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Visualization of the inside of a fluid in a rotating water tank experiment

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Abstract

We have been conducting experiments focusing on the inside of fluids. We tried to clarify the flow mechanism by visualizing the three-dimensional convection in the experimental tank. As a result of the experiment, it is considered that the up flow and the down flow are generated with the change of the flow velocity.

1 Introduction

Last year's research confirmed the fact that "convection in the upper and lower layers is offset by half a wavelength in opposite directions. Therefore, we wanted to visualize the inside of the experimental tank and clarify the flow mechanism. Therefore, in this study, we first tried to visualize the flow in the middle layer of the experimental tank.

2 Three experiments and those results

Experiment 1: Inject the red dye into the surface layer and the blue dye into lower layer of the experimental tank, and observe the motion of the dye by referring to the infrared image and visible light image of the camera attached to the upper part of the experimental device to observe the convective motion of the experimental tank. Hereafter, the experimental apparatus and the shooting conditions are the same.⇒The dye injected into the upper layer fell due to gravity, and the middle layer could not be visualized.

Experiment 2 : Inject the blue dye only in the lower layer of the experimental tank and observe the movement.⇒The updraft seemed to occur on the middle side from the central tank side to the outer tank side, and the downdraft seemed to occur on the middle side from the outer tank side to the central tank side.

Experiment 3: Inject the nylon powder mixture into the lower layer of the experimental tank and take videos.⇒In the videos from the top, it was confirmed that two or more vortices were generated on the outer tank side. In addition, it was found from the image from the side that the amount of nylon powder distributed in the middle layer was scarce.

3 Discussion

In the upper layer, the Coriolis force works in the same direction as the rotation, because there is a flow from the outer tank side to the central tank side. Vortices are generated on both sides of the flow due to meandering, whose vortices are accompanied by centrifugal force, so that the flow also receives this force. Focusing on the working directions of the pressure gradient force and the centrifugal force, the centrifugal force and the pressure gradient force received from the vortex on the side of the central tank have the same direction, so that the flow is accelerated. On the other hand, the centrifugal force and the pressure gradient force received from the vortex on the outer layer side are in opposite directions, so that the flow is decelerated. For this reason, the accelerated fluid goes under the decelerated fluid to allow a downward flow. On the contrary, the decelerated fluid does not catch up with the accelerated fluid, and the underlying fluid floats and an upward flow is generated. Since these upward and downward flows are straight vertically downward, the upper layer waveform and the lower layer waveform are shifted by about half a wavelength. In the lower layer, since there is a flow from the central tank side to the outer tank side, the Coriolis force works in the opposite (clockwise) direction to the rotation. For this reason, the flow in the lower layer is opposite to the flow in the upper layer. The mechanism of the subsequent movement is the same as that of the upper layer. Further, ascending and descending flows formed in the upper layer blow into the vortex in the lower layer, and ascending and descending flows formed in the lower layer blow into the vortex in the upper layer, so the vortex becomes high-pressure or low-pressure.

4 Conclusion

The flow inside the fluid is as shown on the right. In this figure, the experimental tank is cut open in the radial direction and extended. This is the QR code that shows our consideration.