Fabrication of Horizontal Axis Wind Turbine for Power Generation

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Abstract—

Wind energy is one of the promising renewable energy, used to generate electric power. The search for environmental friendly, sustainable energy has promoted in this industrial world. The present global technological society is depended on the availability of energy. The development of industry, agriculture and transportation, etc. is totally depended on the availability of power. The cost of energy is increasing day by day due to the increase in the demand of power and depletion of the conventional energy resources, which are used in the generation of electricity. So, it is very essential to make use of the non- conventional sources of energy like wind energy, solar energy, tidal energy, etc. Wind is considered to be one of the most promising resources in the renewable energy portfolio. Wind energy is used to generate electrical power by rotating the rotor shaft by the conversion of kinetic energy of wind into rotational energy of the shaft. The objective of this work is to develop a domestic wind turbine which works at low wind speeds and which can be made available to the common man at a very low price. Polyvinyl chloride, which is easily available, has been utilized to fabricate the blades. In the design process, basic aerofoil section is considered with various forces acting on the blades are calculated theoretically and the design is optimized to get the optimum power output. The rotational speed of the wind turbine is maximized by using a gear ratio. A DC dynamo which acts as generator is used to extract power.

Key Words: Renewable sources, Horizontal Axis Wind Turbine, wind Energy, hub, blade, fabrication, Gear Ratio, Dynamo.

I. INTRODUCTION

Wind turbines are devices that convert the kinetic energy of the wind into electrical energy. They work on a simple principle: instead of using electricity to make wind (like a fan), wind turbines use wind to make electricity.

1.1 Here's a basic introduction to wind turbines:

Wind Capture: The wind flows across the turbine's blades, which are shaped like airplane wings. This creates a difference in air pressure between the two sides of the blade.

Rotation: The difference in pressure generates lift, causing the blades to rotate.

Mechanical Energy Conversion: The rotating blades are connected to a central shaft, which in turn is connected to a gearbox (in most utility-scale turbines). The gearbox increases the rotational speed of the shaft.

