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DESIGN AND EXPERIMENTAL ANALYSIS OF 2-STAGE SAVONIUS TURBINE

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Abstract -Hydro energy is important as clean energy resource. Savonius rotor is a vertical axis rotor with simple in design and easy to fabricate at lower cost. The rotation of the rotor is due to the drag difference between the advancing blade and returning blade. Net driving force can be increased by reducing the reverse force on the returning blade or increasing the positive force on the advancing blade. Former can be realized by providing a flow obstacle to the returning blade and latter can be realized by concentrating the flow towards the advancing blade. Various Design of 2 stage savonius hydro turbine in which comparison and investigation on performance and make comparison between different design of savonious turbine.

Key words: Hydro Turbine, 2 Stages Savonius, Deflector Plate, Eccentricity

1. INTRODUCTION:

Hydro and geo thermal energy, which are clean and reliable to reduce greenhouse gas emission that leads to global warming. Among them different renewable energy technologies, hydro power generation (it may be large and small scale) is preferable in term of contribution to world's electricity generation. Now a days, turbines are under development to increase torque and efficiency so, that they will be usable for low speed velocity and can provide higher torque and higher efficiency and also increase output power with lowest force.

Hydro energy from the river is one of the best renewable energy sources. Hydro energy source is preferable then wind turbine. Water current turbines are zero head type turbines. They generate electricity using the kinetic energy of natural water resources form canal, stream, river using different types of rotors. Hydrokinetic turbine electricity generation is mainly aimed to use for rural use at sites remote from existing electricity generation. It is a useful for improving the quality of life of people in these locations.

Different designs of water current turbine are available for the extraction of energy from the river, stream, and canals. In application of water current turbines, these turbines generate power from the kinetic energy of water without the use of a dam or barrage. Based on the alignment of the rotor axis with respect to water flow, two positions exist. They are horizontal axis turbine and vertical axis turbine. The suitable water turbines for the application of free flow are Darrius, Gorlov and Savonius type. The Savonius, Darrius, Gorlov type are the most common used in electric power generation.

2. SUBMISSION OF TECHANICAL PAPER

2.1. Kaprawi S.*‡, Dyos Santoso*, Riman Sipahutar* :- Study is to show the effect of single deflector plate on the performance of combined Darrieus-Savonius water turbine. In order to overcome the disadvantages of low torque of solo Darrieus turbine, a plate deflector mounted in front of returning Savonius bucket of combined water turbine composing of Darrieus and Savonius rotor has been proposed in this study. Some configurations of combined turbines with two stage Savonius rotors were experimentally tested in a river of constant velocity 0.8 m/s. The angle of deflector with respect to current flow influences the turbine performance characteristics. the experimental observation of hybrid turbine composed of Darrieus and Savonius turbine in which the Savonius bucket mounted either in the middle and at the outside of the Darrieus rotor, but it is attached at the same shaft. The purposes are to obtain higher torque at low speed and efficiency compared to the solo Darrieus turbine. The torque and the power coefficient of combined turbine with deflector increase for Savonius rotor mounted on the outside of Darrieus rotor. The optimum deflector angle of 30o gives a better performance of combined turbine. The increase attains about 18% for power coefficient and about 16% for torque coefficient and also observe the increase of turbine speed.

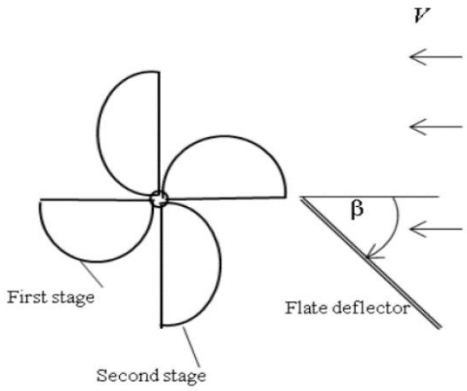

Figure 1 Top view of Rotor

2.2. Kaprawi Sahim, Kadafi Ihtisan, Dyos Santoso, and Riman Sipahutar: - The turbine system should be a simple structure and with a good reliability to fulfil the power generation so that one can construct by itself like for small-scale applications of local production of electricity. The deflector configuration can also concentrate the flow which passes through the rotor so that the torque and the power of turbine can be considerably increased. The placing of Savonius in Darrieus rotor is carried out by setting the savonius bucket in Darrieus rotor at the same axis. The Darrieus-Savonius rotor has also two Savonius buckets with the diameter of a semicircular cylinder. The deflector plate placed upstream to the fluid flow on the returning blade side acts as an obstacle to the flow coming towards the returning blade. This reduces the negative or reverse torque on the returning blade. Experiments are conducted for two positions of the deflector plate on the returning blade side of the combined rotor. The aspect ratio of Savonius rotor is defined by a ratio of the length of bucket and the total width or diameter of two buckets. In this case, the total diameter of buckets is twice the diameter of each bucket. Installing of Savonius in Darrieus rotor without deflector makes the Darrieus-Savonius rotor have lower performance characteristics than solo Darrieus rotor, but the torque has a little increase.

