The Design of Semi-submersible Wind-Tidal Combined Power Generation Device

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***Abstract*— Energy shortage is becoming more and more severe worldwide, so does the environment pollution. Conventional fossil fuels is not sustainable and the storage capacity is decreasing faster than ever before. The exploitation and utilization of renewable energy has become an effective measure to deal with the present energy shortage situation. In order to improve the power production capacity, power output quality, income investment ratio, the comprehensive marine energy has become a new trend of marine renewable energy. At present, the research of offshore renewable energy power generation devices mainly focuses on tidal energy, wave energy and offshore wind energy. For the scale deployment of offshore renewable energy power generation device, safe and reliable platform is essential. The development of safe and reliable, cost effective platform is the basis of the whole industry. Furthermore, single renewable energy power generation device limits the development of the industry due to the poor stability and low income investment ratio. To solve the above problem, a new type of Wind-Flow combined power generation device was designed, including turbine and the wind turbine design. Then, an initial mooring system was designed according to the property of the device. The feasibility of mooring system design is verified by the time-domain calculation of the irregular wave by using AQWA DRIFT. The platform was verified according to CCS Classification of offshore mobile platforms. The static hydrostatic curve of the power plant was calculated by Maxsurf software, the maximum static heeling angle is equal to 30.9°. The stability of the platform was verified according to the IMO-A.749 (18) -Ch3 standard. The maximum offset surge value of the power generation device is below 20m in the target sea area. The maximum tension of the mooring line in the complete survival condition is 1198kN, the safety factor is 3.08. The results Can provide reference for future research in this area.**

***Keywords*— renewable energy; combined power; structure design; stability verification; mooring design;**

I. INTRODUCTION

Energy shortage is becoming more and more severely in the world, so does the environmental pollution problem. The exploitation and utilization of renewable energy has become an effective way to alleviate energy shortage and reduce environmental pollution (e.g.[1]). Marine energy resources, which include ocean waves, tides, open ocean currents as well as gradients in ocean temperature and salinity, could serve as an important low carbon renewable energy source(e.g.[2],[3]). Considering that single renewable energy power generation device is not cost-efficient due to its poor stability and continuity, furthermore, single renewable energy power generation device manufacturing and supporting transmission infrastructure costs lots of money, combined power generation device becomes a new trend in the offshore renewable energy device area. Current research has been carried out at home and abroad.

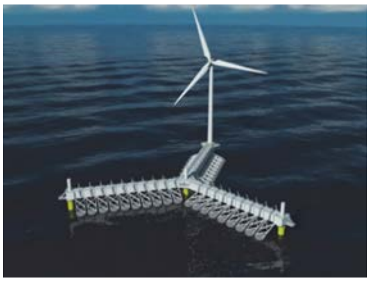

Fig. 1 Oscillating float type wave power generating device

Fig. 2 three-cylinder floating wind-flow combined power generation device

Wave star company in Denmark has published varieties of papers assessing the prospect of combined offshore renewable energy power generation device at some academic meetings since 2012. The company plans to cooperate with Dong wind power company to build a 600kw wave energy device in the Horns Rev2 offshore wind farm at the western coast of Denmark to verify the feasibility of wind-wave combined power generation(e.g.[4]-[6]). A new concept design of wind-wave combined power generation device was built On the basis of the company`s unique Oscillating float type wave power generating device, which is shown as Fig. 1 (e.g.[7]). Ma Yong coming from Harbin Engineering University proposed a concept of three-cylinder floating wind-flow combined power generation device. As is shown in Fig. 2, after the overall design of the device, the wave load and the structural strength was calculated and analyzed (e.g.[8]).

Based on the above research, the new multi-energy complementary power generation device design has made greater progress than ever before. The combination of sea wind, ocean wave, current flow is undoubted the most promising and practical. In this paper, combined with the above problems, a new type of wind-flow power generation device was designed. Finally, the stability of the platform was verified according to the IMO-A.749(18)-Ch3 standard.

II. Page Layout

During the platform selection, the platform demand of ocean wind power generation and ocean current power generation should be taken into consideration separately. Wind power generation device should be designed to withstand greater wind force which might generate bigger pitch and swing response, so the hydrodynamic performance of the platform shall be properly considered. Ocean current power generation device needs much space to deploy the turbine and some relevant power generation equipment, meanwhile, the structure of the platform should have less influence on the flow field of the turbine.

