AVERAGING PITOT FLOWMETER FOR EMISSIONS MONITORING

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The increasing impact climate change is having on the world has not gone unnoticed. Governments all over the world are committing to reducing their greenhouse gas emissions to try and curb further impact caused by emissions being released to the atmosphere. With reduction being the key goal, emissions first must be measured accurately in order to assess what changes are being made and if those changes are being effective. Over 100 years ago Lord Kelvin said, "If you cannot measure it, you cannot improve it" and that still holds true today. The question then becomes how we measureemissions. This article explores the use of differential pressure technology and how one type is extremely well suited to monitoring the flowrate of emissions.

Most instrument engineers will be well versed in the operation and application of differential pressure technology. The use of orifice plates, Venturis, wedges, nozzles and cones, amongst others, are commonplace in industry for successful measurement in a wide variety of applications including custody transfer of gases, steam measurement and general process measurements.

These primary elementsare based on the Bernoulli principle which states that in anyflow stream the summation of energies within that stream is constant. This means that the kinetic, internal and potential energies of any stream are related. More commonly these are thought of as velocity, static pressure and height of any pipeline.

As a primary element is a restriction in the pipe, it reduces the cross-sectionalflow area. The velocity therefore increases as the flow area decreasesin order to maintain the same mass flowrate of fluid. From Bernoulli, the increase in velocity (kinetic energy) causes a corresponding decrease in the static pressure (internal energy) of the system and by measuring the differential pressure from upstream to throat, it is possible to calculate the flowrate rate of the fluid.

With measurement of the differential pressure in operation and knowledge of the fluid density and primary element geometry, the end user can get access to a quick and easy estimate of the flowrate of their process.Its no question then why differential pressure technology has become one of the market leading technologies for the measurement of fluid flowrates.

However, the above description of differential pressure technology is not the full story as it only looks at the difference in static pressure caused by a restriction in the flow. There are other types of geometry that allow for other pressures to be measured which deliver flowmeters with different attributes.

As an example, a pitot tube make use of calculating the dynamic pressure of a fluid and computing the flowrate from that value instead of the drop in static pressure. In practice, the stagnation pressure and static pressures are measured, and the differential taken to obtain the dynamic pressure. Pitot tubes are used in many industries round the world and in applications such as air travel and formula 1 racing. They are more typically used in open environments as opposed to closed conduits.

For comparison of differential pressure flow meters based on static or dynamic pressure measurements, it is important to know the equations used in operation. When the Bernoulli equation is developed in terms of flowrate the generic equations is:

$$q_v = K\sqrt{\frac{2\Delta p}{\rho}}$$

Where q_v is the volumetric flowrate, Δp is the measured differential pressure, ρ is the fluid density and K is a flow coefficient. Kcan be based on other parameters (e.g.,pipe diameter, area, velocity of approach factor, discharge coefficient etc.) or based on testing but when comparing different meters, it is the important factor to see the relation ship between flowrate and differential pressure.

For any application with flowrate q_v and density ρ, the K of the meter then determines the relationship with Δp. Larger K values mean a smaller Δp for that flowrate and vice versa for smaller K values.

Technologies based on dynamic pressure tend to have larger K values in comparison to static pressure based primary elements and therefore generate a smaller differential pressure for the same flowrate.

For fluids flowing in a pipe, thestandard pitot tube doesn't deliver as well as it does in other applications because of the dynamics within a closed pipe. The friction effects of the pipe allow for the generation of a flow profile in pipe which means the velocity can vary across the pipe diameter. With a pitot tube being a point source measurement, its position in the pipe is critical for accurate measurements.

To overcome this issue, the averaging pitot tube has been developed so that aprobe traverses the entire pipe cross section and accommodates multiple holes on the impact face of the probe. The multiple holes allow the dynamic pressures across the diameter of the pipe to be averaged and provide an average dynamic pressure. This delivers a consistent measurement. In addition, as a probe is inserted across the full pipe diameter it allows the meter to be retracted in service through a singular port – it does not need to be an inline meter.

Another interesting concept is the comparison of meter sizes for increasing pipe diameters. Withdevices like orifice plates or Venturis when pipe size increases, so too does the size of the meter in all axis. However, for an averaging pitot tube, the probe diameter is often fixed for a wide range of pipes, although there are various models or probe of different diameters more suitable for larger pipe diameters. The point being that if the probe diameter is effectively constant the meter only increases is size on one axis which is the length across the pipe diameter. Less material used and less time spent machining or fabricating can often be a more cost-effective measurement solution overall.

So in summary, using a dynamic pressure based measurement device like a McMenon averaging pitot tube appears to be suitable and perhaps a better choice for applications where:

- the pipe diameter is large
- the differential pressure is to be low
- accurate flow measurement is required
- minimum intrusions into the pipe are required
- the device needs to be installed/removed when in operation
- lower costs are desirable

Given the above list, emissions monitoring appears to be a perfect fit averaging pitot tubes to provide a measurement solution. Stacks tend to be large diameter and operate close to atmospheric pressure where there is little to no head available to lose to standard differential pressure devices. In addition, as stacks are always in operation when the process plant is operating, it makes sense to have a removable device for safety and security.

Emissions monitoring is becoming a vital part of the measurement chain and companies are taking advantage of Continuous Emissions Monitoring Systems (CEMS) in order to record the environmental impact they are having during operations. With many regulations with tighter restrictionsbeing introduced around the globe, it has never been more important to have a measurement system installed in stacks and flues that is fit for purpose and can deliver accurate indications of flowrate whilst working with the plant to minimise risk.

Many countries have specific guidance or approvals to follow for CEMS and end users require instruments to be QAL1certified which can be provided by the Monitoring Certification Scheme (MCERTS) or TUV certification processes. These certifications have been put in place to regulate equipment and instruments to ensure they are compliant and capable of measuring emissions to the appropriate levels.

An averaging pitot tube forms the heart of the McMenon Emissions FlowGenie, a purpose-built solution for CEMS having MCERTS and TUV certification. Connected to the averaging pitot tube is a panel mounted multivariable transmitter and flow controller module with optional display screen. The multivariable transmitter measures the meter's differential pressure but also provides measurements of the static pressure and temperature of the process. Knowing the fluids typical composition and the measured conditions, it is possible to compute the physical properties of the fluids through an equation of state. This allows for more accurate flow monitoring as the variable fluid density is accounted for.

The Emissions FlowGenie also has options to include a heater unit so the panel and purge control system so the device can operate successfully in harsh conditions. The purge frequency and temperature set point are all user defined to meet the specific needs of an application.The display screen allows the unit to be programmed to suit the user needs in terms of the required outputs and display units.

Differential pressure technology has been used for over 100 years and is a viable solution to the majority of industrial measurement applications. Traditionally, end users think about standard primary elements like orifice plates or Venturi flowmeters as the limit to differential pressure technology but that is not the case. Devices like pitot and averaging pitot tubes which are based on measuring dynamic pressure instead of a drop in static pressure have fantastic attributes associated with them and have found niche markets where those attributes surpass even the most popular of primary elements.