2.3. Golecha Kailash, T. I. Eldho, and S. V. Prabhu: - Savonius rotor is a vertical axis rotor with simple in design and easy to fabricate at lower cost. The rotation of the rotor is due to the drag difference between the advancing blade and returning blade. Net driving force can be increased by increasing the positive force on the advancing blade. It can be realized by providing a flow obstacle to the returning blade and latter can be realized by concentrating the flow towards the advancing blade. The objective of the present work is to identify the optimal position of the deflector plate (on advancing blade side) placed upstream to the flow which would result in increase in power generated by the rotor. Present study shows the promise of using deflector plates on both advancing blade side and returning blade side to increase the performance of the modified Savonius rotor.

2.4. Patel C.R., Patel V.K., Prabhu S.V., Eldho T.I.:-Hydropower from the river is one of the best renewable sources. For generation of electricity using the kinetic energy of natural water resources, Savonius rotor is one of the best types of turbine. In present work, attempt is made for use of Savonius rotor as hydro turbine application. The effect of overlap ratio is investigated for performance enhancement Savonius turbine. In present investigation three different overlap ratios, 0.0, 0.1 and 0.2 are studied, at different angular speeds of rotor. It is found that the maximum torque can be obtained at overlap ratio of 0.2. The most recommended overlap ratio for this type of turbine is $\beta = 0.20$ and with increase TSR, coefficient of power increases and coefficient of torque decreases. At angular position of $\theta = 900$, the maximum pressure arises on the vane surface. It implies that higher structural strength requires for maintain structural stability of turbine. In contrast with Darrius turbine, not much structural strength is necessary for same outer diameter, which is the one disadvantage of Savonius turbine.

2.5. K.K. Sharma*, R. Gupta*, A.Biswas*:- Svonius rotor is the Vertical Axis Turbines rotor, which has many advantages such as self-starting, Omni-directional, suitability for applications like pumping, grinding, sailing etc. However, its efficiency is only in the range of 15%-21%. Investigations are being conducted to improve its efficiency by controlling its design parameters by the performance of a two-stage two-bladed configuration of the Savonius rotor has been investigated. The parameters studied are overlap, tip speed ratio, power coefficient (Cp) and torque coefficient (Ct). Overlap ratio of the design was optimized to generate maximum performance of the rotor. Both power and torque coefficients increase with the increase of TSR up to the maximum and then both decrease with further increase of the latter. Therefore there is an optimum TSR at which the performance coefficients are the highest. Similarly power and torque coefficients decrease with the increase of overlap from 9.37% to 19.87%.

2.6. R. Gupta_, A. Biswas, K.K. Sharma:- A combined Savonius–Darrieus type vertical axis wind rotor has got many advantages over individual Savonius or The Savonius–Darrieus rotor was a combination of three-bucket Savonius and three-bladed Darrieus rotors with the Savonius placed on top of the Darrieus rotor Individual. The various parameters namely, power coefficients and torque coefficients were calculated for both overlap and without overlap conditions. Darrieus rotor, such as better efficiency than Savonius rotor and high starting torque than Darrieus rotor. Comparing the power coefficients (Cp) for simple Savonius-rotor with that of the combined configuration of Savonius–Darrieus rotor, it is observed that there is a definite improvement in the power coefficient for the combined Savonius–Darrieus rotor without overlap condition. The combined three-bucket Savonius–three-bladed Darrieus rotor, at no overlap, the coefficients increase with increase in TSR. And two peaks of Cp and Ct are obtained, one each for the Savonius rotor at lower TSR and for the Darrieus rotor at higher TSR. The combined configuration of Savonius–Darrieus rotor, it is observed that there is a definite improvement in the power coefficient for the combined Savonius–Darrieus rotor without overlap condition.

3. Calculation:-

3.1 Reynolds number based on the rotor diameter is given by,

$$RE = \frac{\rho U D}{\mu}$$

Where,
Re= Reynolds number,
ρ = density of water,
U = free stream velocity,
D = rotor diameter,
μ = absolute viscosity of water.

3.2 Tip speed ratio is given by,

$$TSR = \frac{\omega D}{2U}$$

ω is the angular velocity.

3.3Torque is calculated from the measured load, and spring balance load is given by,

$$T = \frac{(\mathrm{M} - \mathrm{S})(\mathrm{r_{SHAFT}} + \mathrm{d_r})}{1000}$$

Where,

M is the load,

S is spring balance load,

r shaft is the radius of the shaft,

d_r is the diameter of the nylon string

3.4 Coefficient of torque is given by,

$$Ct = \frac{4T}{\rho U^2 H D^2}$$

3.5 Coefficient of power is given by,

$C_P = TSR * C_T$

3.6 Blockage ratio is given by,

$$B = \frac{HD}{H_W W}$$

4. TABLES

2 Stage savonius turbine	Coefficient of Power(Cp)	Coefficient of torque (C_t)
Without deflector plate	0.14	0.20
With deflector plate	0.21	0.26
Optimum position of deflector plate	0.30	0.32

Table 1-Result Table of Reference 2.4

5. CONCULATION:

In the present study, an experimental investigation and analysis of savonious rotor with different design i.e. single stage savonious turbine with defector plate, 2-Savonius turbine with or without difflectorplate, multi-staging of Savonius turbine, savonius-darrieus water turbine. The single stage Savonius turbine with deflector plate has more torque and power than single-stage. In Savonius turbine the stages increase with increase in efficiency. This combined turbines Savonius rotor mounted on the outside of the Darrieus rotor on the same shaft have higher torque and power coefficient than the solo Darrieus turbine.

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