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Experimental Study of Aerodynamic Characteristics for Horizontal Axis Wind Turbine and Performance Evaluation

[1]Dai Yuanjun and [2]Wen Caifeng
[1]Xinjiang Ploy Technical College, Urumqi 830091, China
[2]Hohhot Vocational College, Hohhot 010051, China

Abstract: This study using two different airfoil of horizontal axis wind turbine in order to evaluate the performance good or bad with unit area of power generation. First, under the low speed wind tunnel, two different airfoil of horizontal axis wind turbine on experimental study of the aerodynamic characteristics, got the power curve of wind turbine; Then, based on the wind resource date in 2008 from four areas in Inner Mongolia, which was provided by the China meteorological date sharing service system, the local wind resources were estimated by using Wasp software and the wind atlas could be obtained by analysis and calculation. On the digital map of a given area, the simulated wind turbine station was established. Finally, the annual energy production per unit area of two different airfoil of horizontal axis wind turbine in order to evaluate the performance. The results showed that: in the actual wind farm wind turbine of the new airfoil than wind turbine of the NACA4412 airfoil on wind turbine generating capacity per unit area evenly increased by 28.4%.

Key words: Aerodynamic characteristic, annual energy production per unit area, power characteristic, WAsP, wind atlas

INTRODUCTION

For given Different wind turbine airfoil and how to evaluate the performance of wind turbine is engineering practice problem. That this study solves this problem is which in the actual wind farm simulate wind turbine power generation per unit area to evaluate the amount of different wind turbine airfoil, but the annual generation volume is about how to control the wind turbine (Gu, 2006). As wind energy has low energy density, poor stability of the shortcomings, it is difficult to accurately determine the wind turbine's power output (Alexiadis *et al*., 1999). (Justus *et al*., 1999) proposes the methods for estimating wind speed frequency distributions. In this study, using WAsP software, based on wind tunnel experiment of aerodynamic characteristics of wind turbine power characteristics and the China Meteorological Data Sharing Network of the local wind resource data, making use of WAsP OWC Wizard tool, area of a year wind data was analysised, which want to install wind turbine, obtained the wind spectrum, including the Weibull wind speed and wind direction rose diagram frequency distribution curve. Weibull wind speed frequency distribution curve was proved to be a simple form and can fit well the actual situation of the probability model, fitting the results of a relatively high accuracy (Justus *et al*., 1999; Jaramillo *et al*., 2004; Li *et al*., 1998; Xu *et al*., 2007), so the Weibull equation can represent the mean wind speed (Zinger and Muljadi, 1977); Then the actual wind farm in the local digital map, according to the given coordinates of the location of wind turbine installation, established and simulated wind turbine station in order to solve the wind turbine generating capacity and annual power generation of unit area.

In this study, we have a research of the aerodynamic characteristics experiments adopting two different horizontal axis wind turbines through wind tunnel tests. The two wind power characteristic curves of wind turbine and wind speed wind power coefficient curves were obtained. The results show that the 2# wind turbine airfoil can meet the turbine output, while increasing the utilization of wind turbines on the wind. It reaches the high power factor design requirements at all the series of wind speed as well as increase the output power.

METHODOLOGY

Experiment of aerodynamic characteristics for wind turbine:

Experimental equipment: Experimental equipment consists of low-speed openings DC wind tunnel, 9033G test module, a few wind turbine and so on. The wind tunnel experiments for the B1/K2 low speed wind tunnel, is divided into opening paragraph and closed paragraph, adjust the speed using digital inverter technology, inverter frequency range of 0.0~60.0 Hz. The round Cross-s

Corresponding Author: Dai Yuanjun, Xinjiang Ploy Technical College, Urumqi 830091, China

Table 1: The parameters of wind turbine

Model parameter	1# wind turbine	2# wind turbine
Blade number	3	3
Wind turbine diameter/m	1.5	1.4
Airfoil profil	NACA4412	a new airfoil profil
Rating power/W	400	300
Rating wind speed/m/s	12	10
Generator	The same magneto generator	

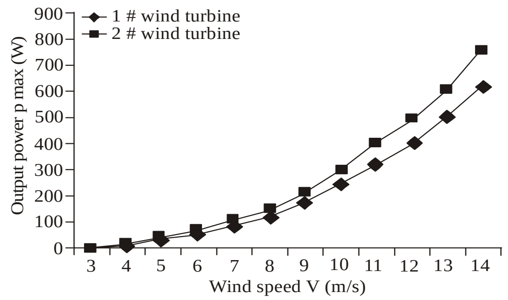

Fig. 1: Power curve of wind speed

ectional diameter of wind tunnel Open test section is 2.04 m. Speed adjustment is range of 0~18 m/s. The 1# wind turbine of 400W is produced by a company, the 2# wind turbine of 300W is designed and manufactured by using the new wind turbine airfoil, conduct experiment of the aerodynamic characteristics. The parameters shown in Table 1.

