Operational Manual

Team 15

Portable Wind Turbine

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Abstract

Although the Portable Wind Turbine prototype is designed to be user friendly and require no previous training or experience to operate, review of an instruction manual is still recommended. This manual outlines the product information, the basics of set up and operation of the Portable Wind Turbine prototype and provides a basic troubleshooting guide for possible issues. In case of a misfortunate accident resulting in the need to replace parts of the Portable Wind Turbine prototype, a list of sources for parts is provided in the event that the user does not wish to purchase the replacement parts through the manufacturer of the Portable Wind Turbine.

1. Functional Analysis

1.1 Base

The base of the Portable Wind Turbine was designed to carry the weight of the blades and nacelle as well as being easily assembled and disassembled for any user. The base is 2 meters tall and can charge a small electronic device. The size of the legs of the base were minimized while the neck section was maximized for the purpose of easy transportation. The base for the portable wind turbine is made out of Standard 6061 Aluminum tubing with a yield strength of 35 KSI, which will be strong enough to withstand the weight of the entire turbine and additional wind loads. The tower is separated into separate sections. All parts are shown in Figure 1 in the Appendix. First are the telescoping leg sections, these can be shown in Figure 1 Sections (A) and (B). These will be connected with a clamp to adjust for any length of the legs determined by the terrain which can be seen in Figure 1 Section (C). At the bottom of the legs will be an all-terrain foot which can be seen in Figure 1 Section (F). This foot will be screwed into the bottom of each tube closest to the ground. The all-terrain foot will accommodate for the angle of the legs to remain the same on all surfaces. The next piece of equipment for the tower will include the connection of the neck to the legs which can be seen in Figure 1 Section (E). This connection is also made out of 6061 aluminum tubing and sheet metal. The tubes for the legs will slide into the connection and will be placed together with pins which can be seen in Figure 1 Section (D). The neck section is made with the same tubing as the legs and will then be connected with pins to the connection piece. The assembly of the base with specified parts can be seen in Figure 2 in the Appendix.

1.2 Nacelle

The nacelle is essentially the housing for the electrical components. The nacelle sits above the base and attaches to the body through the quick-release mechanism that was implemented. This allows for easy assembly and disassembly. The nacelle was designed to maintain a dry atmosphere for the components, while also allowing for air to flow through to help avoid any overheating that might occur. The components inside the nacelle are comprised of a battery, charge controller, diodes, and an alternator. The alternator converts the mechanical energy from the wind to electrical energy that can be stored in a battery and used to charge a mobile device. This electrical energy is

passed through wires to the charge controller. The charge controller acts as a filter to maintain a level output of voltages to charge the battery. If the alternator is outputting more voltage than the battery needs, the charge controller filters the excess. The charge controller is even capable of briefly adding power when the wind slows down for short periods of time. The charge controller outputs the regulated power to charge the battery. The diodes are placed throughout the circuit to safeguard that the current only flows in the correct direction. The alternator is connected to the blade shaft.

1.3 Blades

Two essential components of the wind turbine design are the blades and the way in which they are mounted. Ultimately a company called Windy Nation was chosen to source the blades from. Windy Nation provides much more information about their products than many other suppliers and the company is based in the United States, lowering the lead time for receiving the blades and facilitating communication between the supplier and consumer. Windy Nation offers two options in each of three categories for wind turbine blades. These options can be seen in Table 1.

Table 1. Blade options offered by Windy Nation.

Category	***Option 1***	***Option 2***
Blade Material	Aluminum	UV-stabilized polycarbonate
Blade Length	28in	35in
Number of Blades	3	5

UV-stabilized polycarbonate blades were chosen for this application. Blades made from this material would withstand abuse better than the aluminum blades since aluminum could potentially be permanently deformed. Also the UV-stabilized polycarbonate blades reduced the overall weight of the final design. The airfoil of the blades is a thin under-cambered profile, this shape is practical for low-speed aerodynamic applications such as the Portable Wind Turbines, where high lift force is desired at low flow speeds and corresponding Reynold's Number.

