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Wind Flow Analysis on a Vertical Axis Wind Turbine

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Abstract: ***The main aim of this thesis is to study the flow analysis over a vertical axis wind Turbine. The wind turbine used for the analysis three rotor vertical axis wind turbine. First, a standard vertical axis wind turbine model is designed using solid modeling software such as solid works and using that software a preliminary analysis is carried out. Our aim is to analyze the von Mises stress and deformation occurred to the turbine under the given flow conditions. After generating the wind fields, the existing turbine locations and 3 months wind speed measurements (average value) is utilized for the analysis. The wind velocity used for the analysis is 72 km/hr. For the analysis we use fluent in ANSYS 13.0.***

Keywords: Vertical-axis wind turbines, blade rotor, turbulence, von Mises stress

1. Introduction

If the efficiency of a wind turbine is increased, then more power can be generated thus decreasing the need for expensive power generators that cause pollution. This would also reduce the cost of power for the common people. The wind is literally there for the taking and doesn't cost any money. Power can be generated and stored by a wind turbine with little or no pollution. If the efficiency of the common wind turbine is improved and widespread, the common people can cut back on their power costs immensely. [1]

The blades on vertical axis windmills are designed to give resistance to the wind and are as a result pushed by the wind. Windmills, both vertical and horizontal axis, have many uses. Some of them are: hydraulic pump, motor, air pump, oil pump, churning, creating friction, heat director, electric generator, Freon pump, and can also be used as a centrifugal pump.[2] The sun's heat on the earth's crust triggers air to have different pressures causing the wind to blow, which defines the wind as a renewable energy. One of the best ways to gather wind's energy, and therefore the power, is using high efficiency wind turbines. The reasons behind choosing and using wind energy instead of other sources are explained in the following paragraphs. Fossil based resources are becoming exhausted and gradually getting expensive. Also the diverse distribution of these resource sons the earth causes many problems. In addition, they are polluting the earth with their high "carbon footprint". [3]

2. Design and Analysis

The wind speed is naturally not stable. In other words, it fluctuates in short time scales, typically less than 10 minutes. These variations of the wind speed are expressed in terms of the standard deviation of the wind speed, σu. Turbulence refers to these fluctuations. Two main causes generate turbulence: friction by the terrain surface, especially in hills and mountains; and vertical air movement caused by temperature changes of the air. [4,5]. The wind speed used in this analysis is 72 km/hr. In vertical axis wind turbines there is a base which helps the wind turbine to fix on the ground. It is specially designed to withstand large force of wind.

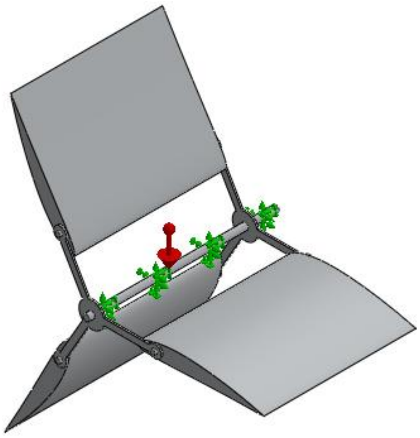


Figure 1: Vertical Axis Wind Turbine

The main parts of the wind turbine are central shaft, holder, wind blade shaft, the turbine blades. THE TURBINE BLADES ARE FITTED TO THE CENTRAL **SHAFT USING HOLDERS.WIND BLADE SHAFT CONNECTS THE TURBINE BLADE TO THE HOLDER.**

Table 1

	In	Out
Mass flow	180.701 kg/s	-152.359 kg/s
Volume flow	149.992 m^3/s	-126.467 m^3/s

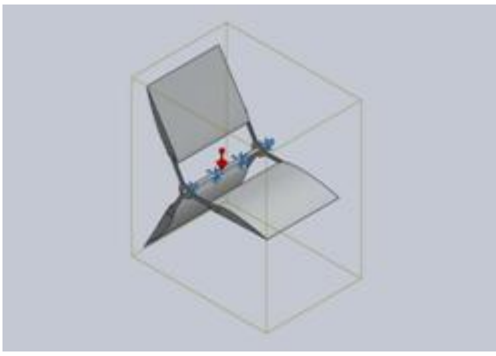
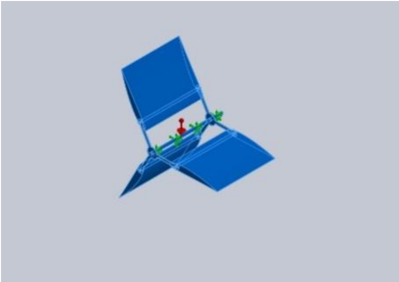


Figure 2

Table 2: Material Properties

Model Reference	Properties	Components
	**Name:** 7075-T6, Plate (SS) **Model type:** Linear Elastic Isotropic **Default failure criterion:** Max von Mises Stress **Yield strength:** 5.05e+008 N/m^2 **Tensile strength:** 5.7e+008 N/m^2 **Elastic modulus:** 7.2e+010 N/m^2 **Poisson's ratio:** 0.33 **Mass density:** 2810 kg/m^3 **Shear modulus:** 2.69e+010 N/m^2 **Thermal expansion coefficient:** 2.4e-005 /Kelvin	Solid Body 1(Boss-Extrude1)(central shaft-3), Solid Body 1(Boss-Extrude1)(holder-1), Solid Body 1(Boss-Extrude1)(holder-2), Solid Body 1(Boss-Extrude1)(shaft-1), Solid Body 1(Boss-Extrude1)(shaft-2), Solid Body 1(Boss-Extrude1)(shaft-3), Solid Body 1(Cut-Extrude1)(vawt-1), Solid Body 1(Cut-Extrude1)(vawt-2), Solid Body 1(Cut-Extrude1)(vawt-3)
Curve DataN/A		