A. Platform selection reference

Floating ocean current power genernation device have 3 common platforms, which include monohull platform, catamaran platform, and semi-submersible platform. The structure of monohull is simple and can be easily built, which is often used in the early stage of ocean current power genernation experiment. The transverse stability of the catamaran platform is better than the other two(e.g.[9]). Furthermore, the platform have much more space to deploy turbine and relevant equipment. Semi- submersible platform have much more working space and better hydrodynamic performance. It can adapt to hash sea conditions. At the same time, the pitch and surge response of semi-submersible platform is better than TLP and close to SPAR platform which are often used as platform of offshore wind power genernation device. Nevertheless, SPAR platform have very little working space and its main body is a big cylindrical structure and can`t provide enough space to arrange the ocean current turbine.

In conclusion, semi-submersible platform manufacturing, assembly, outfitting, debugging can be compeleted at the dock, then dragged to the designed deployment area, which is much more cost-effective (e.g.[10]). In this paper, semi-submersible platform was chosen to carry out the research.

B. Selection of wind turbine and water turbine

The offshore wind energy and ocean current energy in Zhou Shan is more abundant than anyother places in China. The tidal energy density of JinTang waterway and GuiShan waterway is at a ideal range of 24~26kW/m^2(e.g.[11]). Meanwhile, offshore wind resource of ZhouShan islands is abundant

TABLE I
ENVIRONMENT DESIGN PARAMETERS OF ZHOU SHAN

Design Location	**Working Depth**	**Submarine Soil**	**Average Current Rate**
ZhouShan, ZheJiang	40m	2.5m/s	4m/s

Following the table above

Maximum Current Rate	**Mooring Method**	**Mooring Requirements**	**Marine Wind Speed**	**Tidal Range**
4m/s	Mooring Cable	Maximum Offset ≤20m	12m/s	3m

The design parameters of water turbine and wind turbine has to be decided before the detailed design of semi-submersible. Vertical axis water turbine and horizontal axis wind turbine were selected in this design. The geometric dimensions of the water turbine and wind turbine can be determined respectively as far as the rated power is selected according to 2-1 and 2-2 at the circumstance of known environment parameters shown in table 1.

$$P_{tidal} = \frac{1}{2}\rho_w v_t^3 A_t C_{pt} \qquad (1)$$

P_{tidal} is the power of the water turbine, ρ_w is the density of the sea water, 1025kg/m^3, v_t is the tidal speed, A_t is the sweeping area of the turbine, C_{pt} is the power factor of the water turbine, 0.3.

$$P_{wind} = \frac{1}{2}\rho_{air} v_w^3 A_w C_{pw} \qquad (2)$$

P_{wind} is the power of the wind turbine, $\rho_{气}$ is the density of the air, 1.293kg/m^3. v_t is the wind speed, A_t is the sweeping area of the turbine, C_{pt} is the power factor of the water turbine, 0.3.

The geometric dimensions of wind power genernation device is a few times lager than that of tidal power genernation device because the density of water is larger than air. As is shown in table 2 and table 3, the parameters of the water turbine and wind turbine is determined considering the environment factors.

TABLE II
WATER TURBINE DESIGN PARAMETERS

Design Current Rate	**Maximum Current Rate**	**Diameter**	**Installed Capacity**

2.5m/s	40m	6m	110kW

Following the table above

Chord Length	Span	Airfoil	Blade Number	Weight
8m	NACA0018	2	110kW	15t

TABLE III
ENVIRONMENT DESIGN PARAMETERS OF ZHOU SHAN

Rated Power	Impeller Diameter	Tower Height	Cut in/out Wind Speed	Rated Wind Speed
8m	NACA0018	2	3.5/25m/s	15t

Following the table above

Limited Wind Speed	Impeller Weight	Tower Weight	Cabin Weight
59.5m/s	3t	24t	6t

C. General layout design

The design of the platform is mainly referred to CCS Classification of offshore mobile platforms. The main structure of the plaform ia shown Figure. 3. In order to make full use of the space of the platform, a 220kW wind turbine and double 110kW water turbine were selected. The total capacity of the wind-tidal combined power genernation device is up to 420kW.

Fig. 3 Power Generation Device Structure Model

The determination of the main dimensions of the platform sholud consider the structure strength, hydrodynamic perfermance and economy factor synthetically. Couple rotor turbine was selected, considering the structure characteristics and the deployment of the wind turbine, the rotors were deployed parallelly. The detailed main dimensions of the platform is shown in Table 4.

