NAU Collegiate Wind Competition

Operations Manual

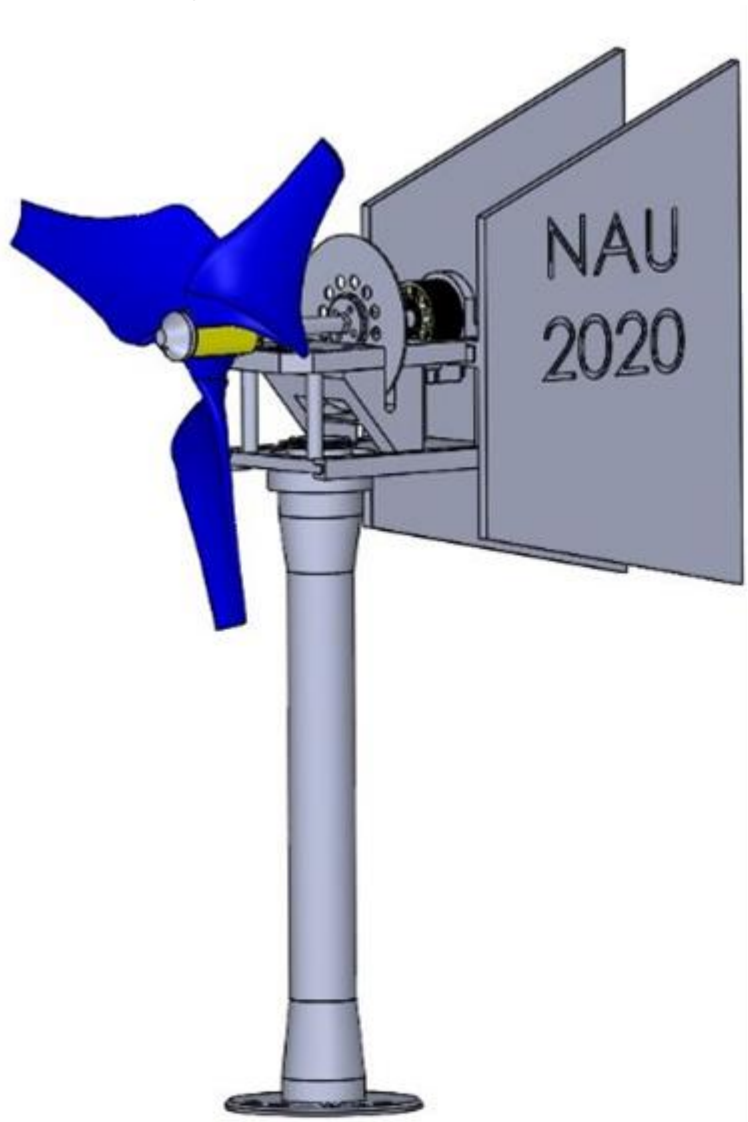

Figure 1: Full Assembly

Table of Contents

1. Overview

1.1 Dimensions

Table 1: Turbine Dimensions

Description	Dimensions
Base Plate	Diameter = 150mm: Thickness = 6mm
Tower	OD (Tapered)= 44.5-50.8mm: ID = 38.1mm: Height = 505mm
Tower Bearing	OD = 80mm: ID = 50mm
Retaining Ring	45mm
Lower Nacelle Plate	190mmX120mmx10mm (LxWxH)
Front Upper Nacelle Plate	91mmX100mmx16mm (LxWxH)
Rear Lower Nacelle Plate	110mmX100mmx16mm (LxWxH)
Nacelle Spacers	Height = 70mm
Motor	Diameter = 56mm: Width = 28.5
Disc Brake	Diameter = 135mm: Width 3mm
Shaft	Diameter = 12.7mm: Length = 240mm
Hub	Diameter = 38.1: Length = 60mm
Blade	Length= 215.5mm
Blades and Hub Assembled	Diameter = 445mm
Assembled Turbine	Height = 780 mm
Center of Shaft Assembled	Height = 595mm

1.2 Bill of Materials

Table 2: Bill of Materials

Part	Quantity
Generator	1
Blades	3
Tower Bearing	1
Shaft	1
Yaw	1
Brake Pad	2
Brake Slider	1
Brake Actuator	1
Motor Mount	1
Lower Nacelle Plate	1
Upper Front Nacelle Plate	1
Upper Rear Nacelle Plate	1
Braking Disc	1
Pillow Block Bearing	1
Wires (varies in size)	12
Retaining Ring	1
Base Plate	1
Tower	1
Hub	1
Hub Cap	1
Cylindrical Spacer	4
Spacer/Disc Housing	1
M3X1.25 15mm Bolt	8
M5x1.25 25mm Bolt	5
M8x1.25 90mm Bolt	6
Female Thread Inserts (varies in size)	11
Yaw	1