To completely eliminate or reduce the need for tools a custom blade mounting hub with retaining mechanisms was designed in Creo Parametric. The final design uses self-locking wing nuts, bumper bolts, and dowel pins will be used to attach the blades.

2. Project/Product Specifications

2.1 Base

The base of the turbine was split into a neck and three connected leg segments. The length of the neck was maximized while the leg lengths were minimized in order to decrease size and number and size of parts while increasing portability. Additionally to increase portability, each of the leg and neck segments have two telescoping aluminum tubes. This ability allows adjustment of the leg height for any change in ground slope up to fifteen degrees. These telescoping segments are held tightly in place with the help of a clamp. These clamps allow quick and easy use for the operator. Designing the tower out of aluminum allowed for lighter weight material in order to be transported easier. The hub height of the turbine is 2 meters. This allows the wind turbine to receive enough wind speed to generate enough power to charge small electronic devices. The exact dimensions of the tower can be seen in Figure 3 of the appendix.

2.2 Nacelle

The nacelle is responsible for protecting the integrity of the most significant components of the turbine, the alternator. In order to charge or power anything, the alternator must be able to efficiently convert the mechanical energy of the wind to electrical energy that can be stored in a battery. The team selected a WindBlue Power DC-540 alternator. With the target goal of being able to charge a 5 watt device, the WindBlue alternator shows what currents and voltages are outputted based on rpm. With the tip-to-speed ratio of the selected blades under the influence of 4 m/s (~10 mph) wind speeds, the expected rpm is to be around 190 rpms. As represented in Figure 4 in the Appendix, this gives a projected ~25 watts of power. While this is significantly higher than is required to charge a device of only 5 watts, there is expected losses as well as the power flowing through the charge controller, which will also be regulated. The charge controller selected, the Windy Nation TrakMax, enables the user to adjust the desired output voltage according to the battery connected (in this case the battery is 12 volts and that would be the standard on the controller). The 12 volt battery selected was a Battery Tender lithium iron phosphate battery. All of this fits snug inside the nacelle. A final feature added to the nacelle was the ability to have the

charge controller slide out of the back when a panel is opened. This removal is for the ease of the consumer if they need to adjust the power regulation.

2.3 Blades

The specifications for the blades ordered from Windy Nation used for the Portable Wind Turbine are given below in Table 2. The company website provided all information in the table, although it should be noted that the exact airfoil specifications of the blades are unknown, however the general airfoil shape is known and is in mentioned in the table. Also the wind swept diameter will vary slightly since the mounting hub is not the standard one that is typically included with the blades. Windy Nation also states that the blades are rate to handle 70mph (31.3 m/s) wind speeds with a safety factor of 2, which is suitable for the Portable Wind Turbine that will operate in wind speeds of 4 m/s. Figure 5, in the Appendix, displays the dimensions for the blades.

Table 2. Product information for the blades.

Material	UV-stabilized Polycarbonate
Length	28in.
Airfoil	Under-cambered
Swept Diameter	59in.
Weight	0.704 lb

As previously mentioned the mounting system for the blades was designed in Creo Parametric and then cut using a water jet. The wing nuts and washers are standard where the wing nuts are 1/4-20 Grade 2 Zinc Plated Zamac Nylon Insert Wing Nuts, the washers are 1/4” x 0.734” OD Low Carbon Zinc Finish Steel USS General Purpose Flat Washers, and the bumper bolts are stainless steel capped pan head bumper bolts. According to imperial torque charts for locking nut fasteners, the average minimum assembly torque for hex sizes 7/16-1/2 in. ranges from 23 to 37.5 ft-lb. These are normally used to fasten the blades to the hub. Research concerning wing nut torque revealed that for a 5/16” wing nut the average torque for a male was about 3.3 ft-lb for a male and 2.5 ft-lb for a female.

