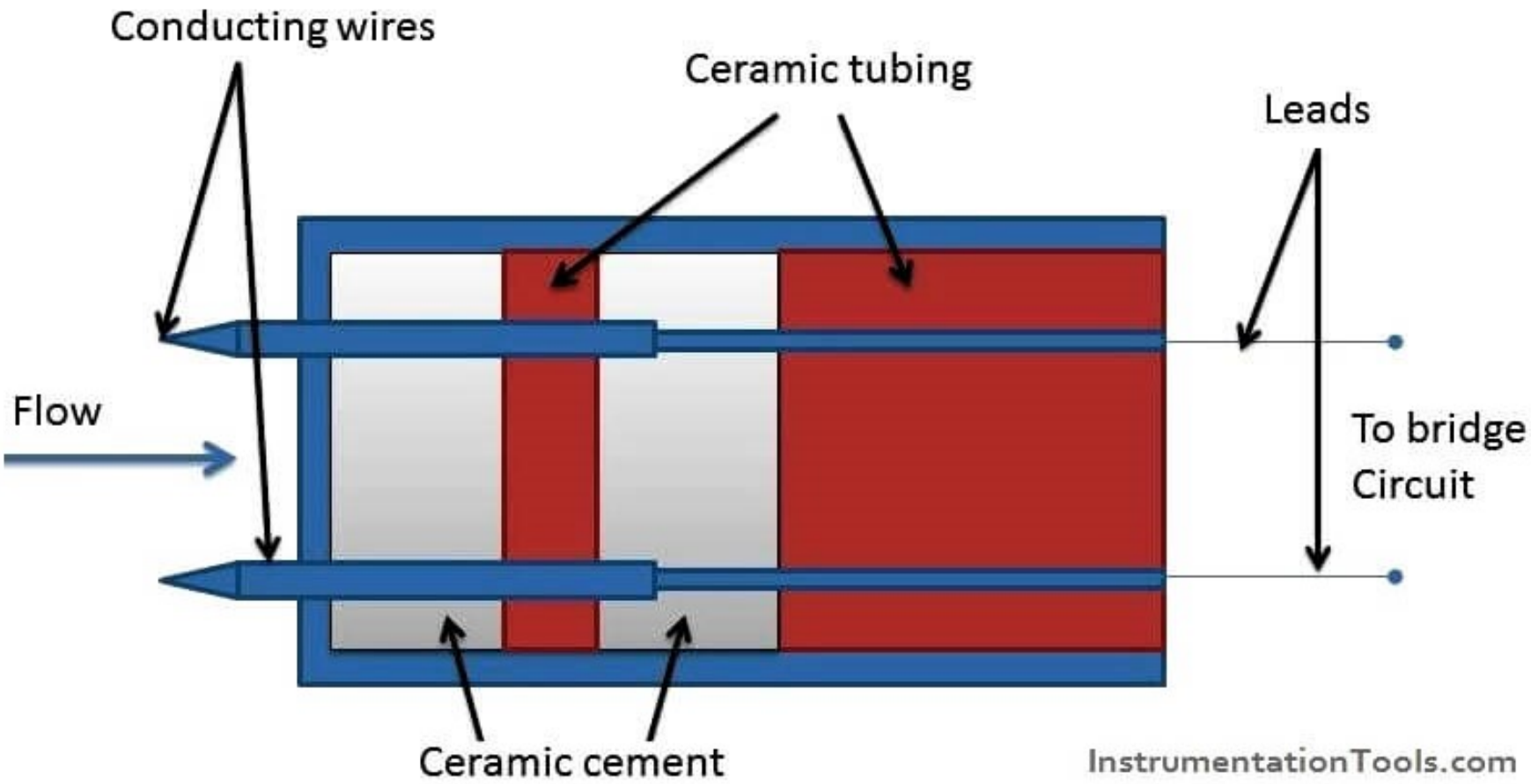
Anemometer applications

- An anemometer usually measures gas flows that are in turbulent flow conditions.
- The vane anemometer, thermal anemometer and cup anemometer (typically used in weather stations) are mostly used to measure the mean velocity, while the hot wire anemometers are usually used when turbulence characteristics are being measured, such as transverse measurements in a cross-section.
- The term "thermal anemometer" is often used to mean any anemometer that uses a relationship between heat transfer and velocity to determine velocity.

Hot Wire Anemometer

- The Hot Wire Anemometer is a device used for measuring the velocity and direction of the fluid. This can be done by measuring the heat loss of the wire which is placed in the fluid stream. The wire is heated by electrical current.
- The hot wire when placed in the stream of the fluid, in that case, the heat is transferred from wire to fluid, and hence the temperature of wire reduces. The resistance of wire measures the flow rate of the fluid.
- The hot wire anemometer is used as a research tool in fluid mechanics. It works on the principle of transfer of heat from high temperature to low temperature.

