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Design and Fabrication of O-Wind Turbine

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Abstract*: Wind as a power source is most commonly used in generating electricity as they are inexhaustible. The project deals with capturing of wind in all directions and thus, leads to generation of electricity with better output. The design is made in such a way that, fins are inclined to an angle and size of the fins varies as one end is larger and other end is smaller, gap between each fins are equally spaced. Medium-density fibreboard is used for machining of internal and external blades which are then used to prepare mould. Here, the usage of Glass fibre is to strengthen the blades. The main application of this type of turbine is that, these can be used in commercial places where the velocity of wind is considerably lower. O-wind turbine does not occupy more space also it can be fixed in balconies. This can also be used in places where the wind flow is higher especially in highways. When vehicles pass by, the turbine rotates at a faster rate to produce electricity which is useful during night.

***Index Terms*: Bernoulli's Principle, Glass Fibre, Omni Directional Wind Turbine, Wind Power Generation.**

I. INTRODUCTION

Wind power generation are usually considered to minimize the use of non-renewable resources as they are not dependent source in future [4]. Turbines may not be most probably used now a days but, these are the future. There are many innovative designs in these types of turbines to capture wind. These are implemented to capture air as a main source in the generation of electricity. These are then used for different purposes as per the requirement of the output. Thus, generating power with these sources are mostly progressed and are well executed nowadays especially for future benefits as these are the upcoming scope. O-turbine plays a vital role in capturing wind in all direction [15]. Every part in this design plays a crucial role to trap wind. These are designed accurately and are precise. It combines the actions of both general types of wind turbine which includes, Vertical and Horizontal turbines [2]. Our turbine can rotate in clockwise as well as anti-clockwise direction, depending upon the wind velocity in that area [3]. Thus, most of the air around us are used for the output. The turbine fins are designed based on Bernoulli's Principle [15]. Which means, one end of the blade is size is larger than the other end. So that, when air enters in the turbine, it flows from one direction to the other. For instance, When the air passes through the larger end of the fin, the velocity of the air over the other end increases which automatically pushes the turbine and thus, it leads to rotation of the turbine [1]. The turbine blades are positioned in such a way that, each blade is tilted at an angle to perform the action of rotation easily without any initial start. Thus, this can be actuated with the starting speed of the wind.

II. PROBLEM DEFINITION

The wind available at the test location is an important factor in designing the wind turbine. [9] Using an average available wind over a mass area is not very suitable in a tightly packed residential area as the air flow tends to change direction without a warning and speed of flow changes based on the obstruction that it faces. So, a customized wind data base is required for the install location. This is done by measuring windspeed of the install location through the day for a brief period. In our case 6 months this gives us a fair idea of what speed to expect in the location. The data was recorded, and average velocity of air is calculated. From the obtained values. Since the turbine has complex curves. The dye must be machined with fine precision. So, a stack of wooden planks was made and machined in vertical CNC machine. The rate of material removal had to be balanced for smooth curve and speed. The blade and fins are supposed to be light weight. In order to function freely. This means a top-grade glass fibre is required to balance weight but the cost of these kinds of glass fibre are higher.Output is obtained from a generator that converts rotational motion into electrical output, this output is highly dependent on the no. of rotation per minutes. Since the turbine is designed for low wind speeds [11], the generator should be capable of giving substantial output. This means the generator will be expensive and large and heavy. The machining to be done so precisely and never let anything to be inaccurate as such holes not to be greater or smaller must be perfect.

III. SELECTION OF MATERIALS

A. *MDF Board-* Medium density fibre board is used in this project for machining to obtain the blade shape and to create mold. The MDF board is comparatively stronger than the wooden board and while machining in VMC, these can withstand without any damage. Hence, we preferred this type of board.

B. *Generator-* Generator is an electrical device that captures mechanical motion and turn it into electrical output it uses a permanent magnet [10]. We mounted it to the bottom part of the turbine blades.

C. *Glass Fibre-* Glass fibre material is used for strengthening of the blades and it does not break easily. The property of this material is in such a way that, these are less in weight and are stronger than other material.

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The glass fibre are of different variations which are classified according to their standards as the quality and strong point increases. The glass fibre here is the chopped strand mat, which is good quality for the fabrication process.

D. *Battery*- Battery in this project is used as a storage device. The battery is recharged by the generator. The generator produce current that is then accepted in to the lead acid container with two pins that are marked positive and negative. The positive receives charge from generator while the negative is used just to complete the circuit.