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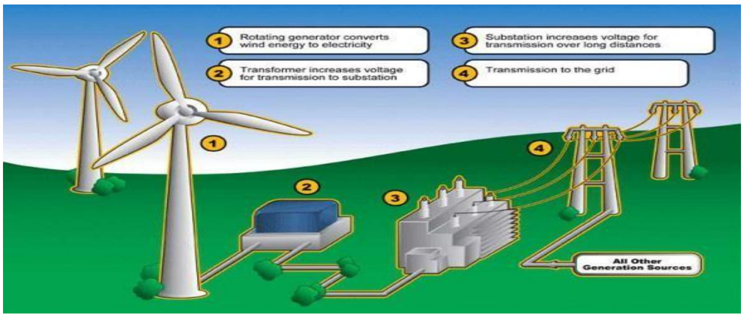
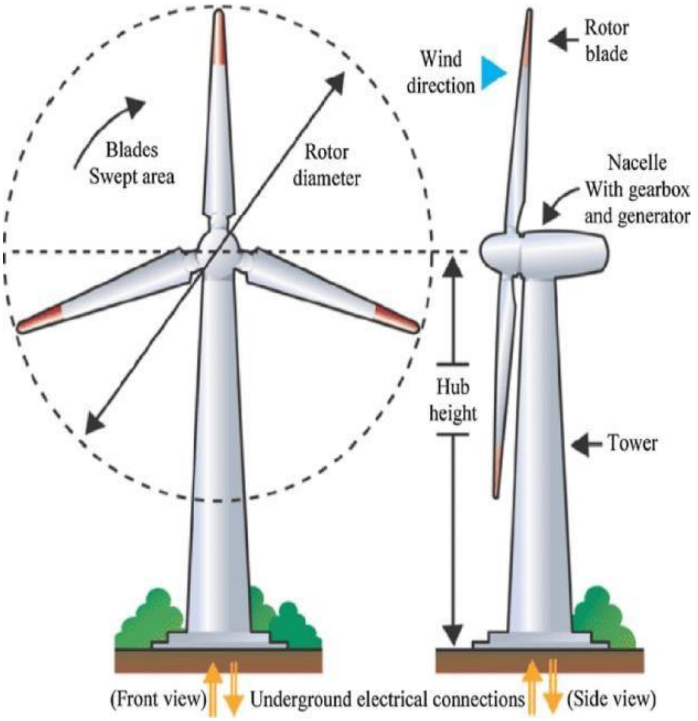
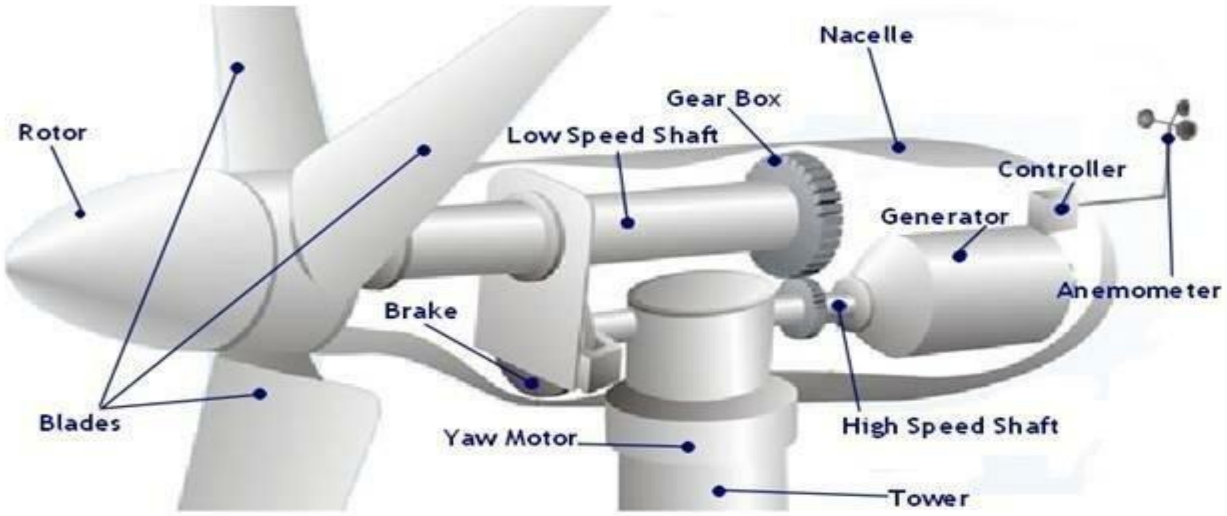
Electricity Generation: The high-speed shaft is connected to an electric generator. As the shaft spins the generator, it converts the rotational mechanical energy into electrical energy through electromagnetic induction.

Power Transmission: The electricity produced is then typically fed into the electrical grid via transformers and transmission lines to be distributed to homes, businesses.





Key Components of a Wind Turbine:



Rotor Blades: These are the large, aerodynamic surfaces that capture the wind's energy. Most modern turbines have three blades.

Nacelle: This is the housing located at the top of the tower that contains the gearbox, generator, control systems, and other components.

Tower: The tall structure that supports the nacelle and rotor. The height allows the blades to access stronger and more consistent winds.

Hub: The central part of the rotor where the blades are attached.

Gearbox (most large turbines): Increases the rotational speed from the low-speed rotor shaft to the high-speed generator shaft.

Generator: Converts the mechanical rotational energy into electrical energy.

Control System: Monitors wind speed and direction, adjusts the blade pitch, and controls the turbine's operation for safety and efficiency.

Yaw System (for horizontal-axis turbines): Rotates the nacelle to keep the rotor facing optimally into the wind.

Example uses for waste heat include generating electricity, preheating combustion air, preheating furnace loads, absorption cooling, and space heating. A heat exchanger is a device which is used to transfer heat from a hot body to a cold body. That lot waste heat is recovered and conversion into useful electricity using Thermo electric generator and converting cooling effect.

