CFD MODEL DEVELOPMENT AND SENSITIVITY ANALYSIS FOR WATER-AIR FLOW IN A CLOSE CONDUIT SEWER PIPE.

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Abstract Biological corrosion of sewers networks and treatment plants constitutes a serious problem, and its effects result in the loss of billions of dollars per year. Hydrogen sulphide (H_2S) gas is the major contributor to the odour and corrosion occurring in the sewer networks. H_2S gas is formed by the breakdown of organic matter in the sewer under anaerobic conditions. These emissions not only increase the cost of maintenance but also pose a threat to human health of sewer workers. To understand and to be able to estimate transformation processes at the air-water interface, it is important to study the hydraulics and flow patterns in sewers. For this purpose, a model has been setup in the open source platform OpenFOAM, which is aimed to improve the data basis for a numerical model of natural sewer ventilation.

Keywords: OpenFOAM, sewer-networks, CFD

Methods

- A two-phase flow model in a rectangular pipe
- Solver: interFOAM (in-built)
- Turbulence properties: laminar/simple turbulence
- Experimental setup: Bentzen et. al. (2016)
- Geometry: rectangular (15 m * 0.3 m * 0.26 m)

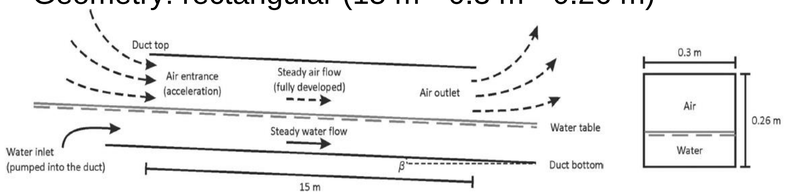

Figure 1: Experimental setup showing the flows involved and the dimensions (Bentzen et al., 2016)

- Turbulent model was not fit for realistically depict the actual flow pattern hence laminar model was chosen

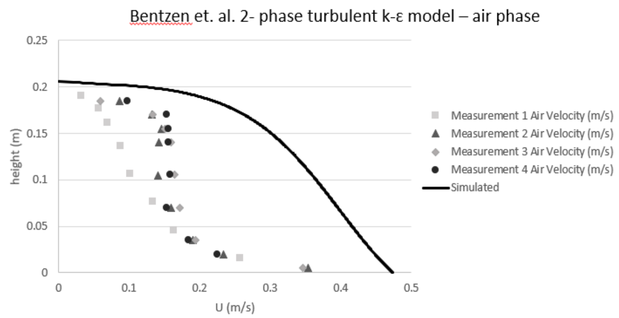

Figure 2: Over approximation of air flow due to turbulent model (measurement data: Bentzen et. al. 2016)

The aim of the study was to lay the groundwork for a robust CFD model that could accurately depict natural sewer systems

Results

- **Plausibility tests:** impact of moving air on stagnant water is significantly lower than that of moving water on stagnant air
- **Mesh density:** Coarse mesh (42000 cells), moderate mesh (72944 cells), fine mesh (343040 cells) and interface + air mesh (343040 cells, difference in special distribution)

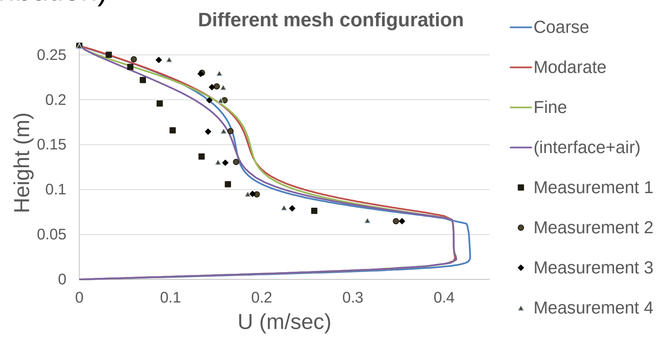

Figure 3: Vertical velocity profile for different mesh designs

- **Changing viscosities**

Table 1: Impact of changing viscosities with RMES

	ν (m^2/sec)		RMSE
	Water	**Air**	**(m/sec)**
Exp. values	1.00E-06	1.51E-05	---
Standard	1.00E-06	1.51E-05	0.005385
Case 1	1.00E-06	1.51E-03	0.075019
Case 2	1.00E-06	1.51E-04	0.077492
Case 3	1.00E-06	1.51E-06	0.078487
Case 4	1.00E-04	1.51E-05	0.122175
Case 5	1.00E-05	1.51E-05	0.034650
Case 6	1.00E-07	1.51E-05	0.070798

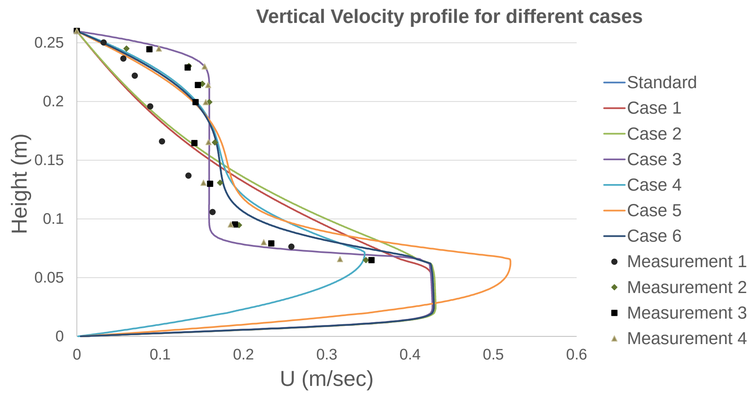

Figure 4: Vertical velocity profile for different viscosities

- Different viscosities have a subsequent impact on the velocity profile
- RMSE not that high when compared to measured data

Conclusions

- Different sets of simulations were able to explain the impact of different factors on a model.
- Increasing the number of cells after a point has no impact on the results but changing the viscosities has a significant impact on flow pattern.
- Future work will include developing a more formal and detailed sensitivity analysis.

Bibliography

Bentzen T., Østertoft K., Vollertsen J., Fuglsang E., Nielsen A. (2016). Airflow in Gravity Sewers–Determination of Wastewater Drag Coefficient. Water Environment Research, 239–256.