1 Introduction

em-tec's flow measurement systems, which can be used within both the medical and the bioprocessing field, are designed for the flow measurement of liquids within (extracorporeal) flexible tubing systems.

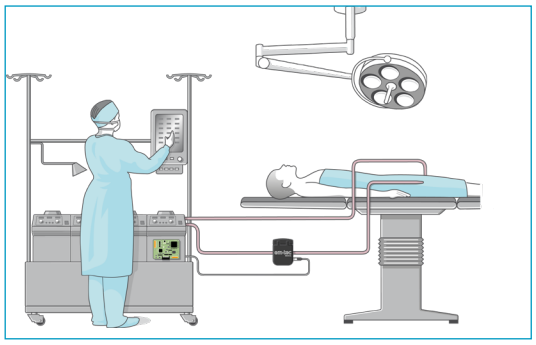

Figure 1: Medical Flow Measurement Application

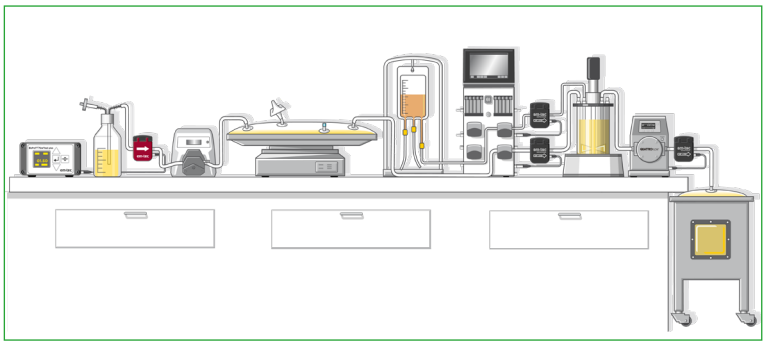

Figure 2: Flow Measurement Application(s) within Bioprocessing

Their function is based on the ultrasonic transit time method, which represents an acoustic measurement principle. This method measures the transit time of ultrasonic signals that are sent with and against the flow direction through a measurement section. The difference in transit time then determines the volumetric flow rate. The following chapters will not only explain how the transit time method works, but also the impact it has on your flow measurement application and em-tec's products.

2 Transit Time Method

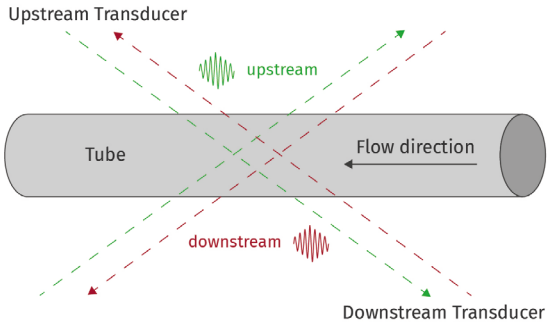

Figure 3: Upstream and Downstream Transducer

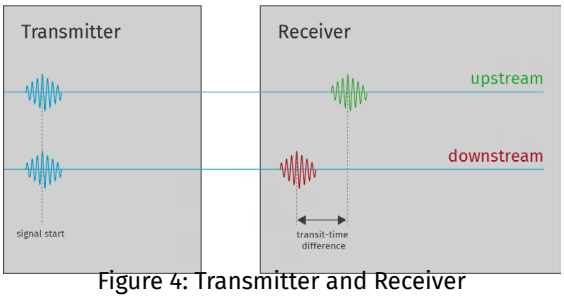

Figure 4: Transmitter and Receiver

Generally speaking, the speed at which ultrasound signals travel through a defined measurement section serves as basis for determining the volumetric flow rate of liquids within a tube. To do so, at least two sound transducers are needed which then alternately send and receive ultrasound waves.

For one, the transmission speed of those signals depends on the flow velocity of the medium, for another on the direction the signal is sent in: Signals that are sent in the flow direction, i.e. downstream, are faster than the signals that are sent against the flow direction, i.e. upstream.