TABLE IV
MAIN DIMENSIONS OF SEMI-SUBMERSIBLE

Length	Breadth	Depth	Draught	Freeboard
28m	30m	10.2m	7.5m	2.7m

Main floating body

The main floating body is to provide sufficient displacement and support strength. The structure of the main floating body is single transverse cross frame (e.g.[12]).

Column

The column of the platform is consisted of 2 small column and 4 main column. The column is to connect the main floating body and the upper deck and provide some buoyancy.

Beam

The beam is to connect the main floating body and enhance the torsion strength, meanwhile, providing some buoyancy. The structure of the beam is longitudinal frame(e.g.[13]).

Deck

The deck is to provide sufficient working space for the power genernation equipment and ensure the structure strength.

III. STABILITY VERIFICATION

The model of the platform was constructed in Maxsurf according the genernal layout. The influence of the water turbine on the stability of the platform can be neglected because the buoyancy of the turbine is reletively small. The light weight of the platform and barycenter data is shown in table 5.

TABLE V
MAIN DIMENSIONS OF SEMI-SUBMERSIBLE

Number	Project	Weight/t	Long.Arm/m	Trans.Arm/m	Vert.Arm/m
1	Platform Structure	635.526	-0.571	0	4.353
2	Platform Ancillary Equipment	4.063	0.000	0	10.705
3	Superst Structure	19.638	0.000	0	12.046
4	Wind Turbine	35.000	-8.000	0	19.548
5	Water Turbine	42.000	5.000	0	4.519
6	Electronic Control System	25.000	0.000	0	9.500
7	Ballast System	500.000	0.500	0	0.500
	Total	1261.497	-0.098	0	3.276

The stability varification of the platfrom is referred to the IMO-A.749 (18) -Ch3 standard. The pitch is set to be free to change according to load, heel ranges from -30°~80°, the calculation step is 10°, the heel is towards starboard. The static stability curve is shown in Figure. 2.

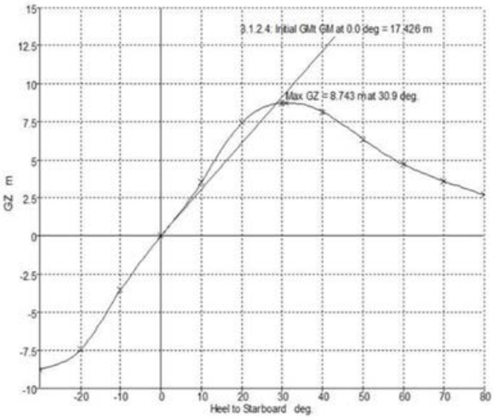

Fig. 4 Power Generation Device Structure Model

As we can see from Figure.4, GM is equal to 17.426m, when the heeling angle is equal to 0°. When the limited static heeling angle is equal to 30.9°, accordingly, maximum static stability arm GZ is equal to 8.743m. the platform can achieve stable balance when the heeling angle is less than 30.9°. The verification results is shown in Table 6. The calculation results showed the stability of the platform meet the requirements of the IMO-A.749 (18) -Ch3 standard.

TABLE Ⅵ
VERIFICATION RESULTS OF THE PLATFORM

	Standard Value	**Unit**	**Design Value**	**Results**
3.1.2.1: Area 0 to 30	3.1513	m.deg	156.3448	Pass
3.1.2.1: Area 0 to 40	5.1566	m.deg	242.0529	Pass
3.1.2.1: Area 30 to 40	1.7189	m.deg	85.7080	
3.1.2.2: Max GZ at 30 or greater	0.2	m	8.743	Pass
3.1.2.3:Angle of Maximum GZ	25	deg	30.9	Pass
3.1.2.4: Initial GMt	0.15	m	17.426	Pass
3.1.2.6: Turn: angle of equilibrium	10	deg	0.0	Pass
3.2.2: Severe wind and rolling	16	deg	0.1	Pass
	100	%	275.66	Pass

IV. MOORING SYESTEM DESIGN AND VERIFICATION

A. Mooring material selection

A catanary mooring system with elastic cable was designed for this plarform. Compared with normal anchor chain, elastic cable can provide more prestressing force and extension force and withstand the torsion force caused by the tidal change. The force-extension curve of the elastic cable is shown in Figure 5.

