Savonius Rotor for Lifting Water in Bangladesh

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Abstract :

An attempt is made to pump water with the help of double savonius rotor for irrigation purposes in developing countries like Bangladesh. The rotor is manufactured with the help of empty oil drums and it is coupled with a locally manufactured diaphragm pump to lift water for different total static lift. Instead of belt and gear mechanism, the pump is driven directly by crank and connecting rod. The starting wind speed for the system is found to be about 1.59 m/sec (3.55 mph) and it can pump reasonable amount of water even at low and variable wind speeds. Reynolds number (based on wind speed and rotor swept diameter) is in the range of 1×10^5 to 1.2×10^5. It is found that discharge increases with wind speed ; but the rate of increase is lower at higher wind speed. The maximum overall efficiency of the system is found to be about six per cent.

Introduction :

Over the last few years, considerable interest has developed in vertical axis wind turbines including Savonius. Savonius rotor was first developed by Savonius in 1924 to propel sailwing vessels (1).

Recently attention has been once again directed towards the development of this simple wind turbine for lifting water, grinding grains etc. in developing countries. It is also used as an auxiliary device for starting a Darrieus Rotor (2). Encouraging results have been obtained by the Internatiional Rice Research Institute in the Philippines. They tested a dozen of Savonius rotors to be used for irrigation purposes.

The Savonius rotor has two halves of the bent sheet displaced so that the wind can pass between them. Thus, in addition to the pressure on the concave surface of the half facing the wind, there is additional pressure, assisting rotation, on the back side of the other half of the rotor. A resultant torque is produced because the wind pressure on the concave surface is greater than that on the convex surface.

This paper describes the overall performance of a double Savonius rotor coupled with a diaphragm pump. As empty oil drum which is easily available in the local market is used for making rotor blades, the dimensions of the rotor are more or less restricted.

Construction of Savonius Rotor :

The rotor consists of two savonius. The lower savonius is 90 degree out of phase with the upper one. Each savonius has two cylindrical blades made of oil drum. The diameter and height of each cylindrical bucket are 60 cm and 90 cm respectively. For each savonius the buckets are 10 cm overlapped, i.e. the gap width to diameter ratio is 1/6. The

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gap between upper savonius and lower savonius is also 10 cm. The cylindrical blades are fitted to a 3.175 cm. outside diameter and 3.3 m long G.I. pipe, which acts as a vertical shaft. The schematic diagram of the whole system is shown in Fig. 1. The top view and front view of the rotor with dimensions are shown in Fig. 2.

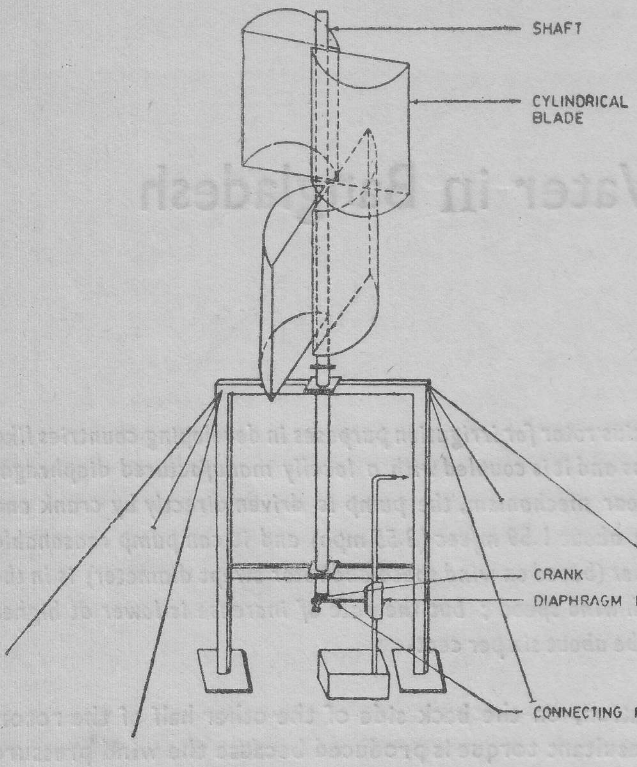

FIG 1 SCHEMATIC DIAGRAM OF DOUBLE SAVONIUS ROTOR.

