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An Approach to the Design and Development of Door Window Type Vertical Axis Wind Turbine

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ABSTRACT

This study developed an innovative model of a vertical axis wind turbine for roof top application. The speciality of this turbine is that it need not be oriented towards the wind direction. Also, it steadies on low wind velocities and is self-starting. It is eminently suitable for water pumping applications which are the needs of the tall building today. The variations in wind velocities and consequent variation in rpm will not affect the pumping operation. It is not suitable for generation of electricity directly due to variations in output rpm and consequent variations in voltage and frequency. Therefore, it is proposed to have intermediate buffer storage in the form of compressed air. This is likely to have significant applications in rural areas.

Key words: Vertical axis wind turbine, wind velocity, compressed air storage, renewable energy

INTRODUCTION

Shortage of power is crippling the industries in India. The rate at which the new power generation units are coming up is not very encouraging. For example, presently the all India demand for power is 1,70,000 MW and installed capacity is only 1, 40,000 MW and available generation is hardly 1,00,000 MW. Since, the demand for power is growing at 10 to 12% per annum, this shortage is likely to worsen in the future. Possibility of using fossil fuel for power generation is discouraged on account of restriction on carbon emission being imposed by the international community. Therefore, an alternative to fossil fuel generation is the need of the hour.

Mankind has been on the lookout for alternate sources of energy in order to keep the supply of power in tune with its growing demand. Solar power has a serious limitation because of its non-availability during nights and on cloudy days. Thus, the only feasible alternative is to develop wind power. Wind energy is a renewable, non exhaustible and a highly abundant source of energy that is capable of providing a clean and an efficient solution to this problem.

The most prominent design of the windmills that are currently in use is the horizontal axis wind turbine. These turbines have a number of disadvantages like they have to be aligned to the wind direction, they are not self starting, they do not steady at a lower wind speed, requirement of large free spaces, requirement of high minimum wind velocity, high stress on the supporting masts and killing of birds during the operation, etc.

However, the other type of wind turbines i.e., the vertical axis wind turbines can run steadily at very low wind velocities, are more quiet, are easily accessible for maintenance, can be located on roof tops and can be located closer to the electrical load point (American Wind Energy Association, 2009).

In advanced countries, compressed air energy storage is being utilized for power generation; however, the compressed air is used for power generation using a gas turbine which runs on fossil fuel causing pollution which defeats the requirement of reduced carbon emission. The existing vertical axis wind turbines are directly converting the wind energy into electricity without any intermediate storage, thus giving a fluctuating output which is inconvenient to the users. Although, intermediate storage in the form of battery storage is available, the capacity of the storage is limited, life of the battery is also limited (3-4 years).

MATERIALS AND METHODS

In this part, it is proposed to develop a new design of self-governing, constant output, vertical axis wind turbine as shown in the Fig. 1. The shaft output of this turbine is proposed to be connected to a positive displacement compressor which will compress the air to a specified pressure. The compressed air will be stored in an air receiver. As and when there is a need of generation of power, the compressed air will be connected to a hydro-pneumatic tank which will pressurize the water in the tank. This high pressure water will be injected onto a Pelton wheel-driven-alternator thus producing power ensuring zero pollution.

Vertical axis wind turbine: The feature of this turbine is that, it is self-governing in nature. That means the speed of the wind turbine will always remain within the specified limits and it will never reach the run-away speed. Following is the description of the constructional details of this mechanism which is a unique feature of this design. There are 4 wings which are in the shape of rectangular panels. Each panel contains a number of flaps capable of turning around a vertical axis, like vertical blinds on a window. These flaps are of aerofoil shape. A common rod actuates all the blades (Fig. 2).

As the wind direction changes, the flaps either close or open depending on their orientation. The panel in which the flaps are completely closed act as the door and the panels with open flaps act

