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Design of Offshore Mooring System

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Abstract. This paper focuses on the design of mooring system, considering the influence of tides and wind speed on the system, analyzes the force of anchor chain, steel barrel, steel pipe and buoy, and establishes the model of particle rigid body, single object and multi-objective programming. The actual results show that the model is accurate and effective. Based on the above model, the problem is solved by using the improved algorithm of cyclic decision and multi-objective programming, and finally, the state parameters of all link rings are obtained based on MATLAB and Lingo, which has the advantages of accurate and efficient.

1. Introduction

Offshore ocean observation is the basic work to understand marine environment, to study offshore marine environment and to develop and protect ocean. The transmission node of the near shallow Sea observation network is composed of a buoy system, a mooring system and a water acoustic communication system, and the mooring system consists of a steel pipe, a steel barrel, a heavy ball, a welded anchor chain and a special drag-and-remove anchor. This paper focuses on the angle of inclination of steel barrel and steel pipe in the stillness of seawater, the relation between the shape of the anchor chain, the depth of the float and the wind speed; When the wind speed is fixed, the anchor point and the sea bed; in the case of wind, water force and depth, integrated design mooring system.

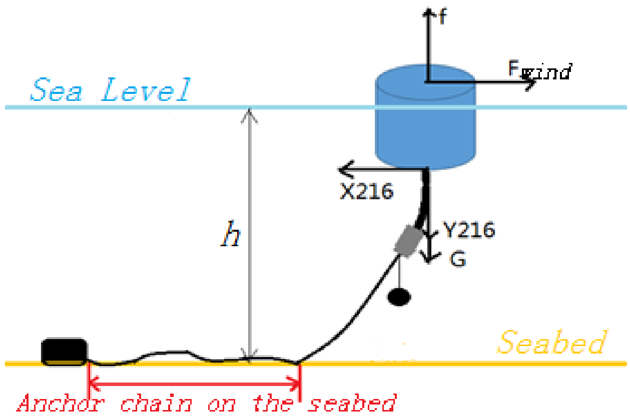


Figure 1: System composition

2. Models

2.1 Wind speed impact

The system is subjected to wind, flow force, seabed friction, buoyancy and so on, considering that the overall analysis (such as the use of catenaries [1]) will ignore the interaction between the parts and the system movement will eventually reach a balance state, so we decided to the system differential, and analyze it little by little.

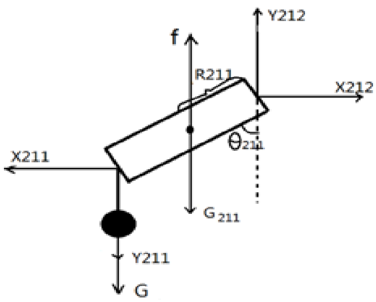


Figure 2: Steel drum force-field analysis chart

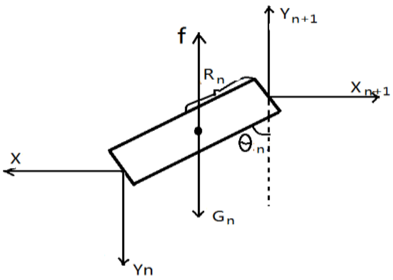


Figure 3: steel force-field analysis chart

By using the lever balance principle:

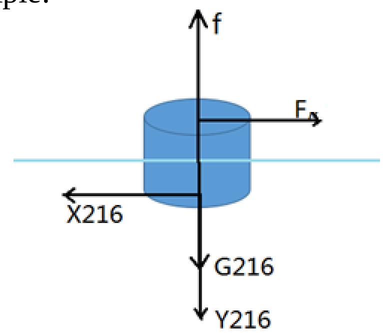


Figure 4: Stress analysis of the buoy

$$Y_{n+1} = Y_n + 7 \times 105 \times 10^{-3} \times g \tag{1}$$

$$X_n = X_{n+1} \quad (n = 1 \sim 215) \tag{2}$$

$$Y_{212} = Y_{211} + G_n + G - \rho g v \tag{3}$$

$$Y_{216} + G_{216} = \rho \times g \times \pi \times h \tag{4}$$

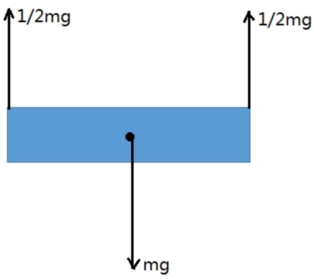
the force distance is expressed by a tilt angle, and the following equations are obtained:

$$Y_{n+1} \times r_n \times \sin\theta_n + Y_n \times r_n \times \sin\theta_n = 2 \times X_n \times r_n \cos\theta_n \tag{5}$$

$$\sum_{n=1}^{215} (2 \times r_n \times \cos\theta_n) + h = H \tag{6}$$

Because to the anchor part of the chain, so we must first find out which section of the chain of the bottom of the contact, the link in the water there are three states, the first is to touch the bottom of the end, the second is the end of the other end of the bottom, the third is not touching the bottom.

The force at one end of the bar is linearly increased from zero until the rod is just lifted, taking this moment as the critical moment. The force analysis of the bar is shown in the right figure, and it can be seen that the minimum force size of the rod lifting is 1/2 times the weight of the rod in the condition of one end force. So if the end of the chain is in the $-\frac{1}{2}mg \sim \frac{1}{2}mg$, this is the point of contact between the link and the bottom in the transition state.

