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Research Article

Generation of Electric Power using Turbo Ventilators

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Abstract

In this world of depleting resources, renewable energy plays an important role. Wind energy is one of the major renewable energy sources. In this paper we intend to study and review various research papers on generating electricity from wind energy using turbo ventilators. This method is economical and feasible by applying various electrical and mechanical techniques. In this paper we also intend to improve the efficiency of the system by using various materials for the fabrication of turbo ventilators. We have reviewed the papers on this topic published by various authors. We have compared their designs and concluded into an efficient model by combining all the designs into one.

Keywords: *Turbo-Ventilator, Electric Generator, permanent magnet, Axial Flow, Wind Energy, Ventilation.*

1. Introduction

It is purely manifested that the stock of all the nonrenewable energy is on the verge of extinction, there are estimated 1.3 trillion barrels of oil reserve left in the world's oil fields, which at present rates of consumption, will be sufficient to last for 40 years only. Therefore, it is obligatory to be using renewable resources such as Solar, Wind, Tidal, Geothermal, etc. Out of all the above renewable energy, wind energy is relatively easy to harness, also the harness efficiency is relatively high (Sirichai Dangeam ,2011) (Chonmapat Torasaa, 2015).

Wind energy is the use of aerial momentum of the wind, to produce electrical power using turbines and generators. Wind Energy is considered to be immensely clean, abundant and pollution-less. It also doesn't require assets like water, Heat and special Domain for errection. There are different alternative available to harness wind energy such as windmills, Turbo Ventilator, Wind Parachutes etc. When high velocity wind passes through the turbine, the conductive core, rotates within the magnetic field and electricity is generated. This is as stated by the Lenz Law. A Turbo ventilator majorly works on two principles, Hydro Mechanics where the air current is produced due to the difference in densities and the kinetic energy of the external breeze. Turbo Ventilators are used in huge factories and industries, where inside temperature is a lot higher than the ambient temperature of the air, due to various equipments and machineries like boilers, Furnaces, Engines etc. Also the heat produced by people accumulates resulting into increased average temperature of the room, decreasing its density. This temperature can be compensated using a vent, through which the low density warm gases pass, giving rise to a natural air current. This air current flow velocity can be utilized to generate electricity using the Turbo-ventilator.

The Turbo-Ventilators are broadly classified as

1. Ventilators driven by motor or forced convection ventilation.
2. Ventilators driven by natural convectional current.

Ventilators driven by motor are driven by a prime mover in this case an electric fan and hot air is forcefully gushed out of the ventilator, due to the forced convection provided by the fan. This method requires an external prime mover, which ultimately reduces the effective efficiency of the system. Thus use of this type of ventilation is usually avoided. Ventilators driven by natural convection do not require an external prime mover and all the necessary work is carried out by the natural convection, thus the absolute efficiency of this system is substantially high. We will be studying about this system in detail (Sirichai Dangeam ,2011) (Chonmapat Torasaa, 2015).

2. Construction

The Turbo ventilator is installed onto the rooftop with the fins extended and exposed to outside air. The base part is extended inside the building. The base is

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modified with a circular frame attached to it. This frame houses the Neodymium-Iron-Boron permanent magnetic discs. The stator is a circular ring wound with wires and forms the armature. It is sandwiched between the magnetic discs. This configuration ensures double the magnetic field with single armature.

This configuration is also useful for variable field strengths. The air gap can be adjusted by varying the heights of the discs. Hence this is an excellent apparatus for experimental purposes.

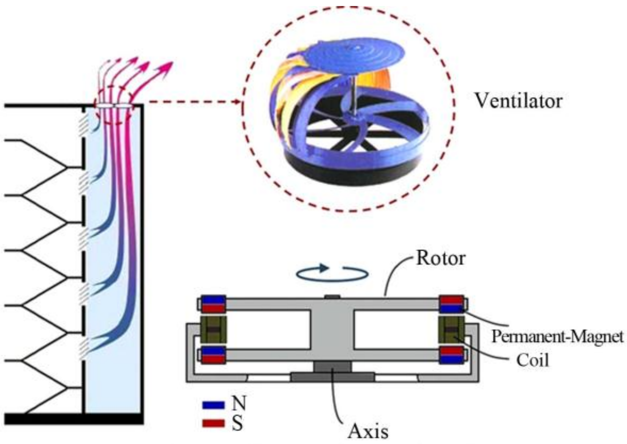

Fig.1 Construction of Turbo-ventilator

The wires are drawn from the stator armature and connected to step up transformer unit situated at the base floor. After step up, it can be either used in the form of AC or can be converted to DC and stored in the battery. The application of the lighting of LEDs is considered in this paper. But other applications of low power requirement can be considered like charging, tablets, electric scooters etc.

