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Development on Clamp On Ultrasonic flowmeters

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ABSTRACT

Clamp on ultrasonic flowmeters, placed on the outside of a pipe, may be used to determine the liquid flow rate within the pipe. Two important factors that cause uncertainty in the measurements are flow profile distortion due to upstream pipe disturbances and corrosion and fouling of the inside wall of the pipe. Previous research has been carried out to estimate safe installation distances of the flowmeter from the upstream disturbances but, practically, there could be scenarios where such a safe installation is not possible. In such cases, flow profile correction factors have been estimated which cannot be applied with certainty in every installation. The basis of the present research is simulation of the operation of a clamp on ultrasonic flowmeter, coupled with the fluid flow in a pipe, with imposed upstream disturbances, using the software COMSOL. This research is intended to address a gap in the available literature. An ultrasonic flowmeter works on the principle of measuring the time of flight of the two ultrasonic signals generated by the transducer and receiver. The delay in the upstream and downstream moving signals is estimated and used to calculate the flow velocity. The fluid flow is simulated by solving Reynolds-Averaged Navier-Stokes and Continuity equations using the k-ω turbulence model closure. The finite element method (FEM) is used to model the dynamics of the piezoelectric transducers of the flowmeter. Finally, the propagation of the ultrasonic waves is modelled using the Convected wave equation model which solves the linearized Euler equations also referred to as linear acoustic equations for moving media. When the flow profile is disturbed, due to any upstream pipe condition, a correction factor can be estimated for that specific case at various flow rates. All the numerical cases are compared and analyzed in conjunction with experimental data obtained from a liquid flow facility having similar upstream pipe conditions. The measurements from a clamp on ultrasonic flow meter installed in the rig are compared with those from a Venturi tube flow meter and from an inline ultrasonic flow meter. It is intended that this research will help increase the use of ultrasonic flowmeters in the industrial and residential sectors with reduced uncertainty, thereby benefitting from their ease of installation and lower operating costs.