Experimental methodology: By the experiments of two wind turbine, the power curve of wind speed were obtained, shown in Fig. 1.

It can be seen from Fig. 1, the output power of the 1# wind turbine at rated wind speed 12 m/s is 405.3W, the output power of the 2# wind turbine at rated wind speed 10 m/s is 303W. They have reached the design condition requirements. The output power of the 2 # wind turbine in wind speed 3-14 m/s is larger than the output power of the 1 # wind turbine.

ESTABLISHMENT AND ANALYSIS OF THE WIND SPECTRA

Wind spectrum is a regional independent factor, in addition to the wind conditions characteristic of terrain and obstacles. According to China Meteorological Data Sharing Network in Inner Mongolia in 2008 to provide 24 regional wind resource data, using statistical analysis software WAsP to elect a representative of characteristics of four regions, namely, Abagaqi, Bayanmaodao, Zhurihe

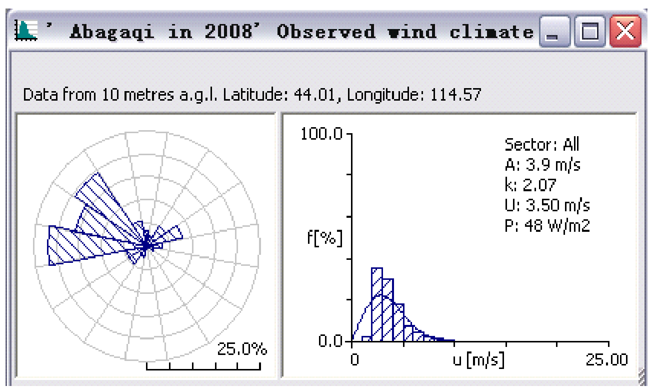

Fig. 2: Abagaqi area wind atlas in 2008

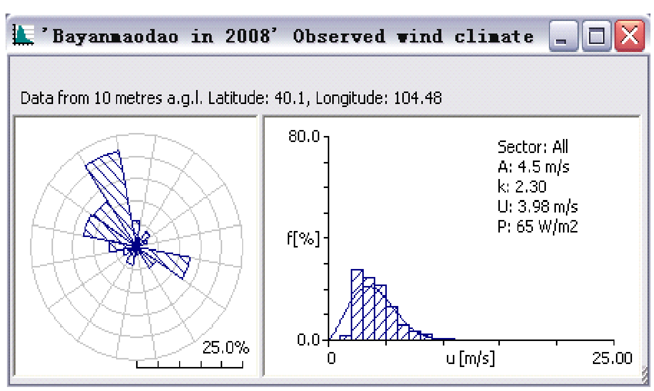

Fig. 3: Bayanmod area wind atlas in 2008

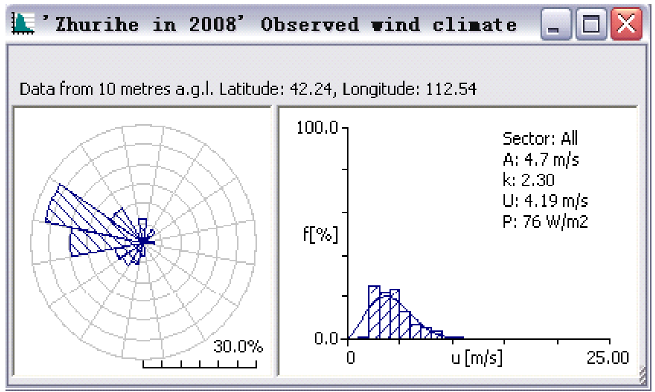

Fig. 4: Zhurih area wind atlas in 2008

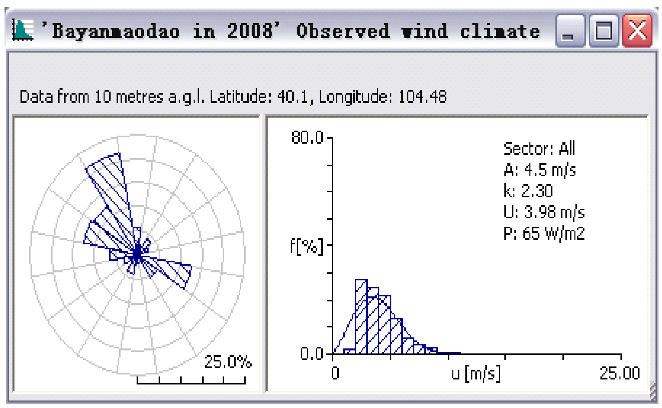

Fig. 5: Hailis area wind atlas in 2008

and Hailisu, more than four areas of analysis, the relevant parameters of the wind spectrum, for the calculation of annual power output of wind turbine to provide data.