3. Working

Turbo Ventilator is an effective and economical ventilator system. The working of turbo ventilators is based upon the pressure and temperature difference which assists natural convection. Turbo ventilators are mounted onto rooftops. The impellers on the rotating parts are exposed to the outside atmosphere. They are rotated by the motion of wind and it does not need any electrical or external power source for functioning.

Turbo ventilators aim at reducing the temperature inside the building by eliminating the hot air and replacing it with fresh cooler air. The hot air formed inside the building is lighter in weight and has lower density. Hence they tend to flow upwards to the roof by natural convection. The rotating turbo ventilators suck these hot gases and eliminate them into the atmosphere. This creates a low pressure area around the ventilator. Due to this pressure drop, fresh cold air of higher density flows inside the building through the turbo ventilator. This cycle continues and the flow of hot and cold air further assists in the rotation of ventilator. Hence turbo ventilator works 24x7 and minimizes inside temperature by 3-4 degree Celsius without any power consumption.

Turbo ventilators are free moving. This rotation of the ventilator can be used to produce electricity. This idea can be related with wind turbines which produce electricity using a wind powered electric generator. Similarly, we can use an electric generator coupled to the turbo ventilator to produce electricity.

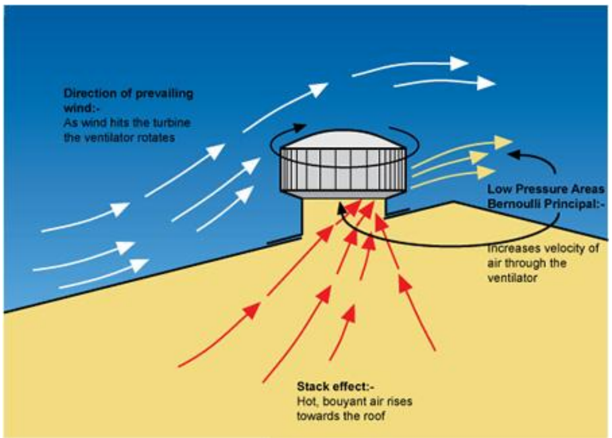

Fig.2 Working of Turbo-Ventilators

Electric generators or alternators are devices which convert mechanical work into electrical energy. The basis of the working of generator is Faraday's law. Faraday's Law states that whenever a conductor moves in a magnetic field, emf is induced in the conductor. Electric generators consist of two primary parts – rotor and stator. Rotor is the rotational moving part and stator is the stationary part. In primitive generators, permanent magnets were used as stator and armature which consists of windings and core acted as the rotor. The armature would rotate in between the magnets and produce alternating current (AC). But such design was not feasible due to use of large brushes in higher rating generators. Hence, a new design was formed. The armature was kept as the stator and the permanent magnet revolved as the rotor. These alternators are termed as Radial Flow Permanent Magnet (RFPM) generators.

RFPMs are ideal for large speeds. But in turbo ventilators, the torque produced is low. It is insufficient to rotate a heavy magnet. Also the RFPM generator system obstructs the thermal convection and hinders the working of the ventilator. Hence, to deal with the Axial Flow Permanent Magnet (AFPM) generators were used. AFPMs uses disc shaped magnets which are lighter. They have higher power density. Such generators are ideally suited for low torque applications. In AFPMs, the stator armature winding is sandwiched between two Neodymium-Iron-Boron permanent magnet discs. The two magnets face each other with opposite polarity of N-S and S-N configuration. AFPMs are coreless generators which again decreases the weight of the system.

The e.m.f produced by the generator is AC in nature. They are low in magnitude i.e. below 10V. Hence they are connected to a step up transformer. In the step up transformer, due to mutual induction of the coil windings, the input voltages are stepped up to a higher output voltage. This can be directly used to supply power to LED bulbs for lighting. Another alternative is to store it in batteries in the form of DC. To convert AC to DC an AD converter in used which consists of rectifier and filter circuits. Then it is given to a battery for storage and be utilized for future applications.

4. Observation

The following values of current and voltage were experimented on using the variable of speed as shown in the following tabular representation.

