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FABRICATION OF BLADES WITH DIFFERENT AIRFOIL FOR A SMALL WIND TURBINE

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Abstract. *Since the 70's the use of wind energy has been growing up, as well as researches about it too. However, research has now been larger in wind power generation with small turbines. Tends in view this need, this research proposes the manufacture of the turbine blade with a different airfoil than the one suggested by producer. After simulations in the Qblade, with some airfoils, were found better results in NACA 63(2)-615. After the simulations, the blade was manufactured using the Resin Transfer Moulding (RTM), but before fabrication of the blade, one model had to be manufactured manually with wood. Therewith, the mold could be made. The mold was made in two parts and in the same way, the blades. A part of each blade was laminated on each part of the mold and after the curing period, another piece of glass fiber was placed between the two parts with the resin and the catalyst to join them. After lamination, the fittings were made for the fit in the turbine and the reduction in the laterals for efficiency improvement.*

Keywords: *Wind turbine, airfoils, blades measurement.*

1. INTRODUCTION

The increasing consumption of electricity worldwide, establishes a need for a growth of alternative energy sources, inexhaustible and not harmful to the environment. In this way, the search for renewable sources of energy has been increasing and recently, Pires and Oliveira (2010), the production of electricity with these sources begins around the 20th century. These can be solar energy, maritime , geothermal, wind, biomass, hydro, etc.

In the Brazil coast, where there is the highest incidence of winds, wind energy has achieved a great advance in its use, due to these natural conditions. For this energy be converted into electricity and distributed, it is necessary to use a device called a wind turbine. This device will transform the wind energy into mechanical energy by rotating the blades, then it will transfer this energy to an electric generator and will send it to a control center where the energy will go through a process to be inserted in the power grid.

Recent work (Song, 2012), horizontal axis wind turbines are the most commonly used. These wind turbines are mainly composed of a set of rotors, blades and the hub. Considering that, the main factor that provides the turbine greater efficiency is how much wind can be absorbed by the airfoils, to be converted into mechanical energy. Hence, this research proposes to work in the study and manufacture of blades with different airfoils.

The Qblade be used for select profile that was compared to the manufacturer's airfoils, these were simulated and their efficiencies were compared. The parameters used were power generated with wind regimes, the power coefficient with the power generated and the extrapolation of the drag and lift coefficients with the variation of the angle of attack.

Recently, Almeida e Silva (2012) constructs blades with RTM (Resin Transfer Moulding) and said that it is used in several applications and could be used in the manufacture of blades, too. However, first a wood model was made. With the model was possible utilize a gel on it so that it suited the surface and after a few minutes of cure, the mold will be laminated. The mold is made of two parts, upper and lower of these two parts, the glass fiber layers are laminated with resin and catalyst, and finally be united with other fiber pieces with the resin and the catalyst. After the blades are ready, the finishing will be given and the blade will be fixed in the rotor.

2. EXPERIMENTAL PROCEDURE

First step in airfoil selection is research some of these that are used in small turbines, as such as the BERGEY XL 1.0. These were found in the UIUC Airfoil and AirfoilDataBase databases. The airfoils are shown in the table.

Table 1. Airfoils found in the research and simulated

E 387	NACA 63-418	NACA 2410	S 834
FX 63-137	NACA 63-615	NACA 2412	SD 2030
NACA 1412	NACA 63-415	NACA 4415	SD 7037
NACA 23012	NACA 66-418	NACA 4418	SD 7062
NACA 2408	NACA 4412	NACA 63-209	SG 6043
E 387	NACA 63-418	NACA 2410	S 834

These profiles are used in some wind turbines and for each of them there are application in a different place. In Qblade, it is possible to analyse the drag or lift coefficient, the higher potency for a Cp (coefficient potency), power in relation to wind velocity, etc., and according to each parameter, it is possible to compare them and verify which is the most appropriate.

First a gel was passed over the wooden model so that it acquired a consistency and remained as same as surface model. After 15 minutes, 4 layers of glass fiber were laminated on the gel with the resin mixed with the catalyst. After a few hours of cure one side of the mould was ready and this was removed from direct contact with the model. The same process was done on the other side and with this process of lamination on the gel the mold was done. So, a finish was given with a rectification in the mould, so that it acquired a better finishing and appearance. Figure 2 shown two mold parts.