3. Product Assembly

3.1 Base

The assembly of the base of the turbine is depicted in Figures 1 and 2 in the appendix. The parts for the base will be located inside the carrying case along with the other parts of the turbine while being transported. After the parts have been removed from the case, the parts should be organized. There should be three small 28-inch tube sections (A), four large 28-inch tube sections (B), three clamps(C), four pins (D), the welded plate (E), and three feet (F) for the base. No additional parts or tools are needed for the assembly of the base.

The four larger tubes should be inserted into the welded plate so that the holes in the tubes are aligned with the holes in the plate. Between the insertions of each of the tubes, a pin should be pushed through the holes and latched. After all four of the larger tubes have been inserted into the weld plate and each of them have been secured by pins, the clamps and smaller tubes can be utilized.

There are two sides to the plate. The side of the plate with three tubes protruding from it (not one) will be the focus of this step. The three clamps should be fastened onto the end of the three tubes on this side of the plate. They will be fastened simply by sliding snuggly into place. After this is completed, the three smaller tubes should be slid into the clamps, into the larger tubes. Then the clamps should be both tightened and closed. Make sure in this step that the tubes are oriented in the correct direction. The side of the small tubes without inserts should be the one entering the large tubes.

Finally, the three feet can be screwed into the bottoms of the smaller tubes through clockwise hand rotations. The threaded end of the feet should screw into the small tubes' inserts with ease. In disassembly, the parts should be disassembled in reversed order, then inserted back into their case.

3.2 Nacelle

The nacelle is one of the few parts of the turbine that the user has little to no assembly on. The nacelle will come as one unit with everything inside. The charge controller will be removable, but on first arrival will be inside the nacelle with the other electrical components. The only assembly

required is to use the quick-release mechanism that has been added to the system, which also requires minimal effort. Simply squeeze on the flanges and pull to remove the nacelle, or placed on. This quick release system is shown in Figure 4 of the Appendix.

3.3 Blades

The blades should be removed carefully from the foam packaging. The hub will already be attached to the alternator and will be retained using the standard bolt and screw used to secure the hub clamp. The user should then ensure that the 8 stainless steel washers and self-locking wing nuts are present, take 6 of each out of the package and set them aside. There are 2 extra wing nuts and washers included for replacement. Once the user has assured that all parts for assembly are present, take the alternator and hub assembly and position it with the threads of the bumper bolts facing up. Then one at a time take a blade and align the mounting holes in the blade with the screws and pin on the face of the hub, do this with the curved side of the blade facing up. Once aligned set the blade down onto the hub so that the threaded bolts and pins go through holes. The user should then proceed to place one washer on each of the threaded bolts, while holding down the blade with one hand and along the flat side of the blade near the base. Once the washers are set, while still securing the blade with one hand grab one wing nut and screw it onto the bumper bolt until the blade is secure, do this for each both wing nuts on each blade. Rotate the hub with blades attached carefully when screwing on the wing nuts. The user should make sure not to over torque the wing nut to prevent damaging the blade, specifically the upmost wingnut.

4. Operation Instructions

The operation of the portable wind turbine depends on the ability of the user to place all of the pieces together. Once this is done the turbine can work in the desired location to generate power. To maintain the parts of the turbine, make sure the individual parts have not been broken or worn down. All parts are necessary for the operation of the turbine.

Startup

After the connections made between the base, nacelle and blades are completed the turbine can operate properly to charge the desired small device. The legs of the base also need to be adjusted for the slope of the chosen terrain and the terrain must be a solid ground in which the turbine stands properly with no tilts.

Operation

Once the turbine is properly assembled and placed on a stable ground the user can plug in their small desired device to be powered.

Shut Down

After the wind turbine has served its purpose it can be disassembled. This is done by taking apart the pieces of the tower, nacelle and blades. Once the turbine is disassembled, they should be placed in the casing provided and can be carried conveniently offsite.

