SIARE ENGINEERING INTERNATIONAL GROUP SRL

Magnetic Flow Sensor

A unique flow sensor crafted for applications in acute care

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INTRODUCTION

Monitoring gas flow and volume exchanges is crucial in critical care to minimize ventilator-induced lung injury. Ventilators, use flow sensors to gauge amount of gas delivered to the patients and adjust the desired amount of gas to be delivered.

It is crucial to identify considerations in measurements of flow to determine appropriate design of the flow sensors for ventilators:

- Sensor should offer the least amount of residual pressure during respiration (i.e. the PEEP – Positive end respiratory pressure)
- The sensor should not generate resistance to the inspired and/or expired flow (the American Thoracic Society suggests for volumetric flowmeters used for the forced expiration tests a resistance to the flow of ≤ 1.5 cmH2O/(l/s))
- The sensor must have a series of performance capabilities such as accuracy, precision, resolution, reproducibility, static sensitivity, controlled zero drift, linearity, wide range, and adequate inlet impedance)
- With respect to expiratory flow, one of the major contaminant is water or water vapor; the sensor should not get affected by water vapor
- The temperature and gas composition changes can vary sensor calibration. The sensor should vary as less as possible across the range of temperature & gas composition that the system is likely to encounter.

TYPES OF FLOW SENSORS

1. ROTATING VANE (TURBINE) SENSOR

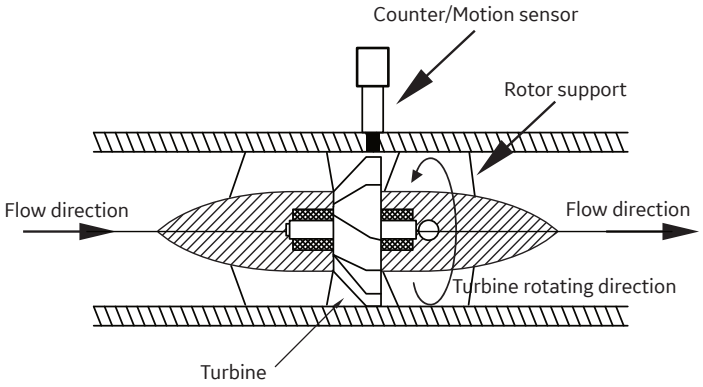
The turbine flow sensors are based on the movement of a turbine that can be synchronized to the gas flow. The measure of turbine rotation provides measurement of flow.

Disadvantage: This type of flow sensors, however, have 2 major limitations:

1. The weight of the mobile parts

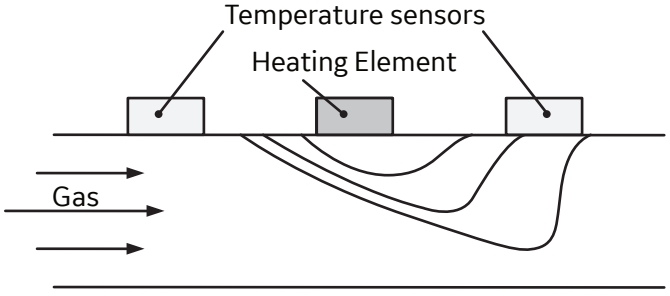
2. The friction generated by the mobile parts

Due to these limitations, the turbine rarely follows the high frequency movement of the flow because of its inertia. It is thus suitable to use this type of flow sensor for initial clinical investigations and not complex investigations requiring depth, owing to their wide margin of error.



2. HEAT CONVENTION (HOT WIRE) SENSOR

These flow sensors use sensitive wires, metallic films and thermistors that vary electric resistance with respect to the temperature. They can be used in different modes. In the self-heating mode, a current is passed through these wires to heat them to a temperature that is higher than the gas flow. When the gas passes through these wires, it reduces(cools) their temperature and the change in temperature depends on various factors like the gas flow, the temperature of the gas, the specific heat, kinematic viscosity and the thermal conductivity of the gas. Now, through a feedback loop, the wire is reheated by passing additional current to maintain constant temperature and this change in current is used to measure the gas flow. The flow sensors that use this principle are known as hot-wire anemometers and are used for both, one-way and two-way flows.



Disadvantage: The wire, however, is adversely affected by water vapor. This type of a flow sensor works well when the properties of the gases remain sufficiently constant.

The variable composition of the expired gases can vary the transfer of heat from the heated wire. The sensor must thus be calibrated for the specific gas mixture to which it is exposed.

The hot wire anemometers must be heated to burn the external substances that enter the sensor. During these phases the reading of respiratory parameters like tidal volume and expired volume, and breathing rate cannot be performed.