1.3 Performance Parameters

- $Maximum\ Wind\ Speed = 25\ {}^{m}/_{s}$
- $Maximum\ Brake\ Pressure\ Applied = 5.4\ Nm$
- $Maximum\ Power\ Output = 48V\ DC$
- $Pillow\ Block\ Bearing\ Rate\ RPM = 23{,}000\ RPM$
- $Motor\ Rating = 160KV$
- $Maximum\ Shear\ Stress\ of\ Tower = 3.5\ {}^{MN}/_{m^2}$

2. Assembly

2.1. Tools Required

- 2mm Allen (M3 Bolts)
- 3mm Allen (M5 Bolts)
- 6mm Allen (M8 Bolts)
- Welder
- Bearing Press
- Retaining Ring Pliers
- Solder Gun

2.2. Exploded View

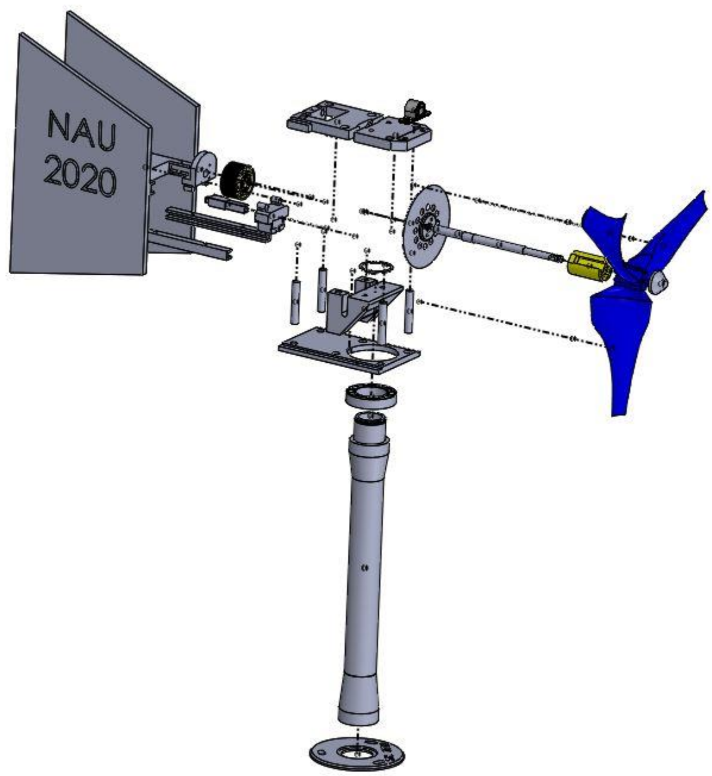

Figure 2: Explode View

2.3 Assembly Process

Step 1:

The first step to assemble the turbine is welding the base plate to the tower.

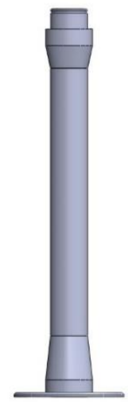

Figure 3: Tower and Base Plate

Step 2:

Evenly press on the tower bearing to the top of the tower.

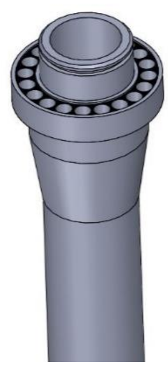

Figure 4: Top of Tower with Bearing

Step 3:

Use a soldering iron to install thread inserts to the 3D printed material. The lower nacelle accepts 8mmx1.25 thread inserts, while the front top nacelle layer and front top of the middle spacer use the M5x1.25 inserts. The back of the top layer nacelle uses a M3x1.25 in order to fix the motor mount from sliding in tracks.

Step 4:

Press the bearing cup attached to the lower nacelle onto the outer diameter of the bearing. Position the retaining ring to lock any unwanted movement using pliers.

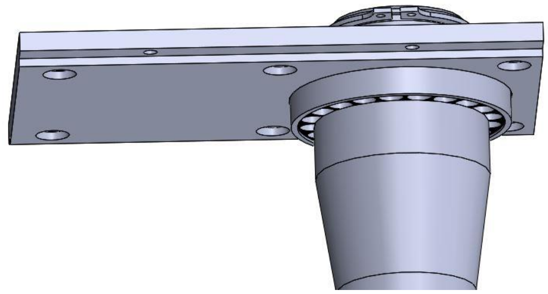

Figure 5: Top of Tower with Lower Nacelle Attached

Step 5:

Place the four cylindrical spacers on each corner of the lower nacelle and the center spacer into the position below.

