Simulation of aerodynamic wind protection of oil platforms workplaces

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Abstract. The paper presents the results of a study of the effectiveness of aerodynamic windproof devices. Considered various options for the placement of wind protection relative to the deck and simulated wind speed and air movement trajectory. As a result of the analysis of the velocity fields, the best layout options for wind-proof devices have been proposed.

Introduction

The continuous production cycle of work on offshore oil platforms is a necessary condition for their economic efficiency. Difficult weather conditions create serious problems in terms of work safety, complications during handling operations, etc. High air velocity at the production site creates technological and environmental problems, increases the risk of work performance. The lack of natural protection from wind and the need to organize continuous work on offshore oil platforms determine the need to solve the problem of reducing wind exposure at workplaces, crossings, and helipads. To solve these problems, we have proposed the design of aerodynamic windproof elements with high protective and operational properties, mobility and low cost.

Methods and Materials

The study of various ways of arranging windproof elements based on the aerodynamic effects on the air flow has become the subject of our study. Windscreen can be organized by installing inclined flat panels, profiled concave sheet elements, devices in the form of a directional reflector. These devices can be placed on the edge of the deck, shifted from the edge, can be lowered below the level of the deck platform. Evaluation of the effectiveness and operational features of these methods, determining the choice of technical solutions, we obtained using a numerical model.

The numerical model includes the Navier-Stokes and continuity equations in difference form:

\[ F_v + g \rho - gradP + \mu \nabla^2 u = \rho \frac{du}{dt} \]  

In Cartesian coordinates for the direction of film flow along the x-axis, the equation takes the form [8]:

\[ \rho \frac{du}{dt} = g_x P - \frac{\partial P}{\partial x} + 2 \frac{\partial}{\partial x} \left[ \mu \frac{\partial u}{\partial x} \right] + \frac{\partial}{\partial y} \left[ \mu \left( \frac{\partial u}{\partial y} + \frac{\partial v}{\partial x} \right) \right] - \frac{2}{3} \frac{\partial}{\partial x} \left[ \mu \left( \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} \right) \right]. \]  

Similarly, the equation is written for the coordinates y and z. Because the change in airflow pressure is small, and the air density varies only slightly, the mass balance is taken into account by the continuity equation for an incompressible fluid:

\[ divu = 0. \]
The design scheme for various ways of placing the aerodynamic protective elements of the platform is shown in Fig. 1.

**Results**

Flat aerodynamic elements can be located with different angles of inclination, barrage offset from the deck, and download slopes from the deck. For each of the options calculations are performed for the angles of inclination of the plates: $20^\circ$, $10^\circ$, $0^\circ$, $-10^\circ$, $-20^\circ$. As an example, Figure 2 shows the results of calculating the velocity field for three ways of placing aerodynamic elements.

![Diagram showing various ways to accommodate the aerodynamic windproof element](image)

**Figure 1.** Image of various ways to accommodate the aerodynamic windproof element
Figure 2. The velocity field and the current line: a - without barriers; b - barrage from the deck; c - barrage offset from the inclined deck to the deck
As can be seen from the figures, in the absence of a windscreen over the deck at a height of 4-5 m, the wind speed is 2 times higher than the background value, at a height of 2 m it is 1.5 times. Currently, wind protection is usually made in the form of a vertical plate placed on the edge of the deck. An example of such protection in the form of an inclined plate can be seen in Figure 3b. Below the upper edge of the plate, the wind speed is small, and a sheet of vortices is observed behind the sheet. With a plate height \( h \), at a height of 1.5\( h \), the speed reaches the value of the background wind speed, and at a height of 2\( h \) it exceeds the background one by 2 times. From this we can conclude that the high efficiency of windproof elements is achieved at heights of lower height of the plates. Increasing the height of the railing on the edge of the platform deck is undesirable in many cases. The work of cranes is complicated by high speed in the areas of movement of cargo.

The shift barrage offset from the deck increases the protection zone in height. The protective effect is achieved by the interaction of the aerodynamic element with the platform side, creating a vertical air flow in the form of an air curtain. The lower air velocity in the area of operation of cranes is also an advantage of this design.

**Discussion**

Figures 3-6 are graphs speed distribution along the length of the deck in various ways to install barriers on the edge of the deck.

![Graph](image)

**Figure 3.** Speed distribution along the length of the deck in various ways to install barriers on the edge of the deck at a height of 0.5 m above the deck.
Figure 4. Speed distribution along the length of the deck in various ways to install barriers on the edge of the deck at a height of 1.0 m above the deck.

Figure 5. Speed distribution along the length of the deck in various ways to install barriers on the edge of the deck at a height of 1.5 m above the deck.
Speed distribution (at a height of 2.0 m above the deck) along the length of the deck in various ways to install barriers on the edge of the deck

Figure 6. Speed distribution along the length of the deck in various ways to install barriers on the edge of the deck at a height of 2.0 m above the deck

The graphs of speed distribution along the length of the deck in various ways to install barriers on the edge of the deck were confirmed by the conclusions on the high efficiency of aerodynamic wind-protective elements made on the basis of the analysis of the velocity fields, barrage offset from the deck. At a distance of 30h along the deck and at a height of 2h the speed does not reach the value of the background wind speed.

Conclusions

Numerical simulation of wind protection of offshore oil platforms allowed us to identify promising areas for the creation of highly efficient aerodynamic elements with high performance. Research will be continued in terms of the specification of the structural parameters of protection to achieve the greatest effect and to obtain the calculated dependencies for the dynamic loads on the structural elements.

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