Study on the Spin-up Flows in a Rectangular Container with a Circular Cylinder Inside

Y. K. Suh[1], *S. K. Kim*[2], *J. H. Park*[1] *and Y. R. Son*[2]
1. School of Mechanical and Industrial System Engineering, Dong-A University, 840 Hadan-dong, Saha-gu, Busan 604-714, Korea
Y. K. Suh : yksuh@mail.donga.ac.kr
J. H. Park : p6783@donga.ac.kr
2. School of Mechanical Engineering, KonKuk University, Whayang-dong Kwangjin-ku, Seoul 143-701, Korea
S. K. Kim : skkim@kkucc.konkuk.ac.kr
Y. R. Son : ingen1000@hanmail.net

Corresponding author ***Y. K. Suh***

Spin-up of a fluid in a container, that is adjustment of the contained fluid to any change in the rotational speed Ω of the system, is an intriguing process, in particular when the container is nonaxisymmetric. Usually "spin-up" refers to the adjustment process owing to an increase in the rotational speed($\Delta\Omega > 0$).

In this study, we present numerical and experimental results of the spin-up flows of a liquid having a free-surface in a rectangular container of the horizontal aspect ratio 3 with an internal cylindrical obstacle. Figure 1 shows the flow model and the coordinate system. Both the experimental and numerical works have been carried out for a variety of obstacle position and liquid depth. The CBC algorithm is used in the PIV analysis and the unstructured grid system is employed in the numerical analysis.

Figure 2 shows the velocity-vector field and streamlines for the case when the cylinder is located at the center of the container at the Reynolds number 3000, the Rossby number 0.1 and the dimensionless liquid depth 0.6. As time elapses from t=0 (when the angular velocity starts to increase), a number of vortical structures emerge gradually and almost but not exactly symmetrically about the center point. The final result also shows asymmetric flow pattern.

Figure 3 shows the velocity-vector field and streamlines for the case when the cylinder is located off the center (one diameter away from a side wall) under the same parameter set as Fig. 2. Results for this case show the asymmetric evolution of vortical structures.

Through a series of numerical and experimental works, we aim to clarify the effect of the solid obstacle on the flow evolution during the spin-up for the special case when the vortices are generated near the corners of the rectangular container.

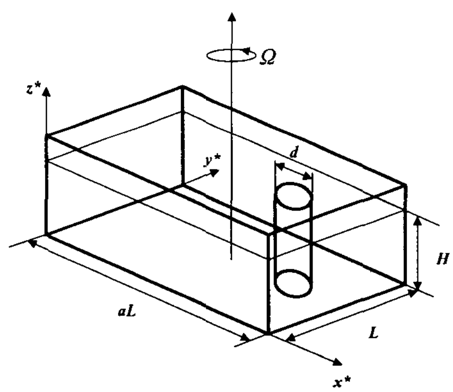

Fig. 1 Schematic diagram of the model basin

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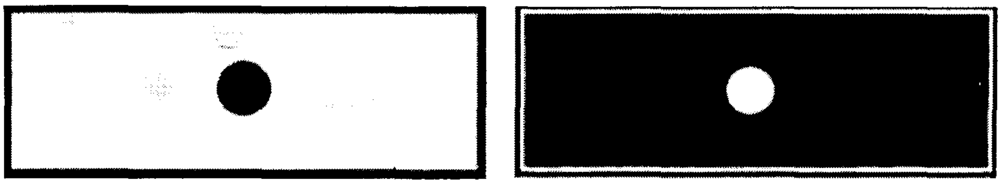
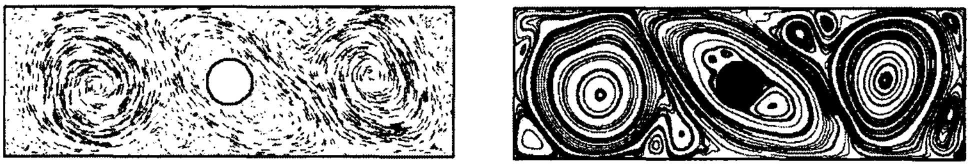


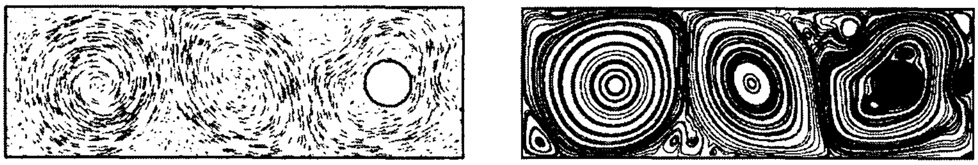
(a) PIV result



(b) Numerical result

Fig. 2 Experimental (a) and Numerical (b) results of velocity vectors(left-hand side) and streamlines (right-hand side) for the case when the cylinder is located at the center ; *Re*=3000, ε =0.1, t = 10.5

(a) PIV result



(b) Numerical result

Fig. 3 Experimental (a) and Numerical (b) results of velocity vectors(left-hand side) and streamlines (right-hand side) for the case when the cylinder is located off the center; *Re*=3000, ε =0.1, t = 10.5