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Wind blade modal analysis (Mode Shape)

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Abstract: *Blade regulates on wind turbines are made to react swiftly to variations in loading conditions, and the blades themselves are becoming increasingly thin. As a result, considering the effects of an unstable load becomes more crucial. In order to keep a wing from operating in resonance, calculations must be made. In this study, a mathematical model was developed, and the simulation program ANSES was utilized to identify potential natural frequencies, as well as the forms and frequencies of those frequencies that should be avoided in design.*

Keywords: Wind blade, Mode Shape, Airfoils

1-Introduction

Over the past few years, wind turbine size has been rising steadily. Already at the prototype stage are rotors with a diameter of more than 120 meters. New trends and technological advancements have been the main focus of research and development to reduce the cost per kWh. Although only a minor portion of the total, the cost of electricity is impacted by the price of wind turbine blades. However, because rotor loads influence the loading of other components, such as the drive train and the tower, the overall cost will fall if an innovative blade design may result in a decrease in loading[1]. Design loads on wind turbines are generally divided into ultimate (extreme) loads and fatigue loads. Fatigue loads are a key factor in the design of wind turbine blades. Reducing fatigue loads can result in a significant reduction in cost, affecting required materials, maintenance costs, and system reliability[2]. Aerodynamics examines how gas forces on bodies are affected by air or other gases passing through them. In order to identify the best model, a lot of aerodynamic study and inquiries were made during the creation of the wind turbine.

2-Airfoils

Aerodynamics examines how gas forces on bodies are affected by air or other gases passing through them. To identify the best model, a lot of aerodynamic studies and inquiries were made during the creation of the wind turbine. Figure1 displays the main properties of an airfoil. To capture the energy from the wind, many types of airfoils are employed along the blades. When creating blades, a variety of airfoils are available. They are categorized using numbers provided by the NACA (National Advisory Committee for Aeronautics)[3],[4] .The three classes of airfoils are seen in Figure 2.

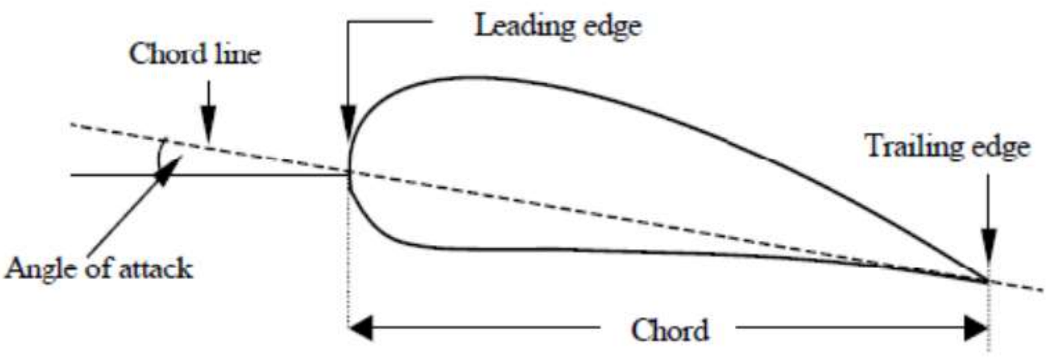

Figure 1. Main parameters of an airfoil[3]

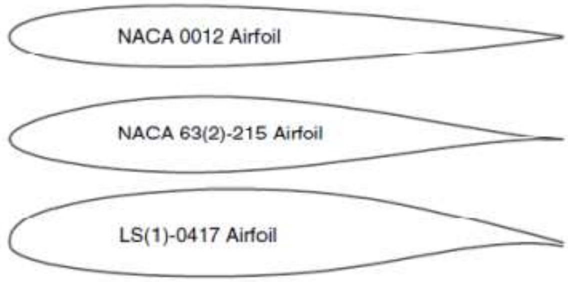

Figure 2. Sample airfoils

3- Geometry

The structural model contains the full geometry of wind turbine which is tower, nacelle and rotor. The 3D model has been created in ANSYS/Design Modeler based upon published information of 5MW wind turbine from Repower[1],[5], as shown in figure 3.