Table.1 Observation Table

Sr. No.	Speed [rpm]	Voltage [V]	Current [I]
1	150	3	0.02
2	175	5	0.038
3	200	7	0.042
4	250	8	0.055
5	300	10	0.06

These results can be optimized by using various methods which are explained in the next sub-chapter.

5. Optimization of Turbo-ventilator

The effective efficiency of Turbo ventilator power generation is low. This can be considerably increased by various ways. Studies about effects of configuration variables on the system performance, have been evaluated in terms of blade height, blade configuration, Turbine diameter, openings and duct diameter.

5.1 Extra fins

Introducing extra fins to the turbo ventilator resulted in increase in the air flow rate of the system. The graph is given below and it is purely evident that the output voltage increase with increase in the number of external fins.

Fig.3 Modified Turbo-Ventilator

These fins are longer in length, and may have other material profile. If we increase the number of fins by more than 3 fins, the total weight of the system increases reducing the air flow rate further reducing the power available for energy conversion. The fin can be different in materials, but the basic requirement is that the fins should be strong enough to withstand the different forces and have minimum weight (I. Daut et. al., 2011).

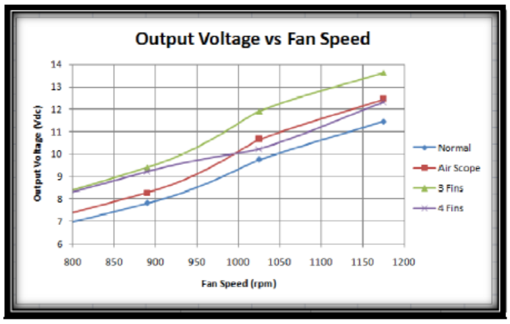

Fig.4 Output Voltage Vs Fan Speed

5.2 Turbine Diameter

Experiments were performed with the variance of diameter variables on its ventilation performance. It was found that bigger the size of the ventilator, higher is the ventilation rate i.e. the rate of discharge of air. However, practically it was found that the change in ventilation rate was somehow negligible. This is usually practiced most of the times to improve the air flow rate (Mazran Ismail, 2012).

5.3 Blade Height

In an experimental study on Long Volume Turbines as shown in Figure 5, it was found that, 13.5% increment in flow rate could be achieved if we increase the blade height by 50%. It was experimentally found out that the vane heights of 185, 260 and 350 mm at a fixed wind velocity of 12 km/h, it would give out different air flow rates of 65, 70 and 75 l/s, respectively (Mazran Ismail, 2012).

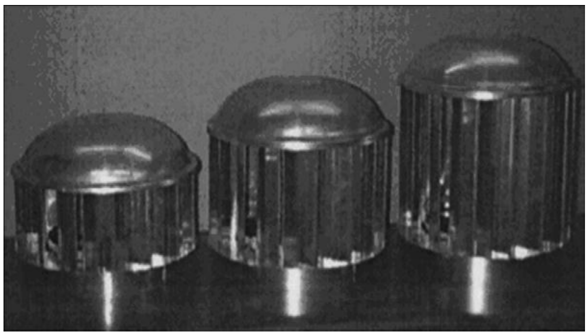

Fig. 5 Variable blade height/LVTs

5.4 Extra Inner Vane

It was practically found that with an extra inner vane of the turbine ventilator, the air flow rate had an improvement in its value. However, it was found that the size of the inner vanes does not have an appreciable amount of change in the air flow rate (Mazran Ismail 2012).

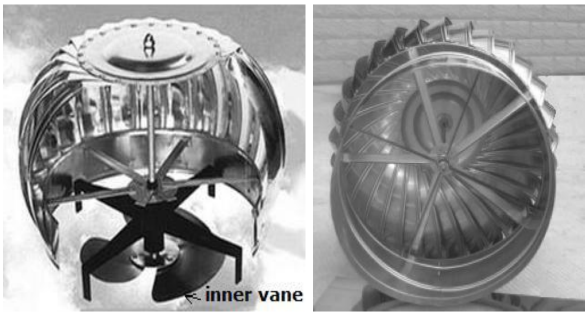

Fig.6 Typical configuration of turbine ventilator (a) with inner vane (b) Without inner vane

5.5 Throat Diameter

Different sizes of throat diameters were experimentally studied for best optimality for the maximization air flow rate, it was found that the ventilator with a bigger throat outperformed the ventilator with a smaller throat diameter as evident from the following readings. 300mm diameter throat is found to outperform the turbine ventilator with 250mm diameter throat. Also the study suggested that a simple bore open stub had the best performance in terms of the air flow rates, but obviously for the need of energy generation a turbine is needed, thus this type of system is obsolete from the point of view of our study and research (Mazran Ismail 2012).

