10th World Congress on Structural and Multidisciplinary Optimization
May 19 -24, 2013, Orlando, Florida, USA

Topology Optimization of Section for Wind Turbine Blade

O-kaung Lim[1], Eun-Ho Choi[1], Eung-Young Choi[1], Jin-Rae Cho[2]

[1] Pusan National University, Busan, Korea, oklim@pusan.ac.kr
[2] Research and Development Institute of Midas IT Co. Ltd., Gyeonggi, Korea

With the instability of the global energy market caused by high oil price, as well as with the regulations of the climatic change convention, there is a worldwide increasing trend of demanding renewable energy and of replacing with it.

This research concerns the design of the wind turbine blade of wind power generator, which is a means of renewable energy production. Wind turbine blade is a core part for converting wind pressure to rotatory power, and there is an urgent demand for the securing of light-weight and durability. A heavier wind turbine blade causes the increase of load on the column or bearing support, resulting in the structural and functional damage to the whole wind power generator. Whereas a light wind turbine blade can exert an effect on the structural strength, because it is a thin plate with a composite structure consisting of core cells and outer tubes.

In the mechanical aspect, a wind turbine blade has the shape of cantilever and is assembled into the main body of wind power generator through a hub, and therefore a larger wind turbine blade causes a great increase of wind load on the wing. For this reason, it must not only be able to tolerate enormous bending moment and torsional load, but also have a structural strength high enough to resist extreme loads such as a squall. The external shape of the section of wind turbine blade takes the advantage of the NACA airfoil used for aircraft, since they are similar in the aerodynamic aspect. However, unlike the structure of the wing of aircraft, its inside is reinforced very simply with core cells. Accordingly, important design variables are the shape, number, installation location and thickness of the core cells. These design variables exert great effects on the structural strength and durability of the whole wind turbine blade.

This study conducted aerodynamics analysis on airfoil model DU25-A17 in order to figure out the optimum shape of the shear web structure on the section of the wind turbine blade and then performed topology optimization based on the result. In the aerodynamics analysis, to gain the pressure distribution on the surface of the blade, under the condition of cut-out wind speed with 25 m/s, two-dimensional CFD analysis was conducted by using the turbulent fluid flow as the FLUENT which passes through the transonic airfoil with the attack angle as 5°. In order to apply the inputted data calculated as the result of the aerodynamics analysis as the load data at the topology optimization of structural analysis, this study used the FSI mapping function internalized in the FLUENT and transmitted the result to OptiStruct, a program commercially used to conduct topology optimization. The load boundary condition for the topology optimization is applied as the nodal load of the mesh transcribed after the aerodynamics analysis in the fluid-structural coupled analysis, and the displacement boundary condition was analyzed with the inertia relief condition to deduce an optimum design plan of the core cell, the internal reinforcement structure of the blade.