Mathematical modeling of ultrasound propagation in multi-phase flow

Industrial PhD project description – Matej Simurda

University: University of Southern Denmark, Mads Clausen Institute, Sonderborg

Company: Siemens A/S Flow Instruments, Nordborg

3rd party: Technical University of Denmark, Department of Photonics Engineering, Copenhagen

Ultrasonic Flowmeters are used in a wide range of applications. This project focuses on a particular group where the flowing media consists of two or more substances. One example of this is bubbly flow problems where the flowing media is a gas/liquid mixture. While extensive research has been done in the field of ultrasonic measurement technologies, only very few studies with modelling of ultrasonic transmission through flowing liquids containing voids and solids have been published. There are two main technologies widely used in ultrasonic flow measurement.

Transit time ultrasonic flowmeter (TTUF) measures flow velocity in the medium by comparing transit times of ultrasonic signals propagating with (downstream) and against (upstream) the flow. Doppler ultrasonic flowmeter (DUF) uses the principle that sound waves are generated in the fluid by reflection from gas bubbles or solids and are returned to the transmitter at an altered frequency if reflectors in the liquid are in motion where the frequency shift is directly proportional to the velocity of the liquid. Hybrid flowmeters combining TTUF and DUF in one measurement path are currently available on the market. They are designed to alternate between the two technologies based on the properties of the flowing media to achieve the best accuracy without interruption of the flow measurement.

The main goal of this project is the development of mathematical model able to predict the propagation of an acoustic signal through a media consisting of two or more substances. The model is to be verified against experimental measurements.

An important outcome of this project will be a model that can simulate the hybrid ultrasonic clamp-on transit-time/Doppler flowmeters and impact of various factors on the accuracy. Using this to predict the flowmeter behavior the uncertainties caused by these factors can then be compensated and the model will serve as a fast optimizing tool that can reveal new flowmeter configurations more accurate than devices presently available on market.

The primary commercial target is to broaden the Siemens products offer by introducing a new type of flowmeter sensor that can be used on wide variety of flow measurements where both, pure and two-phase/liquid with particles are possible to occur. The flowmeter is expected to be always pre-calibrated based on parameters of a specific pipework. The calibration will be performed by a software developed from the mathematical model and ensure smaller measurement errors making the flowmeter attractive product on nowadays very competitive and fast evolving market.