HYDRO DYNAMIC ANALYSIS OF MOORING OF FLOATING PLATFORM WITH 6 DEGREE OF FREEDOM IN WIND TURBINE AT OFFSHORE WATERS PERSIAN GULF

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Abstract- In recent years and in parallel to required energy supply for obtaining progress goal in world countries, there are some steps for decreasing costs and exploitation of unlimited and high efficiency energies. In the past, countries of world extracted their necessary energies by using fossil fuels resources. This process gradually was decreased because of limitation of resource and high costs and finally leads to advanced countries use the clean and renewable fuel. Today wind energy is one of most important renewable fuel which change kinetic energy of wind to electric energy through wind turbine in land and sea and made it available for communities. From natural and climatic condition perspectives, marine environment has too much energy powers. Iran, because of zone of huge water at Oman Sea and Persian Gulf at south and Caspian Sea at north, has desirable potential for obtaining wind energy. In the meantime analysis of sea environmental powers in line with mooring and establishing base of wind turbine and support stability of structure is very important. In present study, researcher by using result of modeling and simulation software Moses, states that the most mobility of freedom degrees is obtained in contact with water wave and currents with 135 contact angle in wind turbines and most effect of mooring force under 180 degree contact angle with floating wind turbine.

Keywords- renewable energy, offshore wind turbine, environmental forces, spar

I. INTRODUCTION

Countries of world always tend to find new method for supply energy in communities. In this regard, because of limitation of resource and high cost of hydro carbon resource and also environmental challenges, there is tendency for changing use of energy resource more than before among countries of world so that according to world statistics, 12% of energy requirement will be supplied by renewable resource. This number shows that more than 37% of people live 100 km far from water zones. Iran because of vast areas of lands and presence of two huge water zones at north and south, has high potential of renewable wind energy that can be supplied main part of energy requirement of country by proper planning and management [1].

Wind turbine, both in land and water environmental with fixed-bottom and floating foundation, because of zone condition has advantages and disadvantages. Generally fixed-bottom wind turbine is designed at shallow environment and floating turbine at deep environment. Establishment of wind farms should be done correctly because of presence of huge and unpredictable environment forces. These studies must be done such as guarantee safety and stability of platform during lifetime and productivity in industry cycle. Ensuring of marine structure stability specially oil, gas and energy sectors have great sensitivity than other areas because of dependency of huge part of energy lines of country and also political and regional advertising[2].

A few studies had been done by experts on stability and establishment of offshore wind turbines so that platform can tolerate against all environmental forces during life time. Among them Larsen analysis spar platform and optimization its geometry [3]. After that Jain and Agarwal studied mooring behavior at spar platform affected by waves [4]. Linde studied hydrodynamic forces, behavior and motions of floating turbine and evaluated its effect on mooring forces [5]. In Iran, Karimi Rad also conducted studies on dynamic modeling of spar platform influenced by environmental forces [6]. Raeis Zade and Motahar stated that use of turbine with horizontal axis is optimal on Persian Gulf [7]. Ketabdari and Mirzaee Sefat studied interactions of linear waves with behavior of spar platform and modeled structure behavior against linear waves [8]. In present study, the researcher modeled and simulated effect of environmental forces on platform stability in Moses software through brief presentation types of wind turbines and mooring methods and by considering contact angels of offshore forces of waves, wind and sea current, its effect on mooring of floating platform of wind turbine was evaluated.

II. TYPES OF WIND TURBINES AND THE FORCES APPLIED ON THEM

Wind turbines can be generally divided into two groups: HAWT and VAWT. Researches done by

Raeeis Zade and Motahar show that offshore wind turbine with horizontal axis (HAWT) is more appropriate and optimal than wind turbine with vertical axis (VAWT) for establishment at Persian Gulf [7].

The nature of environmental forces applied on floating turbine is one of the important factors that have been considered in designing wind turbine (figure 1). Wind and

Earthquake in land are important forces applied on structure, meanwhile forces such as wind (Equations 2, 3), wave (equation 1) and sea current that are naturally accidental and unpredictable were applied on floating platform and can threaten safety and stability of it seriously that should be prevented by using correct mooring [2].