3. Results and Discussion

MESH Model

Table 3: Mesh Information – Details

Total Nodes	76333
Total Elements	46969
Maximum Aspect Ratio	33.077
% of elements with Aspect Ratio < 3	95.5
% of elements with Aspect Ratio > 10	0.121
% of distorted elements(Jacobin)	0
Time to complete mesh(hh;mm;ss):	00:00:15
Computer name:	MFG-MANTIDE-PC

Study Results

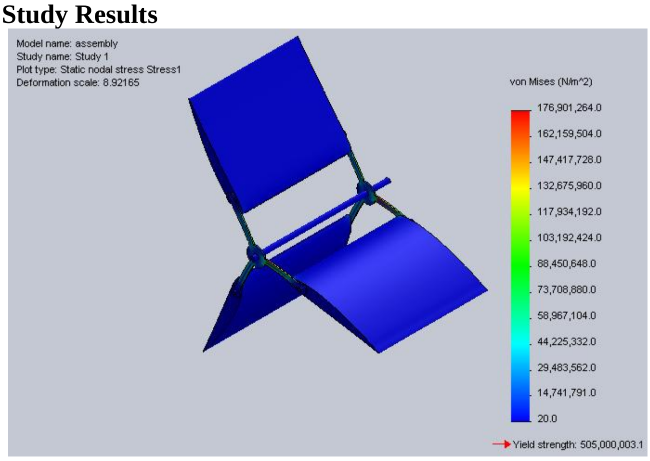


Figure 3: Stress Contour

The maximum value of stress induced is 1.76901e+008 n/m^2 at node 3793 and is less than the strength of the material. Therefore the wind turbine is safe under the given conditions.

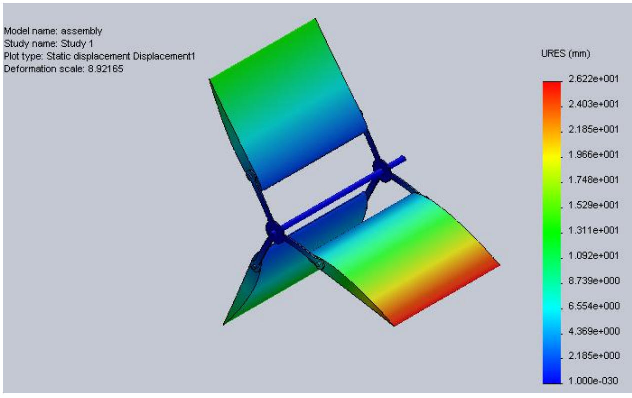


Figure 4: Displacement Contour

The maximum displacement is at node31144 and is equal to 26.21mm.

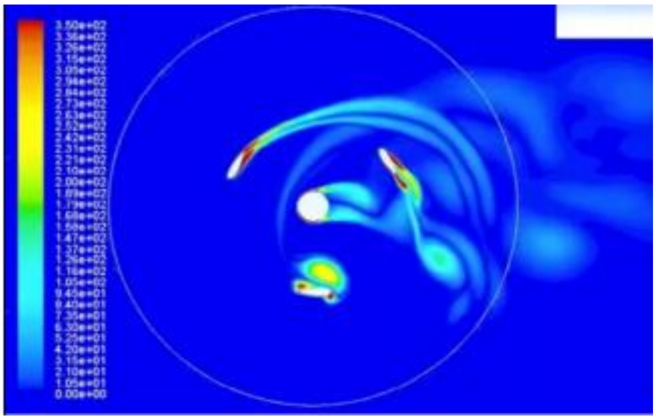


Figure 5: Simulation

Design is found to work safely during analysis of the design vertical axis Turbine.

4. Conclusion

The analysis of the vertical axis wind turbine is done using ANSYS 13.0. The given vertical axis wind turbine is found to be safe under the given conditions. The von mises stress shows a maximum value of 1.76901e+008 n/m^2 which is in the permissible limits. The deformation profile is also with in permissible limits. The maximum deformation happened is 26.21 mm. the flow velocity is taken as 72 km/hr. This value is taken as the average value of 3 months wind speed measurements over the complex terrain area. The turbine blades used in the study are flat ones. These flat blades can be replaced by curved blades which are expected to give better outputs.

5. Scope of Future Work

The work can be extended to curved blades. The pressure variation and stress variation over the blades at different wind speeds can be analyzed to design optimal wind turbine.

References

[1] W.Fox Alan T.McD, Introduction to Fluid Mechanics, 6th edition, 2004.
[2] E.L. Petersen, Wind Power Meteorology, Risoe-1-1206(EN), 2007.
[3] T. Burton, D.Sharpe, N.Jenkins, Wind Energy Handbook, 2001.
[4] Lift Augmentation for Vertical Axis Wind Turbines; Gerald M. Angle II, Franz A. Pertl, Mary Ann Clarke and James E. Smith International Journal of Engineering, (IJE) Volume (4): Issue 431
[5] K.J. Nilsson, A reliability study of two conventional computer software, Master Thesis at Chalmers University and Gotland University, 2010.
[6] A.Crockford, S-Y Hui, Wind profiles and forests, Master Thesis at Risoe DTU, 2007.