Axisymmetric flow in a cylindrical tank with a rotating bottom: comparison between fast and slow cases

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In the terrestrial and planetary atmospheres, non-axisymmetric flows are often formed even under their axisymmetric environments. Such non-axisymmetric flows can be observed in a very simple laboratory experiment wherein a cylindrical tank is filled with water and the disk at the bottom is rotated rapidly. In order to treat theoretically such phenomena, the axisymmetric flow as the basic state is necessary, which has been analyzed using boundary layer theories. This analysis, which is discussed based on the assumption that thin boundary layers are formed along the side wall and the bottom disk owing to the sufficiently small Ekman number, describes very well the data obtained in laboratory experiments.
On the other hand, flows in the same situation except that the rotation of the bottom disk is slow, have been also investigated. In this situation, the viscosity is effective in the whole fluid layer and numerical calculations using finite difference are very effective. Based on this means, the flow pattern has been discussed in particular noticing the shape of the vertical circulation, but the parameters of the fast flow including that in our laboratory experiments are beyond the range which the setting of these numerical calculations covers.
However, with the recent improvement of the computer resources, numerical calculations with relatively fast flows are becoming performed, and it is becoming possible to compare the results with that obtained theoretically using boundary layer theories in some viewpoints. We will discuss the features of the theoretical analys which well predict those of the numerical calculations and also the features which differ between the theory and the numerical calculations.

Keywords: rotating flow, laboratory experiments, axisymmetric flows, structure of boundary layers

