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Numerical simulation of interaction between two Savonius turbines aimed at practical application of ocean current power generation

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Renewable energy is important as a way to solve global warming and energy problems. In this study, we investigate the flows around two Savonius turbines that rotate independently by numerical simulation considering the application of ocean current power generation since the stability of the entire device can be improved by rotating two devices side by side in the opposite direction. This drag type device is chosen considering that the speed of the ocean current is small.

In general, when analysing the flow around a rotating object, a rotational coordinate system is often used. However, it is difficult to calculate with such coordinate system when two objects rotate in the reverse direction independently.

Therefore, in this study, the entire area was divided into a plurality of rectangular areas including one rotating device. At this time, data is exchanged between each area through the sides of each rectangle. One rectangle is divided into an inner circular area and an outer circular hollowed out rectangular area. In the circular area, the rotating coordinates matched to the rotation of the rotating device were used, and in the external area, the stationary coordinate system was used. Since the data in the two areas are passed on the circumference, not only the calculation time required for interpolation is significantly shortened, but also the accuracy of interpolation is improved. The internal region is further divided into several regions in order to generate a grid along the blade of the Savonius type rotating device.

In this method, since an independent rotating coordinate system is used in each region, the rotation speed of the rotating device can be freely changed for each rotating device. Further, this method can be applied regardless of the number of rotating devices. This time, using this method, the flow was calculated for the case where two rotating devices rotate in opposite directions and in the same direction.

The basic equations are the incompressible Navier-Stokes equations expressed by the both rotational and stational coordinate systems. The nonlinear terms of the basic equations are approximated by the third order upwind difference in order to perform stable calculations even at high Reynolds number. The fractional step method is employed to solve the basic equations.

The calculation was performed by changing the angle of attack, the rotation speed of the rotating device, the distance between the devices, etc., and the influence on the torque and power was investigated together with the analysis of the flow field.

It was found that the total value of the torques of the two units may be maximized when the flow hits the line connecting the center of the rotating devices at an angle of 45 degrees. The calculations were performed not only by fixing the rotation speed of the rotating device, but also by changing the rotation speed according to the torque acting on the rotating device where the Newton's equation of motion for the device was solved.

REFERENCES

[1] Minakawa,A. and Kawamura,T.: Flow interaction around two Savonius wind turbines rotating independently, Mechanical Engineering Congress, 2021 Japan, (2021.9)