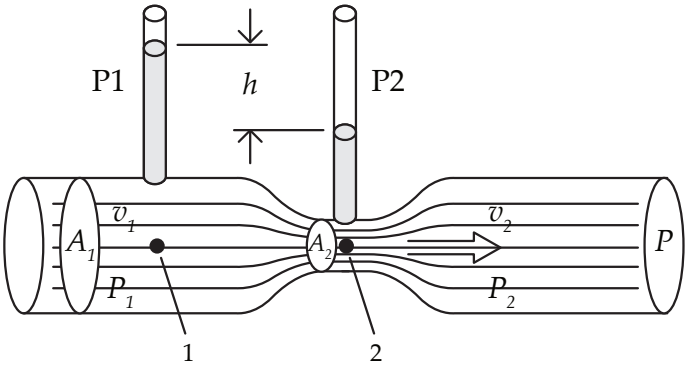
3. DIFFERENTIAL PRESSURE SENSOR

These sensors are based on the known relationship between pressure difference and flow. The sensors measure the difference in pressure and then using calibration tables, this difference is converted into flow values.

There are mainly 3 types of differential pressure sensors:

- Measurement using instruments like the Venturi tube
- Measurement using the Pneumotachometer
- Measurement using Mesh arrangement

In all the methods mentioned above, the pressure of the gas is measured at P1 and then made to flow through an artificially created resistance and then measured again for pressure P2. The difference in Pressure is thus obtained which can be used to determine the flow using calibration tables.



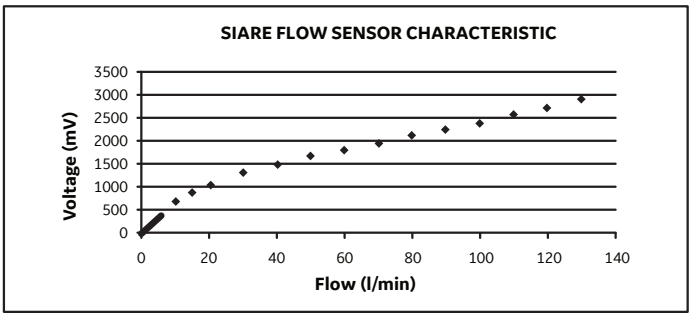
This instrument can distinguish the flow direction. The pressure outlets (orifices) or tubes are placed at critical positions which determine the relationship between pressure and flow.

Disadvantage: The resistive portion of the sensor and the tubes can be blocked by external substances. In respiratory applications these sensors are located near the patient Y connector, and are therefore, likely to receive an expiratory flow rich of humidity and secretions. Such components can easily enter the 2 orifices that detect the gas pressure signal upstream and downstream, and create a variation in the signal, which results in a reading failure.

To prevent the above, these systems foresee periodically the generation of a flow to release the 2 orifices from moisture and undesired particles. During this phase no respiratory parameter, like tidal volume and expired minute volume, breathing rate are detected.

SIARE FLOW SENSOR: Operation Principle of the Microflow Sensor

In consideration of these disadvantages, Siare Engineering International Group in 1993 decided to design a dedicated sensor for spirometry applications in lung ventilation and created a flow sensor which is made of a steel foil with high magnetic permeability (magnetic permeability is the ability of the material to create a magnetic field). This steel foil is connected to a metallic support on one side to form an interlocking shelf. The force created by the gas flow moves the steel coil from its equilibrium position. This movement creates a variation in the inductance of the 2 coils and a corresponding signal is detected and converted into voltage. Finally, the signal, once transformed into electric signal, is elaborated by a microprocessor and sent to a display based on calibration tables.



Advantages:

1. It does not get affected by humidity

2. It does not need periodic calibrations during its use

3. It does not get infected with chemicals and steam, and is therefore, reusable unless an accident or mechanical break occurs

4. Very high sensitivity of the sensor allows it to detect very low flows from 0.1 l/min. This allows clinicians to have readings from 2ml which makes it suitable for use in neonatal applications.

Since 1995 around 8,000 ventilators have been installed across the globe detecting patient breathing parameters through the flow sensor ensuring reliability and accuracy throughout the lifetime of the equipment.

Criteria to Evaluate Flow Sensors	Rotating Vane	Hot Wire	Differential Pressure	Siare Magnetic Sensor
Low Residual Pressure during respiration	✗	✓	✓	✓
Low Resistance for the inspired/ expired flow	✗	✓	✓	✓
Performance (eg. Precision, resolution, linearity, static sensitivity, wide range)	✗	✓	✓	✓
Ability to perform in presence of water vapour and patient secretions	✗	✗	✗	✓
Ability to perform during variations in temperature and gas composition	✓	✗	✗	✓
Longetivity	✗	✗	✗	✓

References:

http://www.flowmeters.com/thermal-technology
https://www.globalspec.com/learnmore/sensors_transducers_detectors/flow_sensing/turbine_flow_meters_meters
http://demonstrations.wolfram.com/TheVenturiEffect/

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