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Taperless blade manufacturing using NREL'S 833 air foil on horizontal axis wind turbine

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Abstract: Wind is an abundant energy source available in nature, which is renewable and environmentally friendly with high work efficiency. Indonesia has a wind potential of 978 MW, with wind speeds ranging from 6-8 m/s in onshore areas to above 8 m/s in offshore areas. Therefore, we should be able to capitalize on this energy resource. This paper will analyze the performance of NREL's 822 taperless type using the Q-Blade application. The research method used begins with a literature study to find natural parameters that will be later calculated using Excel to obtain the geometry parameters of the blades. Then, the data is entered into the Q-blade software by dividing the blades into ten elements and optimizing them. The blade material used in the manufacture is mahogany wood. This paper will discuss the manufacture of taperless blades with NREL's 822 airfoil. The blades were previously designed using MS Excel and Q-Blade applications and then further designed using the Solid Work application.

Keywords*:* NERL'S 822; Taperless, Manufacturing; Q-Blade; Wind turbine

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1. Introduction

One alternative energy to generate electricity is wind energy. In simple terms, wind is defined as air moving from high pressure to low pressure or from low air temperature to high air temperature, which occurs due to solar heating of the atmosphere and the earth's surface (Huang et al., 2022). Wind is a form of energy available in nature which is obtained through the conversion of kinetic energy (Jiang et al., 2022). The energy from the wind is converted into kinetic energy or electrical energy (Edwin et al., 2022). Wind energy can make a significant contribution to emission reductions because no CO2 emissions are generated during the production of electrical energy by windmills (S. Li et al., 2022). The workings of a wind power plant known as a wind power plant is quite simple (Barooni et al., 2022). The wind energy that spins the mill rotates to turn the blades on the generator at the back of the windmill, thus producing electrical energy (T. Li et al., 2022). Indonesia, which has a coast of 80,791.42 km, is an area that has the potential for wind power plant development (Pristiandaru & Pambudi, 2019). The wind speed in Indonesia is generally between 4 m/s to 5 m/s. However, in certain areas, such as on the coast, the wind speed can reach 10 m/s (Fauzy et al., 2021; Nurlatifah et al., 2021).

With this speed, the construction of wind power plants is still less economical. However, if it is built with a certain height and a large diameter of the propeller, it can produce electrical energy with a potential capacity of 10-100 kW. The current installed capacity of wind turbines in Indonesia is 1.96 MW and the total available wind energy in Indonesia is 970 MW (Noviani, 2019). Seeing the potential of the coastal area which is quite wide, the use of wind power as a renewable energy source in Indonesia is very likely to be developed further. This research will analyze the performance of a Taperless wind turbine using an NREL's 822 airfoil on a

Taperless Horizontal Axis Wind Turbine (HAWT) using Microsoft Excel and Q-Blade software in order to get the value of rotational speed, torque, and thrust by taking into account the variables that affect turbine performance. wind, namely Tip Speed Ratio (TSR), twist, angle of attack, Power Coefficient (Cp), blade length, airfoil, and others.

2. Methods

In the process of making or manufacturing blades, there are things that must be done, such as the following: - Select the type of material used, including fiber, styrofoam, or wood. In this discussion, the type of material used is wooden beams for taper type blades.

1. Create element lines on the wood which aim to make it easier to make other lines (twisting angles, chords) and simplify the process of scraping wood.
2. To make taperless blades draw lines from the base to the end of the trailing edge and leading edge.
3. Paste the airfoil shape at the end with the aim of making it easier to draw the leading edge and trailing edge twist lines.
4. Create other auxiliary lines that aim to simplify the scraping process and make it more precise, which includes tolerance lines leading edge and trailing edge, line thickness or highest point of the airfoil arch.
5. Make grooves using a saw on the element lines with a depth to touch the trailing edge line and the highest point of the airfoil arch.
6. Use a machete / crab machine to scrape the parts that need to be removed according to the lines that have been made, in this case scrape and shape the airfoil at the base first which aims to make it easier for the next scraping process
7. In the sanding process use coarse sandpaper first and then use fine sandpaper to smooth the rough parts and use an airfoil mall to make it more suitable. - The next process is finishing, namely by giving a layer on the blade which aims to make it more durable, coating can use paint or epoxy glue.
8. Care is required in the manufacturing process in order to obtain maximum results. To complete one blade on average it takes 2-4 days.

3. Results and discussions

The results and discussions obtained in the writing of this wind turbine blade manufacturing are:

3.1 Material selection

There are several choices of materials that can be used for blades, such as metal, composite, Styrofoam, and wood. The use of steel as a blade material causes the blade to be too heavy and difficult to rotate, while aluminum is not strong enough and tends to fracture. Composites such as polyester resins are commonly used materials, but a mold or master blade is required to make them, and they are more expensive. Styrofoam material is lightweight, easy to shape but easy to break and requires a connection to a generator.

Wood is the most common choice used in the manufacture of wind turbine blades due to its light, strong, malleable and brittle nature. The wood used in the manufacture of slats should be soft and light wood with dense fiber properties and free from knots if possible. Some examples of types of wood that are commonly used for slats are pine, teak, and mahogany. The wood chosen in this manufacturing process is mahogany (swietenia macrophylla) because mahogany has good hardness and flexibility, but the main reason for choosing mahogany is because of the abundant availability of mahogany in the author's research area.

