Dynamics of a Floating Wave Energy Platform with Three Wind Turbines Operating

†Torben J. Larsen, †Bjarne S. Kallesøe and ‡Hans F. Hansen

†Risøe National Laboratory, P.O. Box 49, Technical University of Denmark, Roskilde, Denmark, ‡Danish Hydraulic Institute, Ports and Offshore Technology, Hørsholm, Denmark

ABSTRACT

In this paper we present a comparison between simulated and measured loads and dynamic motions for the floating wave energy platform Poseidon equipped with three wind turbines. In order to simulate the response of the system, the aeroelastic code HAWC2 which is state-of-the-art within wind turbine simulation has been extended to handle multiple rotors and is coupled to the time-domain diffraction/radiation solver for floating systems WAMSIM from the Danish Hydraulic Institute.

KEY WORDS: loads; wind turbine; control, aeroelasticity, floating, waves.

INTRODUCTION

The Poseidon consists of a floating platform with a turret mooring system that allows the platform to align according to the wind and wave direction. The wave energy is absorbed using a set of floaters that convert the wave energy to pressurized water flow using a double function piston. On the platform three turbines are mounted increasing the energy yield of the full system. A 37m wide prototype is build and is being tested in the waters south of Denmark. Three Gaia 11kW turbines are operating on the platform. These turbines are two bladed in downwind configuration with teeter hinge, fixed pitch stall control and has a passive yaw system that align the single rotor towards the incoming wind. The configuration of the wind turbines are with two turbines in the front and one turbine further downwind and in between the first two, seen from the wind.

In order to simulate the response of the system, the aeroelastic code HAWC2 (Larsen and Hansen, 2007) has been extended to handle multiple rotors and is coupled to the time-domain diffraction/radiation solver for floating systems WAMSIM from the Danish Hydraulic Institute. WAMSIM again uses WAMIT by MIT to calculate the hydrodynamic properties of the system. The mooring lines have in this paper been modeled using a static non-linear mooring line characteristic. The simulation complex allows for a full dynamic time simulation of the platform in waves with three turbines operating in turbulent inflow. Since one turbine is located behind the two others, the wind condition for this turbine can be quite different due to wake effects. Depending on how well the platform alignment towards the incoming wind is. These effects are included using the Dynamic Wake Meander model where the wakes of the upstream turbines are modeled as areas of reduced wind speed with an increase of high frequent turbulence. The wave extracting floaters are still not modeled, hence comparison between measurements and simulations are performed for cases where the wave energy extraction is zero, all three turbines are operating in turbulent wind and the platform is affected by wave loading.

THE POSEIDON PLATFORM

The Poseidon consists of a floating wave extraction platform with a turret mooring system that allows the platform to align according to the wind and wave direction. The platform consist of six water channels separated by closed hull constructions giving the necessary buoyancy. In each channel one or two floaters are installed and connected to a double function piston that moves due to the waves passing. These floaters are filled with an amount of water dependent on the wave size in order to create resonance between wave and floater to maximize efficiency for the size of waves present. A big horizontal plate is mounted below as a water entrapment plate increasing the water added mass of the construction significantly. It also increase the wave energy converter efficiency since the waves are compressed between the plate and the floaters at the wave surface. Three wind turbines are mounted on top of the platform increasing the energy yield of the full system.