Output Characteristics of Savonius Windmill Used as a Power Source

[Summary]

A small irrigation pump could be driven by a savonius windmill at a wind velocity of 3 m/s or more. Energy conversion efficiency is a maximum of 0.05 at a tip speed ratio of 0.25. Torque coefficient decreases at a tip speed ratio of 0.25 or over.

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[Background and Purpose]

A savonius windmill that features simple structure, silent operation, and high safety during strong wind without overspeeding is a type of windmill suitable for use as a small power source for farming. The objective is to clarify the output characteristics of a savonius windmill by field tests and identify conditions for its efficient operation.

[Deliverables and Features]

1. A savonius windmill with two double-arranged rotors, each 1.5 m in diameter and 1 m in height, was installed at a frame 5 m in height to drive a wing type pump to pump up water for a lift of 1.7 m (Fig. 1). The results of the test are reported herein. The rotors were made of polycarbonate, so, the total weight was decreased by 24% from one made of steel. The rotation of the windmill was converted to the linear reciprocating movement through the crank mechanism to drive the pump.

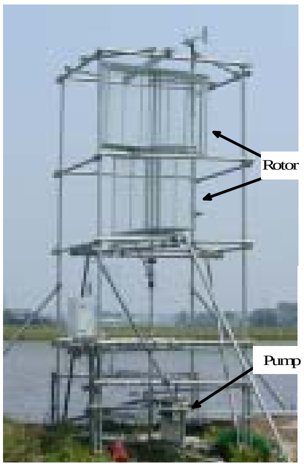

Fig. 1 Savonius windmill

2. The pump was driven at a wind velocity of about 3 m/s or more. During the 10 day test, 39.1 m^3 of water were pumped up by wind power (Fig. 2).

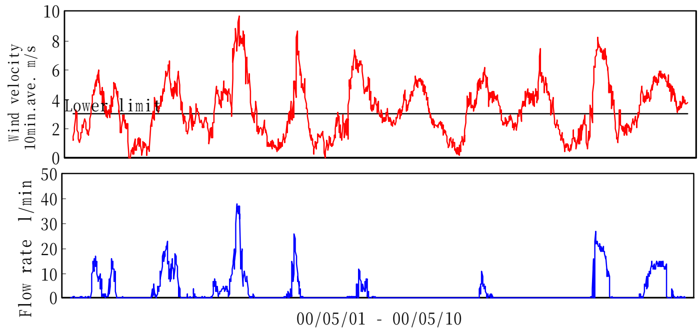

Fig. 2 Wind velocity and pumped-up flow during field test

3. When the rotational shaft of the windmill was directly connected to the crank and when speed was reduced at a gear ratio of 1:1.5, the power coefficient, which represents the energy conversion coefficient of the windmill, reached maximum 0.05 at a tip speed ratio (ratio of the rotational speed at the edge of the rotor to the wind velocity) of around 0.25, as shown in Fig.3. When the speed increased at a gear ratio of 1.5:1, the load to the windmill increased to reduce the rotational speed, eventually decreasing the power coefficient.

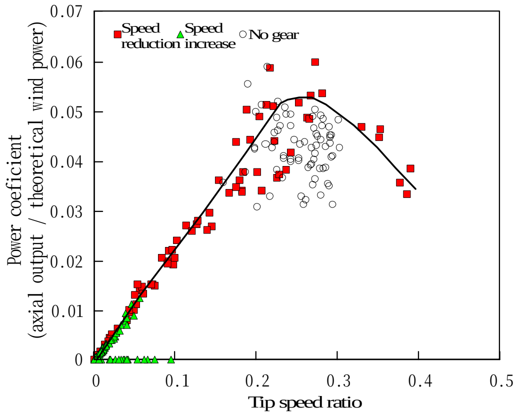

Fig. 3 Relationship between tip speed ratio and power coefficient

4. The torque coefficient that represents the ratio of the axial torque of the windmill to the theoretical torque by wind was constant up to a tip speed ratio of 0.25 and decreased when the ratio rose, as shown in Fig. 4.

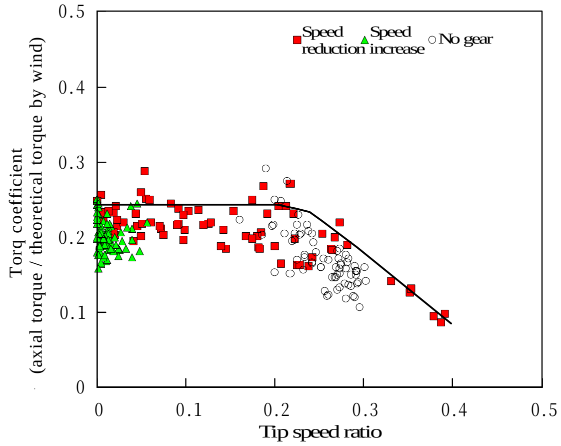

Fig. 4 Relationship between tip speed ratio and torque coefficient

5. The condition in which the windmill can be operated both with a high power coefficient and a high torque coefficient is a tip speed ratio of 0.25. To achieve this ratio, the load conditions are obtained by the following equation:

Optimum load torque = ρ x A x D x V^2 / 4 x 0.25 (N・m)

where wind velocity = V(m/s); rotor diameter = D (m); rotor area = A (m2); air density ρ (kg/m^3); and

rotational speed =60 x V / π / D x 0.25 (rpm)

In cases where the load torque is great, use of the speed reducer realizes operation at an optimum tip speed ratio although the drive rotational speed reduces.

[Application and Points to Note]

The savonius windmill provides a large torque although its power coefficient is smaller than that of a propeller windmill and is therefore suited for application, such as small-scale water pumping or sludge agitation treatment without use of electric power.