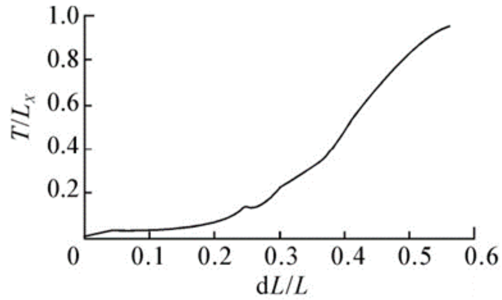

Fig. 5 Power Generation Device Structure Model

Parameters of the anchor chain part is shown in table 7.

TABLE Ⅶ
Main Dimensions of Semi-submersible

Mooring line	**material**	**Diameter**	**Linear mass**	**Fracture force**
chain	R4 studless chain	58mm	67kg/m	3628kN

The design of the platform is on the basis of CCS Classification of offshore mobile platforms, it`s assumed that there is no other structure around the platform. The safety factor of the mooring chain in the CCS standard is shown in Table 8.

TABLE Ⅷ
Main Dimensions of Semi-submersible

Condition	**Complete operating conditions**		**Complete survival conditions**	
Analytical method	quasi-static	dynamic	quasi-static	dynamic
safety factor	2.70	2.25	2.00	1.67

B. Mooring Line Arrangement

As we can see from Figure.6 and Figure.7, there is totally 8 mooring line. The mooring lines aredivided into four groups symmetrically arranged on the carrier platform. The angle between number 1 chain and X axis is 40°. The angle between number 1 chain and number 2 chain is 20°. Each mooring line is a combination of chain-elastic cable-chain. Main parameters of the mooring syestem is shown in table 9.

TABLE Ⅸ
MAIN PARAMETERS OF MOORING SYSTEM

Number of Chains	**Length**	**Elastic Cable Length**	**Prestressing Force**	**Anchor Weight**
8	200m	10m	20.0kN	4000kg

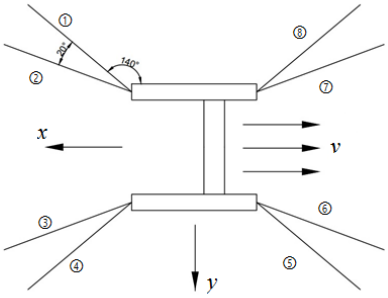

Fig. 6 Arrangements of Mooring Chain

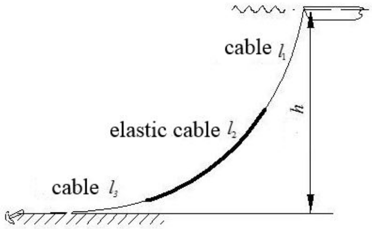

Fig. 7 Structure of Mooring Line

C. Mooring System Verification

Four design conditions should be considered in the mooring system verification according to the CCS Classification of offshore mobile platforms standard. Only complete operating conditions and complete survival conditions verification results were shown in this paper because of paper length limitations.

The mooring system is symmetrical about the longitudinal profile, therefore, 0°,30°,60°,90°,120°,150°,180° of the wave angle is selected in the calculation. JONSWAP wave spectrum is used to calculate the former design conditions. Wave spectrum factor λ is equal to 3.3. Significant wave height and peak spectral period is selected according to the design conditions. To reflect the normal working conditions of the device, the incidence angle is equal to 0°. Each calculation step is set as 5000s.

Complete Operating Conditions

Calculation results of the complete operating conditions is shown in the following tables.

TABLE Ⅹ
CALCULATION RESULTS OF SURGE

Wave Direction (deg)	Surge(m)			
	Max	Min	Average	Standard Deviation
0	-18.5	-15.6	-17.3	0.893
30	-18.5	-15.9	-17.3	0.795
60	-18.1	-16.4	-17.3	0.524
90	-17.7	-16.6	-17.4	0.243
120	-17.9	-16.7	-17.4	0.307
150	-18.1	-16.5	-17.3	0.509
180	-18.1	-16.3	-17.3	0.621

TABLE Ⅺ
CALCULATION RESULTS OF PITCH

Wave Direction (deg)	Pitch(deg)			
	Max	Min	Average	Standard Deviation
0	2.121	4.187	3.323	0.698
30	2.112	4.105	3.302	0.638
60	2.328	3.877	3.528	0.484
90	2.594	3.552	3.223	0.286
120	2.765	3.519	3.228	0.240
150	2.662	3.734	3.290	0.352
180	2.667	3.886	3.336	0.421

TABLE Ⅻ
CALCULATION RESULTS OF SWAY

Wave Direction (deg)	Sway(m)			
	Max	Min	Average	Standard Deviation
0	-0.4	0.421	0.031	0.224
30	-1.26	1.308	-0	0.724
60	-2.44	2.15	-0	1.302
90	-2.95	2.79	0.015	1.696
120	-2.94	2.83	0.021	1.697
150	-1.8	1.93	0.009	1.12
180	-0.41	0.448	0.03	0.242

