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Delegates are invited to meet and discuss with the poster presenters in this topic directly after the session 'Aerodynamics and rotor design' taking place on Wednesday, 12 March 2014 at 09:00-10:30. The meet-the-authors will take place in the poster area.

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Presenter's biography

Biographies are supplied directly by presenters at EWEA 2014 and are published here unedited

HoSeong Ji has completed his Ph.D. in the fields of Wind Engineering at 2001 from Pusan National University and Postdoctoral studies from University of Tokyo. He is the PI of the INNOPOLIS Foundation of Korea Government (Ministry of Science, ICT & Future Planning) (B2013DD0031), the title of the research work is [Novel Spiral Type Urban Small Wind Generation System Commercialization using Hybrid Complex Technology]. And He has published more than 30 papers in reputed journals.

Abstract

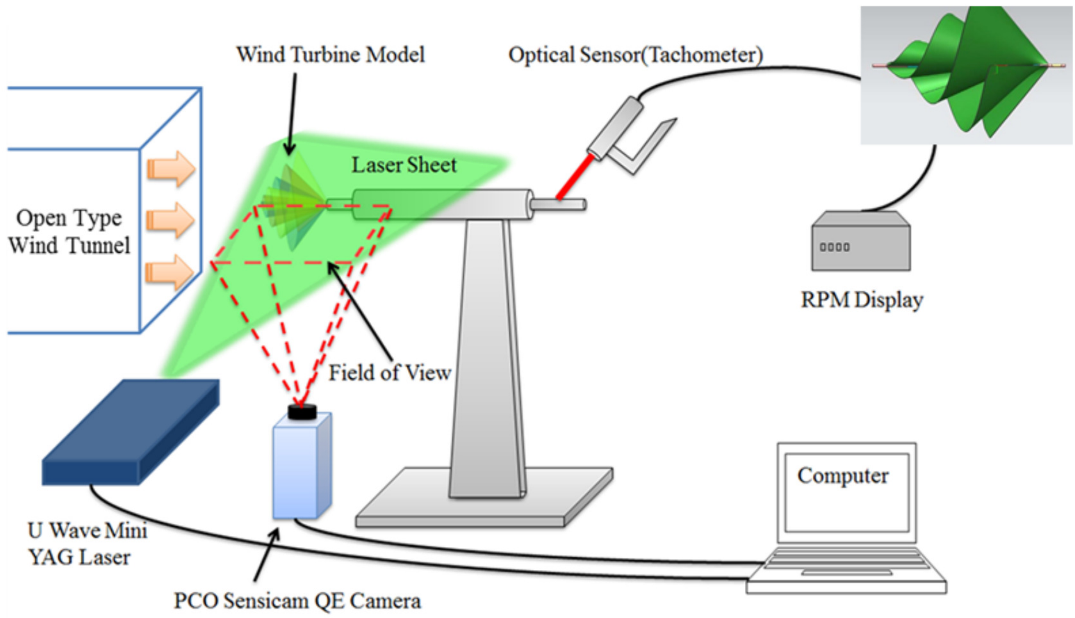
Aerodynamic characteristics of an archimedes spiral wind turbine blade according to the angle of attack change

Introduction

The aerodynamic characteristics of Archimeds Spiral Wind Turbine for small scale wind turbine system were investigated experimentally with respect to the angle of attack in the case of counterclockwise direction and clockwise direction. The flow characteristics around the blade tip were visualized using PIV technique and scale down wind turbine model. And power coefficient and aerodynamic power were investigated using real spiral model.

