A General Information

A.1 Introduction to Pitot Tube Flow Measurement

Pitot tubes are classified as Differential Pressure sensors for flow measurement.

The measuring principle of the pitot tube utilizes the differences between the pressure ridge on the upstream side of a bluff body and the static pressure on its down stream side.

ITABAR-pitot tube sensors, see sample Fig 1, are mainly used to measure the volumetric flow of liquids, gases and steam in closed pipes ranging from ½“ to 480“ (DN 20 to DN 12000).

Examples of their applications are precise volumetric flow measurement in batch processes, continuous measurement of liquid ingredients in the process industry, fuel, air, steam and gases as primary energy source as well as in control functions requiring a high degree of stability and repeatability.

Exemplary in comparison to almost all other flow measuring instruments is the ITABAR-sensor’s ease of installation. The installation consists of these steps: drilling of the pipe, weld-o-let is welded on to the pipe, ITABAR is inserted. Models Flo-Tap FT, see Fig 2, allow installation and removal without shutting the process down.

ITABAR-pitot tube sensors were developed with the goal of high reliability even under difficult conditions. ITABAR-pitot tube sensors are optimized in several ways with respect to fluid stream conditions. Advantages of the engineered sensor profile are their low permanent pressure loss as well as the consistent measurement accuracy over a wide range of Reynolds numbers.

For over two decades ITABAR-pitot tube sensors have been applied in the industrial world. Their exemplary reliability and excellent long-term use record resulted in broad acceptance by customers. Many measurements by independent institutes are testimony to the ITABA-sensor’s high measuring accuracy

Fig 1

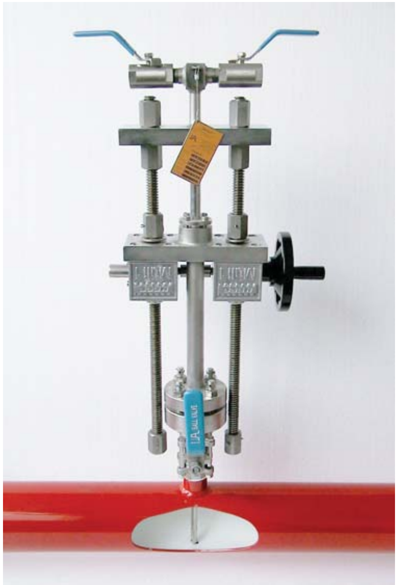

Fig 2: Flo-Tap pitot tube sensor type Itabar® FTM-20 for installation and removal under pressure

A.2 Measurement Principle of Itabar®-Flow-Sensors

According to the continuity law derived by Bernoulli and the energy equation, the sum of the pressure energy and the potential and kinetic energy of a flowing fluid inside a pipe and in conditions of stationary and frictionless flow is the same at any time and in any part of the pipe

$$p_{stat} + p_{dyn} = const \qquad \text{(Equation 1)}$$

The factor p_{stat} is the static pressure equally distributed in all directions. The other term in the equation represents the dynamic pressure, effective in the flow direction, p_{dyn}.

For flowing fluids in horizontal pipes, with a small velocity compared to the Mach-number (Ma <<1), the dynamic pressure p_{dyn} of a fluid with a flowing velocity v, a density ρ and a resistance factor ζ is calculated as:

$$p_{dyn} = \zeta \frac{\rho}{2} v^2 \qquad \text{(Equation 2)}$$

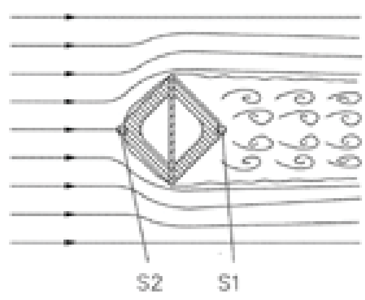

Fig 3: Schematic sketch fluid flow pattern at location

Inserting a fixed body into a flowing fluid causes the flow to dam up immediately upstream of the body and to be completely zero at S2 ,see Fig 3. At this point the total pressure p_{S2}:is

$$p_{S2} = p_{stat} + p_{dyn} \qquad \text{(Equation 3)}$$

The ports of the sensor's downstream side are only affected by the direction-independent static pressure p_{stat}. The difference in both pressures, the differential pressure Δp, which is a function of the velocity with which the inserted body is impacted, see Fig. 4.

$$\Delta p = p_{S2} - p_{S1} \qquad \text{(Equation 4)}$$

Substituting Equation. 2 and 3 into 4 results in

$$\Delta p = \zeta \frac{\rho}{2} v^2 \qquad \text{(Equation 5)}$$

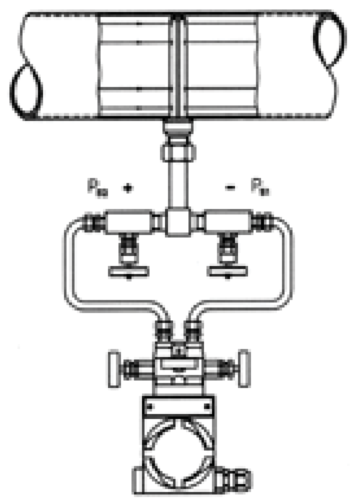

Fig 4: Schematic sketch of generation of differential pressure Δp