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Arctic Drilling Operations

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ABSTRACT

Another surge in arctic exploration is set to begin, and unlike the 80's and 90's exploration of the shallow Beaufort Sea, operations will move to water depths far beyond the capability of bottom founded drilling platforms. The solution will be the development of newer and more capable floating drilling platforms. Their design will have to reflect the challenges of the depths and the unique environmental forces found in the arctic, ice forces in particular.

There are several platform and position control options available, each with the own positive and negative attributes. One of the more promising alternatives is dynamically positioned (DP) drill platforms. A successful platform design will have to take into account both hull and DP controller performance in heavy ice environments. Meeting these requirements is not just complicated by the increased forces and moments, but also by the intermittent nature of ice loadings.

Initial vessels designed to meet these rigid requirements have begun to appear in industry, such as Stena's Drillmax Ice, but none have been put to the test in the arctic. A successful platform will have to be tested eventually at great financial and environmental risk.

1 INTRODUCTION

Since the discovery of petroleum reserves within the arctic, exploration companies have been looking for offshore drilling platforms that are capable of operating successfully and safely in the regions with harsh conditions. The mix of harsh weather conditions, remote locations and sea ice has resulted in some unique and innovative solutions. Some notable solutions include those developed during the Beaufort Sea exploration hay-day ranged from artificial islands, bottom founded caisson structures to moored floating drilling platforms. Each of these solutions had positive and negative attributes; those like the Kulluk and Molipaq were particularly successful and remain in operation to this day.

The future of arctic drilling will not be limited to these shallow regions; instead, it will require drilling in water depths of 150m or more and in severe ice conditions. In order to drill at these depths, different technologies will have to be employed. The most promising alternative for increasing water depths is the use of dynamic positioned drilling vessels. Operating a DP drilling vessel in the arctic will mean overcoming several design challenges such as the design of the vessels themselves and the DP controllers.

2 DP IN THE ARCTIC

The use of dynamically positioned (DP) drilling platforms in the arctic has several advantages when compared to other drilling platforms, such as moored floating platforms. Their mobility allows DP vessels to rapidly change locations in either a local or global sense. This mobility negates the requirement of towing vessels during moves, which reduces cost. DP drilling vessels also enjoy a considerable advantage during the setup to commence drilling operations. A DP vessel simply needs to move to the drilling location and begin operations, while a moored vessel requires the installation of an extensive anchoring system. The time required to place the anchors results in a reduction of the number of well holes that can be drilled in a given season. The placing of anchors will also require the presence of expensive anchor handling support vessels. This combination of mobility and setup advantages enables DP vessels to rapidly disconnect and reconnect to the drill site in the event of adverse weather or approaching severe ice conditions, saving time and money. In addition to these points, there is a certain water depth in which the cost of setting up the anchoring system of a moored drilling platform becomes both economically and physically prohibitive, and the only alternative is a DP vessel. Ice forces will reduce this cut-off margin significantly due to an increase in number of anchors and difficulty in setting (and retrieving) the anchors.

The disadvantages of operating a DP drilling platform in the arctic are primarily centred on the fact that it has never been done before. Although there are new custom-built stationary vessels with DP Systems currently under development, they have not yet been tested in full scale. There are only two instances to date of DP operations in ice conditions; the Arctic Coring Expedition (ACEX) near the North Pole in 2004, and the construction operation in Sakhalin with the CSO Constructor in 1999[2]. While these experiences were very educative, they were not hydrocarbon drilling operations, and thus their risk was much lower than what an oil exploration operation would be. Like these two referenced operations, a DP drilling operation would also require the presence of both an extensive ice management system consisting of ice management vessels and an extensive ice risk management plan. The number and capability of the icebreakers would be dependent on the independent capabilities of the stationary platform. A successful DP platform will have to have fully capable hull form, powering, and DP controller.

