Adrian Rohner

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Topic	Environmental Engineering
Project Partners	Endress und Hauser Flowtec AG , Reinach , BL

Coriolis flow meter

Flow induced noise assessment

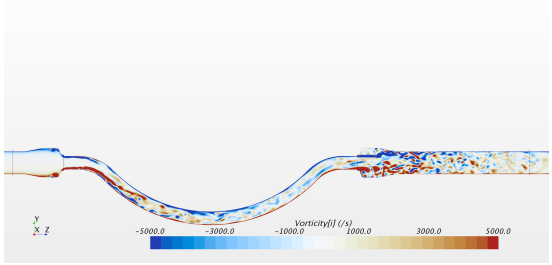

Figure 1: Instantaneous snapshot of the vorticity in x-direction. Dual tube bend and flange outlet are the most turbulent zones. Re = 1'086'000.

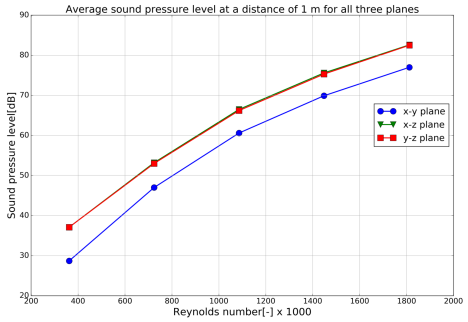

Figure 2: Sound pressure level in a distance of 1 m from the Coriolis in different plane sections evaluated with FW-H.

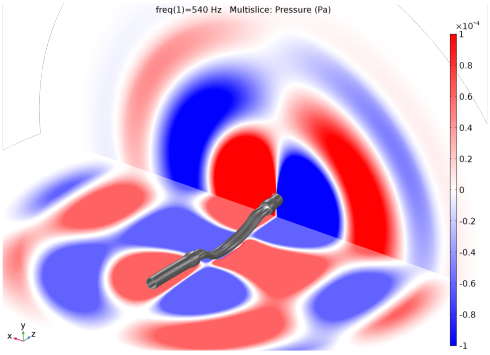

Figure 3: Vibro-acoustic excitation in the x-y and y-z plane of the Coriolis device at a frequency of 540 Hz using COMSOL. Re = 724'000.

Introduction: Endress+Hauser Flowtec AG is a world-leading manufacturer of flow measurement devices. A big part of the revenue is generated by Coriolis mass flow meters, which are used in gas applications where the flow velocity can exceed 100 m/s. At such a high velocities, the noise generated by the turbulent flow in the Coriolis tubes can be disturbing. The focus of this thesis consists mainly in a first estimation of the sound level in the far field.

Approach/Technologies: The chosen approach for this thesis is called Ffowcs William Hawkings (FW-H), which is a hybrid one, where the aeroacoustic problem is divided into a CFD part and an analytical acoustic propagation part, based on surface integral evaluations. Some further studies have been conducted by using real and imaginary part of surface FFT results from STAR-CCM+ as a source term for a vibrational and acoustic excitation simulation in COMSOL. An experimental investigation, including flow, acoustic and vibrational measurements supports the computational analysis with additional data regarding flow induced noise.

Result: The application of FW-H for internal flows, which is also the case of a Coriolis meter, was not clear as the vibro-acoustic part is not modeled at all. Despite this, FW-H showed to have an advantage over vibro-acoustics for such cases. A brief investigation with numerical simulation programs STAR-CCM+ and COMSOL Multiphysics as well as vibration measurements revealed, that the vibrational response of the structure is highly sensible to the boundary setup. The calculated sound level can be assumed at least 5 to 10 dB lower than stated by FW-H, which has been confirmed as well by acoustic measurements. The highest level for a mass flowrate of 5000 kg/h lays around 80 dB, which is still lower than the recommended limit by the OSHA for an eight hour working day. The flanges have been identified as a considerable source of sound through several evidences from simulation and measurements. The excitation takes place in form of a strong internal acoustic mode, an amplified turbulence level due to the cavity and finally also as a structural mode. A redesign of the flange is recommended with the scope of reducing the cavity size and hence recirculation regions as well as an even slower connection between flange and pipe.