Form 2

Dissertation Abstract

Report no.	(Course-based) No. 1072	Name	MD SABBIR ALAM
Dissertation title	Flapping Wind Turbine Using Chebyshev-dyad Linkage (チェビシェフリンク機構を用いた揺動型風車)		

Abstract

Designing the future challenge in energy demands and usage of green energy for sustainable environment, an interest in utilizing renewable energy is growing rapidly. Among all varieties of renewable energies, wind energy considered as the most valuable source of green energy. Traditional mechanics for extracting wind energy has been developed on horizontal axis wind turbines (HAWT) and vertical axes wind turbine (VAWT). To harness wind energy with high coefficients, horizontal axis wind turbines, like propeller-type wind turbines has the advantage in terms of practical utilization because of their scale merit. However, large size and high tip-speed ratio are inherently related to material strength problems and low-frequency noise emissions to the environment. In contrast to the traditional wind turbines, we employ a new concept by adopting flapping mechanics in the present research. The concept involves the unique flapping motion of a wind blade mounted on a Chebyshev-dyad linkage by which the wing transforms wind energy into mechanical rotation. The flapping wing works as a main wing of airplanes, so the system would have wide and impressive feasibility in the application. In our research flapping-type wind turbine driven at low speed and extraction of wind energy through flapping wing is a relatively new field of researcher's interest to be developed, and it will provide an exciting proposition for the wind turbine as it can extract the predictable amount of energy. The objective of our research is mainly focused on more environment-friendly slow flapping wind turbine which can easily operate in or near residential areas or rooftops due to its scale of merit with low-frequency turbine noise and safety consideration.

We developed a new flapping type wind turbine with introducing Chebyshev-dyad link mechanism by which the symmetric wing blade, NACA0012 can transform the wind energy to mechanical rotation through unique motion. The working principle of this wind turbine is mainly lift and drag based, namely flapping wind turbine (LDB-type). A large angle of attack inevitably appears in a certain region, in this case, the wing enters a stall but maintains a large lift coefficient. On the other hand, the drag coefficient also becomes large owing to the stall. By designing a suitable trajectory, we can obtain an effective driving force for the design as an advantage. The results of primitive optimization for determining the fundamental characteristics of motion and the trajectory of the wind turbine blade are demonstrated to obtain smooth rotation of the generator-driving shaft. The feasibility of "figure eight" trajectory diversity is discussed along with geometrical parameters. Assuming one-blade motion with a variable trajectory for optimization, the smooth motion and required torque at slow rotation speeds are studied briefly. The generation of torque developed for one complete rotation found to vary due to the variation of wing blade movement in a unique trajectory with the variation of attack angle. The torque developed from static analysis has been compared with the dynamic analysis for the verification of the simulation model and the results make a good agreement. The prototype model of flapping wind turbine (LDB-type), has been developed for the experimental study and the investigation carried out to analyze the basic performance of the wind turbine. Also, the results obtained from numerical simulation and experimental investigation are compared.

In general, lift based wind turbine show good aerodynamic performance in turbulence environment. During flapping motion of the turbine, the angle of attack changes continuously and the stall occurs due to the flow separation with large attack angle. In the next phase of our research study, we are focusing on lift based slow flapping wind turbine operated within a small attack angle amplitude named as the flapping wind turbine (LB-type). In this design, a unique trajectory for the wing blade motion is projected using the Chebyshev dyad linkage mechanism. Also, the wind energy transferred to mechanical rotation through the single wing blade NACA0012 as

same airfoil profile in previous design. To obtain a smooth flapping motion for the wing blade using Chebyshev-dyad linkage, we optimize all fundamental parameters with our developed simulation model to obtain the optimum performance from the turbine. Both static and dynamic analysis has been conducted to confirm the feasibility of the present design. Wind turbine performance also studied for a suitable range of free stream wind velocities. Also, we made a simple comparative study of the results obtained from lift and drag based flapping wind turbine with lift based flapping turbine operated within small attack angle amplitude in motion. Finally, it has been shown that. both flapping wind turbines can be driven at low speed with a suitable energy conversion rate with decent average power coefficient. Furthermore, the shape and size of the flapping wind turbine are possible to increase for more power generation depending on the region of turbine installation without affecting the objectives of the wind turbine. Moreover, the practicality of operating environment friendly slow flapping-type wind turbines is demonstrated, focusing on usage near residential areas or on rooftops owing to lower noise.