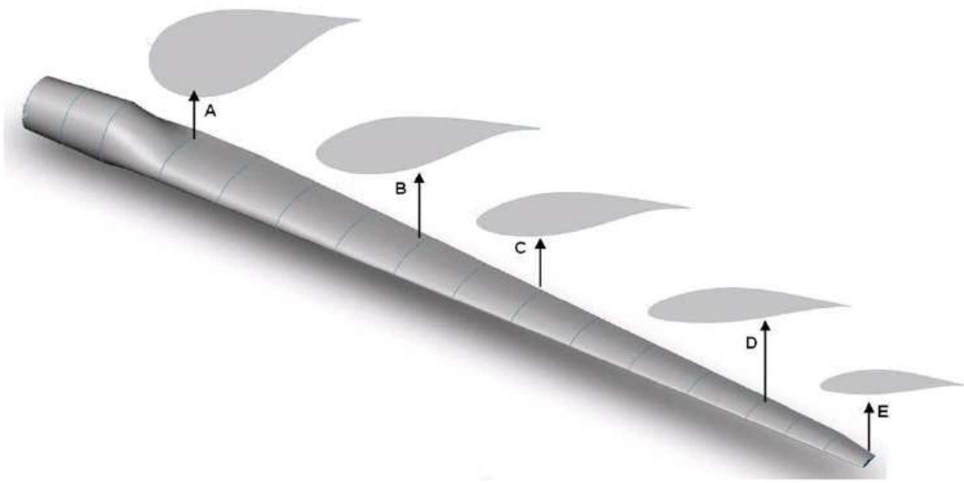

Figure 3.wind turbine suction

Using the time history and spatial distribution of wind as inputs, wind loads and the structural component calculate the dynamic response of the structure (Figure 4).

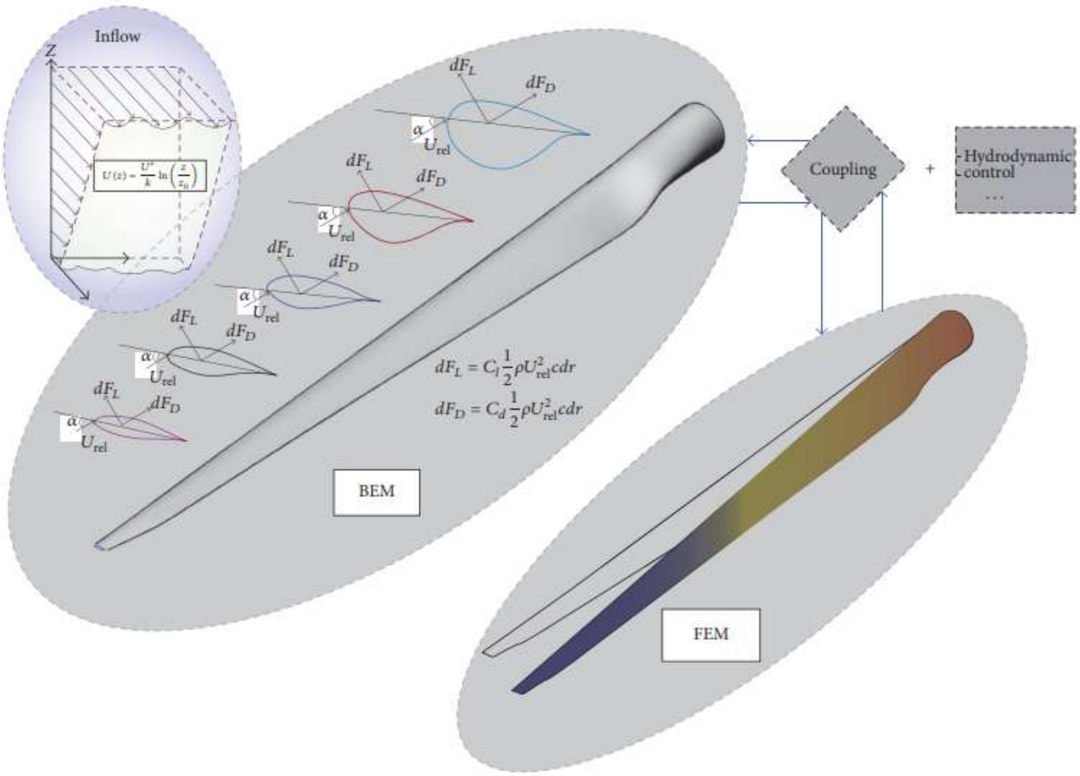

Figure 4: Typical aero elastic tool principle[6].

4. Model analysis

The model analysis was carried out and the natural vibration value was determined for each of the longitudinal, transverse and torsional phases. The model geometry is shown in figure 5. Optimizing the coarse network of the natural frequency is the foundation of the concept of network independency study as show in figure 6 shows the mesh in the model.

