Karlsruhe Institute of Technology

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bachelor or master thesis – numerical

Simulation of the flow interaction of plasma actuator arrays

Background

A possible method of active flow control with the aim of reducing surface friction in turbulent flows is the oscillation of the adjacent wall perpendicular to the main flow direction. To avoid the use of moving mechanical parts, plasma actuators (PA) can be used. These have the ability to transfer momentum to the surrounding fluid close to the wall and thus the effects of wall movement in the flow could be imitated. The resulting flow interaction, or more specifically the implied spatio-temporal effect, strongly depends on geometrical parameters, applied electrical signals and surrounding flow. A numerical model of the PA array would help with their optimisation for future experimental campaigns. To use a fully coupled physical model is too expensive; and the existing literature related to modelling even a single PA using simplified phenomenological models highlights some faults, from the induced force location (i.e. wall-jet thickness) to underestimating its power consumption (i.e. their efficiency). Thus, we aim to build an improved model of the fluid-mechanical interaction of PA that can be used to predict the effects of the actuation, i.e. spatial and temporal distribution of the induced body-force and the resulting wall shear stress.

Content of the Thesis

This work is based on an existing empirical model and will be a continuation of a finished Bachelor thesis where the model validation was done for the case of quiescent air. The distribution of the PA-induced force is designed based on experimental results and is additionally introduced into the incompressible Navier-Stokes equations (NSG), which are solved with a spectral solver, also suitable for simulating turbulent flows.

In continuation, more effort needs to be done to refine the spatial distribution of the body force. As a parallel path, the existing model will be used to investigate the effects of PA arrays on laminar and turbulent channel flows to gain a better understanding of the interaction of the PA array and the flow for different parameters.

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