Figure 1. parts of mould

After manufacturing mould, manufacturing process of the blades was started. On each side of the mold was followed the same process, the glass fiber layers were laminated together with resin and catalyst. When lamination of each one of them were finished, has to be waited some hours for lamination cure of the parts of each blade and after this, blades pass for a sanding process. Subsequently, joining two parts of each blade is started, as well as the final finishing process in the complete blades.

In finalization of the blades, 12k filaments and plain weave were bonded between parts each blade together with the same resin and catalyst used previously in manufacture of mould, so that union of each two parts of each one was made. After parts were joined, it was used a product on the blades side to a better appearance, this was polyester mass M3500 from Sherwin Williams. Subsequently, blades underwent a rectification process on the sides so that it had a better finish. The uncoupled blades and also the blades after having passed through the finishing process are shown in figures 2 and 3.

Figure 2. Blades uncoupled

Figure 3. Blades after used mass

3. RESULTS AND DISCUSSIONS

This research proposes manufacture a blade with an airfoil selected through simulations in Qblade. That one that got better results was NACA 63 (2) -615, which after having its parameters confronted with SH 4038, used in the manufacture of blade supplied by manufacturer. Recently, Souza (2015), shown results found for this airfoil, also prove that this is the best in relation to the others. As previously as mentioned, the Cl / Cd ratio (lift and drag) was compared with the angle of attack variation being extrapolated up to 360 degrees, the power variation with the blade Cp (potency coefficient) and how much power can be obtained with different regimes of wind. Figures 4 and 5 360 degree extrapolations in the angle of attack for the Cl / Cd variation of manufacturer airfoil and chosen one are compared.

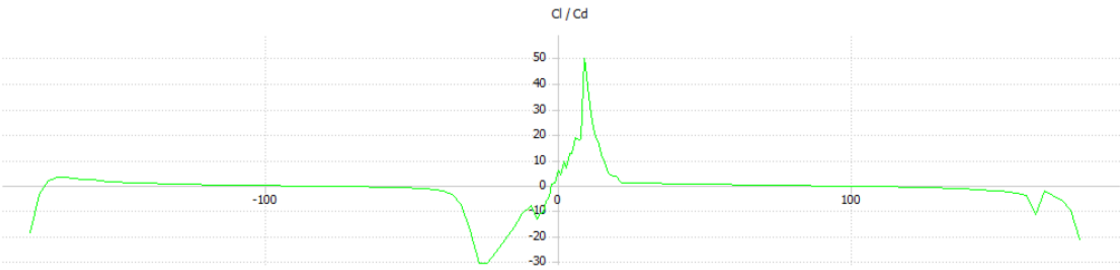

Figure 4. Alteration of lift/drag coefficient with angle of attack extrapolated in 360 ° in airfoil SH4038

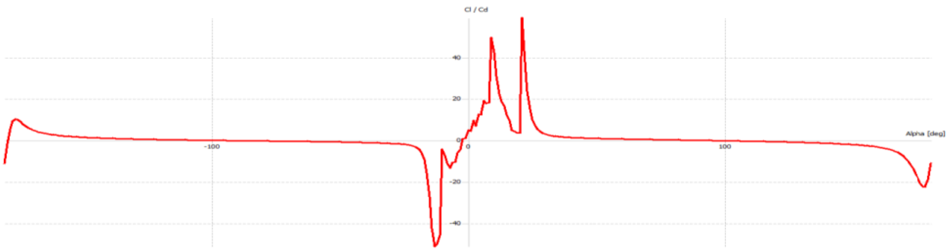

Figure 5. Alteration of lift/drag coefficient with angle of attack extrapolated in 360 ° in airfoil NACA 63(2)-615

In both cases it's possible to observe for small angles and variations in the angle of attack it's where the best Cl/Cd ratios are observed. These will give the best blade resistance for wind regimes submitted, as well as parameters used for simulations, too. Because of this, variations in angle of attack between 0 and 20 degrees.

In figure 6 and 7, the generated powers are presented for different wind speeds.

