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Dual Functional Roof Ventilator

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Abstract: The world is facing a huge energy crisis due to resources depletion. The renewable energies play a vital role in energy generation sector. Fossil fuels such as coal and oil cause enormous environmental pollution. Wind energy is a major renewable source of energy and can replace this fossil energy. This paper aims to study the energy generation methods using roof ventilators. A wind driven, having metallic construction and blades on its periphery is a roof top ventilator. It is installed on the roof of industries as well as machine shops, warehouse and it provide effective ventilation. Hot air becomes lighter and goes upward on the top of industries and is expelled out through ventilator. At the same time fresh air also suck inside due to free spinning of roof ventilator. This free spinning can be converted into electrical energy using different electrical components. This technique is low in cost and feasible because of the minimum quantity of transferring elements and electric systems.
Keywords: Wind energy, Ventilation, Roof top ventilator, Battery, Generator.

I. INTRODUCTION

Renewable energy sources and non-renewable energy sources are two types of energy sources used to generate electricity. Natural resources that use fossil fuels stored underground are called non-renewable natural resources. Since several years, it is found that there is significant reduction in these resources, with faster degradation in some countries. The most important non-renewable energy sources are coal, oil, natural gas, nuclear energy and many others. Renewable energy sources include solar energy, hydropower, bioenergy, geothermal energy, and tidal energy. Using renewable energy has many advantages, but it also has several disadvantages. Renewable energy is considered green and clean because it does not produce harmful emissions or pollutants like fossil fuels and requires less maintenance. Solar, wind, water and tidal energy can play an important role in electricity production without affecting the environment. However, some of the problems in power generation are high construction costs, maintenance difficulties, facility installation space, and power distribution. The Government is trying to develop small power stations to dissolve these problems. One of the means to develop such kind of small power station is effective utilization of Roof top ventilator to generate electricity.[2]

The mechanical devices that run on wind to provide fresh air in the industrial sheds without running cost is called as Roof top ventilator. In addition to providing fresh air in the roof space and living space 24 hours a day, the free spinning roof ventilator also prevents odours. It does not consume any power units and does not require an electrical connection. This technology is popularly installed on the roof in workshops, industrial buildings, ware houses and also in residences. It works on the principle of a flywheel and they gain momentum, spin forward.

The ideal way to replace hot and humid air with fresh and clean air is ventilation. The highly efficient wind powered roof top ventilator provides fresh air for machine shops and industries. Not only can workers enjoy the benefits of better ventilation in the house, but they also have an additional power source for low-power devices such as radios, mobile phone chargers, etc.

In wind mills (an older technology), wind energy is used to rotate mechanical devices to do physical work, such as crushing grains or pumping water. Ventilation creates comfortable and healthy air that is odorless, dust-free, drought-free and quiet. The ventilation in the ventilation system is well controlled. If necessary, replacement heat is collected from the atmosphere. There is no annoying dryness. The main purpose of ventilation is to bring clean air from the atmosphere for breathing and to remove gaseous impurities and various particles inside the building. The cleaner the indoor air, the better the well-being of the residents.[5] That's why the Roof Top ventilator is a good choice in this case, because it works without electricity. In RTV, the hot gases internally, turn the vanes of ventilator. When hot gases are extinguished, the internal density decreases. Thus, cold gases occupy space. This is how ventilation occurs. Our goal is to use the rotation of the ventilators during ventilation to generate electricity. Even a small breeze can be enough to turn the ventilator. The faster the wind, the faster the turbine spins and removes heat, smoke, fumes, moisture, etc. The mechanics of air movement are very simple. Hot air inside the industry tends to rise. When the ventilator rotates, they suck hot air through the vent. This causes a drop in temperature in the shed and lets in fresh air through the doors and windows.[6]

This project aims to generate electricity from a roof ventilator. The second function would be achieved by converting the kinetic energy of the wind into electrical energy. Roof ventilation is installed with technical considerations and is planned appropriately on the roof or external wall of the building so that ventilation can be achieved in the required space. It can be used anywhere like industries, houses, workplaces etc. The hot gases in the room or space are removed by the rotation of the ventilator vanes. As a result, the air density in the room or space decreases. This allows cold air to occupy the empty space. Many aspects of a ventilator, such as size, blade selection, and installation, depend on various aspects such as wind speed, outdoor and indoor temperatures, environmental conditions, and building size.[5]