Hot wire Anemometer



Construction of Hot Wire Anemometer

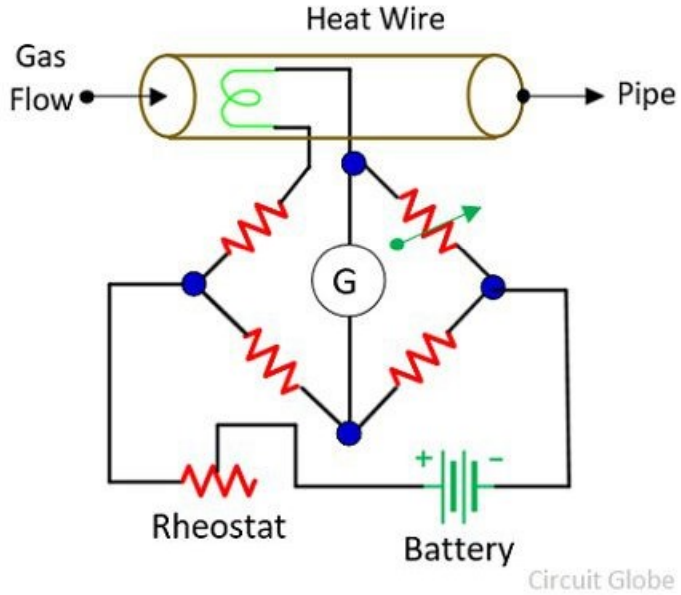
- The main parts of the arrangement are as follows:
  - Conducting wires placed in a ceramic body.
  - Leads are taken from the conducting wires and they are connected to one of the limbs of the wheat stone bridge to enable the measurement of change in resistance of the wire.

  Hot Wire Anemometer works When an electrically heated wire is placed in a flowing gas stream, heat is transferred from the wire to the gas and hence the temperature of the wire reduces, and due to this, the resistance of the wire also changes. This change in resistance of the wire becomes a measure of flow rate.

- There are two methods of measuring flow rate using a anemometer bridge combination namely:
  - Constant current method
  - Constant temperature method

Constant Current Method

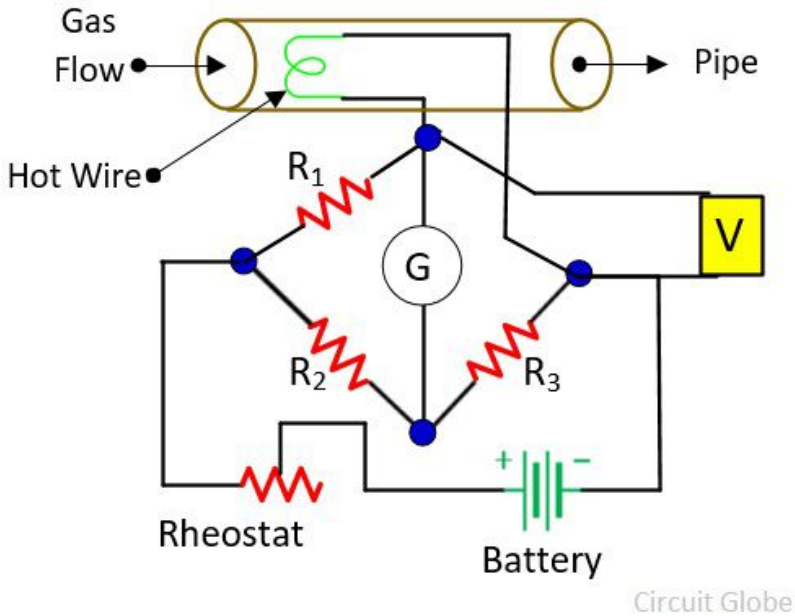
- In the constant current method, the anemometer is placed in the stream of the fluid whose flow rate needs to be measured.
- The current of constant magnitude is passed through the wire.
- The Wheatstone bridge is also kept on the constant voltage.



- When the wire is kept in the stream of liquid, in that case, the heat is transferred from the wire to the fluid. The heat is directly proportional to the resistance of the wire. If heat reduces, that means the resistance of wire also reduces. The Wheatstone bridge measures the variation in resistance which is equal to the flow rate of the liquid.

Constant Temperature Method

- In this arrangement, the wire is heated by the electric current.
- The hot wire when placed in the fluid stream, the heat transfer from wire to the fluid.
- Thus, the temperature of the wire changes which also changes their resistance.
- It works on the principle that the temperature of the wire remains constant. The total current requires to bring the wire in the initial condition is equal to the flow rate of the gas.