E. *Bearing*- Bearing is used as continuous rotational motion with if a shaft without any wobble. It is also used to support the weight of the turbine over a fixed round plate while allowing frictionless rotation of the shaft. The bearing here first chosen was a thrust bearing. But the thrust bearing comes in 3piece the balls the base and the lid. Which meant the balls can sway causing wobble, so a generic ball bearing was chosen the bearing houses several balls that slide over the inner bush that is fixed over the shaft. Another plumber block self-aligning bearing is used to automatically eliminate shaft wobble. The plumber block helps in mounting it to a plain surface.

F. *Shaft*- The shaft is made to connect the stand and the turbine. The shaft has a diameter of 24 mm at the top till 50 mm and the other half have 20 mm diameter. The total length of the shaft is 125mm.The shaft in this are drilled for fixing of generator so that, the power generation is possible. The shaft is to be connected in such a that, it should not be too loose or tight. It should glide in and out with minimum pressure applied.

IV. DESIGN AND FORMULAE USED

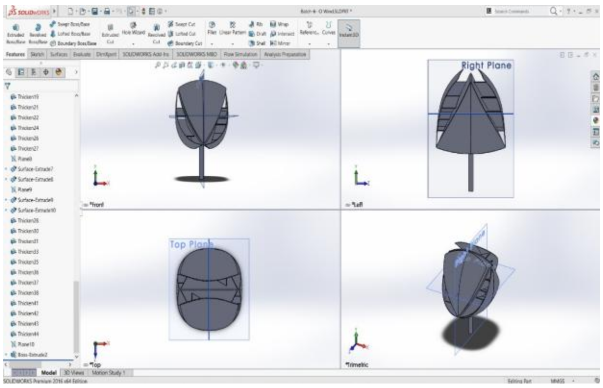

Fig.1. 3D Design of the Turbine

The Design of the turbine was made using Solid works and fabrication is done using the exact dimension from the design. Before 3D Design, a rough sketch was made and with its reference the 3D design is made.

Formulae:

Power P= 0.5*Cp*ρ*A*V^3

Angular velocity ω= 2πN/60

Torque T= P/ω

Radius of the turbine- R=D/2

Angular velocity - ω=2πN/60

Torque T=P/ω

Some Constant Values:

