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DESIGN MODELLING AND ANALYSIS OF A WIND TURBINE BLADE SUPPORT SYSTEM

***Abstract**: Wind turbines and green energy is of high interest nowadays and the size of the powerplants keeps getting bigger and bigger. The forces that arise as the blades increase in size have the magnitude to deform the profiles. This paper proposes a new design of a support system mean to strengthen the wind turbine blade and make it operable at higher wind speeds and withstand higher force concentrations.*

***Keywords**: wind turbines, blade support, design, modelling, analysis.*

1. INTRODUCTION

The first windmill to generate electricity in the rural USA was installed in 1890. Improved turbine design and plant utilization have contributed to a decline in wind energy generation costs from 35 cents/kWh in 1980 to less than 5 cents/kWh in 1997 [1].

Airfoils have been considered a controversial subject in the design of a aerodynamic wind turbine blades. The performance of the airfoils designed for airplanes are not always the best to be used in wind turbine design. Different problems may occur at the blade surface when using it in flows with low Reynolds numbers although they were designed to be used for planes travelling at heights that present high Reynolds numbers. [2]

Blade design dictates the performance of the wind turbine but with high performance comes a higher risk that the forces concentrated on the surface of the blade may bend the blades towards the tower and thus damage the wind turbine (figure 1).

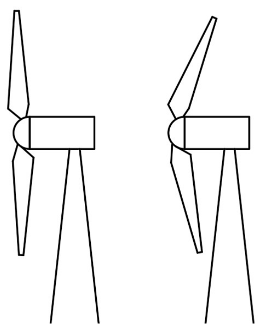

Fig. 1 Bending wind turbine blades.

A recent study on reinforcing the wind turbine blades has been done in Brasov [2] and has concluded that using different designs for reinforcing the structure of the blade through internal support beams will permit higher performance and higher force resilience. The study has concluded that the introduction of longitudinal reinforcement systems may increase that resistence and rigidity of the entire assembly. If the system has a well-built geometry then it can admit lighter structures which contributes to improved aerodynamic structure design.

Considering a wind turbine blade transversal section view as it is presented in figure 2 we can admit that the internal structure of the blade can be improved dramatically preventing damage and improving performance.

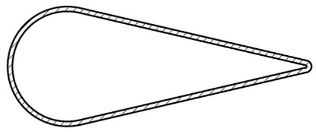

Fig. 2 Transversal section view of wind turbine blade.

Taking into account the latest research [2] improvements could be made by inserting a hybrid system that can support in both longitudinal and transversal directions inside the wind turbine blade.

2. DESIGN AND MODELLING OF A REINFORCEMENT VARIANT FOR A WIND TURBINE BLADE

Taking into consideration the need for such a system as the wind turbine blades gradually grow larger and larger, a wind turbine blade strengthening system was designed (figure 3).

For the strengthening system to work it needs to be placed at each major section change of the wind turbine blade.

In the first part of the design an axial shaft was considered to be the main part that distributes the forces travelling alongside the length of the blade as seen in figure 4.

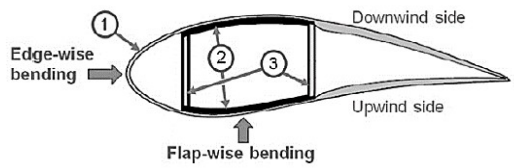

Fig. 3 Cross section of a blade with references to the airfoil shell, spar flanges, and shear webs: #s 1, 2 and 3 respectively [3].

On the axial shaft an o ring was added. The o ring comes with several holes that have grooves mean for fitting the next part as seen in figure 5.

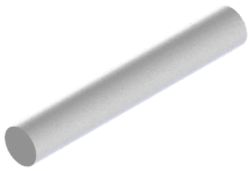

Fig. 4 Axial shaft.

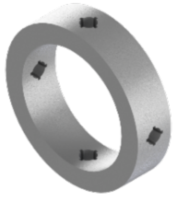

Fig. 5 O ring with grooved holes.

After the o ring is fitted onto the axial shaft of the system the resulting subassembly will look similar to the one in figure 6.

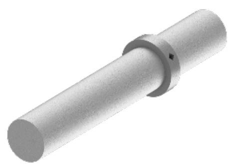

Fig. 6 Axial shaft fitted with a grooved o ring.

