TORQUE MEASUREMENTS AND FLOW VISUALISATIONS IN A WIDE GAP TAYLOR-COUETTE FLOW

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Abstract The Torque acting on the inner cylinder in a differentially rotating Taylor-Couette flow is investigated. In the past a torque maximum has been found in the counter rotating regime. Using flow visualisations and LDA measurements a deeper look inside the flow in the vicinity of this maximum will be done.

TORQUE MEASUREMENTS IN TAYLOR-COUETTE FLOW

The flow between concentric rotating cylinders - namely Taylor-Couette (TC) flow - is a famous reserve model for rotating flows in fluid mechanics. As control parameters the ratio of angular velocities $\mu = \Omega_2/\Omega_1$, the radius ratio $\eta = R_1/R_2$, the aspect ratio $\Gamma = L/d$ and the shear Reynolds number $Re_S = \frac{2R_2R_1d}{(R_1+R_2)\nu} \mid \Omega_2 - \Omega_1 \mid$ [1] are used to adjust a particular state of flow. The indices 1 and 2 indicate the inner and outer cylinder, μ is the kinematic viscosity and $d = R_2 - R_1$ the gapwidth. According to [2] the global transport can be quantified by the conserved transverse current of azimuthal motion $J_\omega = r^3(< u_r\omega >_{A,t} -\nu\partial_r < \omega >_{A,t})$ which is proportional to the measured torque T either on the inner or the outer cylinder. Further in analogy to the Rayleigh-Benard system a quasi-Nusselt number Nu_ω can be defined depending on J_ω. In [3] Merbold investigated experimentally the torque acting on the inner cylinder for co- and counterrotation with a radius ratio of $\eta = 0.5$. He found that for a constant Re_S the torque shows a maximum for a ratio of angular velocities of $\mu = -0.2$. To get a better understanding of the causes for this maximum flow visualisation measurements have been done in [4] for different μ at $Re_S = 5000$. The turbulent Taylor vortices showed an additional axial oscillation in the region of the maximum and the outer cylinder rotation first stabilized the flow for $\mu < -0.2$. The purpose of this work is to continue the experiments mentioned last with measurements of the dimensionless torque, flow visualisations and Laser Doppler Anemometry.

EXPERIMENTAL INVESTIGATION

The experiments are done in a wide-gap Taylor-Couette facility with a radius ratio of $\eta = 0.5$. The outer cylinder is made of acrylic glas to enable optical access and the inner cylinder is made of black anodized aluminium with respective radii of $R_2 = 70mm$ and $R_1 = 35mm$. The gap is closed with the end plates at an aspect ratio of $\Gamma = 20$. Both cylinders and the end plates can rotate independently. While the end plates are kept at rest the inner and outer cylinder rotate in co- as well as in counter direction. The experiment is filled with silicon oil as working fluid with different kinematic viscosities to reach shear Reynolds numbers up to 10^6. In addition aluminium flake particles with an approximated size of $5\mu m$ are mixed into the fluid to visualize the flow. The torque is measured with strain gauges at the inner cylinder. To reduce possible end wall effects the inner cylinder is divided into 3 segments and only the middle segment is taken into account [3].

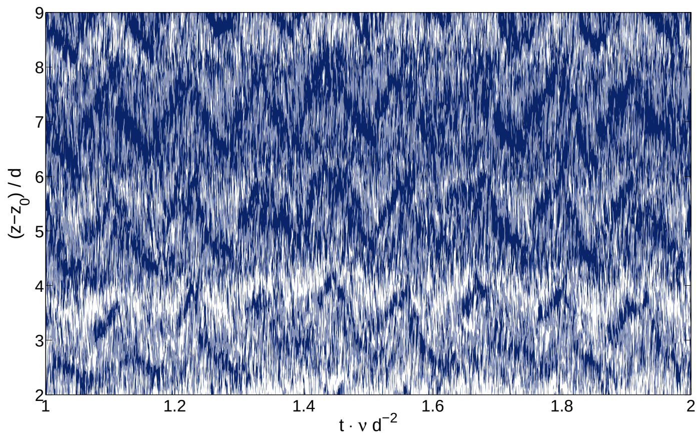

Figure 1. Space time diagram of a Taylor-Couette flow with $Re_S = 5000$ and $\mu = -0.2$ [4].

In Figure 1 a space time diagram from [4] at $Re_S = 5000$ and $\mu_{max} = -0.2$ is shown. Strong axial oscillations of the turbulent taylor vortices are visible which is similar to a zigzag function. The corresponding photograph in Figure 2 indicates a desceleration of the flow in the azimuthal direction at the inflow regions of the vortices. So the rotation of the outer cylinder has still no stabilizing effect on the flow causing a maximum in torque. To prove this theory LDA measurements of the azimuthal velocity component of the flow near the outer cylinder wall are planned to determine the radial position of the neutral surface. Futhermore these effects will be investigated for a wide range of Re_S.

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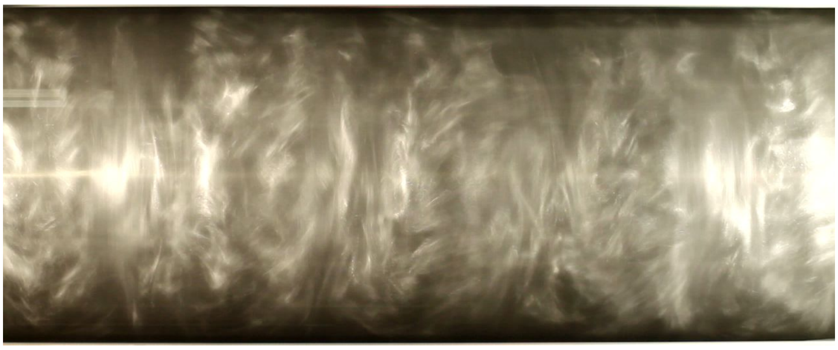

Figure 2. Photograph of a Taylor-Couette flow with $Re_S = 5000$ and $\mu = -0.2$.

References

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