OVERVIEW OF FLOW ANALYSIS USING THE TFL R5000

TYPES OF FLUID FLOW

The most common type of flow occurs when the the fluid completely fills the pipe or vessel. Typical examples of this type of "single phase flow" include the supply of vehicle fuels in service stations and the supply of water and gas through pipes to buildings. It is relatively easy to measure these types of flows with conventional flow meters.

In a second flow category ("Two phase flows"), a mixture of two different fluids exists inside the pipe. This situation occurs, for example, in oil production pipelines, which may contain a mixture of oil and gas and also in process where solid particles (such as plastic pellets, sand, cement, coal or grain) are mixed with air and either flow under gravity or are pneumatically-conveyed inside pipes. It is much more dificult to measure these types of flow.

PRINCIPLE OF OPERATION OF THE TOMOFLOW TECHNOLOGY

Tomoflow's new flow analysis technology offers a practical solution for analysing and measuring 2-phase flows of mixtures of two insulating materials such as oil and gas or coal and air. It works by measuring both the fluid mixture concentration and velocity at a range of locations over the pipe cross-section and calculates the overall flow from these measurements. In most cases, all of the sensing is done from the outside of the pipe, so that there are no physical obstructions inside the pipe and the Tomoflow sensor is completely non-invasive.

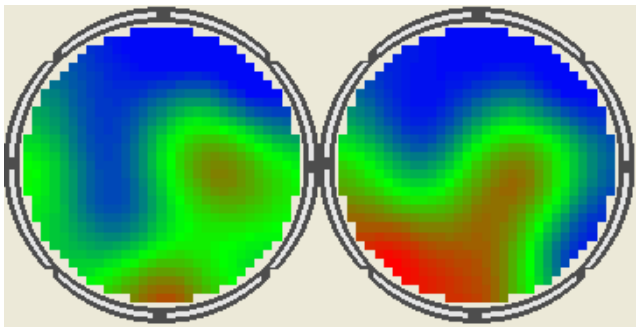

Figure 1. Permittivity distribution images

The TFL500 unit, together with a suitable multi-electrode capacitance sensor, measures the electrical capacitances between combinations of electrodes located on the outside of the pipe or vessel. Changes in the distribution of the fluids inside the pipe cause changes to the values of these electrical capacitances. From these measurements, it is possible to construct a map or image of the concentration distribution of the fluid mixture over the pipe cross-section, as shown in figure 1. In flow analysys applications, these measurements are carried out at high speed and at two separate pipe positions to generate a set of flow data using the TFL Toolkit software. This data is then processed off-line using the TFL Flowan software, where the 2 concentration images are then compared using a mathematical technique called cross-correlation, which allows a further map or image of the fluid velocity to be calculated. The concentration and velocity images can then be processed to yield the accurate fluid flow data.