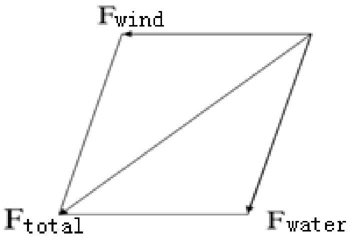


Based on the analysis of the Transition section, we use the MATLAB loop algorithm to start the test from the first paragraph. Until $-\frac{1}{2}mg < Y_n < \frac{1}{2}mg$,the program stops, we can obtain the last paragraph contact the bottom chain ring, then all the contact bottom chain ring in the vertical direction to the back chain link not to have the influence, but the horizontal direction is subjected to the force balance, therefore the later chain Ring may use (1) ~ (6) The Model analysis solution.

2.2 Integrated Design

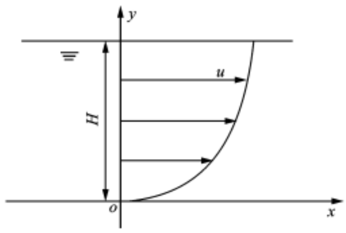
In the real case, the flow and the airflow are two relatively independent environmental conditions. According to theoretical mechanics knowledge, the effect of force is independent of each other, and the effect of air flow and water flow on the system will eventually be synthesized into a plane of the angle [2].

In terms of size, according to the mathematical principle $a+b>ab\cos\theta$ (a>0, b>0), the following figure shows:



Only when the two forces in the direction of the same force, the largest size, assuming the wind speed and flow force direction of the same extreme situation, at this time, the largest outside interference, if the system still satisfies the normal work of the constraints, then the system in general stable and reliable.

Under normal circumstances, the flow velocity in a certain investigation area can be regarded as two-element uniform laminar flow, and the water velocity conforms to the law of uniform laminar flow of two Yuan open channel [3], the following figure shows:



The velocity of the water layer with a height of Y can be expressed as:

$$u(y)=\frac{gJ}{\gamma}(Hy-\frac{y^2}{2}) \quad (7)$$

According to the Force analysis diagram, the stress balance equation and the force distance equilibrium equation are listed as follows:

$$X_1=X_2=......=X_n=X_{n+1} \quad (8)$$

$$\mathrm{Y}_{n+1}=\mathrm{Y}_n+mg \quad (9)$$

$$(Y_{n+1}+Y_n)\times r_n\times\sin\theta_n=(X_{n+1}+X_n)\times r_n\times\cos\theta_n \quad (10)$$

$$X_{n+2}+F_{water}=X_{\mathrm{n+1}} \quad (11)$$

$$Y_{n+2}=Y_{n+1}+(m+\mathrm{M})\,g-\rho g\pi(0.15)^2 \quad (12)$$

$$F_{水}=374\times SV^2=374\times U^2(y)\times 0.3\times 2r_{\mathrm{n}}\times\cos\theta_n \quad (13)$$

$$X_{n+3}+\int 374\times U^2(y)\times 0.3dy=X_{n+2} \quad (14)$$

$$(Y_{n+2}+Y_{n+1}+Mg)\times r_{n+1}\sin\theta_{n+1}=$$
$$(X_{n+2}+X_{n+1})\times r_{n+1}\cos\theta_{n+1}+\int[\sum_{i=1}^{\mathrm{n+1}}2r_i\sin\theta_i-y]\times 374U^2(y)\times 0.3dy \quad (15)$$

$$Y_{n+3} = Y_{n+2} + mg \quad (16)$$

$$(Y_{n+3} + Y_{n+2}) \times r_{n+2} \sin\theta_{n+2} = (X_{n+3} + X_{n+2}) \times r_{n+2} \cos\theta_{n+2} + \int [\sum_{i=1}^{n+2} 2r_i \sin\theta_i - y] \times 374U^2(y) \times 0.3dy \quad (17)$$

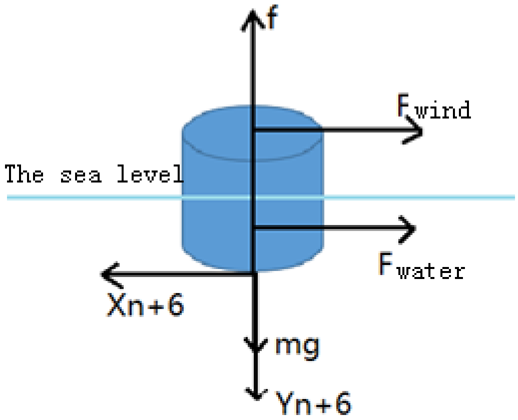


Figure 5 Stress analysis of the buoy

$$F_{风} = 0.625 \times SV^2 \quad (18)$$

$$X_{n+6} = F_{wind} + F_{water} = 0.625 \times 2(2-h) \times V^2 + \int_{18-h}^{h} U^2(y) \times 374 \times 2dy \quad (19)$$

$$mg + Y_{n+6} = \rho g \pi h \quad (20)$$

Combined (7) ~ (20) and constraint conditions, the Multi-objective programming model is obtained in this case and solved by lingo.

3. The advantages of the model

The model does not adopt the traditional mathematical model but uses several simple physical models to make the results of the model analysis more practical, and uses the MATLAB cycle algorithm to find the bottom part of the anchor chain instead of filtering it individually. The efficiency is improved, considering that the velocity of the water flow in the vertical direction is not uniform but the gradient is changed; The three-bit model of multi-objective programming problem is reduced to two-dimensional model, which reduces the parameters and makes the analysis process easier.

References

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