Approach

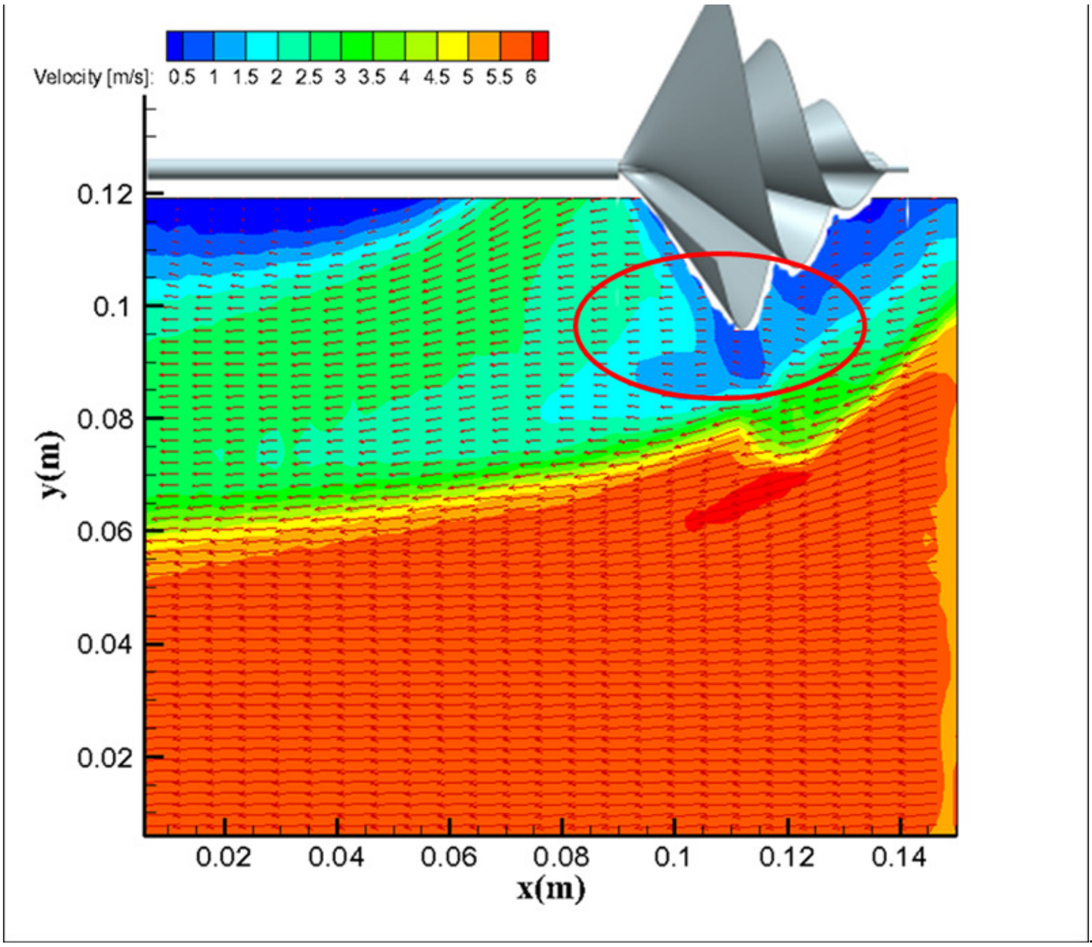
To invetigate detailed flow structures, the scale downed experimental blade model of the Archimedes spiral wind turbine of the 0.5 Kw class wind turbine was employed. The experimental blade model was manufactured by a rapid prototype (RP) 3D printer and a polymer has been selected as the blade material.
To investigate the aerodynamic characteristics and evolution of the tip vortex structures in the near wake of the Archimedes spiral wind turbine, PIV system employed in this study for quantitative flow visualization was consisted with Mini YAG laser (U wave), Digital 12 bit CCD camera (PCO sensicam QE) with 60mm lens, Laskin nozzle for olive oil aerosol generation



