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Calibrating air flow measurement devices is a constant headache for users in the field. Peter Downing explains how sophisticated ultrasonics can overcome the problem.

Users are demanding ever more accurate measurements of air speed, volume and temperature, forcing instrument suppliers to deploy highly sophisticated techniques.

All flow metering instruments should be calibrated and performance certified under strict known conditions of temperature, ambient pressure and flowing liquid or gas media composition. If the media is air, humidity level and component gas ratios (such as oxygen, nitrogen, carbon dioxide, etc.), can all have an effect upon the calibration. Since the calibration of most instruments will vary with changes in some, or all, of these parameters, it follows that the accuracy of an instrument will only hold good under the same conditions as those prevailing at the time of calibration.

This is a very worrying fact when considering the atmospheric variations that occur when making a real measurement "in the field" where conditions are always changing as in the temperature variation between a room and a heating grill outlet, for example.

Reputable manufacturers tend to disclose their calibrated accuracy within the prevailing conditions (e.g. 1,013mb and 20°C, 30"Hg and 68°F), although relative humidity is seldom mentioned.

As an example, a thermal anemometer is likely to read 9% lower when taking readings in Johannesburg, South Africa, at 2,000m (6562ft) above sea level, unless correction factors are applied. Thermal anemometers, in general, have a tendency to drift whilst in use and, unless they are also automatically temperature compensating for the difference in the ambient temperature compared with their calibration standard, they will inevitably be inaccurate and give a reading far removed from the true flow of the gas/air being measured.

Rotating vane anemometers are better at overcoming this effect.

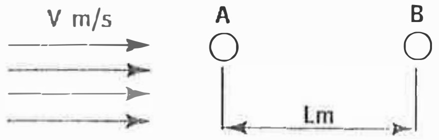
Ultrasonic flow metering techniques are able to overcome these problems and a new breakthrough in technology has finally allowed this to be achieved. Measurements can now be taken with the knowledge that the readings will not drift and that they will be accurate and repeatable, no matter what the temperature, relative humidity or air density.

The majority of ultrasonic flowmeters make use of changes in the velocity of sound due to the velocity of the flowing media. Since, however, the velocity of sound will also change with changes in the parameters how do we overcome the effect of these changes?

The velocity of sound, often designated "c", travels at 340.3 m/sec in air at standard atmospheric temperature and pressure. At 1,000 m above sea level, however, sound travels 1.15% slower. Humidity level can cause a further variation of 0.4%. More disturbingly, if the media were to change, much larger variations will occur e.g. velocity of sound in Helium is 2.93 times that in air. (This is what causes the Mickey Mouse voice after inhaling the contents of a Helium balloon).

It is therefore necessary when designing a velocity meter using sonic, or ultrasonic, techniques to overcome the effects of localised speed of sound.

Consider the simplified case of two probes, A and B, distanced L m apart, parallel to the direction of flow, velocity V, in a uniform flow.



If probe A is energised, the sound will travel towards B at c + V m/s and hence take

$\frac{L}{(c+v)}$ seconds to arrive. If we call this time T1 we get the equation:-

$$T_1 \quad \frac{L}{(c+v)} \quad (1)$$

If probe B is now energised, the sound will travel towards A at a velocity of c - V m/s. Hence, if the time taken to reach probe A is T2:-

$$T_2 \quad \frac{L}{(c+v)} \quad (2)$$

rearranging equations 1 and 2 gives:-

$$c + V = L/T_1 \quad (3)$$

$$c - V = L/T_2 \quad (4)$$

subtracting equation 4 from 3:-

$$2V = L/T_1 - L/T_2 \quad (5)$$

Since L can be measured, and also T1 and T2 determined, V can be calculated from equation 5 which is independent of c, the local velocity of sound.

Hence the calibration of an ultrasonic flowmeter, such as the Airflow Developments UA6 Anemosonic, will not be affected by changes in flow media conditions and can therefore be used to make measurements across the vast spectrum of normally occurring conditions.

In practice, however, two probes parallel to the flow do not give a good result due to the disturbance caused by probe A into the velocity measuring ultrasound path.

This can be overcome by placing the two probes at an angle to the flow direction and making a trigonometric correction. If a third probe is introduced, forming a triangular configuration, several other options become available e.g. correction for misalignment (yaw) of the probe from the direction of flow, measurement of speed and direction to give a true vector etc.

Hence a much more comprehensive ability is achieved giving the user much wider capability. By embodying these features into an ultrasonic flow meter an extremely powerful instrument can be produced capable of being used for the most exacting of air measurement uses; these include reference standards where accuracy and repeatability in varying testing conditions is paramount.

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