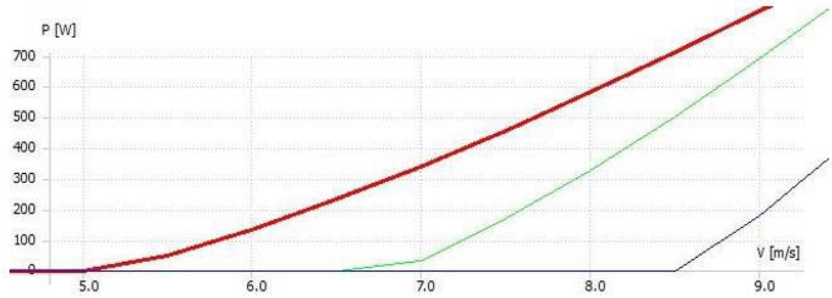

Figure 6. power x windspeed in airfoil SH4038

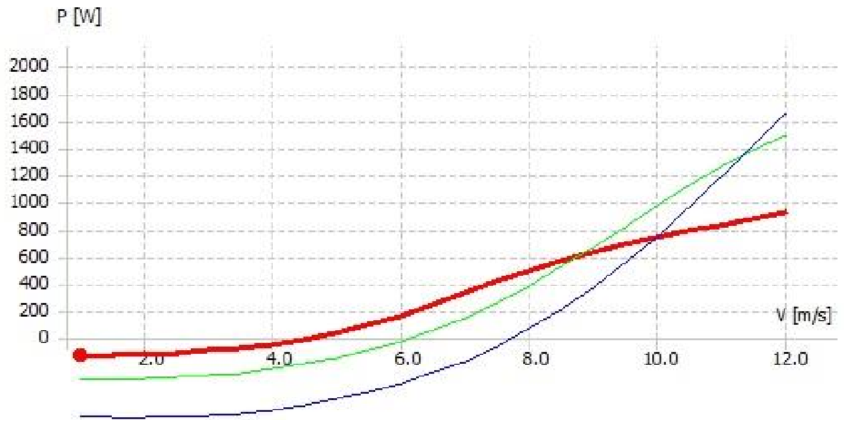

Figure 7. power x windspeed in airfoil NACA 63(2)-615

In figures red lines represent rotor at rotation of 300 rpm, 400 rpm (green line) and 500 rpm (blue line). With SH4038, wind turbine starts to generate power at about 5.5 m/s, with 400rpm starting at 7 m/s and with 500rpm at 8.5 m/s. For these rotations wind turbine presents a power of 400W at 7.2 m/s, 8.4 m/s and more than 10 m/s, respectively. In NACA profile 63 (2) -615 at 300rpm power starts to be observed at 4.2 m/s, at 400rpm 8 m/s and 500rpm 8 m/s. Making same analyses made to other can generate 400W at 7 m/s, 8 m/s and 9 m/s, respectively.

When these data obtained in simulations, the blade was fabricated with airfoil selected and fixed to rotor. The blades are shown in figure 8 and these fixed to rotor are shown in figure 9.

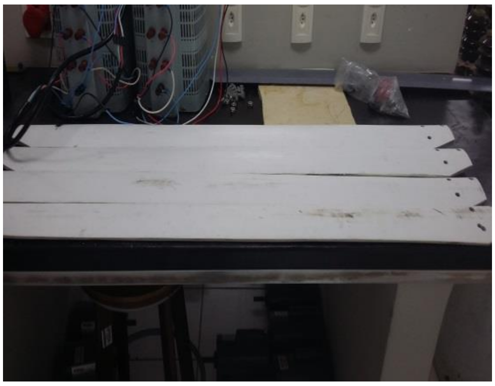

Figure 8. Blades

Figure 9. Blades fixed in Wind turbine

4. CONCLUSIONS

It was observed because airfoil selected was a little more robust than used by the manufacturer, the location of blade rotor anchorages in the rotor was different. So, had to be overlapped on grooves and location of where the holes should be made changed. Details made at the ends of the blade were also expanded so that the fastening was facilitated.

However, it was possible to fix the blades correctly in the rotor and after some field exposures, as well as was verified there are no gaps and no faults that would allow blade to disengage from the rotor and cause an accident.

In this way, the next steps of this research are the tests blades fabricated with NACA airfoil to be confronted with tests of SH4038 and thus to prove veracity of the data obtained through simulations.

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6. RESPONSIBILITY NOTICE

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