HORIZONTALAXISWIND TURBINE:

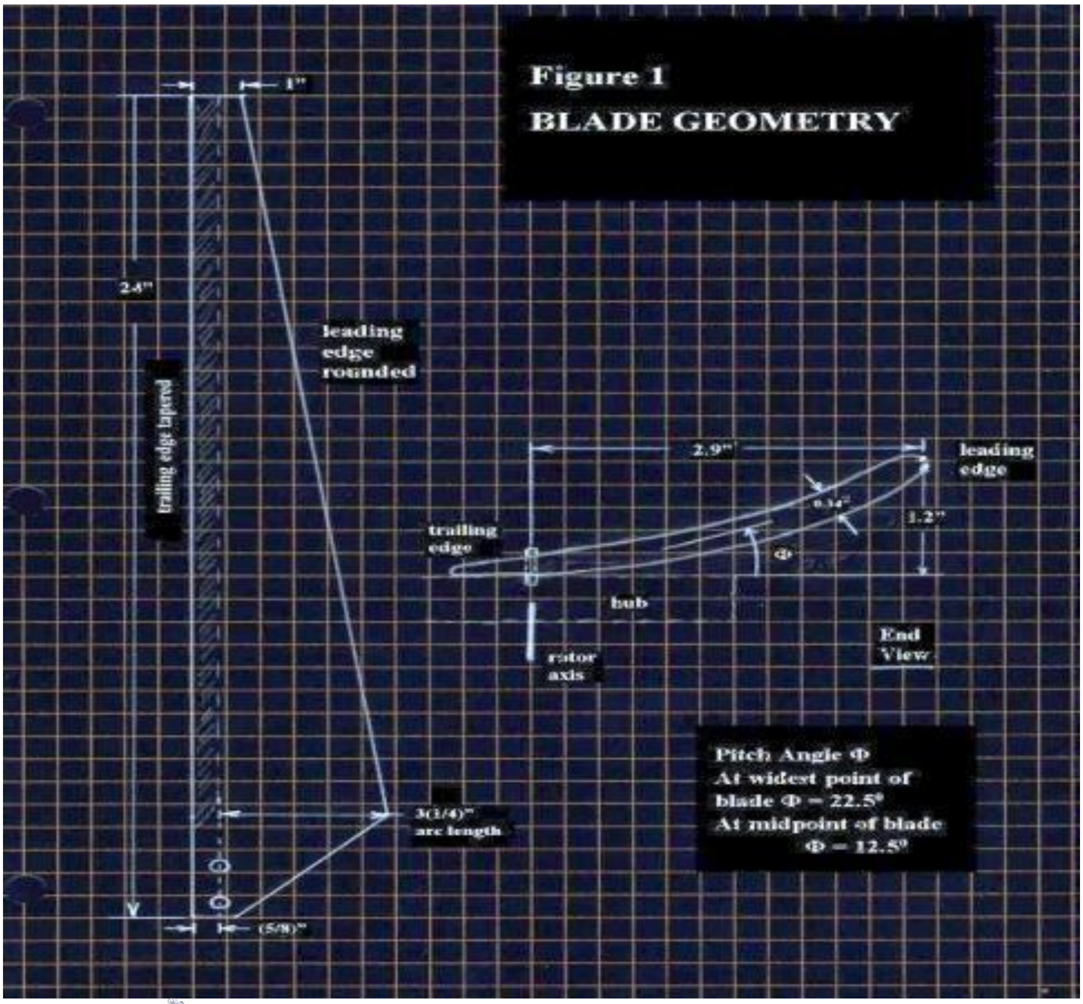
The analysis is carried out on Horizontal Axis Wind Turbine (HAWT) meant for domestic purposes. Components of this turbine are mentioned below.
Blades:

