Optimization Design of Wind Turbine Tunnel Based On Fluid Analysis Results

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Abstract. At present, the problem of wind turbines affecting flying organisms has been highly valued. Wind turbines will not only attack flying creatures through rotating blades, but also the flying organisms will affect the habitat of ground creatures because of the reduction of flying height. In this study, a fan with protection function is designed by designing a wind turbine system with a wind tunnel design that can be smoothly adopted by birds. Because the blade is not in direct contact with the wind, it is introduced into the blade through the wind tunnel. Therefore, in the design of the wind tunnel, not only the wind speed of the introduction is not weakened, but also the wind speed can be fastened through the structural angle. Therefore, the blades can be rotated as scheduled to achieve the purpose of wind power generation. In the design of the wind tunnel, the study conducted the wind speed test of the structure through continuous fluid analysis. In the results obtained, correct all structures that may affect wind speed and re-analyze to ensure that the wind speed can successfully achieve the goal. At the same time, the maximum wind speed obtained will be used to test the torque and power generation by the formula to see if the design is able to reach the goal of power generating.

1. Introduction

Wind power can be hailed as the world's best clean energy, and the reason why wind power can be so high credited is because of its power generating efficiency and the source of power. Although wind power equipment has excellent power generation benefits, few people realize that wind power equipment has a slight impact on the ecology. Wind power plants are often built in high mountains and coastal areas where to find strong wind speeds, and these areas are also easy to inhabit and migrate. In addition to the damage caused by human forced land acquisition, the noise generated by wind turbines, as well as bird strikes and even forced flying creatures to reduce flight altitude, will have an impact on the ecology. Therefore, this study developed a whole new wind turbine type which has both benefits of eco-friendly accelerated wind speed design.

1.1. Comparison of vertical axis wind turbine and horizontal axis wind turbine.

The blade is the most important part of the wind turbine and is also the key structure for converting kinetic energy into mechanical energy. However, because the source and speed of the world wind will cause different wind conditions depending on the terrain, the seasons and other factors. In order to capture the best performance, the blades are designed to adjust to different situations. At present, wind turbines can be divided into two categories in the world, horizontal axis wind turbines and vertical axis wind turbines. The biggest difference between the horizontal axis wind turbine and the vertical axis wind turbine is the blade device. The horizontal axis fan chamber and the rotating shaft are perpendicular to each other, and the reason why it is called the horizontal axis wind turbine is because the wind direction and the rotating axis are presented. The parallel state is called a horizontal axis wind turbine. The difference between the horizontal axis wind turbine and the vertical axis wind turbine is very large. The advantage of the horizontal axis fan is that the height of the windmill tower and the hub can be set higher than that of the vertical axis unit, and it can be obtained because
of the high altitude relationship. The wind speed is also faster. Generally, the number of horizontal axis wind turbine blades mostly falls between 2 and 3 pieces. This number of wind turbines can achieve a higher wind energy utilization coefficient during operation. Although the starting wind speed is relatively higher than that of the vertical axis fan, however, because of the small number of blades and the light weight, the power generation efficiency is relatively high. This advantage is also the biggest difference between a horizontal axis fan and a vertical axis fan. In addition, the horizontal axis wind turbine will also fix the aerodynamic load when the windward angle is fixed, and the damage caused to the unit will be less. However, compared to the vertical axis fan, the rotor of the horizontal axis fan must have a roll control facing the wind direction, and when the direction is controlled, the fan body will vibrate due to the force to withstand the wind direction. At the same time, not only the pressure caused by the wind direction, the large horizontal axis blades will bear the bending moment load due to the wind cut relationship during the movement, and the force will affect the life of the fan, etc., so the fan design The upper horizontal axis unit must consider these factors. The vertical axis wind turbine is a structure in which the blades are rotated around the axis of the vertical axis, and also because the direction is called a vertical axis wind turbine. The vertical axis wind turbine is a bit so that it does not require a special windward surface. When the wind comes from any direction, it can be plucked and converted into mechanical energy without the need to adjust the setting of the device. Vertical axis fans are also less susceptible to wind cuts and therefore generate less load. At the same time, the disadvantage is that because the height of the rotor is relatively low, the wind speed is usually low, so the performance that cannot be achieved under long-term high-speed operation is low. The structure of the H-type fan is relatively simple, but the centrifugal force caused by this structure will cause severe bending stress at the reconnection point of the blade. In addition, linear blades also need to use the crossbar as a connection, which also produces some slight resistance and thus reduces efficiency. The table shows the change and comparison of the type ratio of vertical axis fan and horizontal axis fan.