3 DP CONTROLLERS

The first task to accomplish in fielding a successful arctic DP drilling system will require the development of an ice capable DP controller. The success of a DP controller involves making accurate prediction of the forces acting against a vessel for a given environmental condition. For open water DP controllers there is considerable experience with predicting wind, waves and current forces. During operations in the arctic, ice forces have to be accounted for as well and they complicate predictions greatly. Ice forces are not dependent on a single easily defined variable like wind forces (speed), but instead is dependent on ice concentration, floe size distribution, drift speed, thickness and type (1st year, etc.). The presence of ice will also alter the prediction of other forces as well, which will have to be corrected depending on conditions. Unlike wind, wave and current forces, ice forces are not unidirectional either, even in cases where a vessel is pointed directly into the ice drift, ice will impart longitudinal, lateral forces, and turning moments. This will cause position deviations in both directions, as well as heading deviations.

To further complicate the design of DP controllers, there are many types of ice interaction scenarios and failure mechanisms that can occur, which all have an influence on the loads experienced by the vessel. Ice force loadings do not follow a defined pattern; instead it follows a highly variable and random pattern of loading and unloading. This unloading and loading pattern is a result of the process of floes impacting the vessel, moving along the hull and eventually clearing. In some cases additional floes that not in direct contact with the vessel can form floe chains to those that are in direct contact. These accumulation events can result in extreme peaks in forces that are far beyond the nominal levels. These random patterns require that ice capable DP controllers have faster responses and more accurate position reference systems to reduce position deviations.

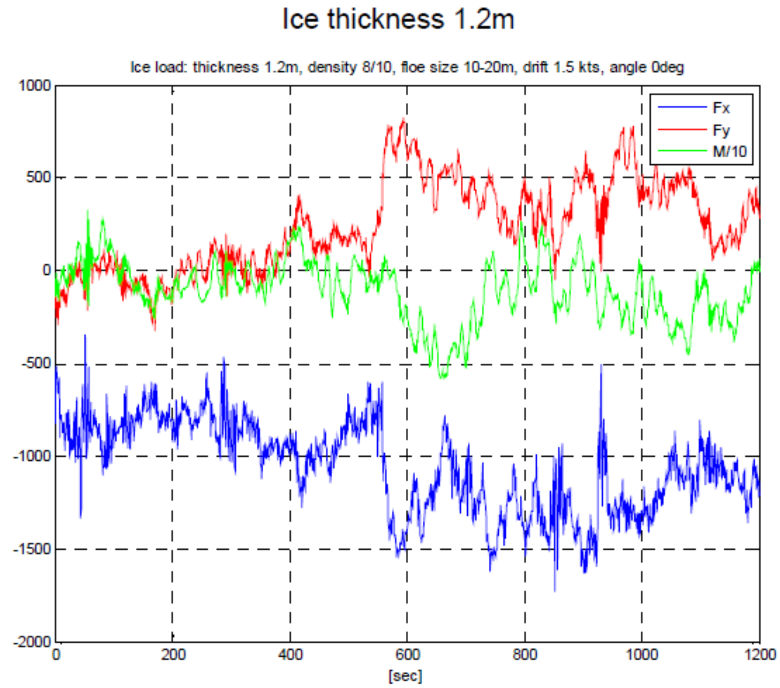

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Figure 1 DP thrust curve 8/10 coverage, 1.2m Ice, Drift Speed 1.5 kts.

The response pattern of a proposed DP controller in Arctic pack ice can be seen Figure 1. Small peaks seen in the loading pattern are the results of small deviations from the target control point. The large upward bugles are the result of floe chaining or the impact of particularly large floes.

4 DRILLSHIPS

In the past there are two traditional configuration options considered for DP drilling platforms, drillships and semisubmersibles. Drillships are mono hull ship shaped drilling platforms, typically constructed with a moon pool and derrick located at or near midships. With a ship shaped hull, drill ships are unique as compared to other drilling platforms. The mobility of drillships allows them to transit to and from remote locations much faster than other drilling platforms, as they are already equipped with powerful propulsion systems. The increased storage space, for equipment and stores, in combination with their large displacement (50,000t to 100,000t Disp), allows for drill ships to operate in remote location with less support for extended periods of time. In some cases, larger drillships are equipped with extended well testing operations, or limited production in some cases, which allows for some of the drilling cost to be offset by oil recovered. The primary disadvantage of a drillship configuration involves the susceptibility of a ship shaped hull to wave motion and ice interaction. In severe weather the movement of the drillship would limit the operational drilling envelope, and is susceptible to very large ice loads if the ice approaches the vessel at angles other than from the bow.