Using WAsP OWC Wizard tool, first, the original wind speed and direction data of wind turbine to be installed were imported in a time sequence in one yea;second, input the data though which obtain the location of wind resources and the height of equipment from the ground level. The height of equipment mainly refers to the actual point of longitude, latitude, local standard atmospheric pressure, temperature and altitude. Then the units conversion factors, upper and lower wind speed and wind direction 16 were set. Finally the wind spectrum was obtained by calculation. The wind spectrums of 2008 in Abagaqi, Bayanmaodao, Zhurihe and Hailisu regions were shown in Fig. 2 to 5 by analysis according to the steps above. The average wind speeds of Abagaqi, Bayanmaodao, Zhurihe and Hailisu are 3.5, 3.98, 4.19 and 4.94 m/s respectively from the Fig.2 to 5.

Wind turbine stations established: First, using WAsP Map Editor tool in the digital drawing board, or graphics file on the scanned map.

The required map which the mouse select directly generate that WAsP can accept map file; and then the coordinates of wind turbine station were provided: Abagaqi is 44.01 degree north latitude, 114.57 degree east longitude and 112.61 m above the sea; Bayanmaodao is 40.10 degree north latitude, 104.48 degree east longitude and 132.39 m above the sea; Zhurihe is 42.24 degree north latitude, 112.54 degree east longitude and 115.08 m above the sea; Hailisu is 41.24 degree north latitude, 106.24 degree east longitude and 150.96 m above the sea. According to the given coordinates the locations of the wind turbine stations were calibrated on a map; At last the obstacle parameters and surface roughness parameters were set according to surrounding of the wind turbine situations. The wind turbines were installed in scenery four regions of very little obstacles, which are the Gobi, grasslands and other very open flat area in Inner Mongolia. The parameters of the obstacles is 0 to 0.5 of from the smallest housing construction to the largest wind trees, so this study select that the barrier parameters of building construction are 0, roughness1.

Calculation and analysis of power generation of wind turbine: Using the wind spectrums of the four regions in

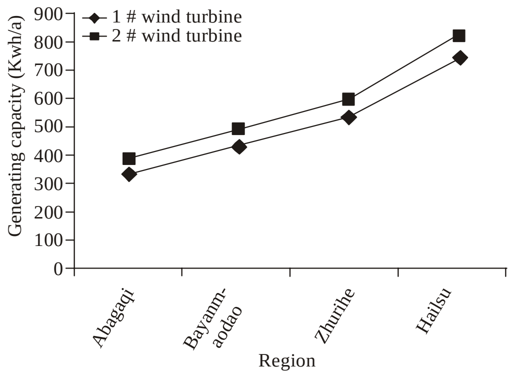

Fig. 6: Generating capacity of wind turbine

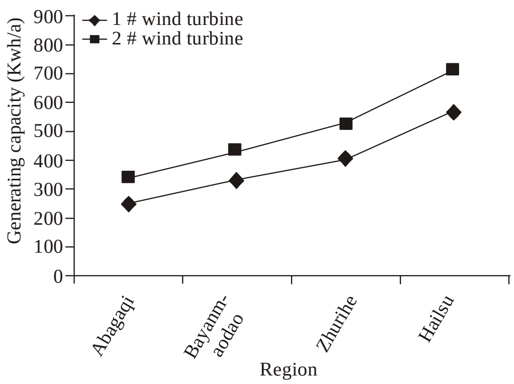

Fig. 7: Annual power output per unit area of wind turbine

2008 and the power curves of two wind turbine, the generating capacity and annual power output per unit area of two wind turbine were calculated in four regions. They were shown in Fig. 6 and 7

Figure 6 and 7 shows that wind generating capacity per unit area of the 2# wind turbine was significantly greater than wind generating capacity per unit area of the 1# wind turbine in Abagaqi of the annual average smaller wind speed, or the annual average larger wind speed. The study makes known that the 2# wind turbine of new airfoil increases the power output, that is, the annual energy output per unit area is improved in the actual wind field. By calculation and analysis, compare the 2# wind turbine with the 1# wind turbine, the power generation per unit area of the 2# wind turbine were increased by 30.6, 29.1, 27.7 and 26.5% in the four wind farm of average wind speed from low to high. The mean value of the power generation per unit area is 28.4%. It indicates that the performance of the 2# wind turbine is better than the performance of the 1# wind turbine.

CONCLUSION

In this study, aerodynamic characteristics experiments were carried adopting two different horizontal axis wind turbines through wind tunnel tests. The two wind power characteristic curves of wind turbine and wind speed wind power coefficient curves were obtained. the results show that the 2# wind turbine airfoil can meet the turbine output, while increasing the utilization of wind turbines on the wind. It reaches the high power factor design requirements at all the series of wind speed as well as increase the output power.

Wind energy resources of the Inner Mongolia Abagaqi, Bayanmaodao, Zhurihe and Hailisu in 2008 were assessed using WAsP software. The annual generating capacity of wind turbine and annual power output per unit area of wind turbine #1 and #2 were calculated by analysis. The results show that 2# wind turbine power generation unit area increased by 28.4% compared with the #1 wind turbine generating capacity per unit area. It is indicated that the performance of 2# wind turbine is better than #1 wind turbine.

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