Based on the speed of the downstream and upstream signals, the transit time difference is calculated in pico seconds by using a multi-step correlation method. The transit time differences are proportional to the current flow, i.e. the higher the flow, the larger the difference in transit time between the signals. To display a volumetric flow, every em-tec sensor is adjusted and calibrated according to customer-specific parameters. The flow value is then displayed on the evaluation device or sent to and displayed by the host system.

Of course, the transit time of an ultrasound signal does not only depend on the flow direction, but is also influenced by other factors. Among these factors are:

- the type of medium
  → Different media have different densities, acoustic properties, etc.
- the temperature of the medium
- the tube
  → Both the tube material and the thickness of the tube wall can impact the acoustic signal.
- the flow rate

To learn more about these factors and how they impact the flow measurement, read our TechNotes regarding this topic, which are available for download on our website:

- for bioprocessing applications: BioProTT™ TechNote: Optimizing Accuracy
- for medical applications: SonoTT™ TechNote: Optimizing Accuracy

3 Sensor Structure

A typical transit time flow measurement system incorporates at least two transducers, i.e. piezo ceramics, that act as both transmitter and receiver. To ensure the highest possible accuracy, em-tec's sensors include two pairs of sound transducers.

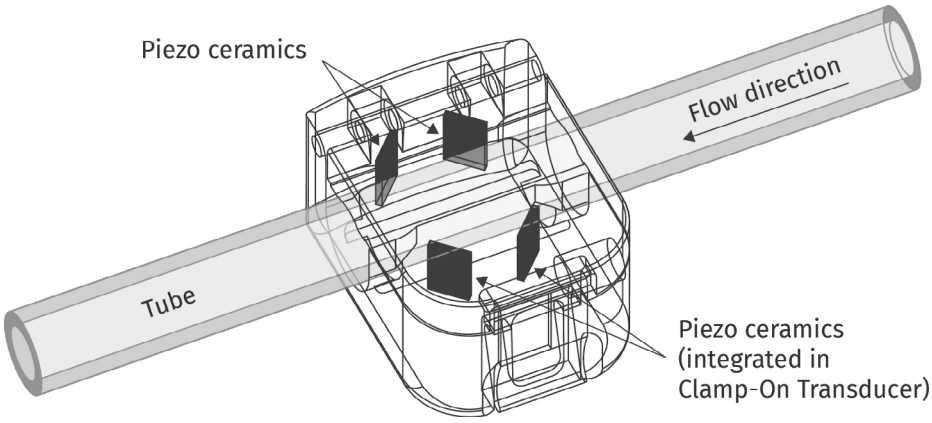

Figure 5: Sensor Structure

They consist of four piezo ceramics, which are fixed within the sensor body and arranged in an X-configuration around the flow channel and therefore the tube containing the flowing medium. This X-configuration creates four sound paths, which allow the whole cross-section of the flow channel to be acoustically illuminated.

Consequently, all velocities contributing to the flow profile are accounted for, meaning the overall flow rate can be determined more accurately. While the ultrasound waves are sent within the sensor using high-frequency voltage impulses, the measurement itself is carried out by the evaluation electronic inside the flow meter or host system.

To further account for the factors that impact the measurement (see chapter 2), and to ensure the highest possible accuracy, every sensor is adjusted and calibrated for the customer's specific application parameters before shipment.

To learn more about the adjustment and calibration and why it is important, download and read our BioProTT™ TechNote: Adjustment and Calibration, which is available on our website.

4 Advantages

One of the main advantages of using the transit time method is the fact that it is non-invasive. For one, this means that there is no pressure drop, for another, it makes a splicing of lines unnecessary and therefore reduces installation costs and effort.

Another benefit of using a sensor that is clamped onto the outside of the tube is the fact that there is no—or very little—wear and maintenance, which significantly reduces the overall costs.

Furthermore, the sensors are easy to set up and use, which also means that existing plants can be easily retrofitted for comparatively low costs; e.g. for quality control.

5 Contact

If there are any questions concerning the information in this document or anything else in relation to our products and/or services, please do not hesitate to contact em-tec GmbH.

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