

Effect of Pitching on Aerodynamic Loads for Floating Wind Turbines

Yong-gang Li, Ji-hua Mo, Yan-ping He, Qing He
 State Key Laboratory of Ocean Engineering, Shanghai Jiao Tong University
 Shanghai, China

ABSTRACT

When analyzing the aerodynamic loads of floating wind turbines, most professional programs didn't consider the motions of foundation. Therefore, deviation is present inevitably. This paper is mainly focused on the effect of pitch motion on the aerodynamic loads and output power performance of the floating wind turbine. Pitching response of the floating foundation was figured out and a comparison was made between aerodynamic loads calculated under pitch motion and the calculation results of fixed wind turbines. The results show that the generator power fluctuates more widely and the flap of the blades is more acute due to pitch motion.

KEY WORDS: Floating wind turbines; Blade element momentum theory; Pitch motion; Aerodynamic loads.

NOMENCLATURE

a	Axial induction factor
a_{skew}	Axial induction factor with skewed wake
a	Tangential induction factor
B	Number of blades
c	Chord length
C_d	Drag coefficient
C_l	Lift coefficient
C_T	Thrust coefficient
F	Loss correction factor
r	Local radius
R	Rotor radius
R_{hub}	Hub radius
U_∞	Mean wind speed
α	Local angle of attack
β	Local element pitch angle
γ	Yaw inflow angle
θ	Platform angle
φ	Local flow angle
λ_r	Local tip speed ratio
σ	Local solidity
χ	Rotor wake angle

ψ	Azimuth angle
Ω	Rotor rotational speed

INTRODUCTION

There is a large reserve of wind energy on earth. Wind energy is a kind of clean energy which is renewable and friendly to the environment. The exploitation and utilization of wind energy is of great importance to the sustainable development of our human society.

For the purpose of reducing the cost and commerce application of wind power generation, high power generator is used more and more widely. Considering the effects on environment and the quality of wind energy, installing high power generator in the deep sea has become the general trend.

As the water depth increases, the cost of construction, installation and maintaining of the fixed foundation such as jacket platform and gravity platform rises sharply. It will make a significant impact on the economical efficiency. In consequence, floating foundation is commonly applied where the water depth exceeds 50 meters. There are several types of floating foundations, including TLP, SPAR, semi-submersible, etc (Jonkman, 2007).

When aerodynamics of the wind generator is researched, the flow field is usually considered as a steady flow which is vertical to the rotor plane. However, the flow of wind is actually very complicated, containing both periodic components, such as mean wind speed, yaw control, influence by the tower shadow, etc, and non-periodic components, such as turbulence and wake.

The flow field of a floating horizontal axis wind turbine is more complicated than that of wind turbines on land or fixed offshore wind turbines. The translational motion (heave, sway, surge) and rotational motion (yaw, pitch, roll) of the floating structure (Thomas and Matthew, 2010) will change relative direction and relative speed between the rotor and wind. As a result, skewed wake should be taken into consideration. The variety of the displacement and velocity is great even though the wind turbine is under normal working condition, which will certainly influence the loads and performance of the wind turbine. Meanwhile, pitch of the tower will intrigue vibration of the rotor along axial direction, which will affect the wake field. Therefore, the loads and performance of the wind turbine will change, too.