Discussion on a boarding and installation system suitable for a movable wellhead platform

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Abstract: This paper introduces a boarding and installation system suitable for movable wellhead platform, and takes Offshore Oil 163 platform as an example, using finite element analysis and theoretical analysis, and verifies that the boarding system can provide safe and effective protection and support for the external riser.

1. Background
In recent years, with the gradual slowdown of China's land oil and gas reserves, and the continental shelf offshore oil and gas reserves increase gradually, the development of offshore oil and gas fields has become an important way to reduce the dependence on foreign oil and protect the national energy strategic security[1]. At present, marginal fault-block oil fields occupy a large proportion of the undeveloped offshore oil fields. In the production and development of marginal oil fields, because the reserves of marginal oil fields are small, the investment in the construction of large jacket fixed platform is high, and it is not recoverable, resulting in the waste of resources[2]. Therefore, a new movable wellhead platform is proposed for the development of marginal oil fields. In other words, the development of marginal oil fields can be realized through the use of jack-up platform, which has the characteristics of reusable resources and low investment cost[3].

One of the main features of a mobile wellhead platform is that it uses a landing riser attached to the leg of the pile to transport crude oil out of the pipeline, which can effectively reduce the impact of wave and flow loads and other environmental loads on the pipeline, thus reducing the increased cost of using shuttle tankers out of the pipeline.

Offshore Oil 163 platform is the first mobile wellhead platform in China, so this paper takes Offshore Oil 163 platform as an example to analyze and introduce the landing system.

2. Introduction to login installation system
The boarding installation system is the core of the external riser which is attached to the pile leg and realizes the crude oil external transportation. The boarding installation system is mainly composed of four parts: the upper guide protection mechanism, the middle protection mechanism, the bottom of the temporary fixing mechanism. This is shown in Figure 1.
The upper guide protection mechanism mainly includes: boarding system protection plate, vertical guide plate and protection plate supporting bracket. Its function is to provide directional and vertical support for the riser. This is shown in Figure 2.

The central protection mechanism includes a guide guard pipe and a brace plate for connecting the guard leg. The guide pipe is usually composed of discontinuous seamless steel pipe, and its quantity and size are determined according to the size of the riser pipe. Its main function is to provide guidance and protection support for the riser and prevent buckling failure and eddy induced vibration of the riser. The structure is shown in Figure 3.
The bottom temporary fixing mechanism comprises a removable temporary guard plate, a fixing connecting plate and a fixing special bolt. Its function is to provide adjustable support capacity for the uncertainty of riser installation position caused by the uncertainty of mud entry of platform pile leg. The result is shown in Figure 4.

![Bottom temporary fixing mechanism](image)

**Fig.4** Bottom temporary fixing mechanism

Note: the labels in figures 1-4 are as follows.
1 boarding system protection plate
2 vertical guide plate
3 protection plate reinforcement elbow plate
4 riser
5 guide guard pipe
6 guard pipe pile leg connecting elbow plate
7 removable temporary guard plate
8 fixed connecting plate
9 fixing special bolt
10 cruciform casting
11 seamless steel pipe
12 fixing pin shaft

3. Login installation system check

It can be seen from Figure 1 that the boarding system adopts a discontinuous overall layout, which can effectively release the stress caused by the deformation of the pile leg and thus better protect the external riser. According to this layout, only the yield strength of the mounted structure is checked, without the need for buckling and nominal stress checks.

3.1. Login installation system yield check

ANSYS finite element analysis software was used for modeling analysis. Shell63 unit was used to construct the pile leg and the pipe guard structure of the landing system. Full constraints were imposed on the lower end of the mud surface of the pile leg to extract the displacement of the pile leg and apply it at the corresponding position. The finite element model was shown in Figure 5.
Fig.5  Finite element model of pipeline boarding system

The displacement of pile leg is shown in Table 1.

