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Study of direct force measurement and characteristics on blades of Savonius rotor at static state

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ABSTRACT

Experiments were conducted to measure and to clarify quantitative variations of fluid force on three kinds of setting blade configuration on a Savonius rotor at the static state in the steady uniform flow. In the experiments, by splitting both the end-disks of the blades into two half parts, the two blades were independent on each other and the one blade attached to both the half end-disks was only connected to the axis rod of the rotor, and the other blade connecting to the other half end-disks was free from the axis rod. Hence, the drag and lift forces acting on the former blade were directly measured in a short time at every phase angle and every overlap ratio of the two blades using the force balance meter. The experiment for the rotor of the diameter 160 mm and the height 160 mm was conducted in the steady wind flow of the Reynolds number, about 0.64×10^5 which based on the rotor diameter and the upstream velocity. From the experiment, value of the drag coefficient of the one blade in two blades with the overlap ratio of zero was taken from about −0.3 to 1.6, and the lift coefficient of it from about −1.0 to 1.4 in a cycle. The minus value of drag only appears in the setting of one blade in two blades, however the minus value does not exist in the distribution of tangential force on every overlap. And it was shown that the force distributions on the one blade in a cycle were very different in the first and second half cycle and interfered by the other blade, and strongly dependent on the overlap ratio between the blades.

1. Introduction

In relating the renewable energy, development or reformation of the wind turbine, the sea wave turbine is recently considering in the world. The Savonius rotor [1] as a wind turbine has two half circular curved blades, two circular end-disks and an axis rod perpendicular to the wind direction, and the rotor converts the wind energy to the mechanical or electrical energy. The two blades are connected on the end-disks with an overlap that characterizes performance or mechanism of the rotor. In the past, characteristics of Savonius rotor are closely related to torque and most investigations have been experimental studies about effects of number [2,4], or geometry [3] of blades, or overlap ratio [3] between blades on characteristics of the rotor without any guide vane.

To augment or control output power of the rotor, there are some investigations of the rotor with static guide vanes [5–7] located on the periphery of it, or the other of a box passage with rounded mouth [5] concentrating wind. In 2007, Irabu and Roy [8] has shown the augmentation in the power coefficient of the rotor using the guide-box tunnel around the rotor. Although these experiments were almost intended to determine the torque and the power coefficients, there are a few to investigate drag and lift on the blades. At first the drag and lift coefficients of rotating Savonius rotor are determined from the pressure difference measured between the upper and lower planes of a blade by Chauvin [9]. In 1992, Fujisawa [10] had estimated the forces acting on the rotor by pressure distributions measured around the blade of rotor. Moreover, there is only described about dynamic properties, no information about static properties with overlap. Relating to overlap ratio on efficiency, Ohara et al. [11] showed that the most efficient configuration was also tested when the overlap ratio of rotor in operation took a value of 0.14.

It is considered that to clarify variation of the fluid forces on the individual blade as varying the overlap ratio in the static or dynamic states of the rotor is very important in more augmenting the efficiency of the rotating rotor, however, there are some technical difficulties to measure them on the rotating rotor, because of one axis rod connecting two side disks and the blades. From some experiments, we know a wind rotor without the axial loads in the wind flow having lower or larger speeds starts at static state and gets gradually increasing of rotational speeds, and it can rotate at the lower limited speed on the maximum torque of loading. It seems the behavior of the wind rotor at near starting or stopping almost resembles that of the static rotor in the flow. Therefore, at least we can approximately deduce the action of the individual

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