TABLE ⅩⅢ
CALCULATION RESULTS OF ROLLING

Wave Direction (deg)	Rolling(deg)			
	Max	Min	Average	Standard Deviation
0	0.454	1.27	0.87	0.219
30	0.179	1.827	0.878	0.52
60	-0.41	1.965	0.879	0.722
90	-0.62	2.473	0.874	0.859
120	-0.79	2.903	0.87	1.102
150	-0.94	2.694	0.871	1.759
180	0.46	1.218	0.869	0.216

TABLE ⅩⅥ
CALCULATION RESULTS OF HEAVE

Wave Direction (deg)	Heave(m)			
	Max	Min	Average	Standard Deviation
0	-7.48	-6.77	-7.14	0.199
30	-7.47	-6.76	-7.14	0.2
60	-7.51	-6.77	-7.14	0.212
90	-7.55	-6.74	-7.14	0.23
120	-7.57	-6.66	-7.14	0.252
150	-7.61	-6.66	-7.14	0.269
180	-7.6	-6.67	-7.14	0.276

TABLE ⅩⅤ
CALCULATION RESULTS OF YAW

Wave Direction (deg)	Yaw(deg)			
	Max	Min	Average	Standard

				Deviation
0	-4.15	3.547	-0.38	2.098
30	-3.54	3.148	-0.38	2.252
60	-4.65	3.703	-0.38	2.749
90	-4.71	4.708	-0.39	2.891
120	-4.53	3.783	-0.4	2.284
150	-2.97	1.945	-0.38	1.644
180	-3.4	2.466	-0.39	2.053

TABLE ⅩⅥ
RESPONSE OF MOORING CHAIN

Wave Direction (deg)	Maximum Response	Force	Safety Factor	Results
0	2	606.9	5.978	Pass
30	3	571.6	6.347	Pass
60	3	532.6	6.812	Pass
90	3	533	6.807	Pass
120	3	580.2	6.253	Pass
150	2	591	6.139	Pass
180	2	542.8	6.684	Pass

As we can see from the Table 10, the power generation device will be offset in the negative direction of the X axis and finally keep a balance at -17.4m. When the wave direction is equal to 0°, the maximum offset value is equal to -18.5m. The offset value of surge will decrease with the wave direction angle increasing. When the wave direction angle is equal to 90°, the maximum offset value of surge is equal to -17.7m, then the offset value of surge will increase again. When the wave direction angle is equal to 180°, the maximum offset value of surge is equal to -18.1m. In general, the offset value of surge is below 20m which meets the mooring requirements of design sea area and amplitude of oscillation is below 2m. The pitch value is around 3.3° which means the platform is a little trim by head. The maximum value of pitch is below 4.2° as the wave direction changes. The average response value of sway and rolling is close to 0. When the wave direction angle is equal to 0°, the maximum value of sway is equal to 0.421m, the maximum value of rolling is equal to 1.27°. When the wave direction angle is equal to 90°, the maximum transverse displacement is equal to 2.95m. when the wave direction is equal to 120°, the maximum transverse inclination angle is equal to 2.9°, which is at the range of acceptability. Furthemore, as we can see from the heave response, the actual draft value is nearly equal to 7.1 which is a little below 7.5m of the design value. The minimum value of draft is 6.66m with the change of wave direction and the blade can always stay below the water. the maximu draft value is equal to 7.61m, meanwhile, the air gap between the deck and water is equal to 1.89m.

Table 16 gives the number of the biggest chain tension force and the actual value at different wave direction. The maximu tension value emrges at number 2 chain when the wave direction angle is equal to 0° and the maximum value is 606.9kN. The safety facor is equal to 5.978 which meets the CCS standard. Fig.8-Fig.14 shows the time-domain curves of the platform 6-DOF motion and the time-domain curves of tension force of number 2 chain at the 0° wave direction angle

