



Flow measurement by forced convection

Thermal Anemometry

Convection denotes heat transfer from a hot surface to a flowing medium. If the heat transport is caused by external influences such as a fan, it is referred to as forced convection. This mechanism is the basis of thermal anemometry – a method for measuring the flow of gaseous fluids based on the equilibrium between heat generation and heat removal by forced convection.

Flow velocities in fluids can be measured by a wide range of measurement principles, such as differential pressure, laser scattering or heat convection. In cases where the pressure loss in tube-bound systems or the costs for a measuring device using

a Laser Doppler anemometer are too high, hot-wire anemometry is an interesting alternative. What is more: It can detect even minimal flow velocities and determine, in addition to their magnitude, also their direction.

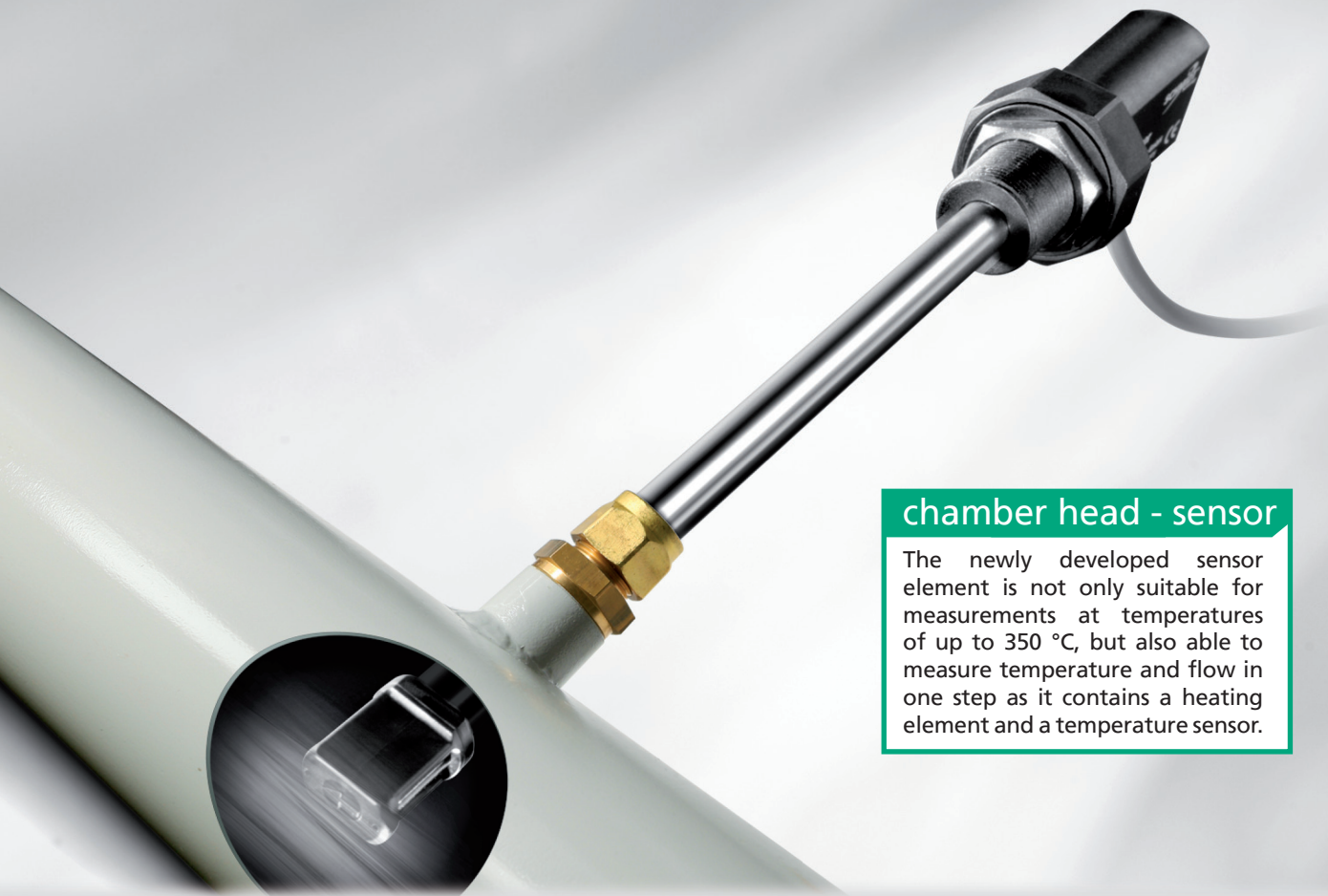


Different sensors

Hot-wire anemometers are based on an electrically heated metal wire clamped between two holding tips. In most cases, the wires are made of platinum, tungsten or nickel. Since the electric resistances of these materials have a high temperature coefficient, they have high measuring sensitivity. Moreover, at high heating temperatures, they are mechanically stable and resistant to media. The so-called dual or X sensors in which the holding tips are fixed in a joint ceramic body have two hot wires arranged vertically to one another in separate electronic measuring circuits. This makes it possible to detect flow velocities in terms of magnitude and direction.

Hot-film sensors have a thin metal film on a glass substrate in place of the hot wire. Cylindrical quartz rods are pre-plated with copper and gilded at the ends and soldered to a support. Hot-film sensors can be provided with cone- or wedge-shaped glass substrates in which the cone-shaped sensor is less sensitive to fluid impurities than the wedge-shaped sensor. Hot-film sensors are used for velocity measurements in gases and liquids.

