Possible Topic for a MASTER THESIS OR STUDY PROJECT

at Brandenburg University of Technology (BTU) in Cottbus, Germany

Electrohydrodynamically enhanced pipe flows

Synopsis – The influence of body forces on turbulence has long been a subject of discussion [1]. The focus is given here to electrohydrodynamic (EHD) body forces. EHD pipe flows can be considered a simplified model of complex process engineering applications. One example is the process of electrostatic precipitation. The sole appearance of the EHD body force allows, for slow moving flows of low to moderate Reynolds numbers, causes a significant enhancement in the momentum, heat and mass transfer, see [2,3]. Preliminary investigations with a reduced order model have shown that inhomogeneities in forced convective flows are the dominant cause responsible for enhancement effects in EHD-enhanced pipe flows [4,5]. In order to complement the research, a classical RANS or LES evaluation of these types of flows is desired, given that the execution of Direct Numerical Simulations (DNSs) is unfeasible from the computational cost perspective. Desired for this work is a parametric evaluation of, so far, undocumented regimes of EHD equivalent natural and forced convective flows [6]. These regimes would be the formal equivalent of naturally convective or forced convective buoyant flows, with the Masuda or EHD number being used instead of the Grashof number. This is a predictive study considering one-way-coupled electroquasistatic fields, which will be validated in a small parameter space for which experimental data for drag and heat transfer enhancement is available [2,3]. The research will be carried out using the open source software OpenFOAM. Any one of the following modalities is possible:

- **a) Master Thesis (1 semester):** In this case the student should focus on the validation of the OpenFOAM 3-D EHD-pipe flow simulations with the available experimental data. The evaluation will focus on the EHD-enhancement of drag.
- **b) Study Project (2 semesters):** Same as a), but the student will evaluate EHD-enhancement of both drag and heat transfer.
- **c) Study Project and Master Thesis (3 semesters):** Same as b). Additionally, the student will perform an extensive parameter space evaluation to verify the existence of buoyant flow-like regimes in EHD-pipe flows, i.e., the formal equivalents of laminar flow, dominant natural convection flows, dominant forced convection flows and mixed convective flows as a function of the Reynolds and Masuda (or EHD) numbers.

[1] Hunt (1995), Effects of Body Forces on Turbulence, *Advances in Turbulence V*, 229-235 — [2] Nelson *et al.* (2000), *J. Enh. Heat Transfer* **7**(2) — [3] Bacher and Riebel (2021), *Chem. Eng. Res. Des.* **167**, 183-197 — [4] Medina Méndez *et al.* (2021), *Proc. Appl. Math. Mech.* **20**:e202000132 — [5] Medina Méndez (2020), PhD Thesis, BTU Cottbus-Senftenberg.

Tasks

- Review of relevant literature and theoretical foundations
- Code development, compilation and testing
- Visualization, post-processing, and data analysis of numerical simulation data
- Comparison of simulation results with relevant reference data

Desired skills and requisites

- Solid knowledge of fundamentals of fluid mechanics
- Affinity to programming (preferably Python and C/C++)
- Scientific attitude (curiosity, self-motivation, and critical reasoning)
- Experience with data analysis, numerical simulation and modeling, or CFD is an asset
- **For the intended take of the Master Thesis:** The student must have approved the modules of Turbulence Modeling and CFD 1.
- **For the intended take of the Study Project:** The student is required to take the modules of Turbulence Modeling and CFD 1 in parallel to the project time frame.

Contact information:

Dr.-Ing. Juan Medina E: medinjua@b-tu.de T: +49-355-69-6033

Chair of Numerical Fluid and Gas Dynamics, Brandenburg University of Technology (BTU)
Siemens-Halske-Ring 15A, D-03046 Cottbus, Germany

URL: https://www.b-tu.de/en/fg-stroemungsmodellierung