

The present invention relates to an off-shore production platform, especially off-shore oil production platform, of the type including an upper barge stretching above the level of the sea and connected to a completely submerged hollow lower base by partially submerged connecting legs forming a buoyancy tank and stretching substantially vertically.

Platforms of this type are known by the name of semi-submersible platforms. In order to make such platforms stable in the production position, the lower base is ballasted, for example by filling it with seawater. In known platforms, the legs are formed by cylindrical columns with solid walls delimiting along their entire height a closed space forming a buoyancy tank for the platform.

These platforms do not rest directly on the sea bed and are simply anchored by mooring lines. They are thus very sensitive to the swell of the sea which causes rising and falling vertical movements of the platform. The amplitude of these movements may reach high values. This phenomenon makes oil production from the platform difficult.

In order to attempt to provide a solution to this problem, it has been proposed to extend the length of the legs so that the base is submerged at a great depth. The result obtained by the implementation of this solution remains imperfect and such platforms are complicated to manufacture and to install. Furthermore, they are temporarily unstable during installation.

French patent application FR-A-2,713,588 describes a jack-up platform including legs formed of a metal lattice along their entire height. Floats built into the legs allow the platform to be made buoyant. However, they are not intended to reduce the vertical movements of the platform.

The object of the present invention is to propose an off-shore production platform which is not very sensitive to the swell, and in which the length of the legs connecting the upper barge to the lower base is

limited.

To this end, the subject of the invention is an off-shore production platform, especially an off-shore oil production platform, of the aforementioned type, characterized in that the legs along their submerged height include at least two successive portions, a first portion with solid walls delimiting a closed space and forming a buoyancy tank and a second portion with openwork sidewall, the interior space of this second portion being open to the surrounding marine environment.

According to specific embodiments, the invention may exhibit one or more of the following features:

- the second portion with openwork sidewall is a metal lattice structure,
- the second portion with openwork sidewall is arranged between the first portion with solid walls and the base,
- the first portion with solid walls stretches at least partially immediately below said barge,
- the first portion and second portion are dimensioned such that over the usual swell range period, the pressure force exerted on the first portion with solid walls substantially compensates for the acceleration force of the platform,
- the first portion and second portion are dimensioned such that for two values of swell period lying within the usual swell period range, the pressure force and the acceleration force are equal,
- the smallest value of swell period for which the pressure force and the acceleration force are equal is greater than 4 seconds,
- the submerged height of the second portion lies between one quarter and three quarters of the total submerged height of the leg,
- the submerged height of the second portion lies between substantially 0.4 and substantially 0.65 times the total submerged height of the leg,
- the legs have a cylindrical external overall shape,

- the base includes at least one passage passing substantially vertically right through it,

- the base is filled with a fluid forming ballast, particularly with seawater,

5 - the barge is mounted so that it can be moved along the legs and mechanisms are provided for the relative movement and locking of the barge with respect to the legs,

10 - the said second portion with openwork sidewall is arranged between two portions with solid walls along the submerged height of the legs.

15 The invention will be better understood from reading the description which will follow, given merely by way of example, and made with reference to the drawings in which:

- Figure 1 is a diagrammatic elevation of an oil platform in accordance with the invention;

20 - Figure 2 is a graph representing the transfer function of a platform of the state of the art as a function of the period of the swell;

- Figure 3 is a graph representing the change in pressure force and in acceleration force exerted on a platform of the state of the art as a function of the period of the swell; and

25 - Figures 4 and 5 are graphs similar to those of Figures 2 and 3 for a platform according to the invention.

30 Represented diagrammatically in Figure 1 is a jack-up oil platform of the semi-submersible type. It essentially includes an upper barge 1 extending above the sea when the platform is in production mode, and connected by legs 2 to a submerged lower base 3.

35 In the conventional manner, the upper barge includes technical buildings and accommodation quarters, not represented, as well as a drilling well and wellheads 4.

Moreover, passages 5 are formed through the barge 1 to allow the passage of the legs 2. Lifting mechanisms 6 are arranged around the passages 5 and allow the legs

2 and the base 3 to be lowered and the barge 1 to be winched up above the surface of the water to an altitude which places it out of reach of the highest waves. The mechanisms 6 are, for example, rack and pinion mechanisms, the racks stretching along the entire length of the legs 2. These mechanisms 6 further include means for locking the legs 2 with respect to the barge 1 in order to provide a rigid connection between the legs and the barge.

The legs 2 are, for example, four in number, and have a cylindrical external overall shape. In the embodiment represented in Figure 1, they have a square cross-section, but they may just as easily have a circular or triangular cross-section.

The legs 2 are all identical and along their submerged height have two successive portions. A first upper portion 10 is formed by a tube with solid wall closed off at its lower end by a bottom 12. This first portion thus delimits a closed space isolated from the surrounding marine environment and forms a buoyancy tank for the platform. The upper part of this first portion stretches above the level of the sea on both sides of the barge 1. Its lower part stretches immediately below the barge 1 and is partially submerged.