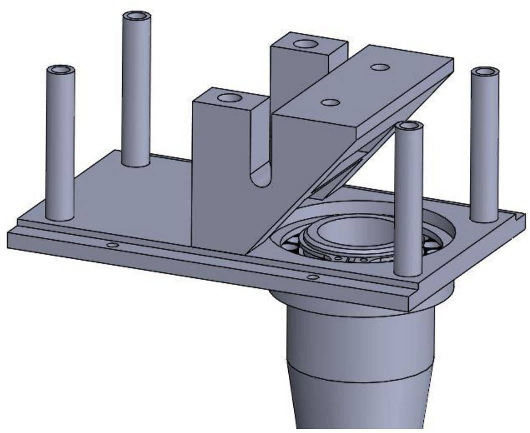

Figure 6: Spaces Attached to Lower Nacelle

Step 6:

Before fastening the upper nacelle, place the motor mount and brake slider within the slots and the brake actuator on the rear upper nacelle plate, as shown below.

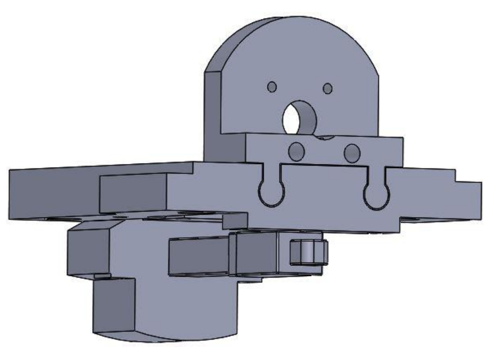

Figure 7: Upper Nacelle with Actuator, Motor and Brake Mounts

Step 7:

Partially fasten the nacelle together with six M8x1.25 90mm bolts that thread into the lower nacelle plate using a 6mm Allen key.

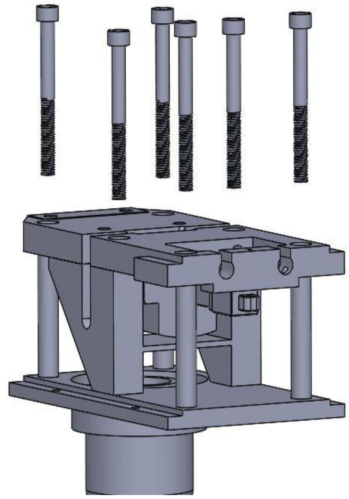

Figure 8: Attaching Upper to Lower Nacelle

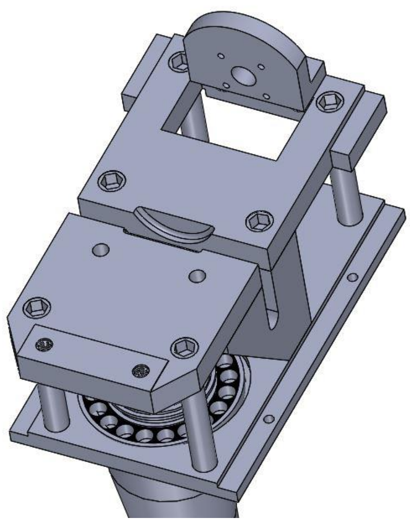

Figure 9: Top View of Nacelle Assembly

Step 8:

Place the pillow black bearing on the front of the top nacelle, fasten with two of four M5x1.25 25mm bolts. Use the remaining two bolts to fasten the upper front nacelle plate to the middle spacer.

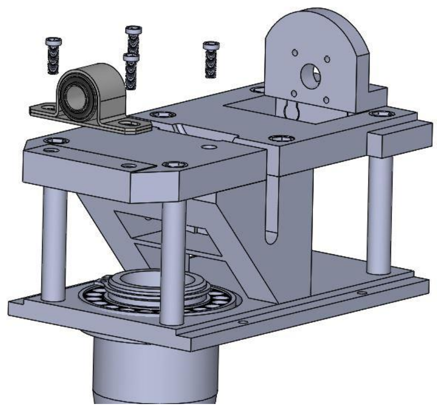

Figure 10: Attaching Shaft Bearing

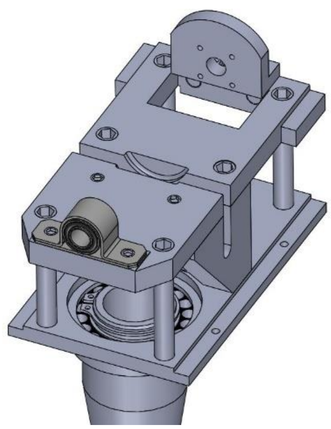

Figure 11: Top View of Nacelle Assembly 2

Step 9:

Attach the motor to the motor mount with a 2mm Allen key and four M3X1.25 15mm bolts that thread into an existing pattern on the back side. Use one more of the same bolts to secure to motor mount from sliding by bolting through the slot in mount into the top nacelle plate.

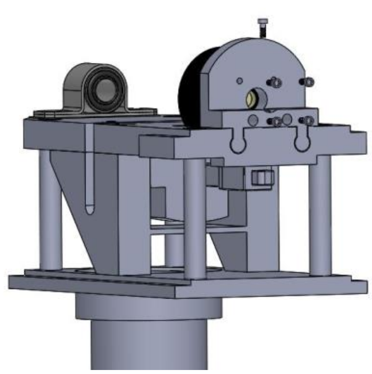

Figure 12: Attaching Motor to Upper Nacelle

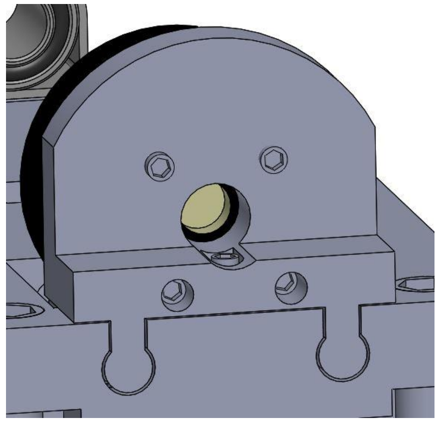

Figure 13: Top View of Nacelle Assembly 3

Step 10:

Attach the shaft by sliding it through the pillow block from the back side with the threads going in first, or else the larger diameter key will not fit through the pillow block. Before coupling the shaft to the motor, be sure to slide the disc onto the key part of the shaft.

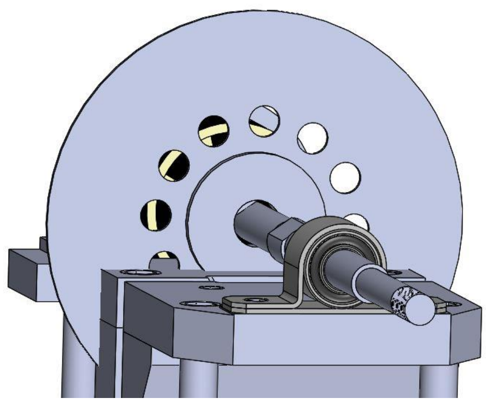

Figure 14: Add Brake Disc to Shaft

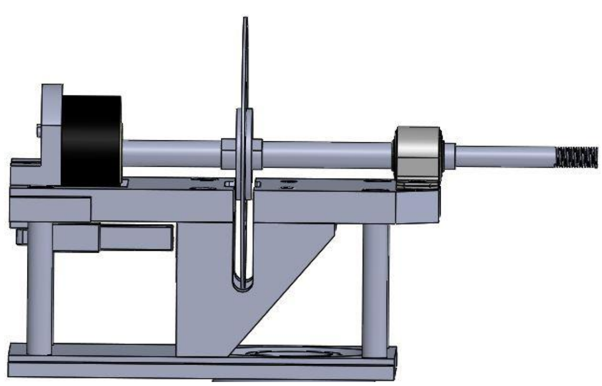

Figure 15: Side View of Disc Attached

Step 11:

Slide the hub onto the end of shaft, place each blade in a keyed slot within the hub before clamping it into place by screwing on the nose cone.