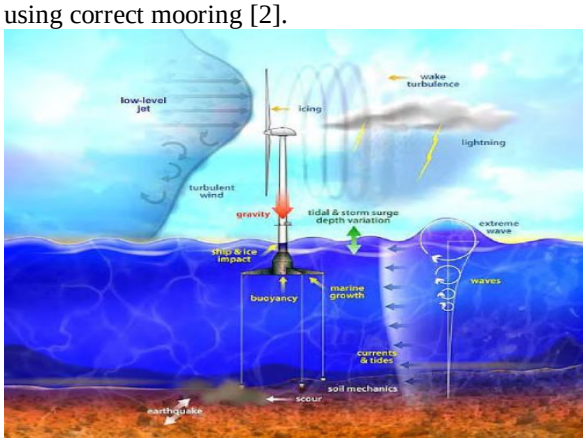

Figure1. Influencing environmental forces

Force due to wave is the most important and influencing environmental force on offshore structures that can be converted to the most critical force by false determination in design computation. Therefore correct computation is very essential. Morrison equation could be used for 40-meter wave. In this relation Cd is drag coefficient and Cm is mass coefficient. Its value is assumed 0.85 [6].

$$dF = \frac{\rho}{2} C_d D |u_r| u_r + \frac{\rho \pi D^2}{4} c_m \dot{u}_r + \frac{\rho \pi D^2}{4} \dot{u}_w \quad (1)$$

Wind force includes interaction, surface friction and drag forces that state CL is defined as lift coefficient and Cd as drag coefficient [6].

$$\Delta L = \frac{1}{2} \rho_{air} c W^2 C_l \Delta r_b$$

$$\Delta D = \frac{1}{2} \rho_{air} c W^2 C_d \Delta r_b \quad (2)\ (3)$$

III. TYPES OF METHODS FOR ESTABLISHING STRUCTURE OF FLOATING WIND TURBINE

The most important differences between wind turbine in land and water are type of substructure and support structures. Three common types of floating platforms are as follow: spar, barge and semisubmersible. Naturally with progressing toward deep waters, tendency to use floating platform will be priority in designing. Floating structures are technically simple and they are inexpensive. They use buoyancy for stability of platform. The behavior of this type of foundation because of horizontal instability is not proper against huge waves. However, because of low price, it can be used usually in calm waters like Persian Gulf that its wave magnitude is low in that area [6].

IV. MOORING FLOATING PLATFORM AND ITS EFFECT ON DEGREE OF FREEDOM

A floating platform under influenced by environmental forces has 6 motion and degree of freedom. In this study, there have been done some reasonable simplifications on computation for clear understanding. So it seems that by selecting floating wind turbine and mooring through cable which is affected constant tension, we can select appropriate choice. The most important factor in orientation for placement of turbine in installation location is the place of wind turbine blades. In addition to buoyancy, floating platform use mooring and ballast for its stability in front of environmental forces and therefore show better behavior against waves. Among this, spar also has good advantages in comparison with other platform. These advantages cause them to become proper for deep waters. Spar usually is made so that can maintain its stability through ballast [1].

V. OPTIMAL SELECTION OF TYPE OF MOORING

Generally, there are three types of mooring method for floating platforms that can be referred them respectively as follow: catenary mooring, taut leg system and tension leg system. Catenary mooring is suggested for shallow waters of Persian Gulf because of lack of initial tension, placement of system under influenced by own weight, easy installation and optimal fitness. Also, by regarding that modeling of mooring system is done by Moses software in this study, it is important that element of whole cable is embedded in software in every moment. This point is considered as automatic in Moses for catenary mooring system. The number of defined catenary mooring in this computation is considered 3 values [8].

VI. MODELING AND SIMULATING FLOATING PLATFORM

The process of model production consists of: defining consecutive sections in length of elements,