Density of air ρ= 1.225kg/m^3

Bet'z constant Cp= 0.4

V. ANALYSIS

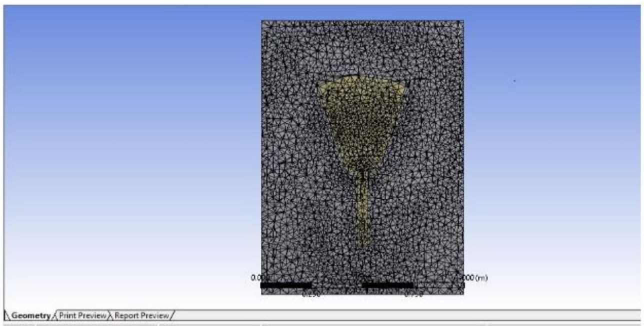

Fig.2. Mesh of the Turbine

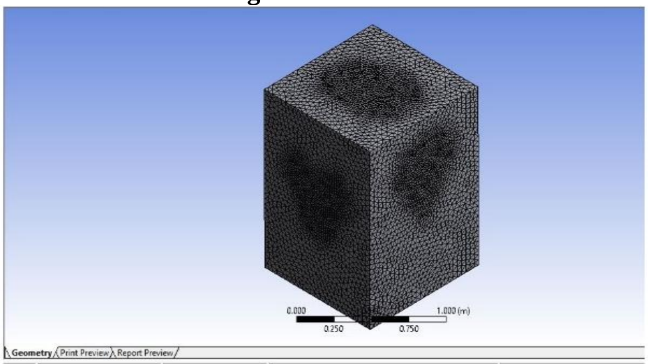

Fig.3. Meshed Sectional View of the turbine

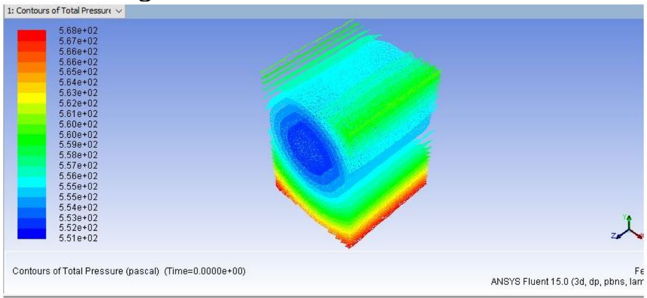

Fig.4. Total Pressure Contour

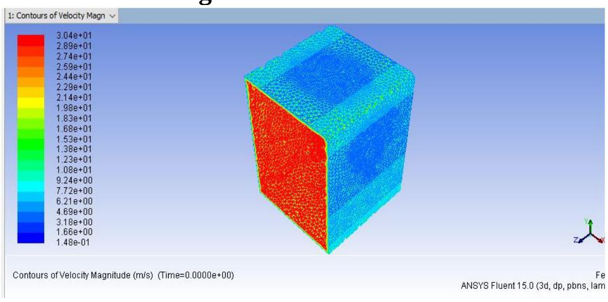

Fig.5. Velocity Contour

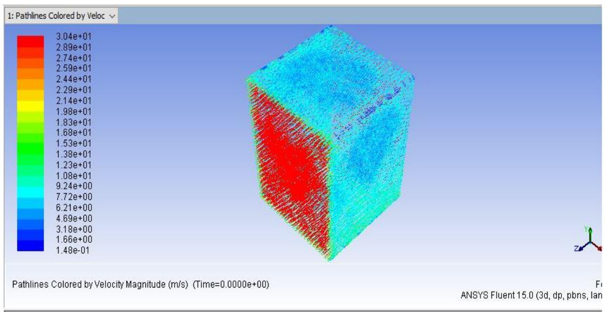

Fig.6. Velocity Path line

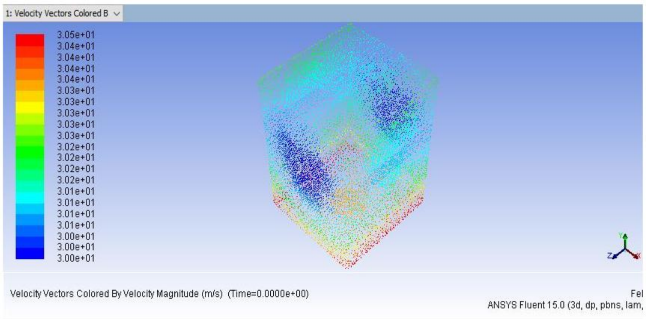

Fig.7. Velocity Vector

Solver: (ANSYS Fluent)
Type: (Pressure based)
Object: (Blade Assembly)
Fluid: (Air)
Boundary conditions:
Inlet: (Velocity inlet)
Outlet: (Pressure outlet)
Wall: (Enclosure surfaces)

VI. FABRICATION

A. *Binding MDF board*- MDF board is bought with dimensions 600mm x 600mm x 16mm. The thickness of the board is 16mm. Total number of boards purchased is 32. MDF board has been cut into several pieces and bound together into 4 parts by applying polyester resin. Each part is glued and bound together as per dimensions needed to machine the blades.

B. *Machining of Blades*- The MDF boards which are made into four parts are machined in vertical milling lathe. Each blade is machined as per the design and with the exact dimensions. Each part had a unique design for the inner and outer side of the turbine. Each blade is machined using G-code and M-code in the vertical milling lathe.

C. *Applying Glass fibre*- The polyester resin is mixed with the primer and it is coated over the master mold with Glass fibre. All the four parts have been coated. The glass fibre are pasted after resin is applied and again the same resin is coated on it and made to dry for some more days so that, the combination of resin and glass fibre provides strength.

D. *Main Mould*- The four parts are dried minimum for 24 hours. After drying, the hardened mold is removed to obtain the main mold. These are used for preparing the several blades.