Measurement of the rate of a fluid using a Hot Wire Instrument

- In hot wire anemometer, the heat transferred electrically to the wire which is placed in the fluid stream.
- The Wheatstone bridge is used for measuring the temperature of wire regarding their resistance.
- The temperature of the wire remains constant for measuring the heating current. Thus, the bridge remains balanced.
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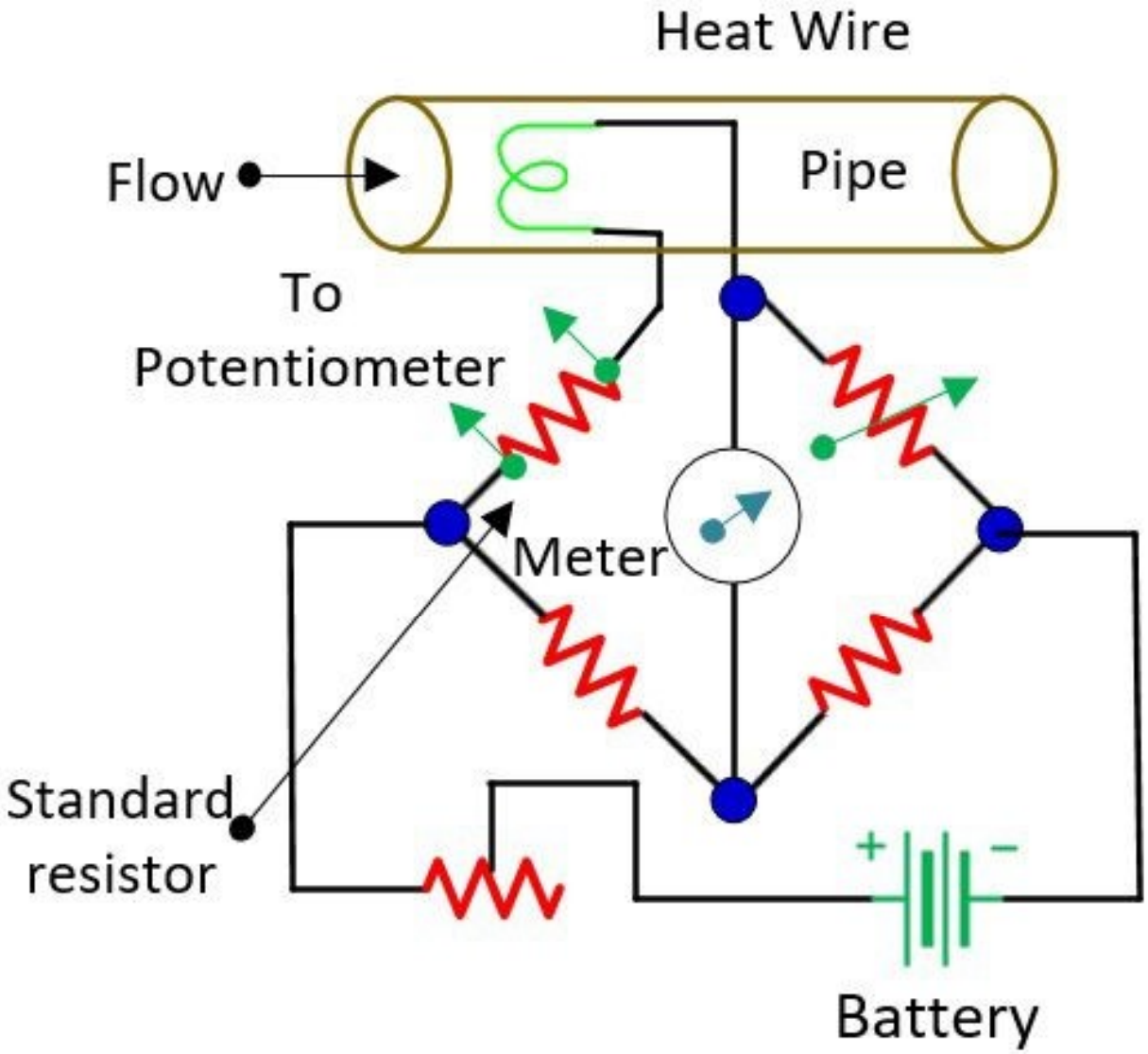
Heat Wire
Flow
Pipe
To
Potentiometer
Meter
Standard
resistor
+
−
Battery
Circuit Globe

- The standard resistor is connected in series with the heating wire. The current across the wire is determined by knowing the voltage drop across the resistor. And the value of voltage drop is determined by the potentiometer.
- The equation determines the heat loss from the heated wire

$$= a(vp + b)^{1/2} J/s$$

  - Where, v – velocity of heat flow,
    ρ – the density of fluid,
- The a and b are the constants. Their value depends on the dimension and the physical properties of the fluid and wire.
- Suppose I, is the current of the wire and the R is their resistance. In equilibrium condition,
- Heat generated = Heat Lost

$$I^2R = a(vp + b)^{1/2}$$

$$v = \frac{\left(I^2R/a^2 - b\right)}{\rho}$$

- The resistance and temperature of the instrument are kept constant for measuring the rate of the fluid by measuring the current I.