Smith Meter® Ultrasonic Flow Meter

Diagnostics technical overview

Diagnostc functions

Introduction

This report aims to provide a detailed overview of the following diagnostic functions

- Velocity of sound
- Gain
- Signal %
- Signal-to-Noise-Ratio (SNR)
- Flow profile measurements

Velocity of Sound

The velocity of sound is a diagnostic function that measures the speed at which ultrasound waves propagate through a medium. By using the velocity of sound, we can assess the characteristics of a medium and identify anomalies. Velocity of sound is measured together with the velocity of the flow. Since the two measurements are done based of the same measurements (the travel time of the ultrasonic signal), the correctness of the velocity of sound will also reveal the quality of the flow measurements. VOS measurements for each path are more useful than the aggregate single value, and it is often difficult to separate out true physical fluid flowing versus a meter component failure.

Gain

Gain is a diagnostic function that measures the amplification or attenuation of a signal. The gain value indicates the increase or decrease in signal strength. The gain is a value that is measured by the automatic gain control (AGC). The AGC tries to keep the signal level at a constant level. The amplification needed to achieve this is the gain number. The gain number is measured by each path. Normally, the current gain should be compared to the gain at the time of commissioning. This comparison helps to identify any deterioration in ultrasonic reception over the operational period.

Signal %

Signal %, also known as signal percentage, is a relative measure of how many signals were not rejected and used in final calculations. It is typically expressed as a percentage and This value describes how many % of the ultrasonic signal are good enough to be used for flow measurement. A high number means that the signal quality is good. Normally, the current signal percentage should be compared to the signal percentage at the time of commissioning. This comparison helps to identify any deterioration in signal quality over the operational period.

Signal-to-Noise Ratio (SNR)

The Signal-to-Noise Ratio (SNR) is a diagnostic function that compares the level of a desired signal to the level of background noise. A higher SNR indicates a stronger signal relative to the noise, which translates to better quality and improved performance. SNR measurement helps evaluate the system's noise resilience and identify potential sources of interference. The signal to noise ratio is monitored both on the sampled signal and the filtered signal. The S/N ratio is calculated by measuring the RMS (Root Mean Square) value of the signal and the noise.

Flow Profile Measurements

This section as written only applies to 8 path meters (and to some extent the old 6 path).

To help evaluate the correctness of the different path velocities a set of values describing the profile is calculated.

1. Profile flatness
2. Profile symmetry
3. Swirl flow
4. Cross flow

To calculate these values the path velocities are first computed into axial and transversal flow components at the 4 different levels of measurements in the pipe. Axial velocities are defined as VA1, VA2, VA3 and VA4, where 1 is the path level in the top of the pipe. Transversal velocities are defined as VT1, VT2, VT3 and VT4.

Profile flatness

This describes the amount of flow on the outer paths compared to the center paths. It is calculated as:

$$Flatness = \frac{V_{A1} + V_{A4}}{V_{A2} + V_{A3}} \bullet 100\%$$

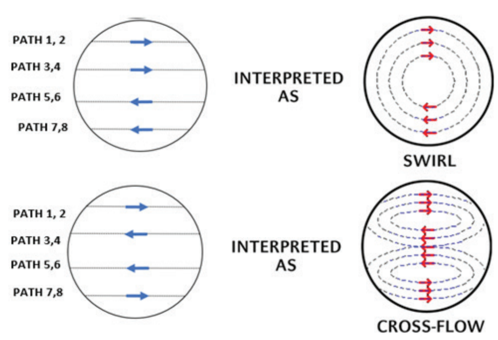
This means that a profile flatness of 88% means that the outer paths see a velocity of 88% of the center paths.

Profile symmetry

This describes the amount of flow on the top paths compared to the bottom paths. It is calculated as:

$$Symmetry = \left(\frac{V_{A1} + V_{A2}}{V_{A3} + V_{A4}} - 1 \right) \bullet 100\%$$

A symmetry factor of 0% means that the flow is equally balanced between top and bottom (a symmetrical profile). A positive symmetry factor means that the flow is higher in the top of the pipe a negative symmetry factor means that the flow is higher in the bottom of the pipe.



Swirl Flow

This describes the amount of transversal flow that is rotating in the pipe. A positive number means that the swirl flow is clockwise if you look downstream. Swirl flow is calculated relative to the average axial flow velocity**.**

The amount of swirl flow is calculated like this:

$$Swirl = \left(\frac{V_{T1} \cdot 0.2 + V_{T2} \cdot 0.3 - V_{T3} \cdot 0.3 - V_{T4} \cdot 0.2}{V_{\bar{A}}} \right) \bullet 100\%$$

Where $V_{\bar{A}}$ is the average flow velocity

Cross Flow

This describes the amount of transversal flow that has two rotating vortexes in the top and bottom of the pipe is rotating in the pipe. The sign of the number indicates the direction of the cross flow. Cross flow is calculated relative to the average axial flow velocity.

The amount of cross flow is calculated like this:

$$Swirl = \left(\frac{V_{T1} \cdot 0.2 + V_{T2} \cdot 0.3 - V_{T3} \cdot 0.3 - V_{T4} \cdot 0.2}{V_{\bar{A}}} \right) \bullet 100\%$$

Where $V_{\bar{A}}$ is the average flow velocity.

In conclusion, the diagnostic functions discussed in this report offer valuable insights into different aspects of ultrasonic flow metering. These functions are crucial tools in assessing performance, identifying anomalies, optimizing signal quality, and ensuring efficient operation.

By utilizing these diagnostic functions, specialists can gain a comprehensive understanding of the characteristics and behavior of various metering systems. They enable accurate measurements, troubleshooting, and the ability to make informed decisions for ultrasonic meter improvement and maintenance.

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