Table 1. Vertical axis fan and horizontal axis fan type change ratio.

| Diameter (m) | Height (m) | Frontal Area (m²) | Rotating Speed (RPM) | Output (kW) | Torque (Nm) |
|-------------|------------|-------------------|----------------------|-------------|-------------|
| Vertical Axis Wind Turbine (VAWT) | 1:1        | 10                | 10                   | 67          | 95          | 23          | 2300        |
| VAWT 1.5:1  | 10         | 15                | 10                   | 100         | 95          | 34          | 3400        |
| VAWT 1.8:1  | 10         | 18                | 120                  | 95          | 41          | 68          | 4100        |
| VAWT 3:1    | 10         | 30                | 200                  | 95          | 68          | 68          | 6800        |
| Horizontal Axis Wind Turbine (HAWT) | 14.7       | -                 | 170                  | 85          | 68          | 68          | 9960        |

1.2. The threat wind energy poses to flying creatures.

According to a journal published in the Mammal Study, researchers conducted bat death surveys from three different wind turbine wind farms in Taiwan between 2007 and 2010 to verify that wind turbines are creating clean energy. At the same time, it also hurts the flying creatures living in this environment.

According to the survey, five different types of bat corpses were found under the fan. The five bat species are: Pipistrellus Abrades, Scotophilus Kuhlisi, Eptesicus Serotinus Horikawai ), Myotis Formosus and Nyctalus Planicy Velutinis. Among these different types of bats, most of the bats from Southeast Asian species are ridiculous, but the Chongchuan's brown bat and the golden rat ear bat are endemic to Taiwan. And although the bat is a night animal, the reason why the bat will die due to the wind turbine is that the bats are used to flying in the wind direction, just because the wind turbines are going to take better wind energy. After setting it on the best windward side. When the bat moves around the fan, the different sounds, magnetic fields, and changes in air pressure generated by the wind turbine may cause confusion to the bat itself, thus causing death to the blade.
At the same time, in the group of birds that are generally slightly known to attack birds, water birds have the greatest impact. As mentioned earlier, wind turbines are set in the optimal wind field in order to achieve the best performance, and the migration routes of these wind farms are usually the breeding and habitat of waterfowl. According to the research, wind turbines are pointed out. After the erection, the waterfowl changed the path because of the continuous impact of the impact. Whether it is changing the original path or adding a new flight path, it will leave the distance of the fan more than 100 meters, but not all birds can have such consciousness, so temporarily changing the direction also caused a lot of damage to them.

2. Wind tunnel design

2.1. The threat wind energy poses to flying creatures.

The main purposes of this study are to provide a safe passage space for flying animals, so there is no direct exposure setting for wind blades. Under such a concept, how to collect and introduce the flowing wind into the air duct is a very difficult problem in design.

This study takes advantage of a very well-known and very efficient physical phenomenon – the Venturi effect, also known as the Venturi effect, as a major conceptual basis for design. The Venturi effect is that a gas or liquid in a high-speed flow generates a low pressure in the vicinity and thus generates an adsorption. At the same time, when the restricted flow of gas or liquid passes through the greatly restricted flow cross section, the flow velocity and the flow increase phenomenon will occur instantaneously, and the flow rate will be inversely opposite to the flow cross section. This phenomenon can be called the Venturi effect and this effect is also very suitable for the design concept of this study.

![Figure 1. Venturi effect.](image1)

In this study, the Venturi effect was used to design the channel with curvature at the air inlet, which greatly reduced the size of the air inlet to enhance the wind speed. In addition to the channel design of the wind turbine blade reinforcement zone.

![Figure 2. The inlet area of this design.](image2)
3. Fluid analysis of wind tunnel

The general mathematical model of solid-force analysis is mainly FIA (Finite Element Analysis) and can also be called Finite Element Analysis (FEM). The fluid analysis architecture is not using these mathematical models.

The operation is performed using the FVM (Finite Volume Method). The finite volume method does not use the explicit pressure equation, but uses the velocity equation to do the calculation. In the calculation, the three Momentum Equations momentum equations plus the Continuity Equation continuous equation form four equations to solve four different variable values.

The finite volume method can evaluate the mesh of the inlet and outlet momentum for each grid. When the momentum is unbalanced, the pressure will change and it will be calculated until the equilibrium is reached.

In order to find the best air duct design, the study is corrected by constant airway angle, and at the same time, the same preset wind speed is added to the same Domain size with 15 m/s for flow field analysis. When the direction flows to this air duct, whether the wind enters the air duct can smoothly introduce the wind into the air duct, or even has an acceleration function. The following figure shows the flow field analysis results of each air duct design.