5. Troubleshooting

Leg or neck segments are sliding and not staying in place.

Make sure clamps are tightened securely.

If the charge controller fails.

Refer to the Windy Nation TrakMax 30L LCD MPPT 30A Charge Controller manual under Reference 1.

Small electronic device is not being charged.

Check to see that the USB is completely plugged in to the USB port on the nacelle.

If pin connectors or telescoping legs do not properly match or slide.

Check to see if the connections can be adjusted without damaging the pins or leg segments. If not, contact manufacturer to receive new parts.

6. Regular Maintenance

Minimal maintenance is required for the Portable Wind Turbine prototype since there are a minimum of moving parts in the design.

Overtime, the lubricated brass bushings in the neck of the turbine that allow free rotation of the turbine nacelle with changing wind directions may wear out. This will be indicated by a failure of the turbine to passively reorient the nacelle to keep the blades facing into the wind. If this occurs:

1) Remove the collar that connects the quick release hex-head to the rest of the base of the turbine.
2) Use an Allen key to remove the bolt holding the rotating shaft in place
3) Press out the brass bushings
4) Purchase replacement bushings from: http://www.mcmaster.com/#standard-sleeve-bearings/=11sb5sv (Part Number 1688K26)
5) Press the new bushings into the tube
6) Reassemble the turbine base

7. Replacement Parts

Should parts of the Portable Wind Turbine become damaged, the best method of replacement is by contacting the manufacturer. If this is not an option, the following sources can be used for replacement of individual components of the Portable Wind Turbine:

- All aluminum and Delrin materials can be sourced from www.mcmaster.com (although some minimal machining may be required if purchasing raw materials).
- All fasteners (such as bolts and washers) can be purchased from a local hardware store or www.fastenal.com
- Replacement turbine blades can be purchased from Windy Nation at: http://www.windynation.com/Blade-Sets/28-inch-HyperSpin-P-Series-Wind-Turbine-Blades-Set-of-3/-/172?p=YzE9MTM=
- Replacement feet for the base can be purchased from B&H Photo and Video at: http://www.bhphotovideo.com/c/product/326243-REG/Gitzo_G1220_130B3_G1220_130B3_All_Terrain_Shoes.html
- Replacement clamps for the telescoping legs can be purchased from RockWest Composites at: https://www.rockwestcomposites.com/bonding-telescoping-clamp
- A replacement charge controller can be purchased from Windy Nation at: http://www.windynation.com/Charge-Controllers/WindyNation/TrakMax-30L-LCD-MPPT-30A-Solar-Charge-Controller-Regulator-12-24-48-Volt/-/1247?p=YzE9MTc=
- A replacement internal battery can be purchased at: http://www.amazon.com/Battery-Tender-BTL09A120C-Lithium-Phosphate/dp/B00F9LPIAC?ie=UTF8&refRID=1BCZJBPP0NR43KP7NSVG&ref_=pd_ybh_a_27
- A replacement alternator may be purchased at: http://www.windbluepower.com/Permanent_Magnet_Alternator_Wind_Blue_Low_Wind_p/dc-540.htm

References

1) Windy Nation TrakMax 30L LCD MPPT 30A Charge Controller Manual https://mlseca.by3301.livefilestore.com/y3mnuqfOUQHT4bIAo1SNDtbIwgatCDt9tu00Q72fdPNZU_NR3z1WX5V63WIzrvua6xbNa2-uQ2-RArZJQ_UiRDKxJ7c_n6jC-Y3jUfU0pN2sb63Vwf-56IDyJa_upGGlbsT6AvgyIdsN5QQxJM5E7nKJNGJ0NWEUSpKCESs-ZmrySQ/TrakMax30L%20Owners%20Manual_R1.pdf?psid=1