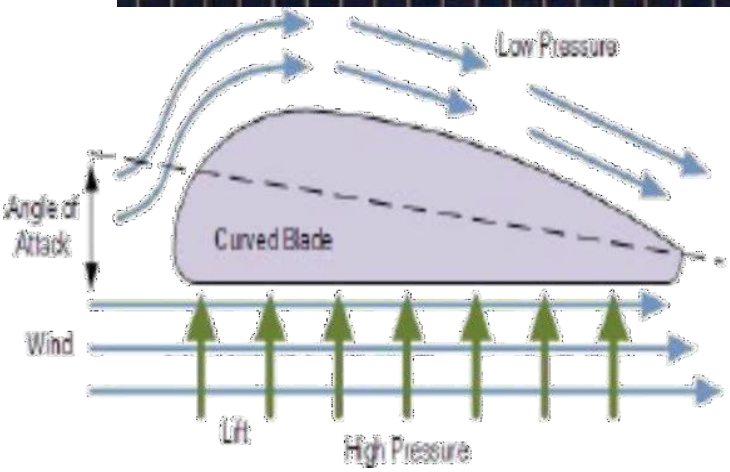
The blades are made up of Poly Vinyl Chloride (PVC). Eight inch diameter PVC pipe is used to fabricate the appropriate wing-shaped curvature. A jig saw is used to cut the PVC pipe. The final blade dimensions are shown in Figure 1.
The leading edge is rounded and the trailing edge is tapered for each blade so that the shape would approach that of an airplane wing.
BLADEDESIGN FOR WIND TURBINE

Generally, wind turbine blades are shaped to generate the maximum power from the wind at the minimum construction cost. But wind turbine blade manufacturers are always looking to develop a more efficient blade design. Constant improvements in the design of wind blades

have produced new wind turbine designs which are more compact, quieter and are capable of generating more ower from less wind. Its believed that by slightly curving the turbine blade, p they're able to capture 5 – 10 percent more wind energy and operate more efficiently in areas that have typically lower wind speeds.

Geometry of the turbine blade.





2.2 Rotor Huband Blade Attachment:

A flywheel is used as the hub for the rotor. A circular metal disc made up of iron is used as rotor hub. It is crucial that the blades are to be attached symmetrically bolted; otherwise imbalances may cause oscillations which can lead to a blade tearing away from the hub. To ensure the blade symmetry, the tip-to-tip spacing is measured precisely before drilling the final attachment holes through the blade.

1) *Blade Attachment Methods:*

- **Fully Articulated:**

Blades are attached to the hub through hinges, allowing independent movement.

- *Semi-Rigid:*

Blades are attached to the hub with a teetering hinge, allowing them to flap together as a unit.

- *Rigid:*

Blades are flexibly attached to the hub without hinges.