The larger the set temperature difference between sensor and fluid, the more sensitive the measurement. The art of efficient instrumentation consists in keeping the sensor temperature as low as possible, while achieving high measuring sensitivity. More robust and less complicated than hot-film sensors are heated NTC pearl-shaped sensors, because they have a protective jacket and are available on the market as standard components for temperature measurement. These so-called thermistors are particularly suitable for the simple measurement of small air flow velocities if the metrology requirements are not too high.



chamber head - sensor

The newly developed sensor element is not only suitable for measurements at temperatures of up to 350 °C, but also able to measure temperature and flow in one step as it contains a heating element and a temperature sensor.

Ready-to-install velocimeters and flow meters

For installation into flow ducts, the sensors are equipped with various support shapes and supply lines. Sensors for mounting have rod-like sensor with a measuring head fitted with a thin-film element or an NTC pearl. Its protective housing gives the sensor necessarily a directional characteristic, which is why this type of sensors is used in ducts with directed flow. Thermal flow meters are suitable in particular for measuring mass flow. They consist of pre-

fabricated measuring tubes with thermal measuring elements and display units. The sensor system consists of an electronic bridge circuit, a control device and digital measured value operators and output interfaces. The measuring circuit works by one of two methods: In the cooling method, the flow is detected via the cooling of the fluid of the heated measuring element. In the constant temperature method, the heating capacity is a measure of

the flow velocity controlled electronically as a function of the removed heat flow.

Both thermal velocity and flow sensors are subject to use-related ageing. Corrosion, soiling or overheating can change the electric heating resistance and heat transfer, making a calibration and readjustment advisable after a certain operating time. Calibration wind tunnels are available for this from manufacturers.



Control circuits in anemometry

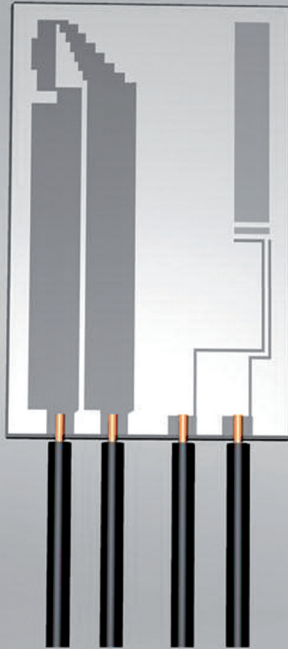
If a medium flows around the thermal sensor element, the convective heat removal will change the electric conditions of the measuring circuit. Suitable auxiliary measurement parameters are detected whose changes are used to infer the flow velocity.

