Karlsruhe Institute of Technology

Institute of Fluid Mechanics

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master thesis – numerical

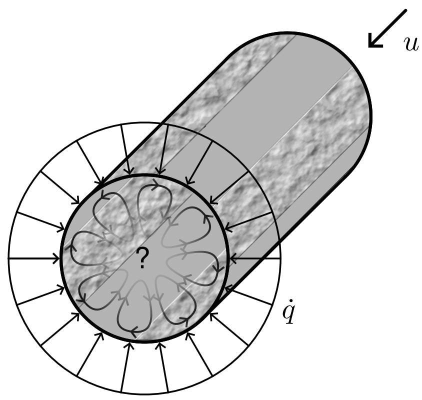
Azimuthally inhomogenous roughness in turbulent pipe flows

Background

Inhomogeneous roughness is ubiquitous in nature and technical applications alike, and turbulent flows over such surfaces have been subject to countless studies. The case of spanwise inhomogeneous roughness in internal (channel) and external (boundary layer) flows has seen particular attention recently, including several experimental and numerical papers from our working group. In this case, the mean velocity field feature a non-zero spanwise and wall-normal component, a so-called Prandtl's secondary motion of the second kind, which increases friction and heat transfer. However, little is known about the analogous case of azimuthally inhomogeneous roughness in pipes and the influence on skin friction and Nusselt number.

Content of the Thesis

In this thesis, the wall roughness will not be resolved, but instead implemented in form of a simplified model based on spanwise / azimuthal slip (Neuhauser et al., 2022). This model has been validated for spanwise inhomogeneous channel flows and is to be transferred to pipe flows. It will be implemented in the C++/OCCA based spectral element (SEM) code NekRS and calibrated against literature data for homogeneous rough pipes. Then, DNS simulations for different azimuthal wavelengths of the roughness strips will be performed and evaluated with respect to turbulent mean quantities (mean velocities, secondary flow, Reynolds stresses, turbulent kinetic energy budget).



Temperature will be treated as a passive scalar under isoflux (constant heat flux) conditions, and the Nusselt number will be evaluated for all cases and compared with the azimuthally homogeneous case as well as literature correlations, such as the Gnielinski correlation. Select cases will also be simulated for liquid metals, which are characterized by a larger characteristic length scale of heat transfer compared to turbulence, resulting in a lower Prandtl number.

Requirements

knowledge in fluid mechanics
numerical methods / programming

Beneficial Skills

C++, theory of turbulent flows

Start: immediately

Contact:

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