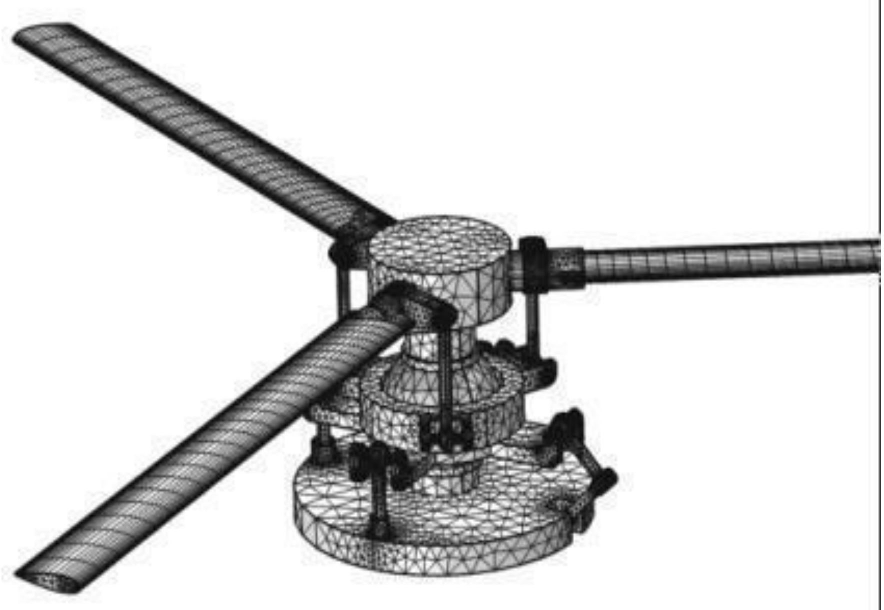


Fig 2. Rotor Hub with blades

2.3 YAWCONTROL:

The yaw system of wind turbines is the component responsible for the orientation of the wind turbine rotor towards the wind. Aluminum (Al) sheet is used for the yaw control the mechanism that rotates a wind turbine's nacelle (the housing containing the generator and other components) to keep the rotor facing directly into the wind, maximizing energy capture **How Yaw Control Works:**

- Wind Direction Sensors:

Yaw control systems use sensors, such as wind vanes or sonic anemometers, to detect the wind direction.

- *Yaw Position Sensors:*

These sensors track the position of the nacelle.

- *Controller:*

A controller uses the inputs from the wind direction and nacelle position sensors to calculate any misalignment (yaw error).

- *Yaw Motors and Drives:*

When a yaw error is detected, the controller signals the yaw motors and drives to rotate the nacelle, aligning it with the wind.

- *Yaw Brakes:*

Once the nacelle is properly aligned, the yaw motors shut off, and the yaw brake is applied to hold the nacelle in position.

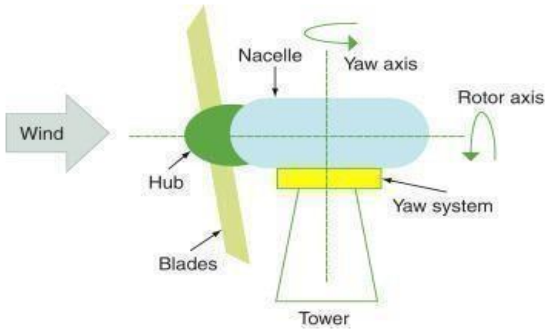


Fig.3, Yaw control

2.4 GENERATOR:

electricity generation, a generator, also called an electric generator, electrical generator, and electromagnetic generator is an electromechanical device that converts mechanical energy to electrical energy for use in an external circuit.[1][2] In most g1enerators which are rotating machines, a source of kinetic power rotates the generator's shaft, and the generator produces an electric current at its output terminals which flows through an external circuit, powering electrical loads. Sources of mechanical energy used to drive generators include steam turbines, gas turbines, water turbines, internal combustion engines, wind turbines and even hand cranks. Generators produce nearly all of the electric power for worldwide electric power grids. The first electromagnetic generator, the Faraday disk, was invented in 1831 by British scientist Michael Faraday.

Any permanent magnet DC motor driven in reverse can be used as a generator. A dynamo rated at 3150 RPM, 40 Volts and 1.62 Amps is used for generating power

Fig.4. Dynamo acting as generator

B. 2.4 BASE:

It acts as a main support for the entire Horizontal Axis Wind Turbine unit. It is made of Iron. It has rectangular shape, supported by four legs. The four legs hold a circular plate on which the tower is placed. It is made up of a rigid material to provide very good support which can with stand high wind speeds. Base is welded with blots and nuts which are fixed to provide the extra support.

2.5 MAIN SHAFT:

It is an important part in the power transmission system of the turbine. It is made up of Iron . Main Shaft is made to pass through the tower using journal bearings for ensuring smooth rotation. they support the main shaft to rotate freely when blades rotate. Main Shaft is connected to the hub at one end and to the gear box at another end.

2.6 TRANSMISSION SYSTEM:

The wind turbine has four blades which are connected to a hub. The transmission is used to transmit the power developed at the wings to the generator.

Transmission linkage consists of blades as power developing elements which is connected to the hub. The hub is connected to the gear box. Then gear box is connected to the generator.