Figure 5:The mesh model geometry is shown in .

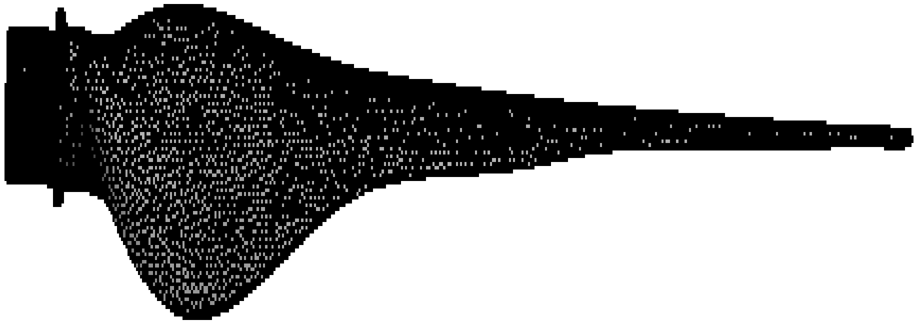

Figure 6: shows the mesh in the model.

To avoid any failure, the natural frequency of the wing must be kept away from the frequency of the force applied to it to avoid resonance. Table 1. Figure7 and Figure 8 shows the natural frequencies of the turbine wing.