The design needed 2 pairs of shafts that can fit into the grooves of the o ring so that they can support the blade and a radial shaft with grooves complementary to the o ring's grooves was modelled in Autodesk Inventor software package [4] as seen in figure 7.

Fig. 7 Radial shaft with grooves.

The radial shaft was mounted into the o ring grooves and several shafts were added to the o ring to complete the subassembly as seen in figures 8 and 9.

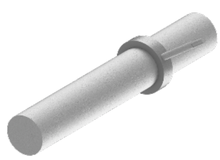

Fig. 8 Subassembly with 1 radial shaft.

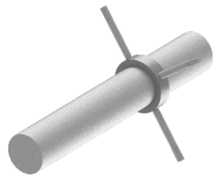

Fig. 9 Subassembly with 4 radial shafts.

The radial shafts have complementary grooves on both sides one side is mounted to the o ring while the other is mounted to a profile geometry that is meant to model the airfoil of the wind turbine blade in different sections perfectly.

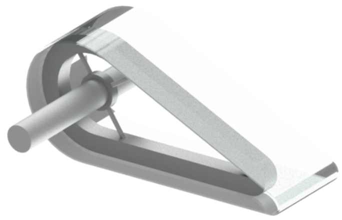

Fig. 10 Assembly of wind turbine blade with support system.

For this to work a profile frame has been modeled and has grooves in order to house the grooves of the shaft and stay fixed. As seen in figures 11 and 12.

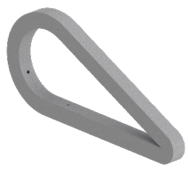

Fig. 11 Grooved frame for radial shafts.

As mentioned the grooved frame is modelled to fit the profile of the wind turbine blade airfoil and helps distribute the forces concentrated on the blade to different parts of the assembly.

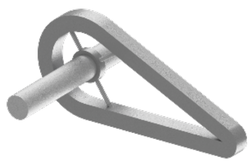

Fig. 12 Grooved frame inserted into subassembly.

Fig. 13 Section of wind turbine blade.

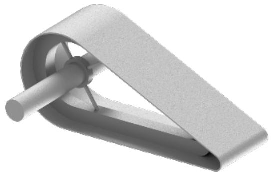

Fig. 14 Wind blade assembly with support system.

The last part in the design is the blade itself. In figure 13 you can see a section of the wind turbine blade and in figure 14 is the blade with the strengthening system in place.

3. ANALYSIS OF WIND TURBINE BLADE SUPPORT SYSTEM

For the analysis, it is considered that the model in figure 10 is a section of a wind turbine blade and forces will be applied and the results will be compared with the wind turbine blade without the support system and only with its width.

On the first simulation, the wind turbine blade profile is subject to a force of 1000 N and gives out a deformation of above 4000 on the X axis as seen in figure 15.

By adding the support system to the wind turbine blade design a weight increase can be observed and could be accepted taking into account the performance increase.

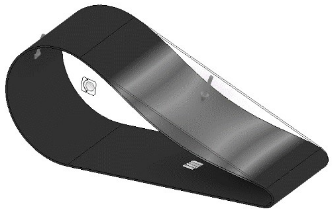

Fig. 15 Wind turbine blade profile without a support system.

As we inflict the same kinds of forces to the whole assembly we get half of the amount at that is about 1900 which proves the design does what is intended and that is to strengthen the wind turbine blade as seen in figures 16 and 17.

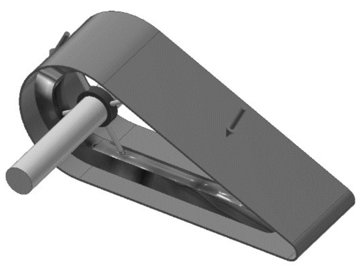

Fig. 16 Forces applied to surface.

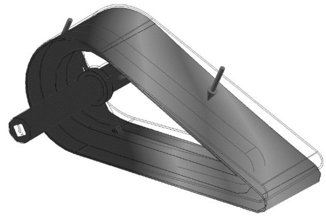

Fig. 17 Result of simulation on assembly with strengthening support.

4. CONCLUSION

A performance increase could be seen with the addition of the support system even though the overall weight of the blade increases.

A well-defined support system can make a difference when it comes to the strengthening of the wind turbine blade design.

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