The rotor is supported with the help of 3·18 cm × 3·18 cm × 6.35 mm angle frames. A standard ball bearing is used at a distance of 1.2 m from the lower end of vertical shaft which is fastened to the cross angle frame by bearing casing and bolts. The lower portion of the shaft is supported by a standard thrust bearing which is fitted to the cross angle frame by a 10·16 cm × 10·16 cm × 9·35 mm cast iron block and bolts. The shaft is extended through the thrust bearing by an amount of 15 cm. At the end of the shaft a crank is fitted. The crank is made of a 9.53 mm diameter and 7.62 cm long mild steel rod, half of which is threaded. The rod is threaded to keep the connecting rod in position by using two nuts. The crank is joined eccentrically to the shaft by arc welding. In this way belt and pulley mechanism is avoided. The length of stroke is 3.81 cm. At the bottom of each vertical angle pole, there is a 30 cm × 30 cm × 3·18 mm square steel plate which is welded to the pole.

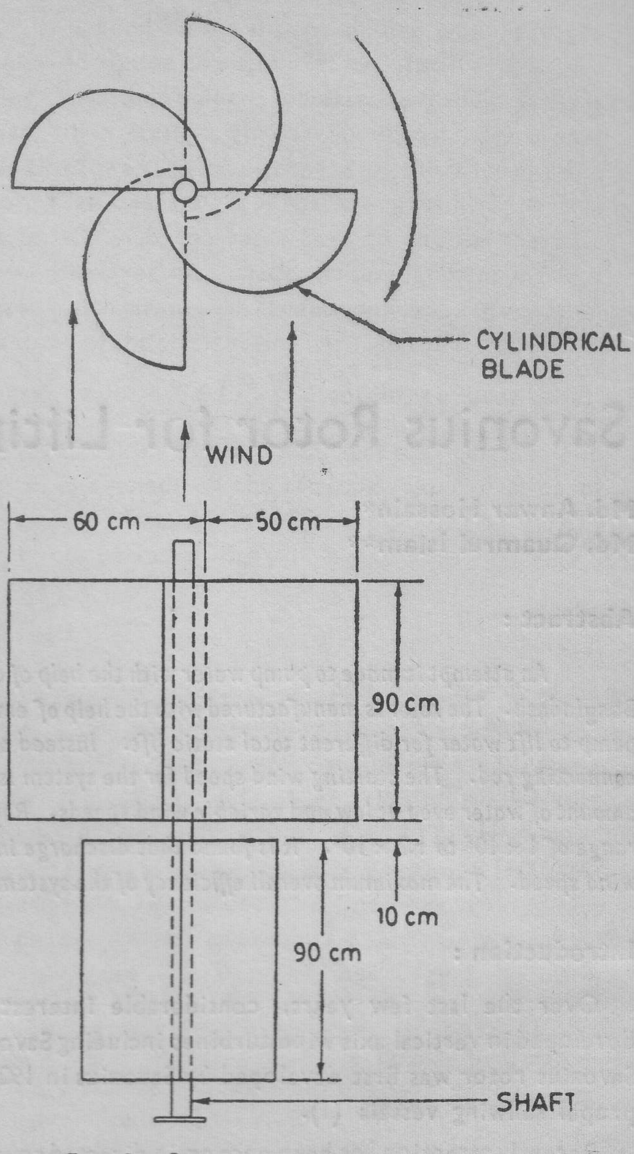

Fig. 2. Dimension of Savonius Rotor

A diaphragm pump (Fig. 3) manufactured locally is connected to the crank by a 60 cm long and 7.94 mm diameter mild steel rod. A circular metal piece made of 2.54 cm diameter and 1.11 cm thick plate, having a 1.11 cm hole at the center, is fitted at one end of the connecting rod. This end is connected to the crank and the other end is welded to a 12.7 cm diameter and 6.35 mm thick mild steel plate. This plate is fitted to the diaphragm by bolts. Instead of usual preshaped rubber diaphragm, leather diaphragm is used which has greater strength and longer life than the rubber diaphragm. Anybody can replace the leather diaphragm without going to the manufacturer by the ordinary shoe making soft leather. The diameter of the diaphragm is 8 cm. The pump is fixed to the lower cross frames by steel angles and bolts.