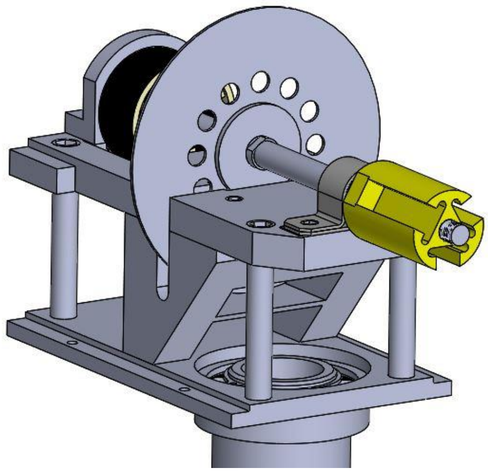

Figure 16: Attach Hub to Disc

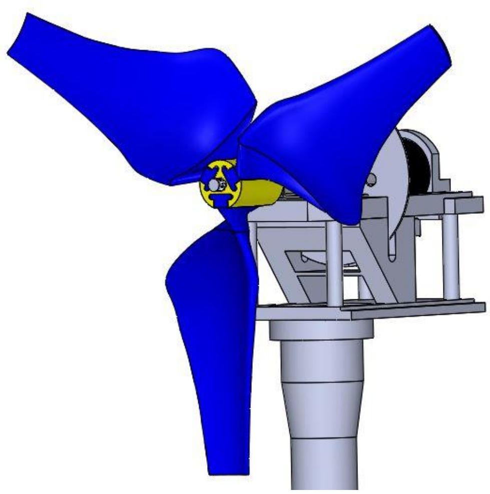

Figure 17: Attach Blades to Hub

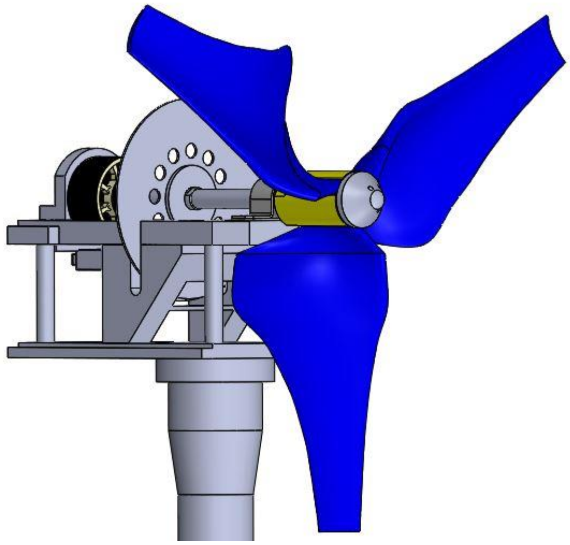

Figure 18: Attach Nose Cone to Shaft

Step 12:

Attach the yaw to the upper and lower nacelle by sliding it onto the rails and locking it in place with four M3x1.25 15mm bolts.

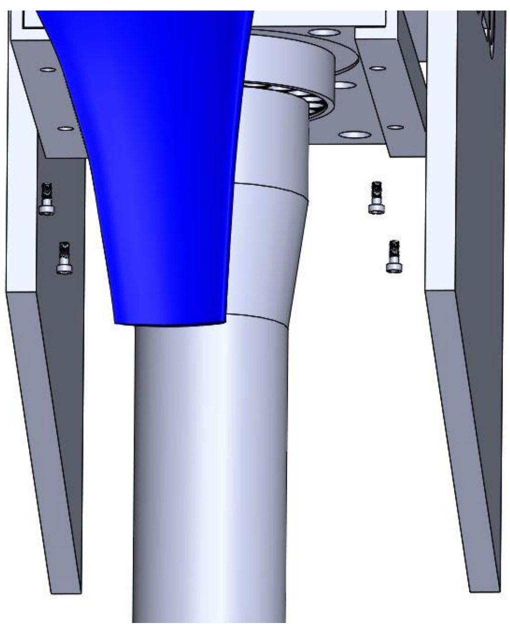

Figure 19: Attach Yaw to Nacelle

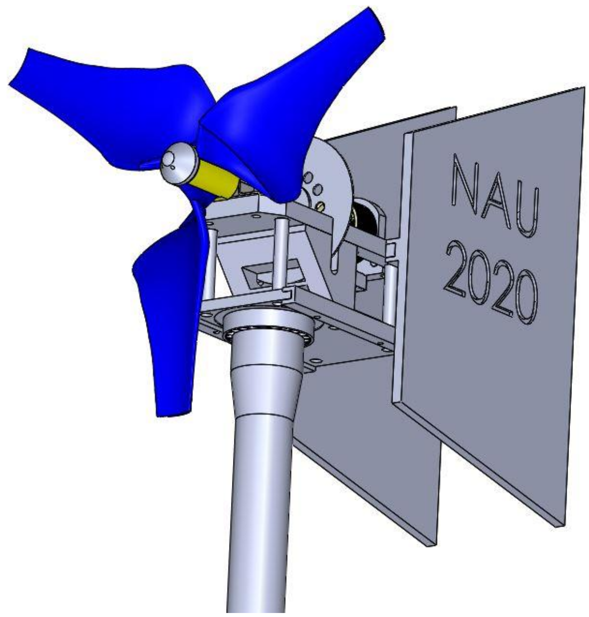

Figure 20: Final Assembly

Step 13:

Attach wire leads with appropriate connectors to motor and actuator, run the leads down the center of the tower to connect to electrical component.