formation of individual element, transfer and connect the components. Given software is able to define mooring system simultaneously and finally the model is determined with water line and rolling angle in natural environment of sea and is balanced. After preparation model of floating platform, the values of environmental variables are determined according to assumed governing relations. Also input variables are determined as follow: spar diameter 9.4 m, tower height 70 m, height of total platform 120m, drag coefficient and added mass 0.85 and tower height 3.8. They will be then used for building model geometry. By applying above coefficients, ballast amount for stability of platform and three catenaries mooring will be connected to spar structure. After that those hydrodynamic forces at Persian Gulf area including wave height, wind rate and current rate are defined at software for every eight directions and lastly condition of platform presence in against every special wave are studied. In this modeling different contact angle of wave and water currents with foundation of floating platform of wind turbine is studied and its effect on platform stability is assessed (charts 2-9). Results show that the mean and maximum of wind rate in Persian Gulf is considerably higher than mean and maximum of wind rate in data of around stations. Although wind force cause mooring forces, it has positive role in hydrodynamic stability. It means that effects due to wind have not incremental role in variation behavior of spar. The reason is great difference period of variations due to hydrodynamic forces of wave and current. In contrast, when wind and wave forces are aligned, most resultant effect is happened and cause increase variations. Also by comparing forces and variations in different directions, it is clear that the main role of forces is on hydrodynamic forces and forces due to wind produce small pare of forces. But in contrast, wind role in increasing or decreasing variations is relatively high.

CONCLUSION

By considering limitation of fossil fuel resources and dependency of Iran and other countries to supply required energy, it seems that Iran because of huge lands and vastness of waters can take great steps in efficiency of renewable energies. Among this, by selecting floating platform, it is possible to transfer platform in special times to prevent defects and pause in energy production cycle. According to obtained results from spar platform modeling, it is claimed that the highest mobility of freedom degrees is happened at wave and current with 135 contact angle and most mooring forces is occurred at 180 degree of contact between environmental forces and floating foundation of Katrnary mooring in wind turbine.

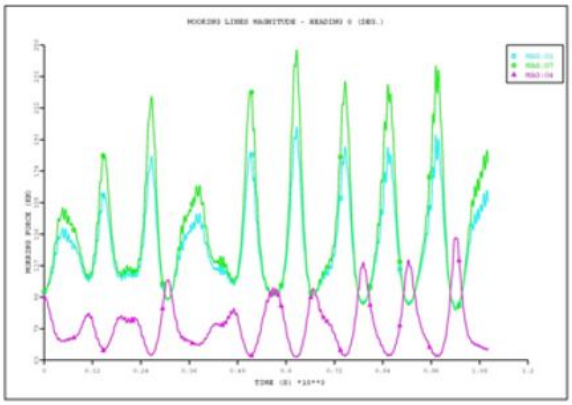

Figure2. The values of mooring forces- wave direction 0 degree.

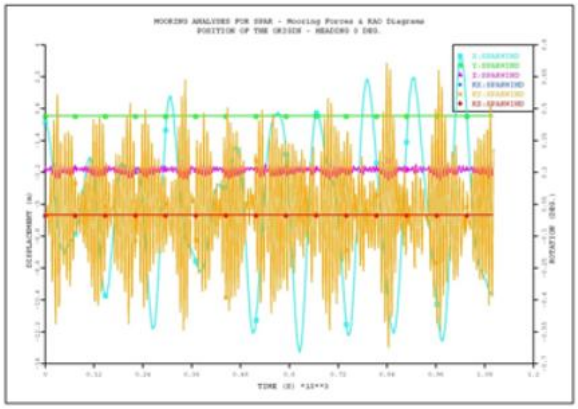

Figure3. The values of freedom degrees- wave direction 0 degree.

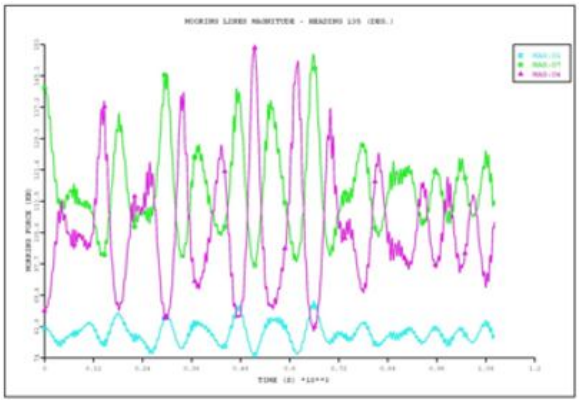

Figure4. The values of mooring forces- wave direction 135 degree.