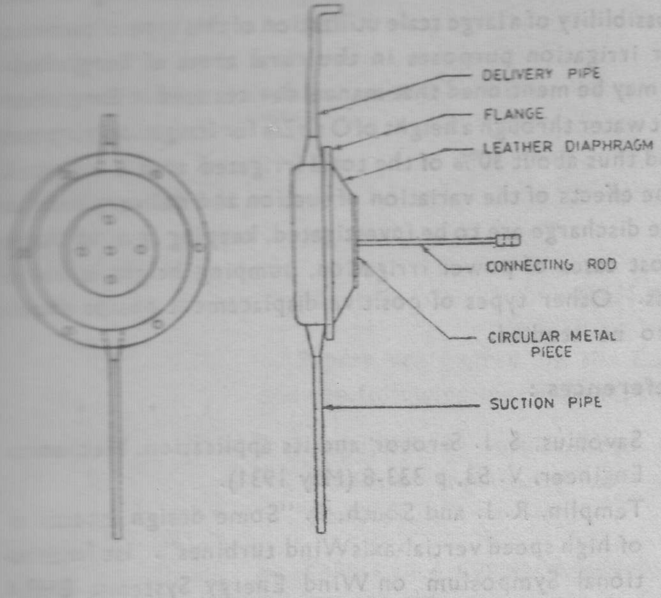

FIG. 3 SCHEMATIC DIAGRAM OF DIAPHRAGM PUMP

The whole structure is kept in position by 1.59 mm galvanized iron wires. The rotor was tested on the roof of Mechanical Engineering Building, Bangladesh University of Engineering & Technology, Dacca.

Results and Discussions :

The variations in the discharge of the diaphragm pump with wind speed are shown in Fig. 4. The static lift is changed by changing the suction lift only. It is observed that for this system the starting speed is about 1.58 m/sec (3.53 mph.). This is encouraging from the point of view that most areas of Bangladesh, especially the areas far away from the coast, have in general low wind speed.

The discharge is found to be higher for lower lift at a given wind speed. With the increase in the wind speed, the discharge increases for both the lifts; but the rate of increase is lower at higher wind speed.

Overall efficiency of the system e, is plotted against the water discharge rate Q (Fig. 5). Overall efficiency is defined as the ratio of (Q wH) to ($\frac{1}{2}$ p AV^3), where w is the specific weight of water, H is the total static lift, A is the swept area of the rotor, p is the air density and v is the wind speed. The overall efficiency is b obviously the product of the rotor efficiency, e_r and the pump efficiency e_p. A maximum of about 6% is obtained at Q of about 2.8 lit/min. Recalling that the efficiency limit for the rotor as given by Betz (3) is 59.3% and considering that e is the