The first portion is extended by a second portion 14 with openwork sidewall, the inside of this second portion being open to the surrounding marine environment. This second portion is thus interposed between the first portion 10 and the base 3 and is formed, for example, of a metal lattice structure. This structure includes four metal uprights 16 joined together by a lattice 18 of metal tubes.

The second portion is welded at its upper end to the lower end of the portion 10 and at its lower end to the base 3.

As represented in Figure 1, in the production position the submerged height Z_t of the first portion 10 with solid wall represents substantially one third of the total submerged height Z_m of the legs 2. Thus, the second

lattice-work portion is completely submerged and stretches in the embodiment represented over substantially two thirds of the total submerged height of the legs 2. In general, the submerged height of the second portion with openwork sidewall lies between one quarter and three quarters of the total submerged height of the legs 2.

In practice, calculation shows that the submerged height of the second portion generally lies between substantially 0.4 and substantially 0.65 times the total submerged height of the legs.

The base 3 is hollow and is of square, rectangular or triangular overall shape. It is filled with seawater and thus forms ballast for the entire platform. It may also include reservoirs incorporated within it and in which hydrocarbons are stored. Furthermore, a central passage 20 passes right through the base 3. This passage reduces the resistive surface presented to the water during vertical movements of the platform. It may also allow drilling tools to run through it.

In the position represented in Figure 1, the platform floats thanks to the submerged part of the first solid-walled portions 10. These portions are subjected to a pressure force denoted F_p exerted on their bottom 12. The pressure force F_p depends on the submerged height Z_t of the first portion 10.

It may be expressed, to a first approximation, in the form:

$$F_p = A_0 e^{\beta z_t} f(t)$$

Where:

A_0 is the area of the buoyancy surface, that is to say the area of the bottoms 12, β is the wave number of the swell and $f(t)$ is the rise in level of the free surface of the sea as a function of time.

Furthermore, the entire platform is subjected to an acceleration force denoted F_a which is due mainly to the movements of the water and especially to their

effects on the base 3. This acceleration force depends on the total submerged height Z_m of the legs 2. It may be expressed, to a first approximation, in the form:

$$F_a = k_1 B e^{p_{2m}} f(t)$$

Where:

5 k_1 is a constant for a given swell period and B is the sum of the mass of the base 3 filled with water and of the added mass. The added mass is a fictitious mass taking account of the action of the seawater surrounding the base on the platform as the latter moves.

10 The two forces F_a and F_p applied to the platform are in phase opposition. In these conditions, it will be understood that it is possible to dimension the first and second portions such that the submerged height Z_t of the portion 10 is such that over the usual swell period
15 range, the pressure force F_p exerted on this first portion substantially compensates for the acceleration force F_a of the platform. In addition, the dimensioning may be such that for two values of swell period lying within the usual range of swell periods, these two forces
20 are equal.

To this end, when dimensioning the platform, the floating surface, that is to say the surface of intersection of the legs with the surface of the water, and the volume of the base, are determined first of all. By a
25 conventional stability approach, the total submerged height Z_m of the legs required is then determined.

The submerged height Z_t of the first portion with solid wall is determined by solving the equation equating the forces F_a and F_p applied to the platform.

30 Using a computer simulation of the behaviour of the platform, it is then verified that the two values of swell period for which the forces F_a and F_p are equal do lie within the usual swell period range. In particular, it is verified that the smallest value of swell period
35 for which the two forces are equal is greater than 4 seconds.

If such is not the case, a new calculation of the heights Z_m and Z_t is performed with a base of a different volume or a different shape. This is because changing the structure of the base, particularly changing its shape, changes the added mass. In this way, the heights Z_m and Z_t are changed as are the values of swell period for which the two forces F_a and F_p are equal.

Represented in Figure 2 is the transfer function of a platform of a state of the art, that is to say one with legs formed of a single solid-walled portion stretching from the base 3 as far as the barge 1, as a function of the swell period T expressed in seconds. The transfer function in Heave is the ratio between the amplitude of the pounding movement of the platform and a swell with an amplitude of one metre, the Heave being a magnitude representative of the rising and falling vertical movements of the platform under the effect of the swell.

It will be observed from this curve that the heave of the platform is great over a range of periods of 18 to 28 seconds. This range of periods corresponds to the high values of swell periods commonly encountered. Furthermore, the Heave is extremely great for swell periods of close to 24 seconds.

Represented in Figure 3 are the change in the pressure force F_p and the change in the acceleration force F_a as a function of the swell period T expressed in seconds for a platform of the state of the art. It may be observed from these curves that the amplitudes of the forces F_a and F_p for a given period of less than 28 seconds are very great. Furthermore, the discrepancies between the values of the forces F_a and F_p are great. Thus, the platform is subjected mainly to the acceleration force F_a , and this results in the great heave seen in the curve of Figure 2. For a period substantially equal to 31 seconds, the values of F_a and F_p are substantially equal, which corresponds to a substantially non-existent heave in this figure.