Roof ventilators have two types: 1. Roof ventilator with motor driven 2. Roof ventilator with natural air driven. This paper discusses second type of roof ventilator. Roof ventilator consist of stationary part and rotational part. The fixed part is comprising of base and fixed shaft and rotational part is made of fan blades and bushings, which are placed on the fixed shaft in the stationary part. There are two principles of rotation in the formation of RTV. The first principle is hydromechanics, which is able to move air from a high-temperature area to a low-temperature area, which tends to rotate. During this time, when the turbine rotates, the high temperature air leaves the room, allowing the air density of the room to decrease so that cold outside air can enter the room. Another principle is the air convector, whose rotation of wings depends on the air in the wind.[3]

Paper is organized as follows; Section II describes the contributions of various researchers in development of electrical energy using roof ventilator. The constructional features of model are discussed in Section III. Section IV presents working concept and methodology of project. An experimental verification and results are given in Section V. Finally, Section VI presents conclusion.

II. LITERATURE REVIEWS

In the present chapter, the contribution made by different researchers and authors in the field of electricity generation using roof ventilator were enlisted in short. It includes the methods, mathematical modelling, different input parameters as well as their output results. The literature is based on roof ventilator and generators, implementation types; finally, the summary of literature reviewed is added.

There are many technological developments to adapt the renewable energy to generate electricity. Various researchers studied wind energy application for electricity generation.

Sirichai Dangeam [1] have studied the energy generation methodology of roof ventilator by adding of three phase synchronous generator for voltage generation. The model contained low flux density permanent magnet as rotational part. The ventilator base was used as for installation of three phase stator winding. The study focuses on Natural air driven roof ventilator. Roof ventilator should reduce around 20% of heat mass under the roof. So, all the sources of heat and its characteristics should be considered before installation of roof ventilator. Calculations for coil turns and wire size, coil span, stator core design, rotor part design are done considering magnetic density, in air gap and poles, cross-sectional area and induced voltage. Generator testing is done in three parts: 1) Individual generator test is done, more over various graphs with speed comparison to voltage, current and power. 2) Generator test with roof ventilator was done with star & delta connections. Results of delta connections is better than star connection, in terms of load. 3) Generator test with roof ventilator on roof building resulted that voltage induction is lower than laboratory test. Akshay zagade, et. al. [3] presents review on micro generation using roof top turbine ventilator (RTV). Papers explains horizontal and vertical axis wind turbine a comparative study between permanent magnet synchronous generator (PMSG), AC-Generator, Axial Flux Permanent Magnet (AFPM) and AC synchronous generator comparison is done on various aspects, such as construction, working, excitation, slip-rings, brushes, losses, cost, efficiency and many more. I. Daut, et al [4] investigated electricity generation using modified roof ventilator. The modifications include adding extra fins to help it to spin faster and efficient working Zink was used to made produce extra fins. Three fins were attached to roof ventilator at the starting of experiments. Fins were increased to four, but resulted in decrease of speed of roof ventilator. Extra fins help roof ventilator to spin at faster rate and optimum design results in adding of three extra fins only. The low torque of AC generated benefited the system in performing in good condition. Chonmapat Torasa, et al [7] aimed to build the roof ventilator equipment system equipped with small direct current electric generator. Paper explains various adaption procedures of wind energy such as, 1) wind energy obtained from horizontal axis wind mill moves water pumping system to collect water for agricultural use. 2) Electric current generated by windmill through wind's kinetic energy is used to move rotor of electric generator. 3) Air ventilator on the roof of buildings. Paper explains detailed methodology for developing model with roof ventilator and 18 watts DC generator, and results were analysed with and without DC step-up converter, which increases voltage.

Rushikesh shinde, et al., [8] aims at improving efficiency of the electricity generation using roof ventilators using various materials. Turbo ventilators power generation has low effective efficiency. Various optimization in turbo ventilator are discussed in this paper.

As number of external fins increase, output voltage also increases. As Turbine diameter increases, ventilation rate or rate of air discharge increases. 50% increase in blade height, has 13.5% increment in flow rate can be achieved. Air flow rate can also be improved by adding extra inner vane to turbo ventilator. Inner vanes do not change the air flow rate. Large throat diameters were also studied for maximization of air flow rate, and better performance. The air flow rate can be increased up to 25% by using curved vane ventilator instead of straight vane. Usage of composite frame in ventilator, reduces net weight of the system and absolute efficiency increases of the system.