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3.2 Manufacturing process

3.2.1 Preparation of wood material

The size of the blade that will be made based on the design that has been done is 100 cm x 12 cm x 3 cm, it takes 3 mahogany blocks. The initial steps in the blade-making process are drying and cutting the wood. In this experiment, it was not equipped with drying facilities, so that the wood was dried, but simply by drying it should not hit the sun directly because what happened at the end of the wood, the purpose of drying was to reduce the moisture content of the wood and so that the mass of the wood was not too heavy and heavy. for easy cutting and grinding. In this experiment, the wood was dried for 3 days.

Figure 1. Wood drying process

3.2.2 Blade mall process

The next step is the manufacture of a mall or slat airfoil mold. The results of the image of the blade on the Solidworks that have been made, especially the cross section of the blade or airfoil, are printed on a 1:1 scale and then pasted on the plywood. The plywood is cut into 2 parts and then shaped to follow the shape of the airfoil from the mold using a screw saw. In the design of Taperless blades, usually only 1mal is used. But in this study, we used 10 malls to get more detailed and precise results.

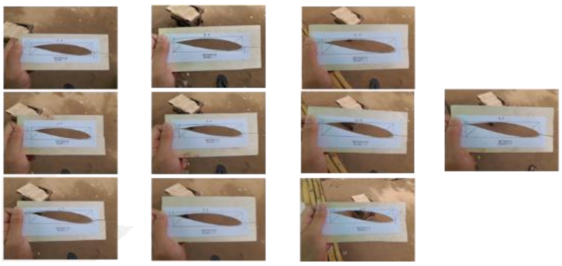

Figure 2. Making an air foil using plywood

3.3 Blade formation

After drying the wood, the next stage is the sawing and pruning process, this process is carried out to adjust the size of the blade according to a predetermined design and facilitate the grinding process according to the required shape. If the size of the wood is appropriate then the next step is to attach the airfoil mall using glue to the end of the blade. In the airfoil mall, you can see the airfoil at the end of the blade so that points and auxiliary lines can be made on the wood. The auxiliary lines made are intended to assist the scraping process so that the twist of the blade from the tip to the base of the blade can be formed and the shape of the blade remains in accordance with the airfoil without the blade being eroded too deeply. After that, the wood is scraped following the guide lines that have been made using an sandpaper grinder and following the guide lines that have been made, the blades are shaped to follow the airfoil malls that have been made.

The use of sandpaper grinding starts from sandpaper with a smaller number or coarse sandpaper, and progresses to a larger number of sandpaper or fine sandpaper. Scraping is done by using coarse sandpaper if the area to be scraped is large so that the scraping process does not take a long time, while the scraping uses finer sandpaper so that the eroded area is not eroded too deeply. In the process of making this blade, sandpaper numbers 80, 180, and 240 are used.

The finished blade is formed following the airfoil mall in each element, smoothed with hand sandpaper, then proceed to the stage of making the base shape with a 2D mall first. In this process to re-check the blade manufacturing of each element so that it remains in accordance with the working drawings.

Figure 3. Blade turbine

3.4 Turbine blade base formation

After the dimensions of the blade airfoil have been formed, the next step is the formation of the base of the blade. As with the airfoil, the base of the blade also requires a mall as a measure of measure. The malls used are printed on paper with a 1:1 scale. This mall is affixed to the base of the blade at a point from 0 cm to 17 cm. The thing to note is that the attachment of the paper must be precise and in terms of the length of the blade, the slope of the blade mal sanding can result in an inaccurate base shape and incorrect bolt holes, so that the blade is difficult or even impossible to install on the generator hub. After the mall is attached, drilling is carried out at the marked point on the mall. The drilling process is carried out with a seated drill so that the drilling direction is perpendicular to the plane of the base of the blade. Furthermore, the base is smoothed and can be tried to be installed in the generator hub.

4. Conclusions

The conclusions that can be drawn from the above manufacturing process are: The manufacturing process of the Taperless type Horizontal Axis Wind Turbine (HAWT) with NREL's 822 airfoil consists of designing, selecting materials, manufacturing processes. Materials used for manufacturing the horizontal Axis Wind Turbine (HAWT) blades of Taperless type with NREL's 822 airfoil using mahogany wood. When drying the slat beams against the direct sun, one slat beam is found to be bent. There was a human error when drilling a hole at the base of the blade which resulted in the slope of the hole and made it difficult for the writing team to attach the blade to the generator. The NREL S822 Taperless blade with a radius of 1 meter does not air because the blade experiences a large vibration when testing on a 1-meter pole.

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Declarations

Author contribution

Arya Zulhendrik was responsible for conceptualizing, analyzing data, and writing the article. Samuel Samuel collected data, analyzed data, and also contributed to writing the article. John Rey A Jimenez collected data, analyzed data, and also contributed to writing the article.

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Conflict of interests

The authors declare no conflict of interest.

Ethical clearance

There are no human subjects in this manuscript and informed consent is not applicable.

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