For the platform according to the invention, represented in Figure 1, the transfer function is repre-

sented in Figure 4, while the forces F_a and F_p are represented in Figure 5.

It may be observed from Figure 5 that by virtue of the design of the legs as two successive portions, one of which has solid walls and the other of which has an openwork sidewall, it is possible for the values of the forces F_a and F_p to be brought very close to one another for a wide range of swell periods lying between 0 and 24 seconds and corresponding to the usual swell. Furthermore, the curves representing the forces F_a and F_p intersect at two points over this range of values, which in material terms, given that these forces are in phase opposition, corresponds to a cancelling-out of the resultant excitation force applied to the platform.

It will be observed from Figure 4 that since the acceleration force F_a and pressure force F_p compensate for one another substantially over the entire range of periods corresponding to usual swells, the heave of the platform is very low. In particular, the maximum heave obtained in this range corresponds to substantially 1/6th of the maximum heave obtained with platforms of the state of the art.

Furthermore, in this figure, the curve cancels itself out for two different periods T (15.5 seconds and 23.5 seconds) and not just one value as in the case of known platforms. These two cancelling-out values are the result of the two points of intersection of the curves representing the acceleration force F_a and pressure force F_p .

The curves represented here were obtained with a platform of which the submerged height Z_t of the first portion 10 with solid walls was equal to 50 m and of which the total submerged length Z_m of the legs was equal to 140m. The volume of the base was equal to 33,000 m³ the surface area of the float surface (sum of the areas of the bottoms 12) was equal to 841 m². The added mass of the platform was equal to 194,750 tonnes.

As an alternative, not represented, it is also possible to interpose between the lower end of the

lattice-work portions 14 and the base 3, of the solid-walled portions forming additional buoyancy tanks or storage tanks for the platform. In these conditions, the lattice-work portions 14 are arranged between two solid-walled portions along the submerged height of the legs.

Moreover, any other arrangement of successive portions, some of which have solid walls and others of which have openwork sidewall is also possible when producing the legs of the platform.

It will be noted that with this type of platform, the length of the legs is independent of the depth of the production site.

What is more, the good stability of the platform allows wellheads to be installed on the barge.

CLAIMS

1. Off-shore production platform, especially off-shore oil production platform, of the type including an upper barge (1) stretching above the level of the sea and
5 connected to a completely submerged hollow lower base (3) by partially submerged connecting legs (2) forming a buoyancy tank and stretching substantially vertically, characterized in that the legs (2) along their submerged height include at least two successive portions (10, 14),
10 a first portion (10) with solid walls delimiting a closed space and forming a buoyancy tank and a second portion (14) with openwork sidewall, the interior space of this second portion (14) being open to the surrounding marine environment.
- 15 2. Platform according to Claim 1, characterized in that the second portion (14) with openwork sidewall is a metal lattice structure (18).
3. Platform according to Claim 1 or 2, characterized in that the second portion (14) with openwork sidewall is
20 arranged between the first portion (10) with solid walls and the base (3).
4. Platform according to any one of the preceding claims, characterized in that the first portion (10) with solid walls stretches at least partially immediately
25 below said barge (1).
5. Platform according to any one of the preceding claims, characterized in that the first portion (10) and second portion (14) are dimensioned such that over the usual swell period range, the pressure force (F_p) exerted
30 on the first portion (10) with solid walls substantially compensates for the acceleration force (F_a) of the platform.
6. Platform according to Claim 5, characterized in that the first portion and second portion are dimensioned
35 such that for two values of swell period lying within the usual swell period range, the pressure force (F_p) and the acceleration force (F_a) are equal.
7. Platform according to Claim 6, characterized in



that the smallest value of swell period for which the pressure force (F_p) and the acceleration force (F_a) are equal is greater than 4 seconds.

8. Platform according to any one of the preceding
5 claims, characterized in that the submerged height of the second portion (14) lies between one quarter and three quarters of the total submerged height of the leg (2).

9. Platform according to Claim 8, characterized in
10 that the submerged height of the second portion (14) lies between substantially 0.4 and substantially 0.65 times the total submerged height of the leg (2).

10. Platform according to any one of the preceding
claims, characterized in that the legs (2) have a cylindrical external overall shape.

11. Platform according to any one of the preceding
15 claims, characterized in that the base (3) includes at least one passage (20) passing substantially vertically right through it.

12. Platform according to any one of the preceding
20 claims, characterized in that the base (3) is filled with a fluid forming ballast, particularly with seawater.

13. Platform according to any one of the preceding
claims, characterized in that the barge (1) is mounted so that it can be moved along the legs (2) and in that
25 mechanisms (6) are provided for the relative movement and locking of the barge (1) with respect to the legs (2).

14. Platform according to any one of the preceding
claims, characterized in that the said second portion
(14) with openwork sidewall is arranged between two
30 portions with solid walls along the submerged height of the legs (2).

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