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DEVELOPMENT OF WIND TURBINE BASED COMPRESSED AIR STORAGE SYSTEM FOR POWER GENERATION

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Abstract: A wind turbine is a device that converts the wind energy into rotational energy by means of vanes called blades. Usually wind turbines are coupled with electrical generators and producing electrical energy directly. In the present work, an attempt has been made which deals with a wind turbine based compressed air storage system. The stored compressed air is used to drive the air turbine without any fluctuations. The alternator is coupled with the shaft of the turbine rotor. Part of the power developed by the rotor is converted into electrical energy using an alternator and the remaining power available in the rotor (mechanical energy) is used to run the compressor and produces compressed air and stored in the storage tank. The stored compressed air is used to drive the air turbine to generate electricity without any fluctuations.

Key Words: Compressed Air Storage, Wind Turbine, Renewable energy, Wind velocity

1. INTRODUCTION

Among various renewable energy resources, wind energy is one of the fastest growing technologies in India. Even though wind energy is an intermittent source of energy and it is not completely reliable. Actions must be taken to increase the reliability of wind energy.

The wind has dynamic behaviour. Sometimes the wind velocity is more than what is required, and in sometimes it is very less. During high wind, the amount of excess energy produced through wind is not used and hence wasted. To address this issue, a strategy needs to be employed to exploit the use of excess wind at times when there is not enough wind to meet the demand. One of the solutions is to install compressed air storage technologies at wind farms. These storage technologies would serve the purpose of storing compressed air during excess energy produced through wind. The energy produced using the compressed air could then be used to make up the mismatch between wind generation and the load during times when the wind is not able to serve the load completely.

Compressed Air Energy Storage (CAES) is one of the most reliable energy storage technologies for wind farms. Among other storage technologies, CAES is known to have one of the highest power and energy rating. During off-peak hours, an air compressor driven by an electric motor is fed the excess amount of power produced through wind. The compressor compresses the air and stores it inside an air storage tank. The storage tank can be underground or above the ground.