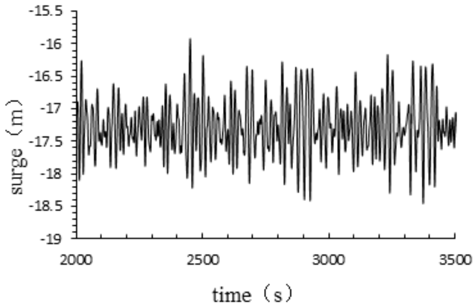

Fig. 8 Surge response of the platform

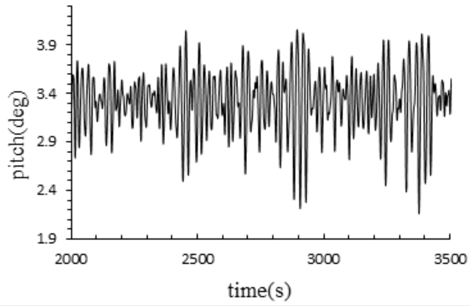

Fig. 9 Pitch response of the platform

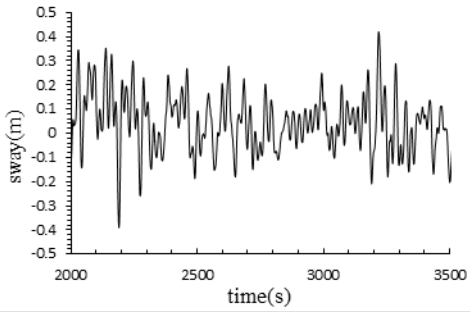

Fig. 10 Sway response of the platform

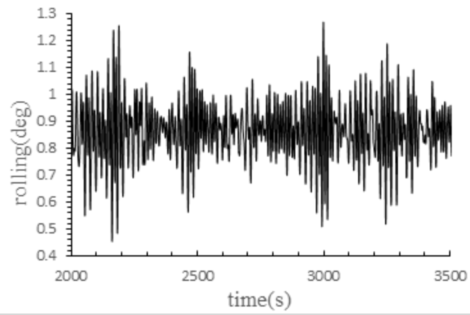

Fig. 11 Rolling response of the platform

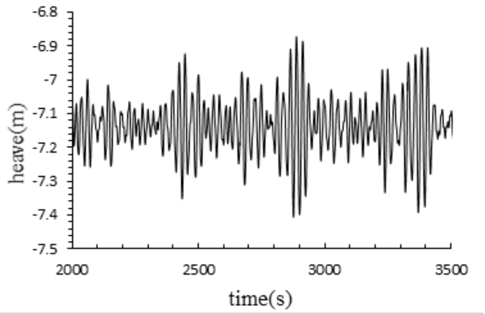

Fig. 12 Heave response of the platform

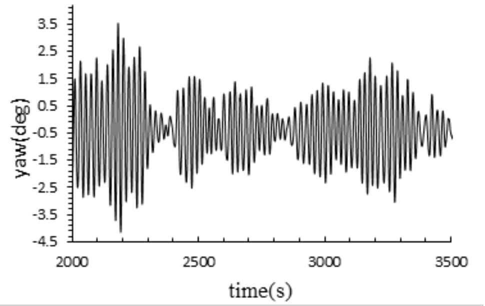

Fig. 13 Yaw response of the platform

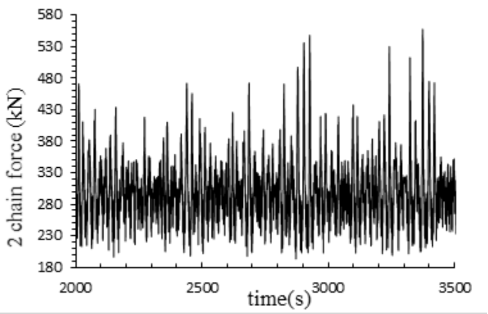

Fig. 14 Mooring line tension of chain 2

Complete Survival Condition

TABLE XVII

CALCULATION RESULTS OF SURGE

Wave Direction (deg)	Surge(m)			
	Max	Min	Average	Standard Deviation
0	-19.4	-17.9	-18.7	0.402
30	-19.4	-18	-18.7	0.37
60	-19.2	-18.1	-18.7	0.301
90	-19.1	-18.1	-18.7	0.257
120	-19	-18.1	-18.7	0.263
150	-19.1	-18.3	-18.7	0.28
180	-19.1	-18.2	-18.7	0.295

TABLE XVIII

CALCULATION RESULTS OF PITCH

Wave Direction (deg)	Pitch(deg)			
	Max	Min	Average	Standard Deviation
0	-2.55	-1.63	-2.07	0.25
30	-2.49	-1.67	-2.07	0.246
60	-2.45	-1.61	-2.08	0.232
90	-2.52	-1.69	-2.08	0.219
120	-2.47	-1.63	-2.07	0.198
150	-2.33	-1.75	-2.07	0.157
180	-2.28	-1.84	-2.07	0.149