3. Maintenance

3.1. Blades

The blades are one of the most essential parts of a turbine. To ensure the blades are in optimal condition, check the blades after each tunnel test. Since the blades are 3D printed polycarbonate, they are more prone to fatigue. Check sharp edges for possible shearing. Each set of blades should be changed after a few test cycles.

3.2. Motor

After a set amount of time, the motor bearings may need to be changed out. In addition, always keep motor in a metal free zone to prevent metal shards from sticking to the magnetic poles. Motor should not be running under a heavy load too long to ensure motor longevity.

3.3. Braking System

Since the braking system is essential for the durability of the turbine, regular maintenance of this system is necessary for safety while operating the turbine. Below are the main components of the braking system that should be checked before and after each use of the turbine.

3.3.1. Brake Pads

Check and make sure that the brake pads are not worn down, warped, or have inconsistent wear. If the pads show any of the signs listed above replace both pads.

3.3.2. Brake Disk

Check the disk for wear and ensure that the disk thickness is greater than 1.8 mm, if not replace.

3.3.3. Actuator
Test the actuator to ensure electronics are properly connected by using the push button to actuate the stroke. If actuator does not work check electrical connections and if they are all properly connected replace the actuator.

3.3.4. Braking Slide
Check the brake slider for any signs of cracking and ensure that the railing is free of debris.

3.4. Nacelle
3.4.1. Fasteners
All bolts that hold the turbine together should be checked for appropriate torque. If the bolts are loose, they should be replaced to avoid failure in case bolts have been damaged or worn due to vibrations.

3.5. Bearings
When the turbine is in operation, listen for any noise coming from the bearings. If a sound is present, remove the bearing for inspection and replace if needed. Bearings in this system are sealed so lubrication should be applied as needed over time.

3.6. Yaw
Check yaw rails and yaw itself for possible shearing or deflections in surface, if not repairable, then replace.

4. Operations
4.1 Braking System Operation
The braking system will activate from the use of a push button, disconnection of power, and when a sensor reads wind speeds of 18 m/s. The reason the sensor actuates the braking system at the wind speed of 18 m/s is so that the turbine can safely stop. If the turbine is running at wind speeds greater than 18 m/s the factor of safety of the braking system is below the allotted value of 2.

4.2 Motor
The motor of this turbine is used to generate electricity. With a 160kv rating, rpms created by the blades produce an easily calculated voltage which outputs as a 3phase alternating current and graphs linearly against revolution speed. Through manipulation of current, the motor creates a DC voltage which can be controlled through the braking system.

4.3 Nacelle
The nacelle can be considered the “frame” of the turbine design. Made up of two layers, this system is meant to secure all other subsystems in place. An added function of this design includes a built-in rail system for accurate and smooth functioning of brakes as well as an easily adjustable motor mount. The lower layer is pressed onto the outer diameter of the tower bearing for better yaw performance in the event of wind direction change. The nacelle also has rails built into the outer edges with holes to mount the yaw in a consistent location.

4.4 Shaft

The shaft is responsible for transmitting all rotational energy. One end of the shaft has threads which fix the hub and blades into position and rotation, while the other end couples to the motor. Between the motor and hub lies a pillow block bearing for support and reduction of friction in system. The design includes a larger diameter section in the middle of shaft aped into a key for the brake disc to slide onto and lock rotation.

4.5 Blades

The blades functions are to take advantage of the oncoming wind flow in order to cause rotation about an axis. This will start spinning around 2.5 to 5 m/s. Added friction in the system from bearings leads to a start up speed closer to 3 m/s. Once the blades start spinning, the voltage will continue to ramp until about 10-11 m/s, which is the rated wind speed. The blades were simulated to have a cut-out wind speed of about 30 m/s.

4.6 Yaw

The function of the yaw is to use excess moving air behind the blades to help keep the position of the nacelle at an optimum angle. The better a yaw design is the more often the direction of wind will be perpendicular to the plane in which the blades spin. To help with ease of rotation around the tower, a bearing is integrated for smooth rotation cause by air hitting the yaw.