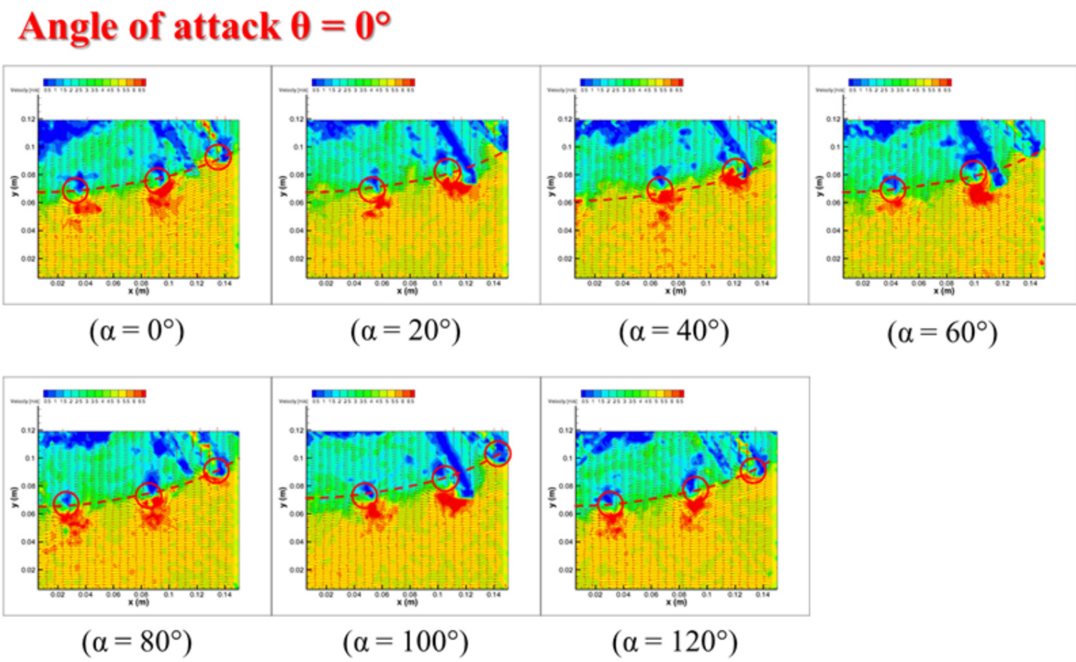
. The quantitative flow visualizations were carried out wind speed and angle of attack change. The angles of attack were controlled from 0°to 30° (with 5°interval) for both clockwise and counter clockwise directions. The laser beam, generated from the U wave mini-YAG laser, was transformed into a light sheet (1 mm thickness) using cylindrical and spherical lenses.
A digital 12bit CCD camera (PCO sensicam QE camera) fitted with 60mm lens was setup vertically under the Archimedes wind turbine to capture particle images in x-y planes. The instantaneous images provide the relationship between tip vortex structures and tip-speed-ratio in detail, and the vorticity of tip vortex was calculated to examine the turbulent flow structures in order to gain further insight into the aerodynamic characteristics of turbulent vortex flows in the near wake of the Archimedes spiral wind turbine blade model.
The aerodynamic characteristics on real model were experimentally investigated. The experiments were carried out in large wind tunnel with 4m×2m as a test section. The flow was controlled from 6m/s to 12m/s with 3m/s step. With the aerodynamic characteristics measurements, electric power generation through the experimental model was also carried out in same wind tunnel facility.

Main body of abstract

The number of cases for the PIV experiment is 28, in which angles of attack 0°, 5°, 10° and 15° for both clockwise direction and counter clockwise direction at four different flow velocity conditions. In each case of the PIV experiment, 2,000 instantaneous velocity fields were obtained. The field of view to obtain the velocity field was 150 mm by 120 mm which corresponds to 1280 by 1024 pixels in CCD camera. Velocity vectors were interrogated using two frames cross correlation method and post processing of the data was accomplished using PIVACE house coded. The X-axis represents the stream wise direction of the incoming airflow in the field of view, and the Y-axis represents the span wise direction, perpendicular to the X-axis from the light sheet of the laser to the experimental wind blade model. Instantaneous velocity fields and the ensemble averaged velocity fields were obtained by using the in-house PIVACE post processing software