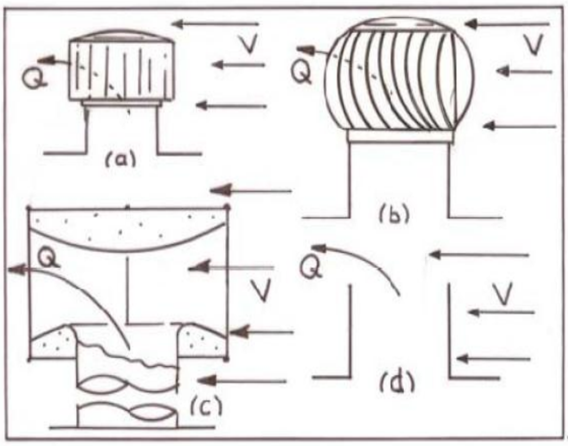

Fig.7 Diagram of the four ventilating devices tested (a) 250 mm throat turbine type; (b) 300 mm throat turbine type; (c) 300 mm throat Omni directional venture; (d) 300 mm bore open stub

5.6 Fan blade Geometry

In case of vertical vane, the same size of 300mm turbine ventilator, the curved type of ventilator yielded an increase in the air flow rate by 25%. Also it was found that the fabrication and the surface quality plays an important role in the air flow rate of the turbine-ventilator. Also the vane size and flow angle played a considerable role in deciding the air flow rate of the system (Mazran Ismail 2012).

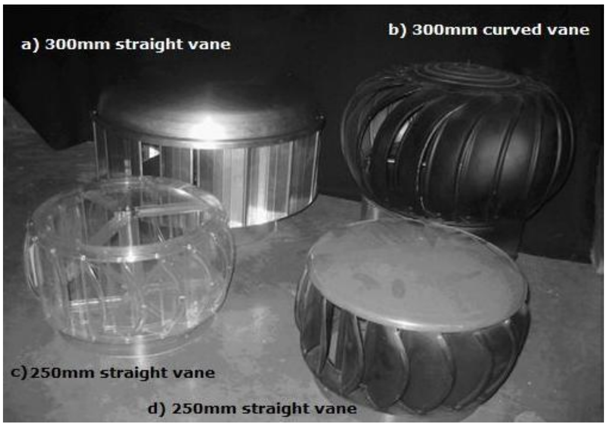

Fig. 8 Different types of turbine ventilators test (a) 300mm straight vane turbine (b) 300mm curved vane turbine (c) 250mm straight vane turbine (d) 250mm straight vane turbine

5.7 Composite frame

In conventional Turbo-ventilators, metallic frame is used. This frame can be replaced by a composite frame made of materials like plastic or composite fiber. The total weight of the system reduces and there is no danger of corrosion. Also if the net weight of the system is reduced, the total absolute efficiency of the system increases (Mazran Ismail 2012) (I.Daut , C.Shatri ,2011).

Fig.9 Plastic Prototype

Table 2 Summary of the above optimization techniques

Sr No	Configuration	Description
1	With external fins	Providing external fins can improve the air flow rate, although more than 3 extra fins may result in increase in the total weight causing the rate to reduce
2	Turbine diameter	Bigger the size of the ventilator, higher is the ventilation rate
3	Turbine height	13.5% increment in flow rate could be achieved if we increase the blade height by 50%.

4	With inner vane	Extra inner vane of the turbine ventilator, the flow rate grew
5	Throat Diameter	The larger size of throat/diameter of the duct could induced higher ventilation rate
6	Fan blade geometry	The curved vane ventilator induced 25% larger air flow rate than the straight vane
7	Composite frame	Net weight of the system is reduced, the absolute efficiency of the system increases

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Conclusions

This paper explains the brief idea about generation of electric power using turbo ventilators. It gives the scope for future development of the system and encourages use of renewable energy at small scale. This paper also gives us a brief idea about how to create an optimized model by improving the air flow rate thus increasing the available energy at the output. The observation illustrates that the output voltage and current is directly proportional to the wind speed rotational speed of the turbo ventilator. This paper has a very good future scope for further improvements and developments in the industrial as well as the domestic applications.

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