Appendix

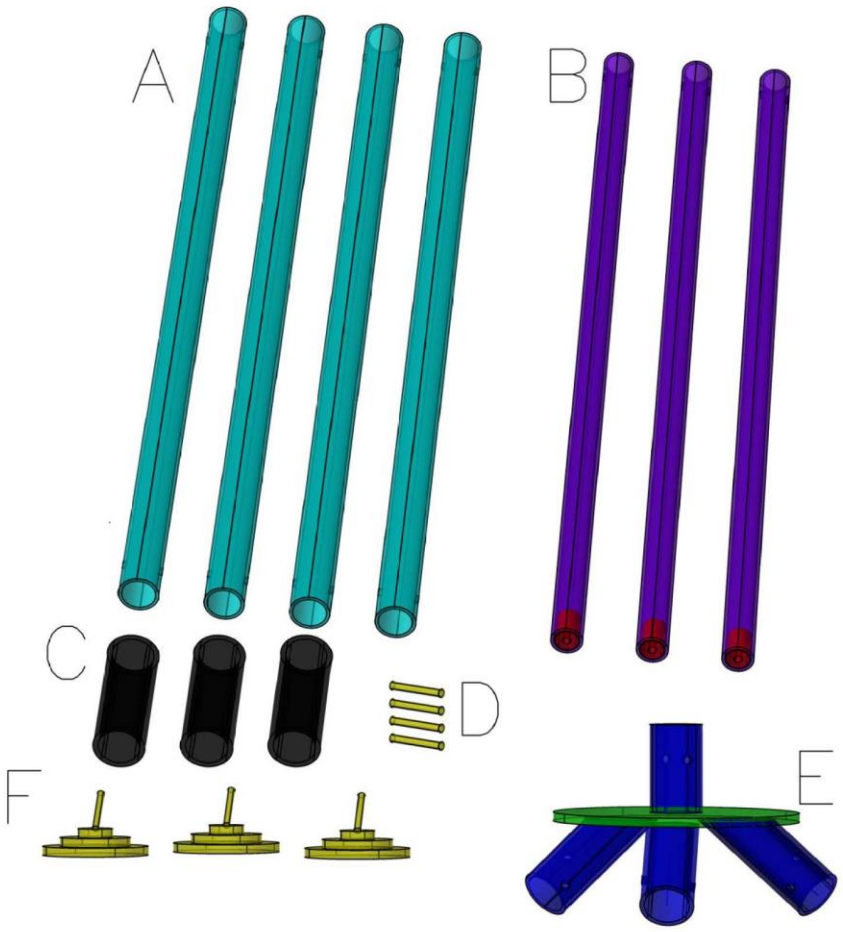

Figure 1. The components of the base

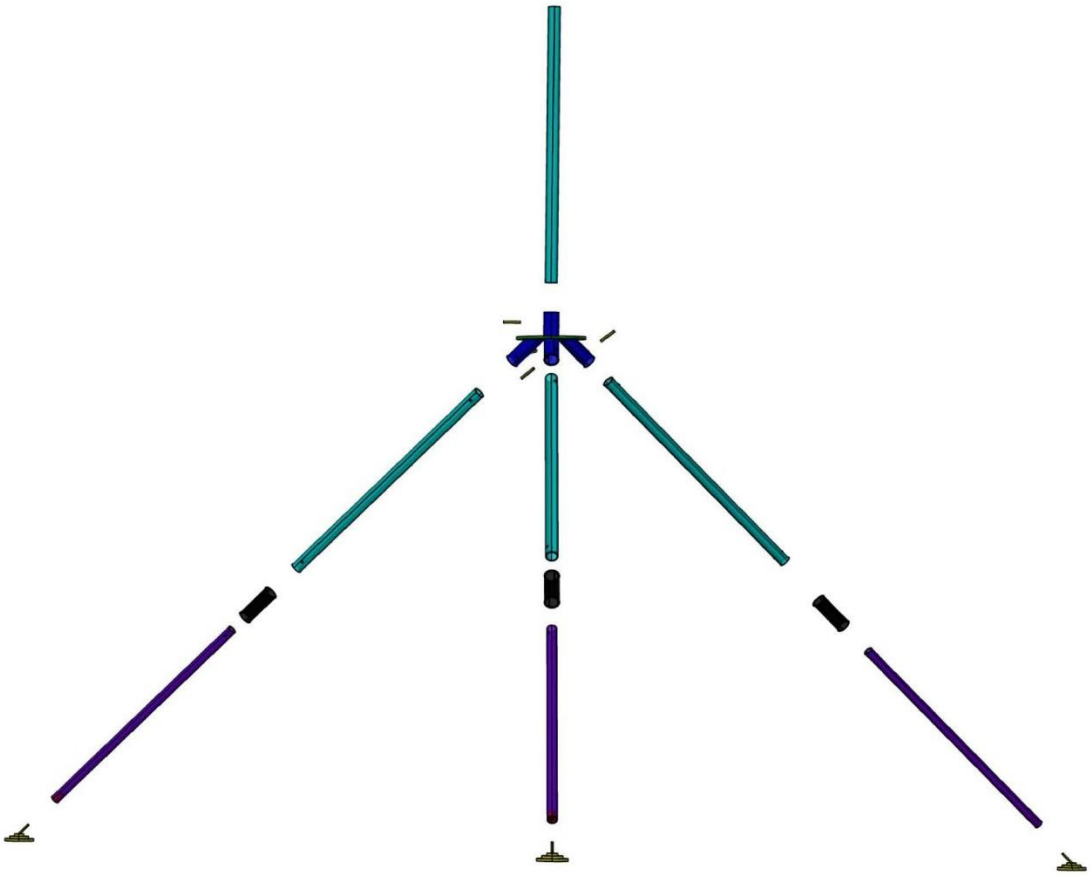