Table 1  Pile leg displacement table

| location | 0°  | 42°   | 90°   | 138°  | 180°  |
|----------|-----|-------|-------|-------|-------|
| -36m     |     |       |       |       |       |
| Dx (cm)  | 33.8994 | 23.8819 | -1.7922 | -22.0759 | -27.8326 |
| Dy (cm)  | 0.0049 | 25.4765 | 34.3774 | 19.7719  | 0.0005  |
| Dz (cm)  | -0.1099 | -0.0673 | -0.1032 | -0.2124 | -0.2723 |
| -28.1m   |     |       |       |       |       |
| Dx (cm)  | 55.5841 | 39.2018 | -2.9484 | -36.1753 | -45.6300 |
| Dy (cm)  | 0.0081 | 41.8317 | 56.4291 | 32.3976  | 0.0009  |
| Dz (cm)  | -0.1811 | -0.1095 | -0.1698 | -0.3533 | -0.4540 |
| -3.1m    |     |       |       |       |       |
| Dx (cm)  | 106.5378 | 75.6068 | -5.7621 | -69.1208 | -87.4871 |
| Dy (cm)  | 0.0162 | 80.8133 | 108.8301 | 61.8735  | 0.0046  |
| Dz (cm)  | -0.3938 | -0.2270 | -0.3676 | -0.7951 | -1.0298 |
| 14m      |     |       |       |       |       |
| Dx (cm)  | 117.8836 | 83.9446 | -6.4556 | -76.4317 | -96.9867 |
| Dy (cm)  | 0.0190 | 89.7924 | 120.8644 | 68.3726  | 0.0101  |
| Dz (cm)  | -0.5079 | -0.2830 | -0.4725 | -1.0489 | -1.3653 |
| 17.5     |     |       |       |       |       |
| Dx (cm)  | 118.0401 | 84.0667 | -6.4717 | -76.5568 | -97.1404 |
Note: The origin of Z coordinate is horizontal plane.

AH36 and DH36 are used to protect the plate. The allowable stress is $[\sigma] = \sigma_s/1.11 = 320$MPa according to the Classification Code for Marine Mobile Platforms issued by China Classification Society (2020). The material of the guard pipe is Q345E, and according to the Classification Code for Marine Mobile Platform (2020) of China Classification Society, the allowable stress is $[\sigma] = \sigma_s/1.11 = 311$MPa.

Finite element stress nephogram is shown in the attached figure.

| location | 0°  | 42°  | 90°  | 138° | 180° |
|----------|-----|------|------|------|------|
| dx (cm)  | 0.0193 | 89.9204 | 121.0550 | 68.4727 | 0.0116 |
| dy (cm)  | -0.5278 | -0.2919 | -0.4907 | -1.0953 | -1.4271 |
| dz (cm)  | -0.5278 | -0.2919 | -0.4907 | -1.0953 | -1.4271 |
| 34.4m    | 118.1913 | 84.2055 | -6.5124 | -76.7816 | -97.3729 |
| dy (cm)  | 0.0207 | 90.0491 | 121.3294 | 68.6163 | 0.0188 |
| dz (cm)  | -0.5328 | -0.2969 | -0.4956 | -1.1003 | -1.4321 |

| The incident Angle | 0°  | 42°  | 90°  | 138° | 180° |
|--------------------|-----|------|------|------|------|
| Maximum stress (MPa) | 278.696 | 220.252 | 71.584 | 157.412 | 178.478 |

Fig.6  Finite element stress nephogram of yield strength check 0°C (MPa)
Fig. 7  Finite element stress nephogram of yield strength check 42°C (MPa)

Fig. 8  Finite element stress nephogram of yield strength check 90°C (MPa)
Fig. 9  Finite element stress nephogram of yield strength check 138°C (MPa)

Fig. 10  Finite element stress nephogram of yield strength check 180°C (MPa)
3.2. Checking bending strength of self-holding pin of boarding system

The riser is fixed by a latch while in operation. The bolts are arranged in the main deck and the pile chamber, and each floor is provided with 2 groups, a total of 4 groups of bolts.

The size of riser is: Φ254×12.7;

\[ F_1 = G_{\text{riser}} + G_{\text{wartt}} + G_{\text{guide}} = 54kN + 36kN + 40kN = 140kN \]

Load allowance coefficient \( n = 1.5 \)

\[ M = F_1 \times S \times n = 140kN \times 0.5m \times 1.5 = 105kN\cdot m \]

The size of the pin shaft is 50mm×120mm in rectangular section, then the bending modulus is \( W = 0.00012m^3 \). Its material is a high strength alloy steel 42CrMo with a yield strength of 930MPa. According to the Classification Code for Offsea Mobile Platform (2020) issued by China Classification Society, the allowable stress is \( [\sigma] = \sigma_s / 1.25 = 744\text{MPa}. \)

\[ \sigma = M_{\text{force}} / W / 3 = 105kN\cdot m / 0.00012m^3 / 2 = 437.5\text{MPa}< [\sigma] \]

Then the bolt bending strength meets the specification requirements.

4. Conclusion

Through finite element analysis and theoretical analysis, it can be concluded that the design and strength of the mounting system of the boarding system meet the requirements of the movable wellhead platform, and it can provide protection and support for the counterpipe in a safe and effective state.

Reference
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