The elements of the transmission are the hub and the gear box The blades are attached to the hub. The hub is connected to the gear box attached with the dynamo. The gearbox converts the high torque low rpm into high rpm low torque which is in the ratio 1:3. The specifications of permanent magnet type DC dynamo are as follows

Fig.5. Bevel gear arrangement

S.No	Characteristics	Value	Unit
1	Speed	3150	rpm
2	Voltage	40	Volts
3	Current	1.62	Amps
4	Torque	0.14	N-m

Specifications of DC Dynamo

FABRICATION

Steps for making a Horizontal-Axis Wind Turbine Rotor

1) 1. Design and Planning

Define Specifications: Rotor diameter, number of blades (usually 2 or 3), rated power, wind speed range.

Blade Profile: Choose an aerodynamic airfoil shape (e.g., NACA series).

Materials Selection: Common materials include fiberglass, carbon fiber, wood, or aluminum for blades; steel or aluminum for the hub.

2) *2. Material Preparation*

Blades: Based on the selected material:

- **Wood**: Choose high-strength, lightweight woods like cedar or balsa.
- **Composite**: Prepare fiberglass or carbon fiber sheets and resin.
- **Metal**: Cut aluminum sheets or profiles.

Hub: Select a steel or aluminum disk or custom-fabricated hub for blade mounting.

3) *3. Blade Fabrication*

Cutting:

- Mark and cut the rough shape of each blade from the chosen material.
- For wood or metal: use a handsaw or CNC machine.
- For composites: lay up in a mold and cure.

Shaping & Profiling:

- Shape the blades according to the airfoil cross-section and twist angle along the length.
- Use planers, files, or sanding tools for wood; grinding tools for metal or composite.

Sanding & Finishing:

- Smooth the surface for aerodynamic efficiency.
- Seal or coat the blades (e.g., epoxy resin for wood or paint for composites).

4) 4. Hub Fabrication

- **Design**: Should accommodate the number of blades and transmit torque to the shaft.
- **Machining**: Drill holes for blade mounting and shaft coupling.
- **Reinforcement**: Ensure structural integrity with flanges or gussets if needed.

***5)** 5. Blade-Hub Assembly*

- **Mounting**:
  - Attach blades to the hub using bolts, welds, or clamps depending on the material.
  - Ensure equal spacing and correct pitch angle.
- **Balancing**:
  - Dynamically or statically balance the rotor to prevent vibration during operation.

***6)** 6. Testing and Validation*

- **Visual Inspection**: Check for cracks, warping, or misalignment.
- **Spin Testing**: Rotate manually or with a motor to verify balance.
- **Load Testing**: Check structural integrity under simulated wind load.

7) 7. Painting and Protective Coating

- Apply UV-resistant paint or coatings to protect from weathering.
- Label blade orientation and add reflective strips for safety.

8) 8. Installation

- Mount the rotor on the turbine shaft and secure with locking nuts or couplings.
- Test full turbine operation under wind or artificial loading.

STEP 2: CONNECTING OF SHAFT TO ROTOR

- Preparing of shaft with require dimensions
- Shaft should be in horizontal position with the Rotor.

- Welding of shaft to the Centre of the rotor.

STEP 3: BEARING UNIT ASSEMBLY TO THE SHAFT

HORIZONTAL SHAFT BEARINGS

STEP 4: CONSTRUCTION OF TOWER

- Making of tower with required dimensions of 10ft
- Tower links or joints can be welded by arc welding.

STEP 5: CHAIN SPROCKET AND GENERATOR ASSEMBLY

1. System Design & Planning

Determine Power Output Requirements (e.g., 500W, 1kW).

Select Gear Ratio between rotor and generator to match RPM (rotor spins slowly; generator needs higher RPM).

Decide Chain Type: Bicycle chain (common for small turbines), motorcycle chain for heavier loads. Choose Generator Type: PMDC motor, alternator, or permanent magnet generator (PMG).

2. Materials & Component Selection

Sprockets: One for the rotor shaft and one for the generator shaft (different sizes for gear ratio). Chain: Matched to sprockets (pitch and size).

Bearings & Shafts: Smooth rotation.

Mounting Plates or Frames: For generator and chain tensioner. Tensioner (optional): To maintain proper chain tension.