III. CONSTRUCTION

The main component of the project is a roof ventilator. There are different sizes of ventilators that range from 14″ to 36″. The standard roof ventilator in the market comes with 24 inches diameter size. The kinetic energy in the wind is captured by 32 curved blades. Most often, zinc is used to make a roof ventilator because it cannot be affected by rust. Perhaps, the roof ventilator used in the project is made of stainless-steel blades having 0.5 mm thickness. As ventilators are installed on the roof and exposed to rain and birds, therefore they are made rainwater and bird proof. Since they are located at the highest point of the roof, they are able to ensure optimal ventilation. They must also be strong and resistant to corrosion. The ventilators are also designed to prevent leaks and drafts into the building by allowing air to enter through side vents. Finally, wind turbine ventilators have a pleasing appearance and enhance the architectural appearance of the building. Efforts to remove smoke, polluted air, and moisture from homes, ships, and factories resulted in a variety of ventilators, sometimes installed through chimneys to facilitate drafts, but mostly on roofs. These ventilators also release hot gases instead of rain and pests. The basic structure of the rooftop ventilator comes from a commercially available ventilation turbine. To achieve the goal of an easy-to-install system, all changes to the turbine are superficial or surround the visible outer surface of the turbine.[6]

The mechanical features of this product are simply a simple bearing and proper installation of components. The alternator is a solution that manages to achieve the purpose of the product. An important feature of the AC generator is that the torque must be low so that it can start at low speed. The rubber belting is attached to the moving object of the roof ventilator. A pair of pulleys are used to transfer the motion. The drive shaft is selected with 15 mm which is connected to roof ventilator Pulleys are coupled to belt drive having circular cross-section. The length of belt drive is 180 mm and rubber are selected for belt material. Rubber has excellent elastic properties which can with-stand the drag force of wind. Chrome steel material is selected for bearings.[2]

The AC generator is connected to the belt with a small plastic wheel. When the wind blows on the fins and creates enough drag, the roof ventilator spins. The plastic wheel of the generator and the moving roof ventilator rotate synchronously, generating electricity.[4]

A DC generator is somewhat simpler than an AC generator. In an alternating current generator, a magnet rotates inside fixed loops wires that carry the current produced. A DC generator looks like a simple cartoon with circuits rotating within the field created by a fixed magnet. Most DC generators are essentially simple rotary AC generators whose designers tried to keep the current direction reversed. although a DC generator only makes the current flow in one direction, it does not produce constant current - the current still fluctuates between zero and maximum, meaning that the power produced is intermittent. Therefore, all but the earliest and most primitive DC generators are arranged in multiple coils of wire at different angles, so that the output power is the sum of many rectified sine waves, and is therefore much smoother (although it can never be perfectly smooth). Finally, the advent of modern electronics means that the worlds of AC and DC don't have to be so separate. Generators can actually be used to produce direct current as well, as rectification can now also be done electronically using diodes which only allow current to flow in one direction. Small domestic wind turbines that use AC generators often have their power rectified to DC in a similar manner. Using a wind turbine for DC can avoid the need to regulate its speed to produce 60 Hz power and allow the turbine to run at whatever speed produces maximum power.

Ceiling fans absorb wind energy and their individual blades move slower than the speed of the wind. The difference in speed creates a drag force to drive the blades. The drag force Fw acting on one blade is calculated as:[4]

FW = [CD A ρ (UW-Ub)2]/2

where A is swept area of the blade; ρ is air density (about 1.225kg/m3 at sea level and at temperature of 150 C); UW is wind speed; CD is the drag coefficient (1.9 for rectangular form); and Ub is the speed on the blade surface. It is seen that the wind velocity UW dominates the wind force as compared to other parameters A, CD and ρ. As expected, more driving force FW is easily and effectively to rotate the turbine and to gain more electricity eventually. The maximum power is obtained while [4]

Ub = UW/3

IV. WORKING

The main component of the system is the AC generator. It converts the kinetic energy of the wind into electrical energy for usage. The generated electricity then passes through an AC-DC regulator and converts it into direct current (DC) voltage. This free electricity must use a battery charger to continue the charging process. This ensures no backflow when the roof ventilator is not running. An inverter is used to convert direct current to alternating current for use with an alternating current load.