The aerodynamic characteristics, such as tip vortex structure, turbulent kinetic energy distribution, and near wake structure can be revealed by the obtained PIV experimental data. Mean velocity field and instantaneous velocity field at different phase angle of the blade were compared to investigate the effect of wind direction. To investigate the aerodynamic characteristics in the near wake of the blades instantaneous velocity fields at different phase angles were obtained using the PIV experiment



Especially, it is useful and helpful to understand tip vortex flow structure. The aerodynamic characteristics at different relative positions of the Archimedes spiral wind turbine blades can be shown by the contours of instantaneous velocity and vorticity fields for different phases during the processing of the rotating of the blades more comprehensive. Most of the horizontal-axis wind turbines which include the Archimedes spiral wind turbine have three centrosymmetry blades. It means that there are three same processes during one cycle. For one process of the blade of the wind turbine, the range of phase angle is 120°. Because of the three centrosymmetry blades structure of the Archimedes spiral wind turbine, the range of the phase angles was selected from 0° to 120°. The contours of instantaneous velocity and vorticity fields, which obtained at different phase angles from 0° to 120° in the case of 0° angle of

by the blade position and the time for one revolution of the blades at a given condition. It is easy to find the signature of tip vortex and its evolution process near the outermost blade of the Archimedes spiral wind turbine with respect to the phase angles change at the incoming airflow velocity is 5.5 m/s. The distance between two vortices is about 0.76 R (R is the radius of the wind turbine). The spacing between two vortices can be changed with the incoming velocity and the rotating velocity.
The other experiments on real spiral wind turbine model were carried out at large wind tunnel with 4m×2m (width×height)as a test section

. The maximum aerodynamic power coefficients for real wind turbine model
with Archimedes spiral shape were investigated 0.52, 0.48, and 0.49 in the case of 6m/s, 9m/s and 12m/s as incoming flow, respectively. The maximum aerodynamic power coefficients were observed approximately 2.2~2.5 as Tip speed ratio. And the output power for each experimental conditions was investigated 123.8watt, 382.3watt and 915.9 watt, respectively.

Conclusion

An experimental study has been conducted for the effect of wind direction on aerodynamic characteristics of Archimedes spiral wind turbine. Measurements of rotating velocities and velocity field in the near wake using PIV technique have made for the range of incoming airflow velocity, 4.5m/s ~8.5m/s, and for the range of different angle of attack, 0° ~15°, in both clockwise and counter clockwise direction. And the experimental investigation on the aerodynamic characteristics of Archimedes Spiral Wind Turbine as 0.5kW class were also carried out for the incoming airflow velocity, 6m/s, 9m/s and 12m/s, respectively. Conclusions are summarized as follows:
1. The formation and evolution of the tip vortex with respect to the position of the blades are revealed by a series of the instantaneous velocity fields obtained at different phase angles of the wind turbine. The signature of tip vortices generated from each blade is clearly observed for the range of 0° to 120° phase angle. The spatial distance between the tip vortices generated from each blade is quite uniform in cases of small angle of attack.

2. The formation and evolution of the tip vortex with respect to the position of the blades are revealed by a series of the instantaneous velocity fields obtained at different phase angles of the wind turbine. The signature of tip vortices generated from each blade is clearly observed for the range of 0° to 120° phase angle. The spatial distance between the tip vortices generated from each blade is quite uniform in cases of small angle of attack.

3. The maximum power coefficients for each experimental condition was investigated apporximately 0.52, 0.48 and 0.49 for a tip speed ratio, respectively. And the maximum aerodynamic output power was investigated as 915.9Watt in the case of 12m/s wind velocity.

4. The results from this research provide a useful information to find an optimal installation position of the Archimedes spiral wind turbine especially on the root of a building in which upward wind flows in usual.

Learning objectives
More higher Power Coefficient in the small scale wind turbine fields to householder or small business.
Power generationable characteristics and initial rotational characteristics at low wind velocity.

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