3. Rotor Shaft to Sprocket Mounting

Fabricate/Obtain Rotor Shaft: This is the main shaft connected to the rotor hub. Mount Sprocket to Rotor Shaft: Weld or bolt the larger sprocket to the rotor shaft. Ensure alignment to avoid chain misalignment.
Use Keyways or Set Screws: To lock the sprocket securely onto the shaft.

4. Generator Shaft to Sprocket Mounting Attach Smaller Sprocket to the generator shaft:

Drill a hole in the sprocket if needed to fit the shaft. Secure with set screws, a keyway, or welding.
Mount Generator on an adjustable base or bracket for alignment and chain tensioning.

5. Frame/Bracket Fabrication Build Support Structure to hold:
Rotor shaft (with bearings). Generator (on an adjustable base). Chain sprockets in proper alignment.
Use steel or aluminum angle iron or plates for strength. Weld or bolt components for ease of maintenance.

6. Chain Installation

Place chain around both sprockets.

Adjust generator position to create proper chain tension.

If needed, install a tensioner pulley or idler gear to maintain tension. Apply lubricant to the chain for smooth operation and less wear.

7. Generator Wiring

Connect the generator's output wires to:
Rectifier (if AC generator). Charge controller.
Battery or inverter (depending on system setup).

8. Testing & Fine-Tuning

Spin rotor manually to check chain movement. Ensure:
Smooth chain rotation. Proper tension.
No slipping or jumping.
Run at low wind speeds first and monitor RPM & voltage output. Check vibration, noise, and overheating.

Optional Additions

Freewheel Mechanism: To prevent generator drag when wind speed is low. Brake Mechanism: To stop the rotor during storms or maintenance.
Enclosure: Protect the chain and generator from weather.

STEP 6: ASSEMBLY OF TAIL:

- Making of tail with the required dimensions

- The metal sheet was connected at one end of the rod

Tail which is connected to rectangular cross section having junction of rotor shaft and tower shaft.

STEP 7: FOUNDATION OF TOWER

- Finding the position on the roof of building which it is to be placed
- Taking the four corners of the tower and then placed on marked position
- Prepare a welding supports to bottom of the tower
- Brick work to the four bottom corners of the tower Concrete mixture used for foundation of tower.

RESULTSANDDISCUSSION

Initial testing is done in the terrace of our college campus. Winds speeds vary day by day. Readings are taken by connecting the output of the dynamo with a multimeter with a purpose of measuring voltage. We took the readings on two consecutive days. The first day the average wind speed was found to be 15 kmph (4.17 m/s) measured using a Global Positioning System (GPS) tracker. With wind speed as equal to 4.17 m/s, the wind turbine spun at an average speed of 350 RPM. This rotational speed is increased by three times i.e. 1050 RPM by using a bevel gear with a gear ratio 1:3 read from a tachometer and the multimeter read 12.6 V.

S.No.	Wind Speed (m/s)	Wind blade rotational speed (R.P.M)	Voltage (V)
1	4.17	350	12.6

Table 2: Rotation of wind turbine blade corresponding to wind speed

On the second day the average wind speed was found to be 9 to 10 kmph (2.5 to 2.8 m/s), With wind speed as equal to 4.17 m/s, the wind turbine spun at an average speed of 350 RPM. This rotational speed is increased by three times i.e. 1050 RPM by using a bevel gear with a gear ratio 1:3 read from a tachometer and the multimeter read 12.6 V. It is expected to find a very low cut-in speed so that we could capture as much of our small quantities of available wind as possible. The ability to consistently produce 12 volts at around 15 kmph. 12 volts is necessary to push the power into the 12 V battery. The following reading has been observed in practical conditions.

CONCLUSIONS

II.

The analysis is yielding with the following conclusions.

1. Rotates the turbine at low wind speeds.
2. Manufacture of blades is simple and easy.
3. It produces high torque and does not require starting thrust.
4. More force is developed from wind energy.
5. More mechanical work is developed by the turbine.
6. Low cost as manufacture of blade is si

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