The Ventilator is an efficient and economical ventilation system. The operation of ventilators is based on the pressure and temperature difference, which promotes natural convection. Ventilators are installed on the roofs. The impellers of the rotating parts are in contact with the outside air. They are turned by the movement of the wind and do not require electricity or an external power source to operate. Ventilators works to lower the temperature in a building by removing hot air and replacing it with fresh, cooler air. The hot air generated inside the building is lighter in weight and less dense. Therefore, they tend to flow up to the ceiling by natural convection. Rotary ventilators suck in these hot gases and release them into the atmosphere. This creates a low-pressure area around the ventilator. Due to this pressure drop, fresh, cold air flows through the turbo ventilator inside the building with a higher density. This cycle continues and the flow of hot and cold air helps the ventilator to spin. Thus, the ventilator works 24x7 and minimizes the internal temperature by 3 degrees without electricity consumption. Ventilators move freely. This ventilator rotation can be used to generate electricity. This idea can be combined with wind turbines, which produce electricity through a wind-powered electric generator. Similarly, we can use an electric generator connected to a turbofan to produce electricity.[8]

The operation of the generator is based on Faraday's law. Faraday's law states that when a conductor moves in a magnetic field, an emf is induced in the conductor. Electric generators consist of two main parts - the rotor and the stator. The rotor is the rotating moving part and the stator is the fixed part. Primitive generators used permanent magnets as a stator and an armature consisting of coils as a rotor. The armature would rotate between the magnets and produce alternating current (AC). However, such a design was not possible because advanced generators used large brushes. Therefore, a new model was formed. The armature was considered the stator and the permanent magnet rotates like the rotor. Radial-Flow permanent magnet generators are ideal for high speeds. But the torque of the ventilators is low. Spinning a heavy magnet is not enough. The generator system also prevents thermal convection and makes it difficult for the ventilator to operate. Therefore, axial flux permanent magnet (AFPM) generators were used for processing. They have a higher power density. Such generators are ideal for low torque applications. The e.m.f produced by the generator is alternating current in nature. They are of small size i.e., less than 10 V. That is why they are connected by a step-up transformer. In a step-up transformer, the input voltages are stepped up to a higher output voltage due to the mutual inductance of the coil windings. It can be used to directly power LED lamps for lighting. Another option is to store it in batteries as a DC source. An AD converter consisting of a rectifier and filter circuits is used to convert alternating current to direct current. It is then transferred to the battery for storage and can be used for future applications.[8]

Fig. 1 Assembled Model

Fig. 2 Roof Ventilator with Pulley Arrangements

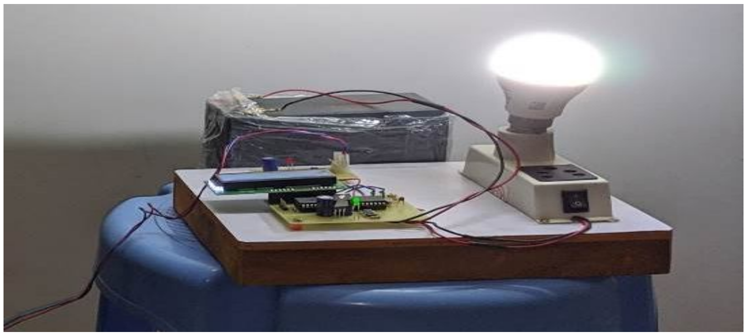

Fig. 3 Detailed View of Circuit

V. EXPERIMENTAL VERIFICATION

The output voltage of generator at different speeds of roof top ventilator by belt drive mechanism is tabulated below. Voltage is the parameter that is dependent of speed. Energy generation is directly proportional to speed of system. As the speed of system increases system voltage also increases.

Sr. No.	Ventilator Rotations or Speed (RPM)	Voltage generated (V)
1.	30	0.94
2.	60	1.16
3.	100	1.71
4.	150	2.47
5.	200	3.37

VI. CONCLUSION

Every year energy demands are increasing with huge development of technology around the globe. For sustainable future, renewable energy is becoming more and more necessary. The paper outlines, power generation method using roof ventilator from the free wind energy.

When warm air flows under the roof, it helps turn or rotate the rooftop ventilator. When the ventilator moves, the motors work and thus electricity is generated. And this prototype is relatively small and not more expensive.

The voltage induced by the generator is directly proportional to the speed of the rooftop ventilator. In practice, when installed on a roof, the voltage induced by wind changes is lower than measured in the laboratory.

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