E. *Blades*- The blades are obtained by repeating the same process of the mold but this time from the main mold. The blades are dried for 24-36 hours. The longer the drying time lesser the shrinkage and warpage. These are of 8 blades and that has the combination of 4 inner and 4 outer blades. These are attached to form a complete structure of the turbine blade and these can be used to generate electricity upon complete rotation of the turbine. The blades obtained from the mold after drying and removal, the blades are formed in this way and made to dry upon preparation of the mold

VII. ASSEMBLY

The inner blades and the outer blades are removed from the mold and trimmed to remove excess materials then the edges and corners are grinded to remove sharp edges. the profile of the curve is then examined carefully before using them. To prepare the seat a round plate is drilled, with hole to accommodate the shaft and bearing. The ball bearing has its own custom bush that is permanently welded to the base seat. The turbine has inner set I blade is arranged according to design and a bright steel rod is placed to support as well as connect the turbine to the base. This rod has holes that align with another bright steel rod, but smaller inn sizes this piece sits over another custom bush with a groove to fit the rod. The rod is then permanently welded to the bush after aligning and balancing of the complete model The shaft that runs from the turbine bush through the bearings to the generator. The shaft as cross holes that are used to secure the generator to the shaft. Two bearings are used in this model. A ball bearing, and a plumber block self-aligning bearing. This allows reducing sway in shaft. It auto corrects itself without manual interventions. This plumber block bearing is attached below the seat by lowered support. The generator depending on the drive mode can be mounted using a holder or directly to the shaft. When the drive is in direct mode the wires are then tied to the stand. This reduces the wobble acting as a shock absorber. The shaft has hole for the generator and cross holes tightening it. The stand is a basic tripod stand welded with L shaped rod to the stand serves the purpose of raising the turbines above the floor. After mounting the inner blade assembly and mounting them on stand the fins were cut according to measurements in a fibre glass sheet and then pasted to the inner blade's faces the fins not only act as spacing for the outer blade but also act as a support. The fins are angles precisely according to the design. Then the outer blades are then pasted over the fins in their locations and then any excess or out of shape places were trimmed. The external circuit for the inverter setup is done separately by connecting a diode to stop reverse flow to the battery. And a regular circuit for an electrical device with a switch. After which testing was made.