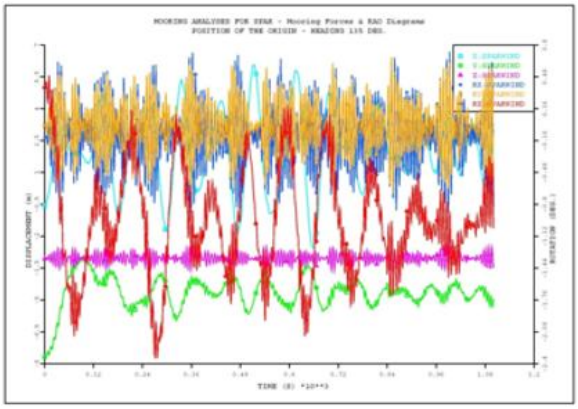

Figure5.The values of freedom degrees variations - wave direction 135 degree.

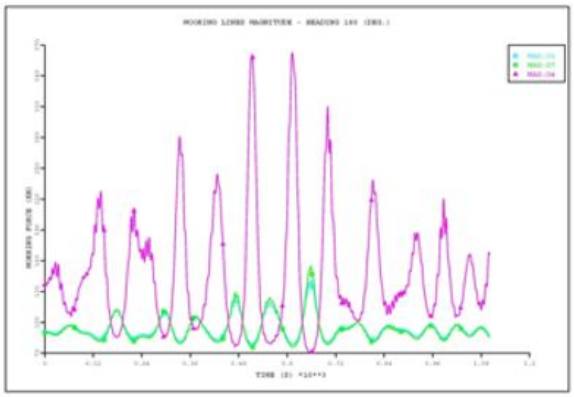

Figure6. The values of mooring forces- wave direction 180 degree.

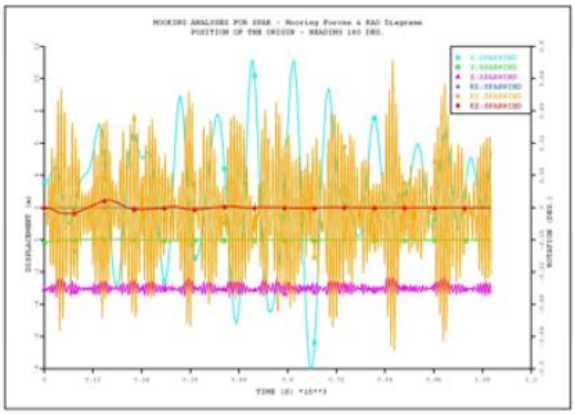

Figure7.The values of freedom degrees variations - wave direction 180 degree.

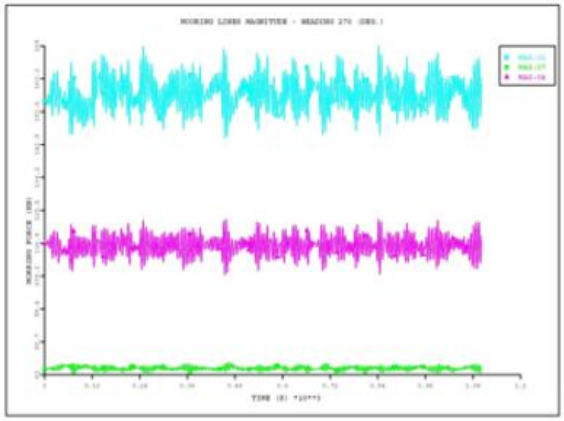

Figure8. The values of mooring forces- wave direction 270 degree.

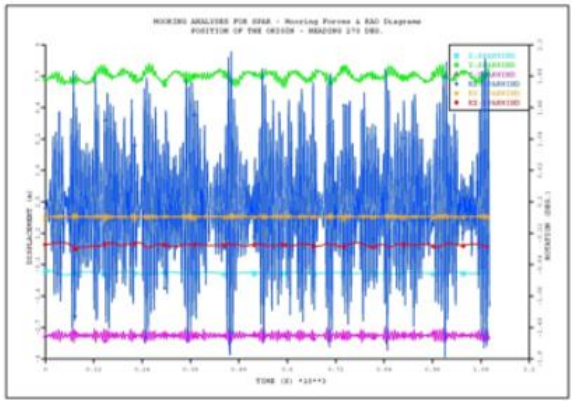

Figure9.The values of freedom degrees variations - wave direction 270 degree.

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