Auxiliary measurement parameters depend on the selected heating condition. At a constant heating output or constant heating voltage, the temperature difference is measured, while at a constant heating current the heating temperature, at a constant heating temperature the heating current and at a constant temperature difference the heating voltage required for this are measured.

The most common methods for operating anemometers include Constant-Current Anemometry (CCA) and Constant-Temperature Anemometry (CTA). The first of the two does not require complicated control since the sensor is heated with constant current. It measures the sensor resistance, which, due to the cooling of the hot-wire sensor by the flowing medium, changes. This increases the measurement voltage as a result of Ohm's law. The CCA measuring circuit is highly suitable for small flow velocities. However, the thermal inertness of the sensor has an adverse effect on the measuring dynamics, since its resistance with its large thermal time constant cannot keep up

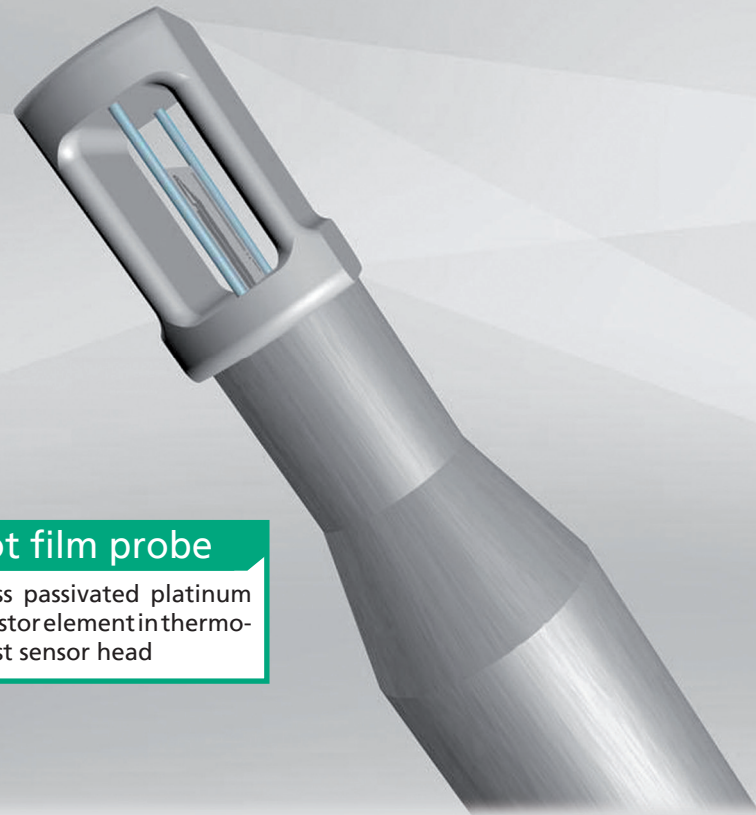
with quick changes in flow. This drawback is eliminated by CTA.

Very quick control circuits keep the sensor in CTA measuring circuits at a constant temperature by resupplying current or voltage. The cooling of the hot wire is compensated, thus also keeping its resistance constant. With this method, it is advantageous that the sensor temperature can be determined, which also allows the temperature effect to be corrected theoretically. In contrast to the Constant-Current Anemometer, CTA also has much higher sensitivity over a broad temperature range.



hot film probe

glass passivated platinum
resistorelement in thermo-
plast sensor head



Advantages of thermal flow measurement

The thermal measurement method allows a very broad measurement range from approx. 0.1 to 200 m/s. Small and medium velocities can be detected with very high resolution. Moreover, small sensor dimensions are possible, at which the sensor has low inertia to variations in flow. Frequency limits of up to 600 kHz and quantitative determination of the degree of turbulence are possible. Its simple measurement circuit and the low complexity of fluid temperature compensation are some of the other advantages.

Flow measurements with thermal anemometers are not only suitable for small duct flows. Measurements of mass and volumetric flows under standard conditions can be carried out directly without requiring any other secondary measurement parameters. Its independence of pressure and temperature, quick response to fluid variations, highly dynamic measurement range and direct detection of mass flow make thermal anemometry indispensable in flow metrology.

More information

<http://www.schmidttechnology.com>