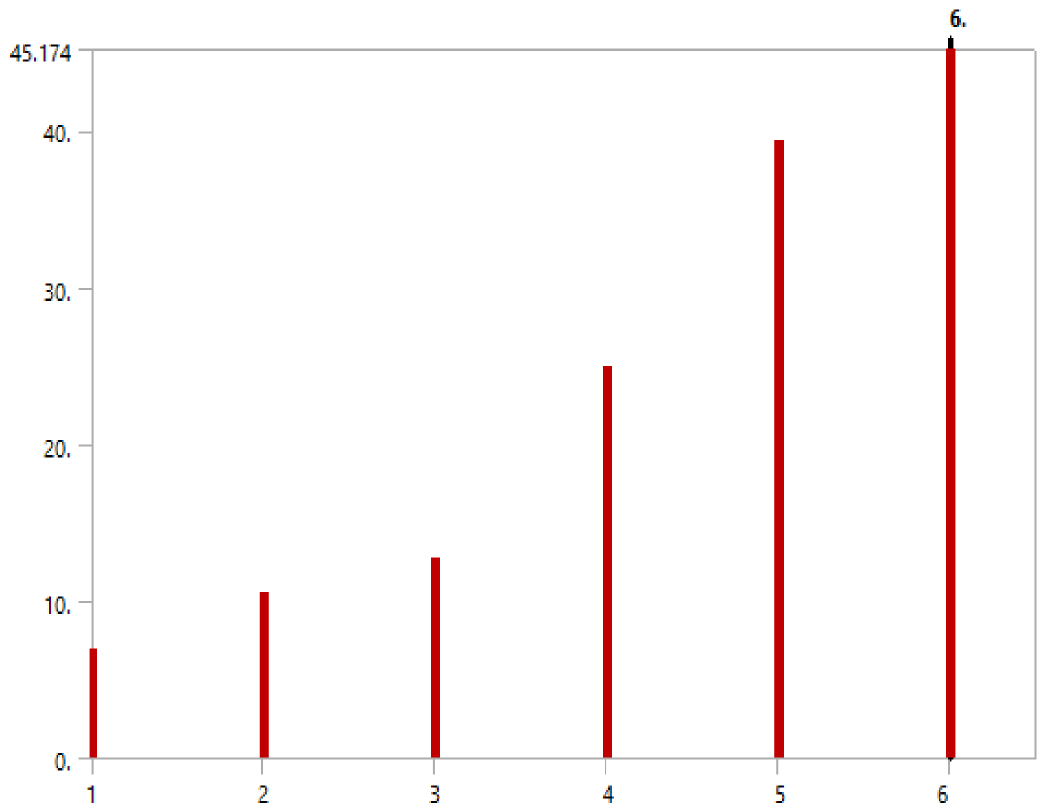

Figure 7: natural frequencies of the turbine wing

Table 1: natural frequencies of the turbine wing

Mode	Frequency [Hz]
.1	6.9571
.2	10.505
.3	12.694
.4	24.906
.5	39.376
6.	45.174

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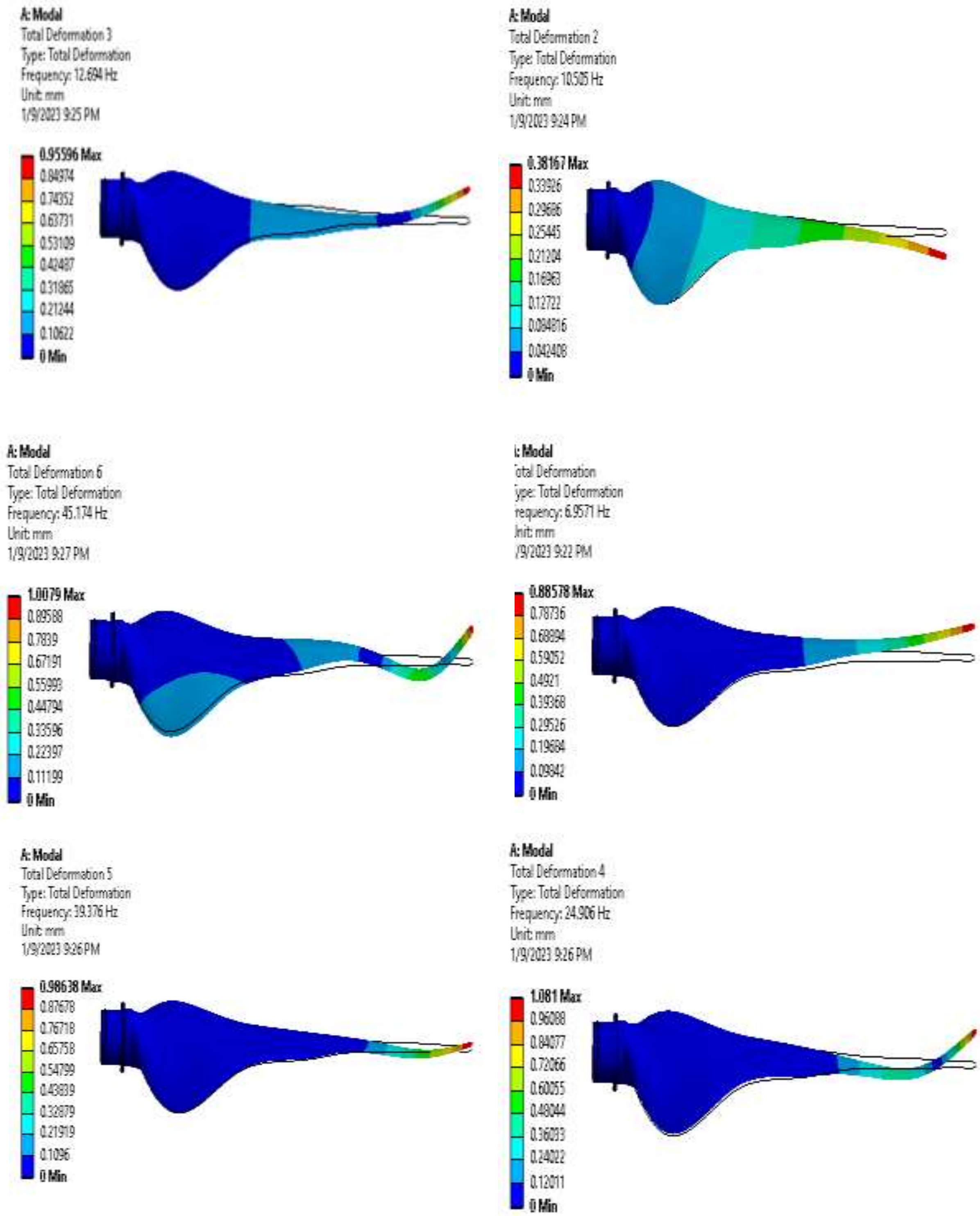

Figure 8: natural frequencies of the turbine wing (Mode Shape)

Conclusion

Particle image velocity measurements were used to assess the effect of the span wise spacing between neighboring vortex generators on the stream wise vortices' separation from the airfoil surface. This approach proved to be effective in both quantifying and visualizing the vortices' positions. The following findings were noted:

Usually one mode of vibration appears during the application of a force. It can be longitudinal (L), torsional (T), or bending (F). To create a new type of movement, it is also possible to combine these vibration modes. Three possible combinations of vibration modes; Torsional bending modes (TF), longitudinal bending modes (LF), and longitudinal torsional bending modes (LT) are effective in many contemporary applications.

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