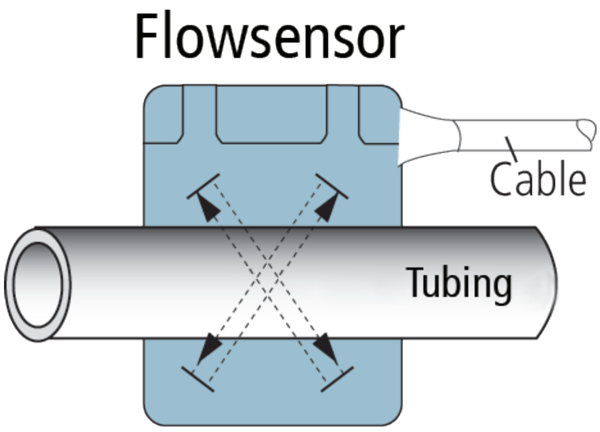
Technical Note

Theory of Operation



Transonic® clamp-on Tubing Flowsensors (Fig. 1) consist of a probe body which houses ultrasonic transducers and a fixed acoustic reflector. The transducers are positioned on each side of the vessel or tube under study. Electronic ultrasonic circuitry directs a Tubing Flowsensor through the following cycles:

UPSTREAM TRANSIT-TIME MEASUREMENT CYCLE

An electrical excitation causes the downstream transducer to emit a plane wave of ultrasound. This ultrasonic wave intersects the tubing under study in the upstream direction, then bounces off the transducer on the opposite side of the tubing, again intersects the tubing and is received by the upstream transducer where it is converted into electrical signals. From these signals, the flowmeter derives an accurate measure of the "transit time" it took for the wave of ultrasound to travel from one transducer to the other.

DOWNSTREAM TRANSIT-TIME MEASUREMENT CYCLE

The same transmit-receive sequence is repeated, but with the transmitting and receiving functions of the transducers reversed so that the flow under study is bisected by an ultrasonic wave in the downstream direction. The flowmeter again derives and records from this transmit-receive sequence an accurate measure of transit time.

Just as the speed of a swimmer depends, in part, on water currents, the transit time of ultrasound passing through a tubing is affected by the motion of liquid flowing through that vessel. During the upstream cycle, the sound wave travels against flow and total transit time is increased by a flow-dependent amount. During the downstream cycle, the sound wave travels with flow and total transit time is decreased by the same flow-dependent amount. The Transonic flowmeter subtracts the downstream transit time from the upstream transit time utilizing wide-beam ultrasonic illumination. This difference of integrated transit times is a measure of volume flow.

WIDE BEAM ILLUMINATION

One ray of the ultrasonic beam undergoes a phase shift in transit time proportional to the average velocity of the liquid times the path length over which this velocity is encountered. With wide-beam ultrasonic illumination, the receiving transducer sums (integrates) these velocity - chord products over the vessel's full width and yields volume flow: average velocity times the vessel's cross sectional area. Since the transit time is sampled at all points across the tubing diameter, volume flow measurement is first-order independent of the flow velocity profile.

LEARN MORE

To learn more about the Non-Invasive Flow Measurement solution from Transonic Systems give us a call at (800) 353-3569 or visit us on the web at www.transonic.com/BioProcess.

REFERENCES

Drost, C.J., "Vessel Diameter-Independent Volume Flow Measurements Using Ultrasound", Proceedings San Diego Biomedical Symposium, 17, p.299-302, 1978. U.S. PATENT 4,227,407, 1980.

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