TABLE XIX

CALCULATION RESULTS OF SWAY

Wave Direction (deg)	Sway(m)			
	Max	Min	Average	Standard Deviation
0	-0.17	0.092	-0.03	0.088
30	-1.22	1.14	-0.04	0.673
60	-2.44	1.993	-0.05	1.288
90	-2.81	2.604	-0.05	1.684
120	-2.81	2.615	-0.04	1.664
150	-1.73	1.593	-0.03	1.038
180	-0.15	0.115	-0.05	0.079

TABLE XX

CALCULATION RESULTS OF ROLLING

Wave Direction (deg)	Rolling(deg)			
	Max	Min	Average	Standard Deviation
0	0.494	1.086	0.808	0.181
30	-0.44	1.948	0.812	0.742
60	-0.81	2.605	0.813	1.083
90	-1.15	3.02	0.813	1.27
120	-1.6	3.567	0.812	1.653
150	-0.05	1.79	0.809	0.544
180	0.519	1.104	0.808	0.167

TABLE XXI

CALCULATION RESULTS OF HEAVE

Wave Direction (deg)	Heave(m)			
	Max	Min	Average	Standard Deviation
0	-7.96	-7.21	-7.66	0.222
30	-7.96	-7.19	-7.57	0.226
60	-7.96	-7.15	-7.57	0.243
90	-8	-7.12	-7.57	0.266
120	-8.06	-7.11	-7.57	0.298
150	-8.07	-7.04	-7.57	0.313
180	-8.09	-7.02	-7.57	0.319

TABLE XXII

CALCULATION RESULTS OF YAW

Wave Direction (deg)	Yaw(deg)			
	Max	Min	Average	Standard Deviation
0	-0.96	0.519	-0.25	0.453
30	-3.46	3.302	-0.25	2.196
60	-4.65	4.52	-0.26	3.014
90	-4	3.681	-0.27	2.672
120	-3.64	4.022	-0.27	2.583
150	-2.27	2.08	-0.25	1.358
180	-0.98	0.422	-0.27	0.418

TABLE XXIII

RESPONSE OF MOORING CHAIN

Wave Direction (deg)	Maximum Response	Force	Safety Factor	Results
0	3	1082	3.353	Pass
30	2	1142	3.177	Pass
60	2	1141	3.180	Pass
90	2	1143	3.174	Pass
120	3	1198	3.028	Pass
150	3	1081	3.356	Pass
180	3	1004	3.614	Pass

As we can see from the calculation results, the average surge value of the device is -18.7m, the offset value is bigger than the complete working condition by 1.4m. When the wave direction angle is equal to 0°, the maximum surge value is equal to -19.4m which is still below 20m, meanwhile, amplitude of oscillation is below 1.5m. The pitch value of the device balance at -2.07°. The maximu pitch value comes to -2.55° when the wave direction changes. Comparing with the complete working condition, there was a negative value of the pitch for the first time which means the platform is a little trimming by stern. The average sway value is close to 0°. When the wave direction angle is 90°, the maximum transverse inclination is equal to -2.81m. The average rolling value is equal to 0.8°. There is biggest rolling value, 3.6°, when the wave direction angle is equal to 120°. Furthermore, the average draft value is close to .57m, which is a little below the design draft. The minimum draft value is equal to 7.02m as the wave direction differs. The blade can always stay below the water. The maximum draft value is equal to 8.09m, meanwhile, the air gap between the deck and the water is equal to 1.41m.

Table 21 gives the number of the biggest chain tension force and the actual value at different wave direction. The maximu tension value emrges at number 3 chain when the wave direction angle is equal to 0° and the maximum value is 1198kN. The safety facor is equal to 5.978 which meets the CCS standard. Fig.15-Fig.20 shows the time-domain curves of the platform 6-DOF motion and the time-domain curves of tension force of number 3 chain at the 0° wave direction angle