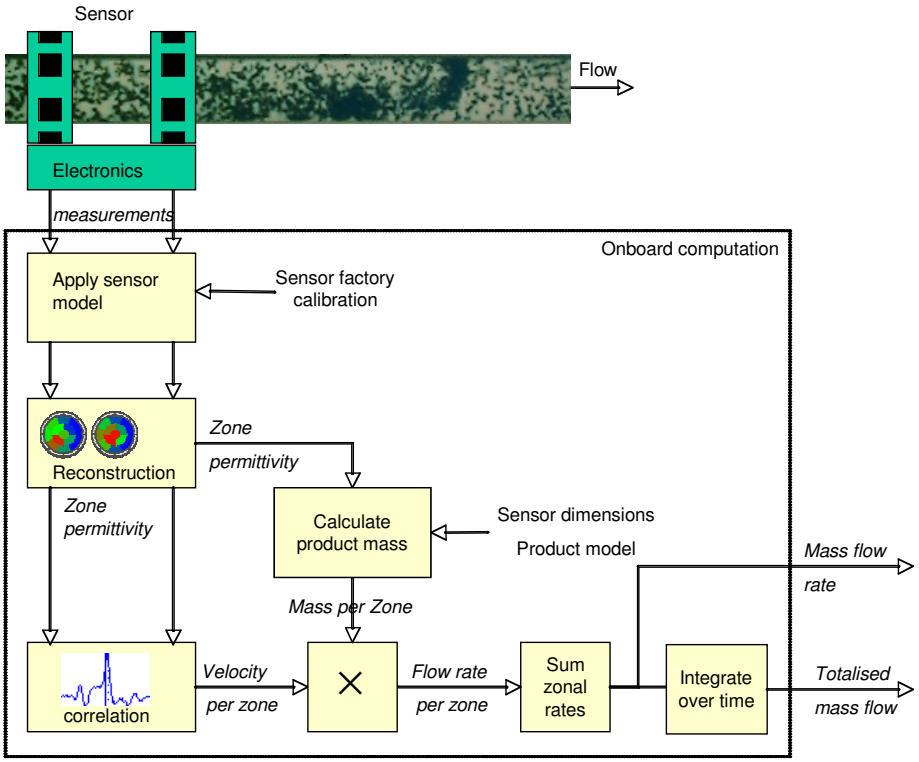

Figure 1. Tomoflow Flow Analysis system

Figure 2 shows a simplified diagram of the measurement system. A twin-plane, multi-electrode capacitance sensor is located on the flow pipe or vessel and capacitance measurements are made at high speed (typically 500 images per second) between all combinations of electrode pairs at each measurement plane. These two sets of capacitance measurements are converted (reconstructed) into a pair of concentration profiles at the two measurement planes using Electical Capacitance Tomography (ECT). The concentration values of similar cross-sectional zones at the two pipe locations are correlated to extract the average velocity in each zone.

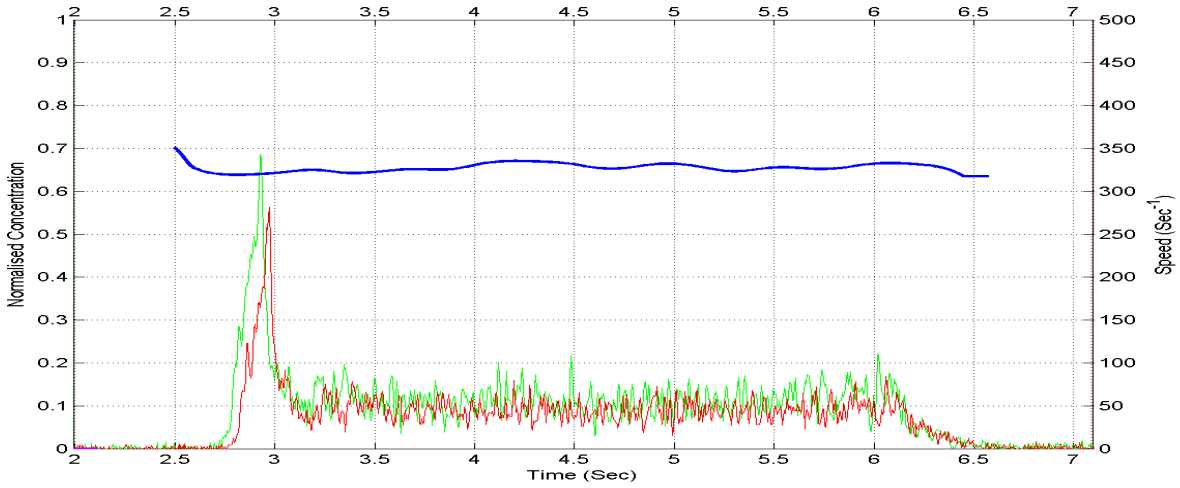

Figure 3. Concentration and velocity plots

Figure 3 shows the calculated concentration in a pair of zones at the 2 measurement planes (green and red plots) and the calculated velocity in those zones (blue plot). The volumetric flow profile across the sensor is calculated from the concentration and velocity flow profiles and the sensor dimensions.

CONCENTRATION MODELS

The Tomoflow technology actually measures the permittivity distribution inside the sensor. Permittivity is an electrical property of insulating materials and is related to the volumetric concentration distribution of a mixture of 2 fluids by a mathematical model based on particle physics. It is very important to select the correct physical model to obtain accurate flow measurements. If the product mass flow is required, the product density must be known or measured separately. If a third fluid (eg small quantities of water in the form of moisture) is present, variations in the moisture content will also affect the measurement accuracy. However, in some cases, the sensor can be made to measure the product moisture content under flow conditions.

ADVANTAGES AND LIMITATIONS

The Tomoflow technology gives accurate results even when the fluid concentration and velocity varies over the pipe cross-section, provided the imaging system can distinguish between the two phases. The Tomoflow sensor normally contains no components inside the pipe and is completely non-invasive, so that it can be used where abrasive flows would destroy other flow sensors. The lack of internal features or moving parts means that there is no extra pressure drop across the sensor. As the velocity is calculated in each zone across the flow cross-section, the measurement does not suffer from the gross errors exhibited by other measurement systems which rely on calculating an average velocity figure over the pipe cross-section.

Most alternative measurement technique either require the fluid concentration and velocity to be constant over the pipe cross-section or that the two flow components are separated before measurements can be made. They may also contain internal components which disrupt the flow and are vulnerable to wear or damage by the flowing fluid.

It is only possible to use electrodes located outside the pipe if the pipe wall is an insulating material such as plastic, glass or ceramic. In the case of a metal pipe, an insulated liner containing the electrodes can be inserted, but this increases the cost and compexity of the sensor. The Tomoflow technology can only measure materials which are themselves electrical insulators (or predominantly so). This normally rules out its use with any form of aqueous fluid mixtures.

For further information, please contact us at enquiries@tomography.com, or visit our web sites (details below).

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