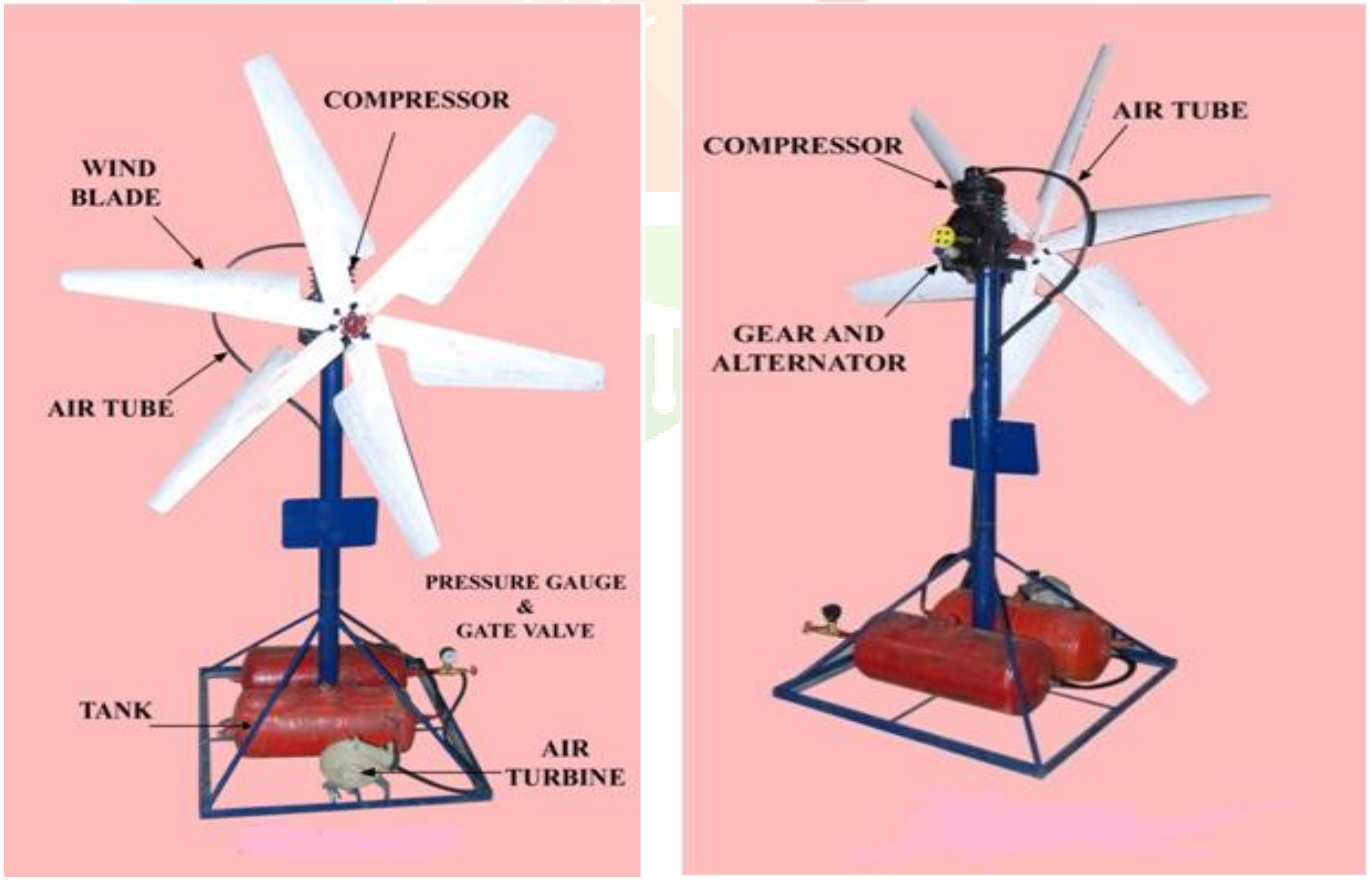
2. EXPERIMENTAL SETUP

The experimental setup consists of a six bladed rotor, a compressor, an air storage tank, an air turbine and an alternator. The compressor and the fan are fitted on a single mild steel pipe column. The fan blades are made of 1.5mm thick mild steel sheet. Six blades are fixed at 30' inclination for smooth flow of air. The widths of the blade at the fixed end and free end bottom are 100mm and 150mm respectively.

The air tank and the air turbine are fitted on the base of the setup. The pressure gauge and the pressure relief valve are fitted on the air tank in order to release excess air when the air pressure exceeds the tank withstand pressure. The tube is used to connect the compressor outlet and the air tank inlet. Two alternators of 12 Volt and 24 Volt capacities are used for producing power. 24 Volts capacity alternator is coupled with the air turbine shaft and 12 Volts capacity alternator is coupled with the shaft of the fan for producing electrical energy.

In the present work the wind turbine rotor is coupled with a reciprocating air compressor. When the wind turbine rotor rotates, the air compressor compresses the air, and this compressed air is stored in the air storage tank. The stored compressed air is used to run the air turbine.

The photographic views (front view and rear view) of the wind turbine based compressed air generation and storage setup are shown in Figure 1.



Front View **Rear View**

Figure 1 Photographic views of the wind turbine based compressed air generation and storage setup

Specifications of the Components in Present Setup

- **Compressed air storage tank**

Length of the cylinder	: 45 cm
Diameter of the cylinder	: 20 cm
Capacity of the tank	: 14.84liters
Maximum pressure of the tank	: 4 kg/cm^2
Number of cylinders	: 2 Nos
Cylinder position	: Horizontal

- **Alternator Capacity**

Direct coupled alternator	: 12 Volt, 15 Watts, 1.2amps
Turbine alternator	: 24 Volt, 30 Watts, 1.2 amps

- **Compressor**

Type	: Reciprocating
Bore diameter	: 60 mm diameter
Stroke length	: 80 mm length
Cubic capacity	: 226.29 mm^3

3. PRINCIPLE OF WORKING OF WIND TURBINE OPERATED COMPRESSOR

The wind energy with the required velocity (15 to 20 km/hr) in the atmosphere is forced to rotate the fan. As the fan rotates, the reciprocating air compressor coupled with the shaft of the fan and compresses the air and the compressed air is stored in the storage tank to run the air turbine for future energy generation. The remaining part of the available energy in the shaft is used to convert into electrical energy using an alternator, which is fitted with the shaft of the fan. The direct coupled alternator produces electricity with 10 to 20 volts according to the speed of the shaft that depends on air velocity. The stored compressed air is used to run the air turbine, and the alternator which is coupled with the shaft of the air turbine generates 12 volts of electrical energy.

3.1 Experimental Procedure

The wind velocity is measured using vane anemometer, and the time taken to increase the air pressure in every 1 kg/cm^2 in the air tank is observed using a stop watch until the tank pressure reaches 5 kg/cm^2. Thereafter the stored compressed air is released to rotate the air turbine. The multi-meter is used to measure the voltage generated by the two alternators, one is coupled with the shaft of the fan and another one is coupled with the air turbine.

4. RESULTS AND DISCUSSION

The vane anemometer is used to measure the air velocity and pressure gauge fitted in the air tank is used to measure the air pressure in the storage cylinder. The multimeter is used to find the voltage generated by the alternator.

The wind velocity is 20 km/h, the fan shaft rotates with a speed of 200 rpm. Figure 2 shows the variation of air pressure rise in the storage tank with respect to time. It is seen from the figure that the air pressure in the storage increases linearly with respect to time. The time taken to reach 5 kg/cm^2 pressure in the storage tank is 35 minutes.