Fig.8. Blade Front Side

Fig.9. Blade Back Side

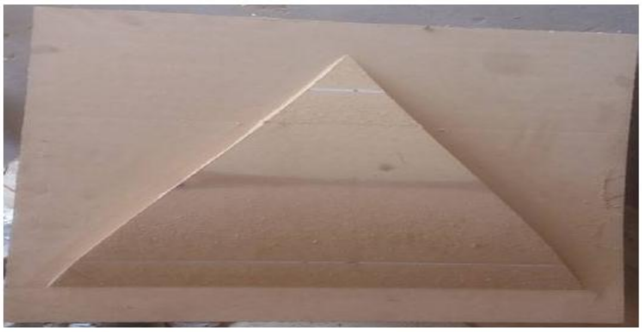

Fig.10. Blade Left Side

Fig.11. Obtaining Main Mold

Fig.12. Main Mold

Fig.13. Blades

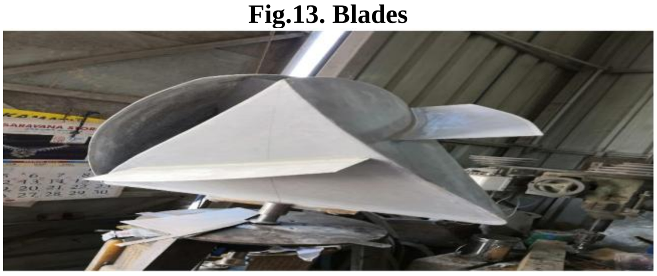

Fig.14. Fins

VIII. TESTING

Testing was done with various configurations of the same design, namely with different fin angle and shape. An optimal shape and arrangement were determined before they were all assembled. The full setup was tested in normal ambient wind as well as forced winds at rated wind speeds. And the power generation setup was also tested with turbine operating at different speeds. The generator was mounted in direct drive mode first to test the output while the same was repeated with a speed stepped up 5 times with a matting gear. Both the output was recorded, and the rated calculations were verified. The same experiment was tested with different generator before fixing the optimal one. The wind first was low when the initial testing was done speed lower than the stall speed. which is the minimum speed required by the turbine to nudge. The wind was forced with an air cooler, the air cooler had rated or desired operational speed for the turbine, so an airstream was concentrated at various angles and distance to ensure the turbine works. The distance plays a role. This was because the air stream from the air cooler or a lead blower is concentrated and narrow while the natural wind is widespread. Thus, the testing proves that the wind turbine is functional and capable. Though the turbine design is perfect the mounting mechanisms was a challenge in the existing setup or model the turbine is supported by a shaft that connects the base of a turbine and generator the weight distribution of the turbine itself is even.So, the shaft had to be centered so, that the turbine is aligned. If not, the sway causes the turbine to wobble and the efficiency and balance of the setup will be disturbed so the turbine was centered based on dimensions. The initial thrust bearing was changed to ball bearing that is housed in a bush this allows less sway to further reduce sway another self-aligning plumber block bearing is used this is done because any defect that causes misalignment will be adjusted by itself. The generator performance data though was readily available the use case differed, so the available output was measured by fitting it to the turbine. The potential developed by the turbine was measured using a multi-meter and the output was used for calculations as well as the choosing of external circuit. The circuit should be chargeable by the generator while providing output independently without disturbing the generator so, a Schottky diode is used to reverse operation as to work as generator. The height of the stand was decided with the deployment location in mind. The stand does not have any effect in performance of the turbine other than to rise the turbine above the ground. The turbine is capable being mounted upside down or even sideways. Since the stand here was just so the turbine clears the height of the sidewalls.

IX. RESULTS AND DISCUSSION

The O- wind turbine could serve as an alternate source of energy which is both compact and economical to use. In the further development of the design, the turbine not only use it as a backup or reserve system but to use it as a main stream device for household power generation. Thus, saving both money and the strain on the conventional source of energy.

This turbine has proven that it not only capable to serve as a source of energy but also to recharge batteries when required. It can operate when the availability of the rated wind flow is the low as well as when the wind velocity is higher. In cases like, if this turbine is placed in highways, where fast moving vehicle passes by, therefore rotates at a faster rate.In the future, renewable source of energy is the only option for energy production. The other sources are harmful and are not available in unlimited quantity. The use of environmentally safe and unlimited source of energy that is available through the wind is one of the ways to solve the energy crisis. These kinds of turbines allow us to utilize wind energy more efficiently and economically.

They allow personalized wind power generation and proving their presence as an asset. Our Turbine can be used in commercial places and once the mold is prepared, many blades can be obtained. This can be cost effective and compact compared to other turbines. These can be implemented in all places and can be used to generate electricity using wind.This also proves that, the placement of fins on the turbine can lead to the rotation of the turbine. Thus, leading to increase in kinetic energy and increase in velocity of the wind that comes out.

X. CONCLUSION

Wind as a source of energy is unlimited and has capacity to satisfy the ever-growing need of electricity this means efficient trapping of wind utilizing the potential. Small turbines and large turbines working in tandem can trap the wind to produce the precious electricity that is now in this modern century has moved from being considered luxury to a basic need. Conventional source of energy has limited availability and the need for a switch is an undisputable truth. Regulating to new methods is the only way by which we can satisfy our needs. Small wind turbines such as the omnidirectional wind turbine can solve the problems by serving as house hold equipment for personalized power production. They also help in cut down the cost of electricity also being much cheaper replacement for it. This type of Omni directional wind turbine can be used to trap air and can eventually convert to produce electricity and the turbine consumes less space compared to other turbine. Hence, these types of turbines can be used in commercial places and can be helpful when there is a need for the generation of electricity. Thus, this type of turbine can be used by all and does not require any steering mechanism. It occupies less space with good amount of wind that can be captured for the turbine blades to rotate.

Fig.15. Final Prototype

Future Scope- The design of the turbine blades and fins with aero foils could basically improve the aerodynamics of the model. With commercialization in mind the generators need to be custom made and with those changes made, the turbine would be ready for using at houses. Analyzing and doing a complete wind study of this turbine reveals areas of weakness such as points of drag and various other parameters such as minimum and maximum stall speeds and drag. The wind tunnel will also tell us the amount of torque and rpm and other performance curves that allows us to comfortably modify the design for various speeds and locations. The different mounting system such as hanging the turbine upside down mounting it by the sides can also give us much flexibility in mounting the turbine reducing weight even further without compromising on stench by using carbon fibre or by using nylon materials instead of glass fibre gives more strength. Improving the design to be used along the shore lines and along the roads, this design would be much suitable in places where the wind speed varies. Improving the efficiency of the generators, which can generate electricity even though the turbine rotates at a lower speed. These types of turbines can also be used in areas where the electricity problems play a major role. Upon installation of these kinds of turbine can be cost effective and easy to mount on required places from which people can be benefited and useful for the people in rural areas.

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