ULTRASONIC DOPPLER FLOWMETERS

Flow Reference Section

INTRODUCTION

The Ultrasonic doppler flowmeter incorporates a technology offering an increased range of applications. Because of its non-invasive nature, no pressure drop is created, and this type of flowmeter can be used to measure the flow of fluids and slurries which ordinarily cause damage to conventional sensors.

The basic principle of operation employs the frequency shift (Doppler Effect) of an ultrasonic signal when it is reflected by suspended particles or gas bubbles (discontinuities) in motion. This metering technique utilizes the physical phenomenon of a sound wave that changes frequency when it is reflected by moving discontinuities in a flowing liquid. Ultrasonic sound is transmitted into a pipe with flowing liquids, and the discontinuities reflect the ultrasonic wave with a slightly different frequency that is directly proportional to the rate of flow of the liquid (Figure 1). Current technology requires that the liquid contain at least 100 parts per million (PPM) of 100 micron or larger suspended particles or bubbles.

A typical system incorporates a transmitter/indicator/totalizer and a transducer. The transducer is mounted on the exterior of the pipe. It is driven by a high frequency oscillator in the transmitter through an interconnecting cable. The transducer generates an ultrasonic signal which it transmits through the wall of the pipe into the flowing liquid. The transmitter measures the difference between its output and input frequencies and converts this difference into electronic pulses which are processed to provide an analog indication and a voltage or current output signal. Additionally, the pulses are scaled and totalized to provide flow quantity.

The transmitter frequency power levels and transducer configuration are selected to accommodate a wide variety of liquids, pipe sizes, percentage of solids, and pipe liners.

The transmitter also incorporates circuitry which allows adjustment of the signal threshold, permitting elimination of undesirable ambient noises (both mechanical and electrical). As a result, instrumentation is possible in a variety of locations subject to high levels of sonic, mechanical, and electrical noise.

ACCURACY

Without Field Calibration

The accuracy of a flowmeter operating on the Doppler principle is mainly a characteristic of flow velocity profile integration by the ultrasonic wave. The ability to do this is basically a function of: percentage of sound reflectors (solids and bubbles), their size, variation and distribution, the line size, and the flowmeter's design features. Therefore, it is unrealistic to state a general accuracy without knowing the full application details and the transducer selection.

With Field Calibration

The accuracy of this method with a field flow calibration can be as high as ±1% plus the accuracy of the flow calibration on the actual application at given conditions.

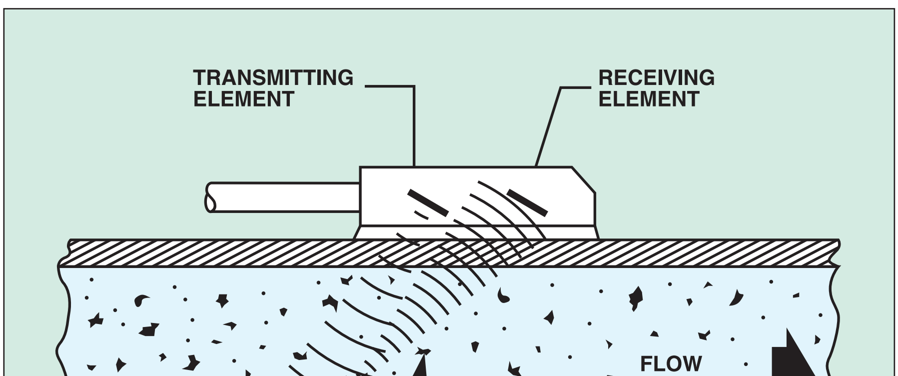

Figure 1: The Ultrasonic Doppler Flow Sensor

Clean Liquids

As noted, the basic ultrasonic Doppler flowmeter requires that the liquid to be measured contain a minimum of at least 100 PPM of suspended solids or bubbles at least 100 microns or larger in size. The transducer frequency for these requirements is 1 megahertz. Lower frequencies require more PPM and a larger micron size. Until recently, 100 PPM of suspended solids or bubbles of at least 100 microns or larger, constituted the cleanest measurable application. The solution for clean liquid applications is the FDT family of Transit Time Ultrasonic flow meters FDT-30, FDT-80 and FDT100 products. In these designs, the time of flight of the ultrasonic signal is measured between two transducers- one upstream and one downstream. The difference in elapsed time going with or against the flow determines the fluid velocity. Transit time flow meters feature the world's most advanced non-invasive flow measurement technology—providing a measuring system with unsurpassed accuracy, versatility, ease of installation and dependability. Designed primarily for clean liquids, the flow meter operates reliably with small amounts of suspended solids or aeration. Transit time flow meters are designed for long- or short-term measurement flow surveys on full-pipe liquid systems and are ideal for verifying calibration of permanently mounted flow meters of all types.

When the flow is zero, the time for the signal T1 to get to T2 is the same as that required to get from T2 to T1. When there is flow, the effect is to boost the speed of the signal in the downstream direction, while decreasing it in the upstream direction. The flowing velocity (Vf) can be determined by the following equation:

$$V_f = Kdt/T_L$$

where K is a calibration factor for the volume and time units used, dt is the time differential between upstream and downstream transit times, and T_L is the zero-flow transit time.

Transit Time Ultrasonic flow meters are specifically designed to work in clean and ultra-clean liquid applications. Bridging the gap is the FD-7000 enhanced ultrasonic flow meter. Examples of liquids that fall into the gap between Doppler and Transit Time technologies include: ground water, gray water, carbonated beverages, waste or return activated sludge, mining slurries and filter backwash.

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