Figure 2. The assembly of the base.

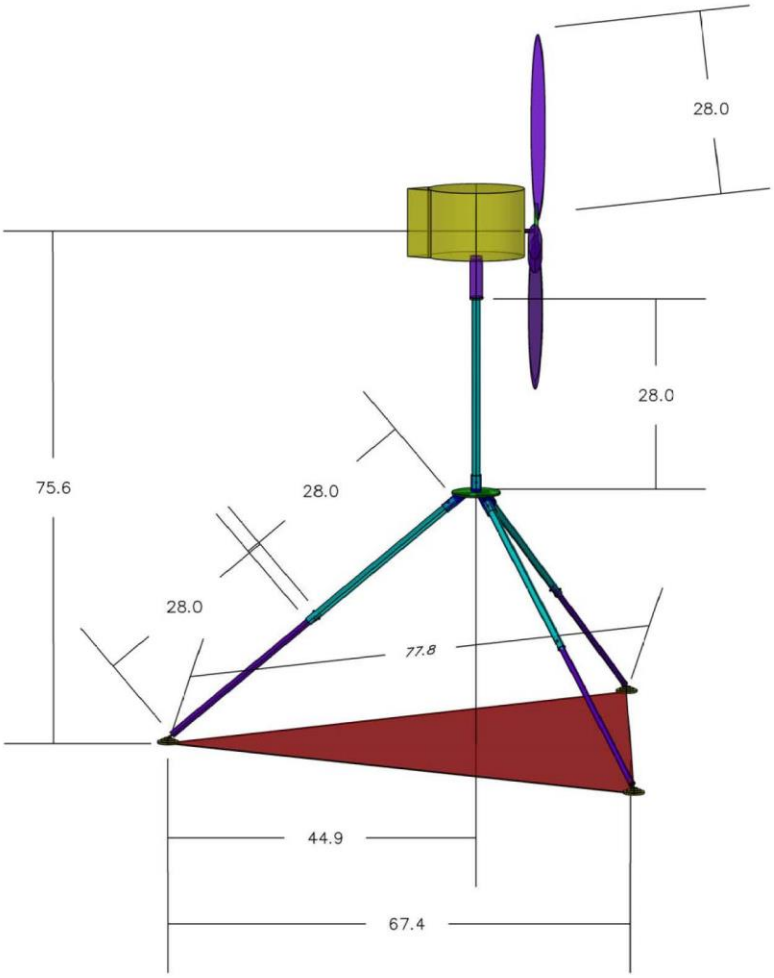

Figure 3. Base set up and dimensions.