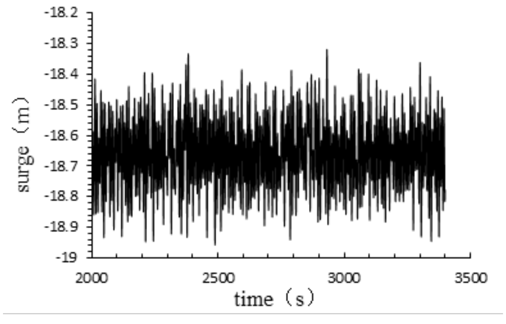

Fig. 15 Surge response of the platform

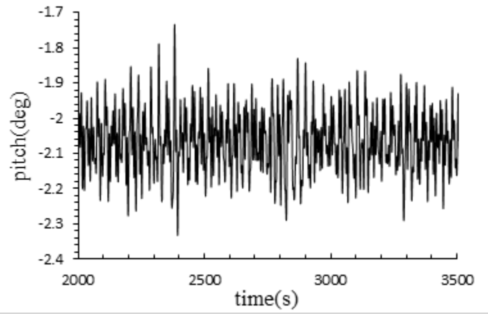

Fig. 16 Pitch response of the platform

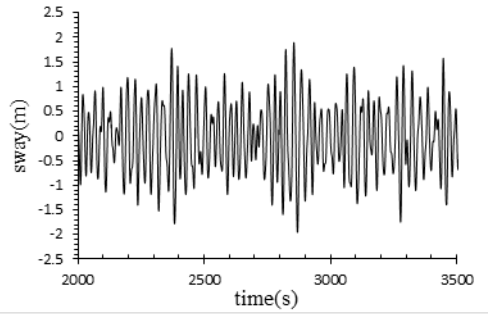

Fig. 17 Sway response of the platform

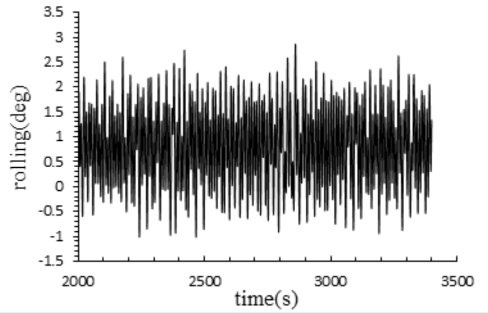

Fig. 18 Rolling response of the platform

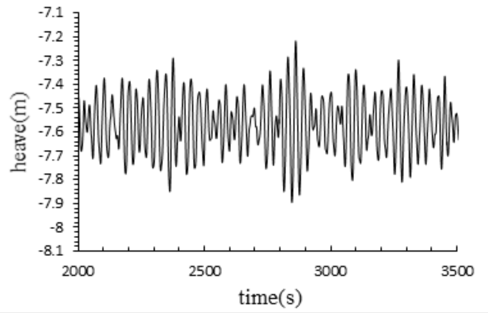

Fig. 19 Heave response of the platform

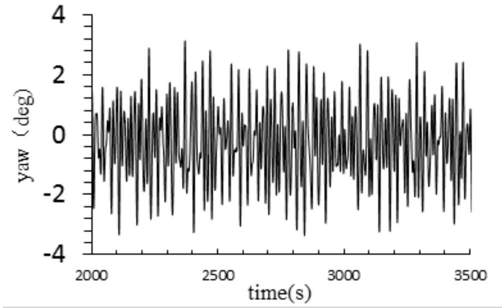

Fig. 20 Yaw response of the platform

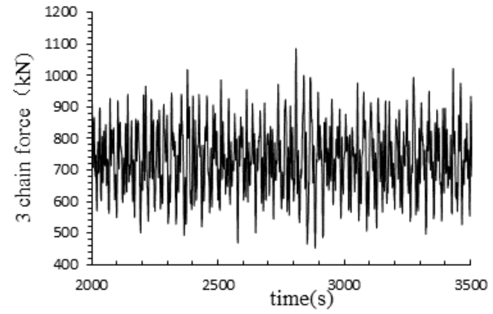

Fig. 21 Mooring line tension of chain 3

V. CONCLUSIONS

At present, combined power generation device has difinitely become a new trend in the marine renewable energy development. A practical combined power genernation device was developed according the new conception. The water turbine and wind turbine was selected according to the design sea environment and the structure of the platform. After a series of calculation, we come up with the following conclusions. The stability calculation results reveals that the stability of the platform meets the requirements of the stability standard, the maximum static inclination angle is equal to 30.9°. The maximum offset surge value of the power genernation device is below 20m in the design sea area, the device can meet the mooring requirements. The maximu chain tension force in the complete survival condition is 1198kN, the safety factor is 3.08. The maximum chain tension force in the complete working condition is 5.978.

Single renewable energy power generation device is not cost-efficient due to its poor stability and continuity. The new combinnation power genernation device development might help solving the present situation. The work has been done might provide research basis for further development in this area.

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