

Boundary condition influence on instabilities in a low Reynolds free surface rotating flow

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- Fixed cylindrical cavity of radius R
- Rotating disc at the bottom
- Filled with a height h of water or water/glycerol mixture

$$\Rightarrow \text{Aspect ratio } G = \frac{h}{R}$$

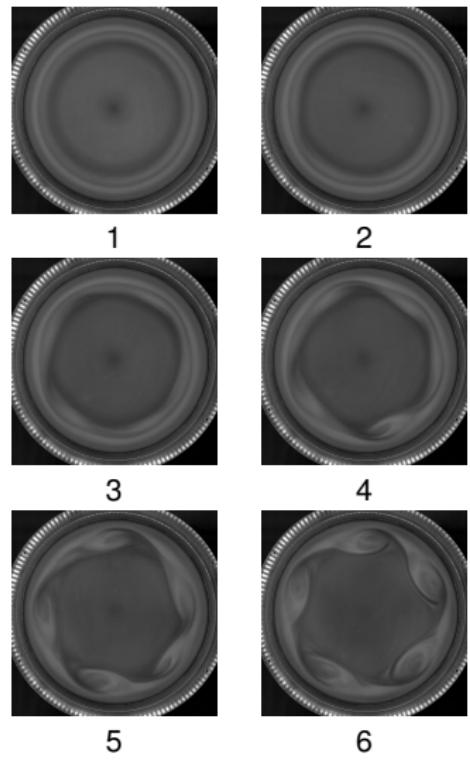
- Free surface at the top
- Low rotation speed Ω

\Rightarrow Small Reynolds number

$$Re = \frac{h^2 \Omega}{\nu}$$

\Rightarrow Small Froude number

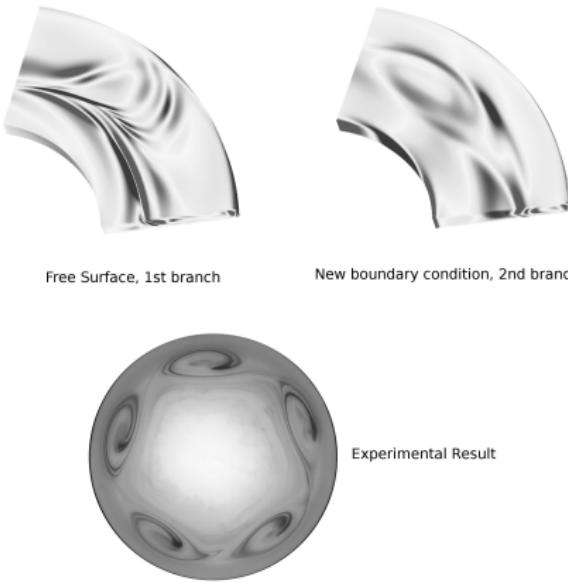
$$Fr = \frac{R\Omega^2}{g} \ll 1$$



5

6

$h = 10\text{mm}$, $\Omega = 8\text{rpm}$,
water + Kalliroscope,
 $Re = 84 (> Re_{c_{XP}})$.



⇒ Huge discrepancies on critical Reynolds number

⇒ “Free surface” is maybe too ideal to modelize the experimental boundary condition at the top.

- New α weighted Robin condition :

$$0 = \alpha * V_{r_{surf}} + (1 - \alpha) * \omega_{surf}$$

⇒ Highlighting a new instable branch

⇒ Qualitatively much more satisfying numerical visualizations

⇒ Numerical critical Reynolds number divided by two

Thanks for your attention.

For any question, remark or discussion, come meet me near this poster ⇒

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ABSTRACT

In previous works, we have shown that flow instabilities in a rotating domain rotating disk flow develop with both numerical predictions [1] and publications [2]. After several investigations on

NUMERICAL METHODS

We compute our flows on a finite-difference grid, with a finite volume method and the finite element method [3].

Our domain is a square, with a free surface at the top and a rotating boundary at the bottom. The angle of rotation is Ωt , where t is the time.

The code is a second-order finite difference scheme, with a semi-implicit time integration. The code then solves the Navier-Stokes equations by a Newton method.

Convergence is checked by comparing the numerical solution with the analytical solution of the Stokes problem for a rotating cylinder [4].

With both codes, we measure the free surface as far out as possible, and we compare the results with the analytical solution of the Stokes problem for a rotating cylinder [4].

The Reynolds number is $Re = \frac{U_0 R}{\nu}$, the Froude number $F = \frac{U_0}{\sqrt{\nu R}}$, they are fixed, and is reduced since the experiment.

EXPERIMENTAL METHODS

Our experiment is composed of a PIV system and a rotating frame bottom disk. The rotation of the disk is precisely controlled by a motor with a resolution of 0.001 rad/s and a maximum speed of 10 rad/s.

In the first case, for $Re = 0.12$ and $F = 0.12$, the rotation is set to 1 rad/s, and the rotation of the disk is set to 0.1 rad/s.

For $Re = 10$, the rotation of the disk is set to 1 rad/s, and the rotation of the disk is set to 0.1 rad/s.

For $Re = 50$, the rotation of the disk is set to 1 rad/s, and the rotation of the disk is set to 0.1 rad/s.

For $Re = 100$, the rotation of the disk is set to 1 rad/s, and the rotation of the disk is set to 0.1 rad/s.

For $Re = 200$, the rotation of the disk is set to 1 rad/s, and the rotation of the disk is set to 0.1 rad/s.

The detection of the threshold to shear with Laser Doppler Velocimetry is performed by a combination of our theory and detection of optical techniques on PIV, PIV, and the fluid.

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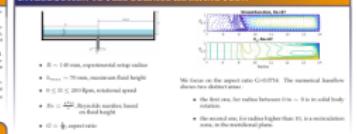
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CONTACTS

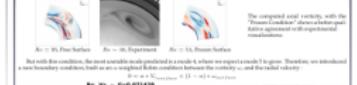
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INTRODUCTION TO FREE SURFACE ROTATING FLOW



RESULTS

Experimentally, we consider the axisymmetric rotation for profile radius, but the LIMSI numerical investigation showed that the flow is not axisymmetric. Therefore, we consider the flow in the cylindrical coordinate system, and the critical Reynolds number depends on the G :



The computed axial vorticity with the "Tomas-Lundström" scheme shows qualitatively good agreement with experimental measurements.



The calculation of mean Reynolds number as a function of aspect ratio is compared with the numerical results of three different models. It is a confirmation of the numerical results obtained for the "Tomas-Lundström" scheme for $Re = 100$ and $Re = 50$.



CONCLUSION

We show that the low Reynolds number rotating disk flow with a free surface, the top boundary condition applied is a natural simulation have a strong impact on flow. As a consequence, the instability threshold is divided by a factor 2, and the solution is more stable. This is confirmed by the numerical simulations. The flow is forced to two experimental findings. More work is needed to find the exact flow in a hydrodynamic situation, and to bring quantitative comparisons between simulation and experimental measurement.