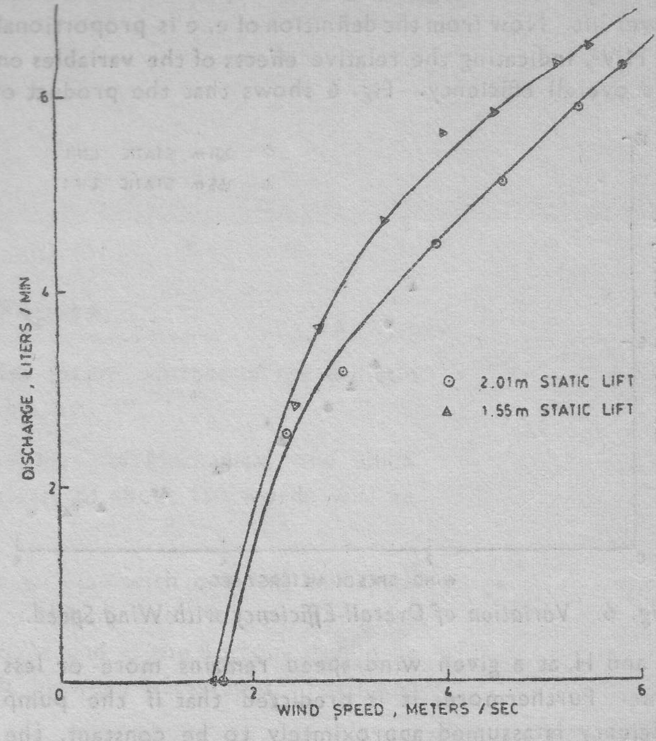

FIG. 4 VARIATION OF WATER DISCHARGE WITH WIND SPEED

product of e_r and e_p and that the diaphragm pumps in general are of lower efficiency, 6% overall efficiency is quite encouraging. Again, attention may be drawn to the fact that the

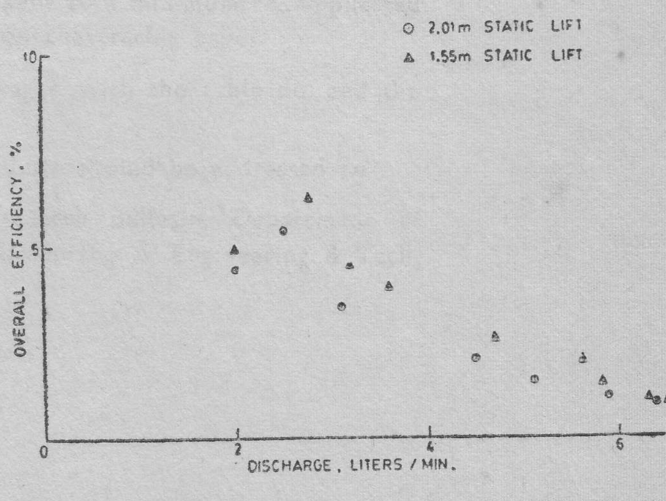

FIG. 5 VARIATION OF OVERALL EFFICIENCY WITH WATER DISCHARGE.

maximum value of e occurs at lower values of Q i.e. at lower wind speeds. This observation is important from the view point of low wind speed inside the country for a good period of the year. It is also found that for the same discharge, e is higher for the lower lift. Fig. 4 shows that for a given discharge lower wind speed is needed for lower lift. Now from the definition of e, e is proportional to H/V^3, indicating the relative effects of the variables on the overall efficiency. Fig. 6 shows that the product of

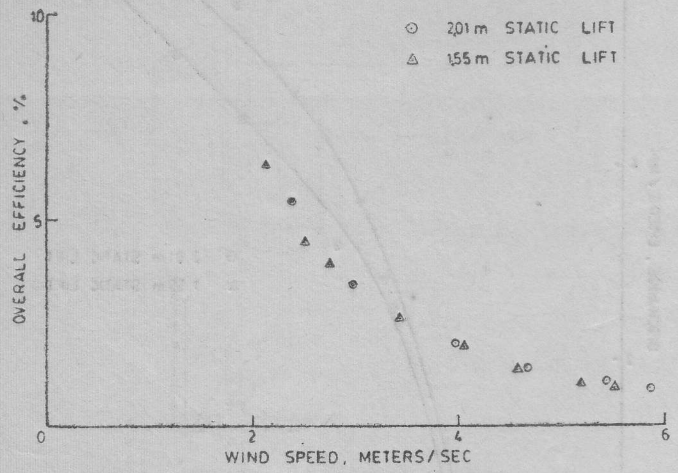

Fig. 6. Variation of Overall Efficiency with Wind Speed.

Q and H at a given wind speed remains more or less same. Furthermore, it is predicted that if the pump efficiency is assumed approximtely to be constant, the maximum rotor efficiency (power co-efficient, Cp) occurs at the rotor tip speed ratio (rotor tip speed/wind speed) of about 0.25.

Further works are needed before commenting on the possiblility of a large scale utilization of this type of turbines for irrigation purposes in the rural areas of Bangladesh. It may be mentioned that manual devices used in Bangladesh lift water through a height of O to 2m for irrigation purposes and thus about 30% of the total irrigated area is irrigated. The effects of the variation of suction and delivery head on the discharge are to be investigated, keeping in mind that in most cases of power irrigation, pumping height is 6m or less. Other types of positive displacement pumps should also be studied.

References :

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