TORQUE MEASUREMENTS IN A TAYLOR-COUETTE EXPERIMENT WITH A VERY SMALL RADIUS RATIO OF 0.357

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The flow between concentric rotating cylinders - namely Taylor-Couette (TC) flow - is a famous example of 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 $Re_S = \frac{2r_2r_1d}{(r_1+r_2)\nu} \mid \omega_2 - \omega_1 \mid$ [2] 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 gap width. According to Eckhardt et al. [3] the global transport can be quantified by the conserved transverse current of azimuthal motion J_ω which is proportional to the measured torque T either on the inner or the outer cylinder.

$$J_\omega = r^3(\langle u_r\omega\rangle_{A,t} - \nu\partial_r\langle\omega\rangle_{A,t}) \tag{1}$$

In analogy to the Rayleigh-Bénard system a quasi-Nusselt number Nu_ω can be defined depending on J_ω. This Nusselt number exhibits a maximum in the low counter-rotating regime and its location depends on the radius ratio [4]. For Taylor-Couette flows with $\eta \leq 0.71$ Brauckmann & Eckhardt [1] derived a prediction for that location suggesting that μ_{max} tends to zero for $\eta \to 0$. Up to now, no experimental and numerical investigations of this maximum exist below $\eta = 0.5$.

In our study we investigate the angular momentum transport in a very wide gap Taylor-Couette experiment. The radii of the cylinders are $r_1 = 25\,mm$ and $r_2 = 70\,mm$ and both have a length of $L = 700\,mm$. Therefore, the geometrical parameters are $\eta = 0.357$, $d = 45\,mm$ and $\Gamma = 15.6\,mm$. The cylinders can rotate independently up to $35Hz$ reaching shear Reynolds numbers of $Re_S \leq 3\cdot10^5$ depending on the working fluid. During these experiments silicone oils of different viscosities will be used ($20\cdot10^{-6}\,mm^2/s \leq \nu \leq 3\cdot10^{-6}\,mm^2/s$). The inner cylinder is mounted on a shaft which is connected to the driving via a shaft-to-shaft rotary torque sensor ($2\,Nm, 0.1\%$ precision) to measure the torque over the whole length of the inner cylinder. The temperature of the working fluid is recorded by a thermocouple.

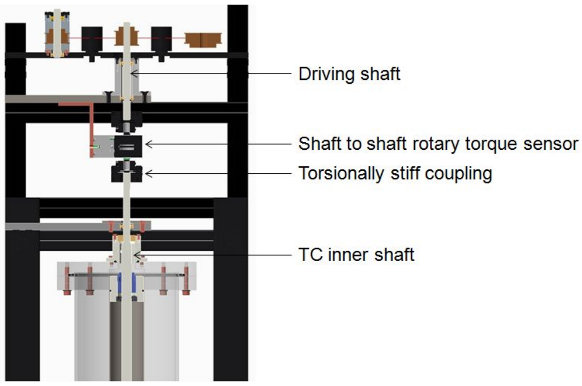

Figure 1. Sketch of the experimental setup with torque measurement unit.

Within these investigations we analyze the torque scaling for pure inner cylinder rotation and the location of the torque maximum in the parameter range $Re_S \leq 8\cdot10^4$ and $-0.5 \leq \mu \leq 0.2$. Further, flow visualizations will be performed to understand the mechanism behind the expected torque maximum for very wide gaps.

References

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