This model is the first wind turbine of the wind turbine designed by the Study. At the beginning, this study designed the design as a torch in the city. The reason why this image is used is because modern people often feel helpless and helpless in the life of the city, and the torch torch gives the impression of a burning power. Such a concept stands in the city. When people feel overwhelmed by the pressure of life, looking up at the city's functional landscaping in the city can remind them to stick to it.
However, such a design seems to still have to be adjusted in actual use. According to the results of the flow field analysis, although the wind received by the air duct has flowed into the air duct, due to the structural design, the wind accumulated in the middle section and being introduced into the air is instantaneously dissipated and the wind speed is immediately weakened, representing the wind. Road needs to be improved through structural correction.

![Figure 5. Second design fluid analysis result.](image)

In the second edition of the wind tunnel design, in order to continue the original torch concept, it must be adjusted for efficiency. Therefore, in the middle part, the design of the torch hand is still left, but like the first version of the design, the wind speed at the beginning, there was a certain wind speed at the time of inflow, but when the fluid was introduced into the middle handle, the wind speed was still dispersed and weakened instantaneously, so the research still needs to be adjusted.

![Figure 6. Third design fluid analysis result.](image)

This model is the third edition of the wind tunnel design. This study still uses a relatively slender design concept to introduce the design, and also continues the concept of a torch like trying to bring wind turbines into inspirational life aesthetics.

According to the previous version of the duct design, it seems that the middle part of the road seems to be widened in an instant, so the introduced wind speed will be slowed down and unable to concentrate in an instant, so the design is reduced in the middle part, but it seems that the angle into the duct is too sharp, so Wind speed not only does not increase in the air duct, but also slows down the wind speed and reduces the flow. Therefore, the design of the wind turbine is continuously improved.
Since the windshield design of the first three editions has not been able to achieve the expected wind speed progress, in the fourth edition, the concept of life aesthetics that wants to be included in the torch was broken, and the practical aspect was mainly changed. Since the first three editions have been found in the flow field analysis, it has been found that the wind cannot be gathered and therein, so in particular, try to lengthen the partition at the center point to see if the wind can be gathered and accelerated. However, according to the results of the flow field analysis, it is shown that such a structure can not only concentrate the wind, but the wind speed has completely dropped to 0 m/s when the wind flows to the tail end, indicating that there is no wind speed at all, so this structure is still not feasible. Previously, in order to find the best design, it took too much time to design the wind turbine's air duct. Therefore, when the fifth edition design was carried out, it was considered that it should be integrated into the theoretical research. Therefore, in the theoretical research, the venturi theory mentioned in the literature was found. This study immediately considers that if venturi theory can be incorporated into this airway design, it is bound to achieve the goal of concentrating and accelerating wind speed at the beginning of this study.

By using venturi theory, the angle of the air inlet is still reserved for the design of the wide mouth, but the venturi theory is applied to the trend of the venturi and narrowly narrowed. After establishing this design and analysing the flow field through computer 3D modelling, it is found that the wind speed starts to slow down when the wind flows into the entrance, but it is accelerated because of the narrowing of the wind channel. In this analysis, The wind speed in these areas even maintained the original set wind speed of 15 m/s, which was not weakened at all. Therefore, the design of the air duct was designed as the best design, and the air duct design to be used for this study was also determined.
In the previous analysis, the flow field of 15 m/s through Flow Simulation of the modelling software Solid works, the result shown in the previous section is that the wind speed is maintained at a certain wind speed. Therefore, the wind speed of the inlet is set to 15 m/s as in the Ansys Fluent analysis, but the Domain is pulled down because the wind is an unstable fluid phenomenon. The Fluent analysis of the small Domain shows that when the wind enters the wind turbine, the wind speed is sharply enhanced. The strongest wind speed reaches 38.31 m/s, which is more than twice the present wind speed of 15 m/s. However, because this Domain’s inlet distance is relatively close, the wind speed is likely to be so strong, but it can be understood that the design can maintain or even accelerate the design regardless of the analysis software.

4. Conclusions
According to the analysis, different angles of the wind tunnel will affect the result and the efficiency of the wind flow. In the previous designs, the inlet was designed too large and also there is no area to speed up the wind flow. And because of the analysis results, allows the design to be modified immediately and made it better. By using Venturi Effect into the design to solve the problems of wind speed slowed down when the wind blew into the tunnel. This effect not only maintains the same speed of the wind but also speed up the wind flow. When designing a new engineering design, analysis on variety of functions is very important. By observing every result came from analysis software allows designers and engineers to modify the structure immediately. This helps cooperation or any facility to cost down the fee of development new items. In this study, the main concept is to design a brand-new wind turbine system which has the function of eco-preservation. By putting eco-friendly idea into wind turbine is hard enough, but the harder thing is how to overcome the fact that it is very hard to balance the efficiency and the environment preservation. Therefore, by using analysis software helps this study rapidly modify the structure and test again to reach the optimization design. And by non-stop modifying and testing, finally find the best design for this study.

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