Multibody Analysis of Floating Offshore Wind Turbine System

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Introduction

As waters around Japan is mostly deeper, deployment of floating offshore wind turbine is necessary. Toward widespread use of floating offshore wind turbine in Japan, authors focus on load analysis of drivetrain components on floating offshore wind turbine. This research is performed under Development of next-generation floating offshore wind turbine systems in NEDO and project scope is development of low cost floating wind turbine for shallow water.

Analysis model

In our research, four different floater concepts (TLP, semi-sub, pontoon and spar [see Figure 1]) are analyzed and the obtained results are compared with the result on land based wind turbine. Specification of RNA and tower is summarized in Table 1. We revised the NREL 5MW model[1] as the common RNA and tower model which is used for all floater concepts.

To identify critical drivetrain components on design process of floating offshore wind turbine, we constructed ADAMS multibody drivetrain dynamics model. The model structure and its topology are shown in Figure 2.

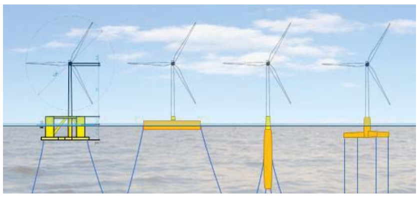

Figure1 Four different floater concepts in this study

Specification of 5MW RNA and tower（red font is revised part from NREL 5MW baseline model）

Rated Power	5	[MW]
Rotor	Upwind , 3Bladed	
Control	Variable speed, Collective Blade pitch	
Drivetrain	High Speed, Multiple-Stage Gearbox	
Rotor diameter and Hub diameter	126, 3	[m]
Hub Height	83.1（=80.7+2.4）	[m]
Cut-in, rated and Cut-out WSP	3.0, 11.4, 25.0	[m/s]
Cut-in and rated rotor speed	6.9, 12.1	[rpm]
Circumferential speed	80	[m/s]
Overhang, Tilt and Precone	5 5（tilt）, 2.5（precone）	[m] [deg.]
Rotor, Nacelle and Tower mass	110,000, 240,000, 514,000	[kg]

Table 1 RNA Specification

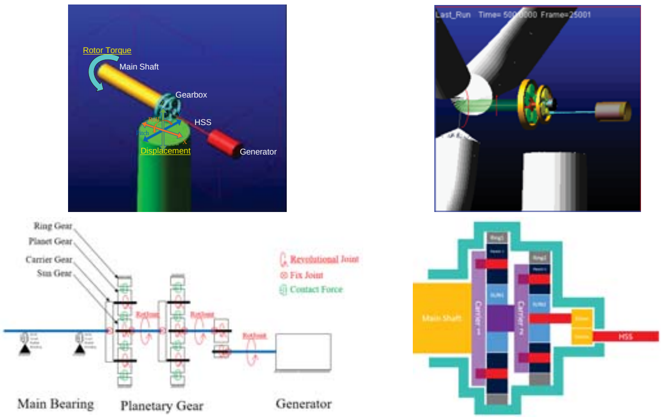

Figure2 Drivetrain analysis model

Analysis condition

For our comparison study, DLC1.2 of rated WSP condition which is most likely to have the large load fluctuation, was chosen as analysis condition. Wind and wave condition are summarized in Table 2. We have two steps for our drivetrain analysis. The first step is FAST[2] simulation for the whole system of floating type offshore wind turbine. In the next step ADAMS drivetrain dynamics simulation is performed and the obtained FAST time series result of tower top displacement and hub load is used as boundary condition of ADAMS Drivetrain model.

Wave		Wind	
water depth	150 [m]	Hub height WSP	12 [m/s]
wave model	NSS (Normal Sea State)	TI : Iref	Class IB
wave spectrum	Pierson-Moskowitz	inclination angle	0 [deg]
current	NA [m/s]	wind shear	0.14
Significant wave height	1.73 [m]	yaw misalignment	0 [deg]
peak spectral period	6.6 [sec]	Turbulence model	Kaimal

Table2 Analysis condition in FAST

Results

Normal operation condition with average WSP of 12[m/s] is analyzed and the results are compared between four different FOWT(TLP, semi-sub, pontoon and spar) and land based WT.

As seen from FAST result of rotor torque and speed fluctuation indicates in Figure 4, controller is suitably tuned for FOWT. Different order of Sun-gear bending moment fluctuation is obtained due to the platform pitch motion of FOWT in Figure 6.

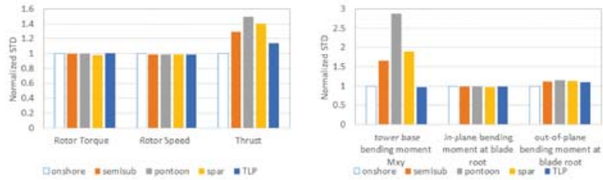

Figure 3 Fluctuation on Rotor Torque, Thrust, Rotor Speed and Moment by FAST

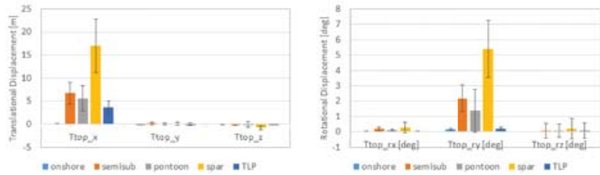

Figure 4 Comparison of tower top motion by FAST

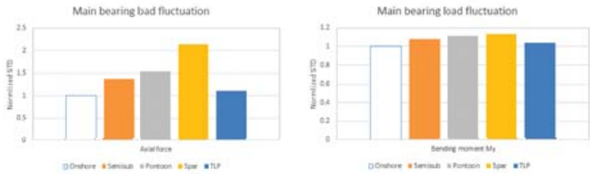

Figure 5 Load fluctuation of main bearing by ADAMS

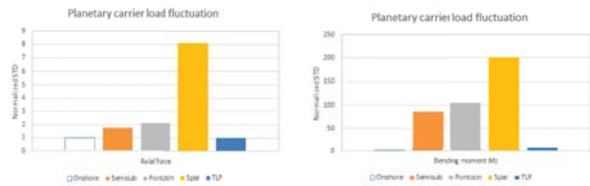

Figure 6 Load fluctuation of sun gear by ADAMS

Conclusion

Multibody simulation model of floating offshore wind turbine system is constructed and we carried out load analysis of Drivetrain components for floating offshore wind turbine. Different order of bending moment fluctuation is obtained due to the platform pitch motion of floating offshore wind turbine.

Verification work for new load reduction concept is continued for further advanced drivetrain model of floating offshore wind turbines.

Acknowledgement

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Reference

1. J. Jonkman et. al., Definition of a 5-MW Reference Wind Turbine for Offshore System Development, NREL/TP-500-38060, 2009.
2. J.M. Jonkman and M. L. Buhl Jr., FAST User's Guide, NREL/EL-500-38230, 2005.

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