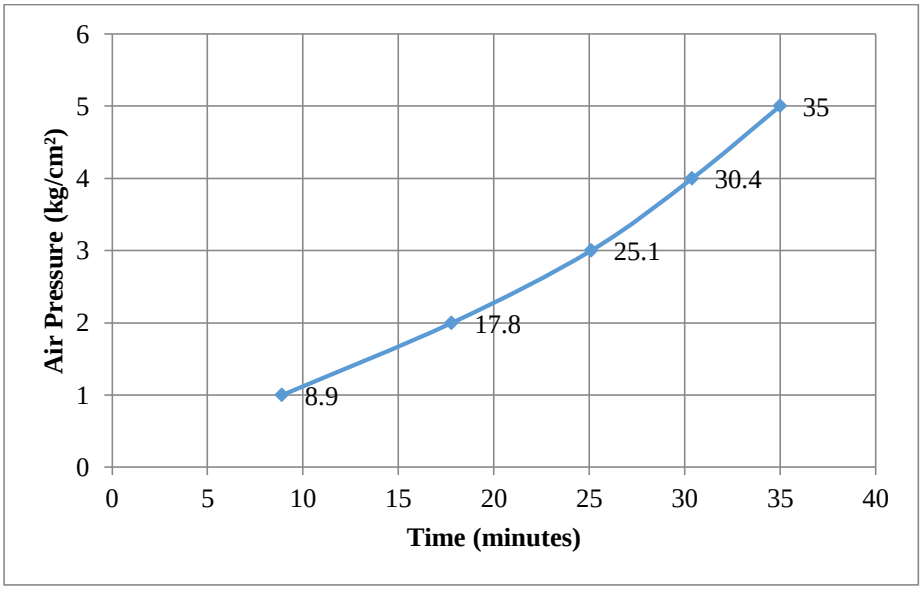


Figure 2 Variation of cylinder pressure with respect to time

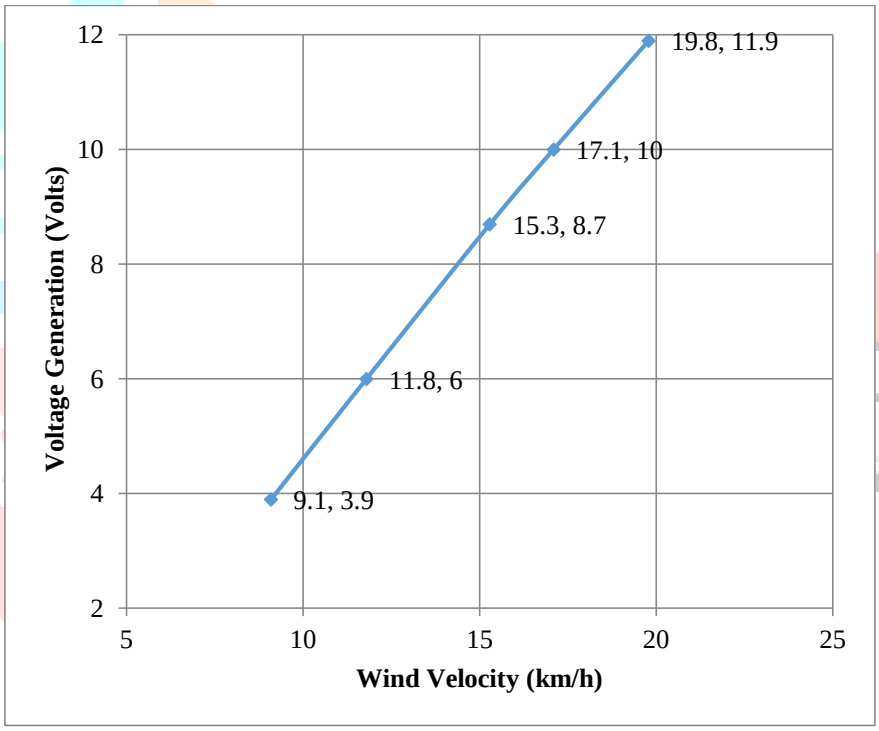


Figure 3 Variation of voltage generation with respect to wind velocity

Figure 3 shows the variation of voltage generated by the alternator connected with the shaft of the fan with respect to wind velocity. It is seen from the figure that the generated voltage increases with an increase in wind velocity, and it reaches 12 volts when the velocity of the wind is 20 km/h.

5. CONCLUSION

The attempt of the present work deals with a wind mill with compressed air storage for dual power production. In the present work, in addition to direct production of power by wind mills, a reciprocating air compressor is coupled with the shaft of the fan to produce compressed air. The stored compressed air is utilized to run the turbine to produce electricity. The alternator is coupled with the shaft of the fan is used for converting the remaining mechanical energy available in the shaft of the wind mill in to electrical energy.

Energy storage provides an opportunity to grasp and balance the wind energy as it is produced. It may be stored and used later when the demand is expected to increase the capacity of wind energy production. This technology is pollution free and makes the environment clean and reduces the need for future conventional power plants.

- Generally, wind mills produce power and supply it directly to the usage. But in the present setup, the part of the developed mechanical energy is stored in the form of compressed air. The stored compressed air is used for power generation during the demand period.
- Power produced in two ways. Hence the efficiency of the system is more.
- Compressed air can be used for various purposes like water pumping; running pneumatic based equipments, etc.

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