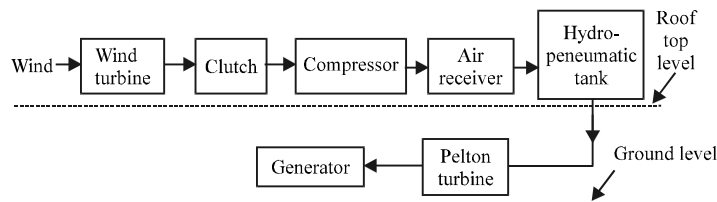


Fig. 1: Block diagram of proposed model

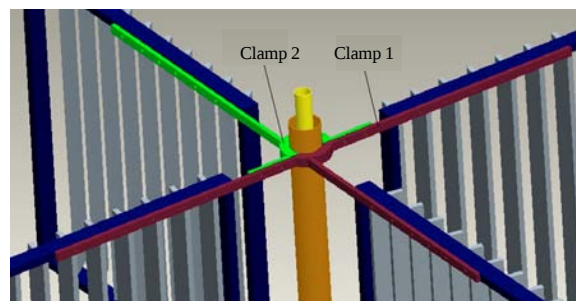


Fig. 2: Top view of the door window type VAWT

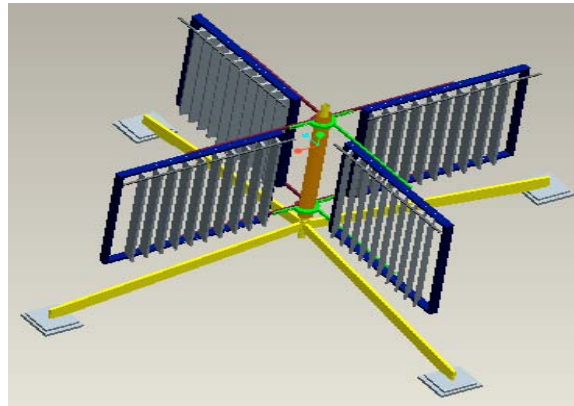


Fig. 3: Overall view of the door window type VAWT

as window. Window pushes the door panel but cannot push the panels acting as window. Thus, it is ensured that irrespective of the wind direction, the tapping of the wind energy is completely achieved (Park, 1981). The speed control is proposed as follows. When the speed exceeds the set limit, the disk and string mechanism keeps the flaps in open condition resulting in all the panels acting as windows. Thus, the wind has no effect on the turbine and the speed gradually reduces. When the speed falls below the lower limit, the clutch connecting the turbine with the compressor can be disengaged using an eddy current/centrifugal clutch.

Figure 3 shows the overall view of the Door window type VAWT. Anchors are provided for supporting the whole structure. One end of the anchors is connected to the stationary shaft by fastening the nuts and bolts. Another end of the Anchors is welded with the base plate. The advantages of this mechanism are like it is completely free of any kinds of electronics items which requires skilled attention, it does not require any auxiliary source of energy such as battery, it is completely mechanical in nature and it can be easily repaired by unskilled and semi-skilled people in rural areas (Chiras, 2006).

Compressed air energy storage: The shaft of the vertical wind turbine is coupled to a screw compressor through a centrifugal clutch. The reason for having a centrifugal or eddy current clutch is to ensure that the turbine is disconnected from the compressor load at low speed. The compressed air from the compressor is stored in a high pressure storage vessel. The vessel will have all the necessary accessories such as safety valve, pressure gauge, condensate drain etc. The capacity of the air-receiver depends upon the duration of power cut.

Hydro-pneumatic tank: This hydro-pneumatic tank converts the high pressure air into high pressure water. A pipe connects the air tank and the hydro-pneumatic tank equipped with flow control valves, flow measuring instruments etc.

Pelton wheel and generator: The high pressure water from the hydro-pneumatic tank is passed through a pipe and nozzle with governor control. Thereafter, the high pressure water is injected on the blades of the Pelton turbine. The governor ensures constant speed of the Pelton wheel irrespective of the electrical load. The shaft of the Pelton wheel is connected to the alternator which

will generate power. All the specification of the components will be calculated for a power requirement of about 10 kW.

The operational feasibility of this entire plant is suitable for Indian conditions. However, when the temperature falls close to the freezing point, there is a likely hood of water in the hydro-pneumatic tank solidifying which may hamper power production. This can be solved in two ways: One is to provide heaters inside the tank to maintain the temperature; the second is to use a fluid which has a low freezing point.

Novelty of the work: Combination of tapping wind energy, storing it in the form of compressed air and then using it for power generation without causing pollution has never been so far attempted (Takao *et al.*, 2007). The vertical wind mill has the new feature of self-governing speed control built-in into the system, ensuring working of the wind-turbine at all wind velocities at a constant speed and thus ensuring power generation at all wind speed. Cost-effective power generation in the range of Rs 5/ to 8/- per kWh and discouraging the industries from using the diesel generating sets and thereby reducing carbon emission.

CONCLUSION

A conceptual approach is presented for the design and development of door window type VAWT, featuring positive displacement compressor, air receiver, hydro-pneumatic tank, pelton wheel-driven-alternator thus producing power with zero pollution. The features of this design model can be scaled up to the desired size as per the output torque and speed requirements. This type of wind turbine model can be extensively used in applications like pumping, grinding, battery charging etc. By employing various control mechanisms like cam, motor or solenoid the constant rotational speed can be obtained and the same can be used in generating power. These windmills can be installed on roof tops of buildings closer to the point of usage thus reducing transmission losses (Sivasegaram and Sivapalan, 1983).

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