Impact of swirl on flow measurement in stacks – CFD modelling

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Measurement of flow rate in stacks is important component for determining of amount of emissions released to the atmosphere. Current regulation documents (e.g. EU Industrial Emissions Directive) are introducing lower emission limit values bringing new requirements for accuracy of the emission measurement methods. The most common method for flow rate measurement in stacks is using Prandtl tubes for determining gas speed in a net of points inside a stack (e.g. ISO 10780, EN ISO 16911). Another method is using ultrasonic flow meters. Both of them are sensitive to orientation of the meter with respect to the gas flow direction and therefore also to a swirl which often appears in the stacks.

The aim of this paper is to investigate the flow in certain typical stack configurations, to determine swirl velocities for various parameters like shape of the supplying pipe or Reynolds number of the gas flow and to estimate related errors in flow rate measurements using the two above mentioned methods. The stack configurations considered consist of a vertical pipe with T-shape connection of a supplying pipe. The supplying pipe is either straight or with 90° elbow or with double out-of-plane 90° elbow. The range of Reynolds numbers typical for the stack flow is 105 to 107.

The method used for this investigation is CFD modelling using OpenFOAM software validated by experimental data from air velocity profile measurements in T-shape geometry [1]. The determination of errors of the flow rate measurement with Prandtl tubes is based on known experimental data on indication of S-type Prandtl tubes exposed to air streams of various directions [2]. The influence of flow direction to ultrasonic flow meters is derived from their physical principle.

**References**

[1] J. Szmyd et al., *Experimental and numerical analysis of the air flow in T-shape channel flow*, Arch. Min. Sci., Vol. 58 (2013), No 2, p. 333–348

[2] I. I. Shinder et al., *NIST’s New 3D Airspeed Calibration Rig Addresses Turbulent Flow Measurement Challenges*, Proceedings of ISFFM 2015