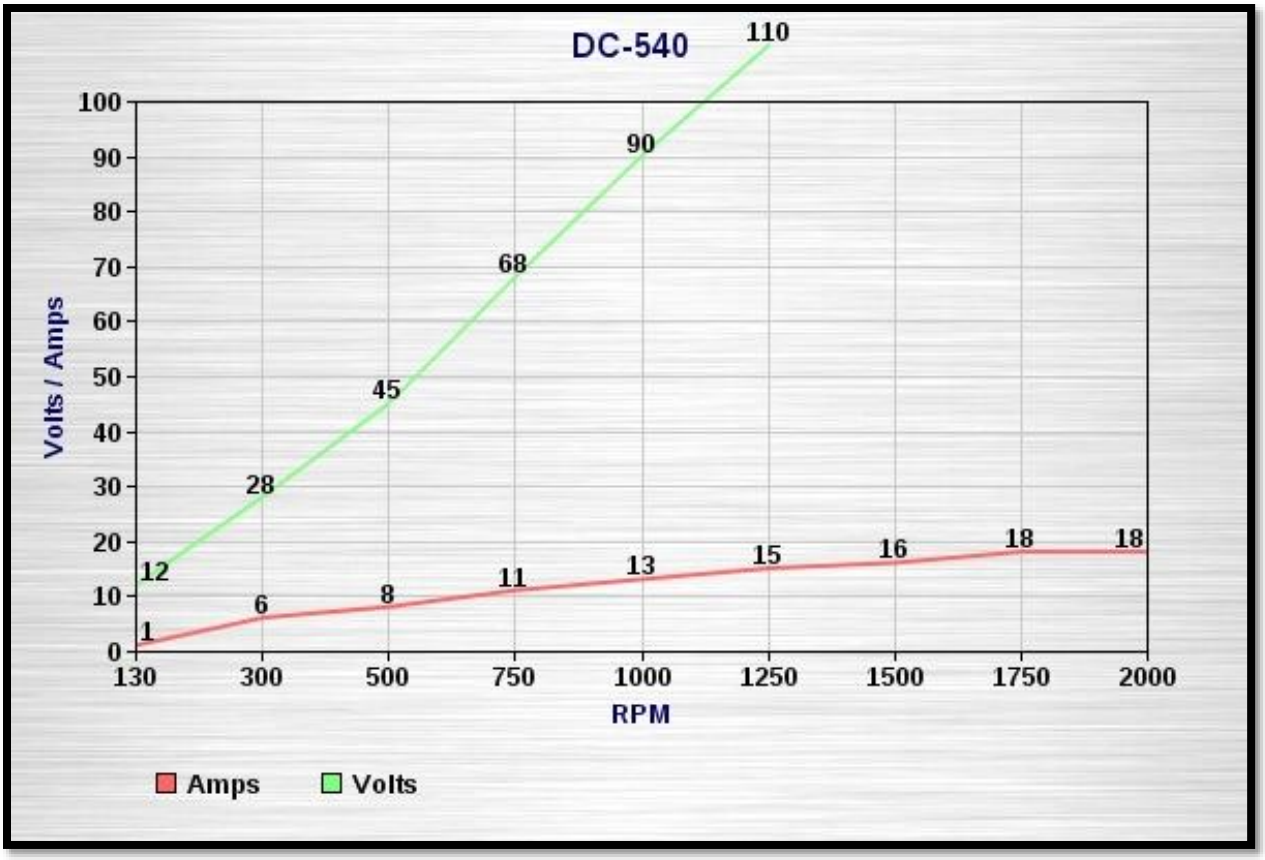

Figure 4. DC-540 alternator voltage and amperage output for different RPMs

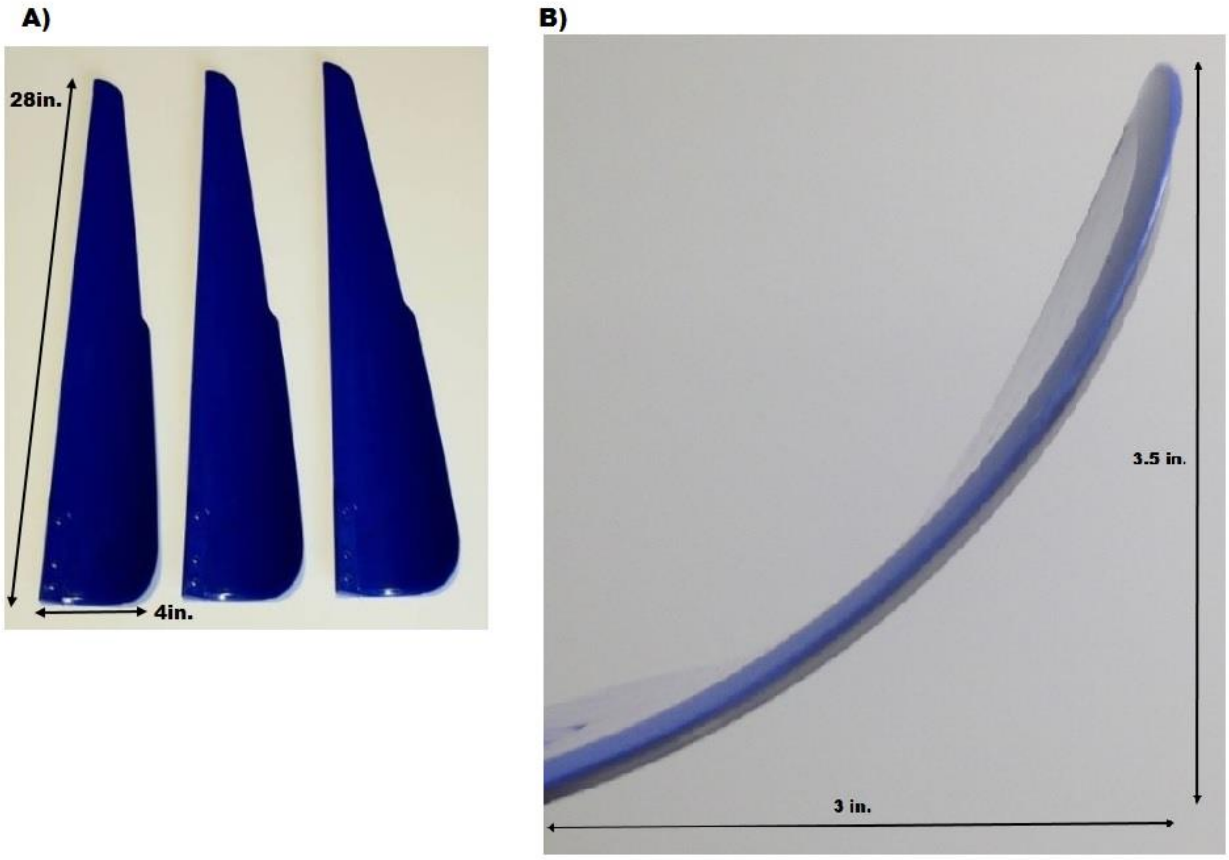

Figure 5. Figure 5-A shows the general dimensions fort he Portable Wind Turbine's blades. Figure 5-B shows the under-cambered airfoil style design of the blades.

Figure 6. The quick release nacelle mounting system.