During operations in ice, drillships will be pointed bow first into the ice drift. The reduction in size of interaction area reduces both the frequency and magnitude of ice interaction events. However, the hull geometry of a drillship is a concern when the drift floe direction changes rapidly. When floe direction changes occur, the area of interaction increases dramatically as the longer dimension of the vessel begins to interact with the ice flows. This will result in a corresponding increase in the ice forces and moments. These rapid drift vector changes would require that an arctic drillship be capable of rapid 180 degree heading changes with the help of ice management vessels. In addition the moonpool aboard, a drillship extends all the way through the hull; this configuration confers protection to the riser/drill string from ice impacts and accumulation.

Adapting DP drillships to operate in the arctic will involve some changes to the vessel design, which will involve a strengthening of the hull in order to survive ice forces, as well a possible redesign of the vessel bow to a shape more suited to the breaking and deviation of ice flows. Drillship hulls may require some redesign in order to reduce propeller interactions with submerged flows and possible intrusions into the moonpool. The powering requirements for a vessel operating in such rugged environments will increase dramatically to offset both the increase caused by ice forces and the required redundancy in case of either engine or thruster failure.


[3]

Figure 2 Stena Drilling Drillmax Ice

5 SEMISUBMERSIBLES

Today semi-submersibles are a very common type of offshore drilling rig. They have been developed in response to increased operations in deeper and more hostile waters, and the invention of the superior motion characteristics of a semi submersible hull. The stability of a ballasted semi submersible is a combination of the large amount of submerged buoyant hull, wide spacing between the pontoons, and an extremely small effective water plane area. The submerged hull and wide spaced columns make a semi submersible significantly more resistant to sea motion than a normal ship in both the vertical and horizontal planes.

Dynamic positioned semi-submersibles are currently being used in some of the harshest open water regions on earth and in water depths of up to 3000m. However, their adaptability to the arctic is still unknown. There are several inherent problems and benefits in the typical design of semi submersibles when exposed to arctic conditions. The small effective water plan area of a semisubmersible would, in theory, make it less susceptible to severe ice conditions but, in tow tank tests performed during the 1980s (Noble et. Al, 1981)[5], it was found that with round columns in level ice does not allow ice to simply flow around and between the columns; instead it accumulated and formed a solid wall as wide as the outside dimensions of the rig. This significantly increases the cross sectional area of the rig, and thus the power requirements as well. The shape and small water plane area also make a semi-submersible less susceptible to off heading drift angles and more manoeuvrability in ice. Ice accumulation at the columns can lead to vertical and horizontal loadings, which because of the small waterplane area, makes this type of vessel particularly susceptible to large heels and trims. Another problem with the design is the typical placement of the drilling riser/drill string. Usually placed in the centre of the rig between the pontoons; the riser is not protected from either ice flow impacts or accumulation. Another problem concerning semi sub operations in the arctic is the requirement of supply and storage capacity, due to the inherent sensitivities associated with variable payloads and their relatively small waterplane areas. The reduced storage capacity of semi-submersibles will require supply boat operations more often and tanker support, if well testing and production is to be attempted.

Adaptation of DP semi submersibles to arctic operations will involve significant changes to the basic design. The redesign will involve the development of protection for the riser/drill string, which will complicate the issue of ice accumulation between the columns. This might be offset with redesigning the column shapes and spacing to reduce ice accumulation.

Other more unusual semi submersible hull configurations have been proposed, in particular JBF's Arctic. JPF proposes a semi submersible design with two different operating drafts. The shallow draft allows the rig to be situated like a typical semi submersible and at the deeper (heavy ice) draft, the vessel columns are fully submerged and a secondary ice hull is lowered into place.

[4]

6 CONCLUSION

With arctic exploration in deeper waters becoming a reality, Dynamic Positioned vessels are going to be essential. In order for this to be accomplished a lot of the technologies, equipment and methods required to operate in such a hostile environment will have to be developed. Their development will be an enduring progressive process, as different ideas will have to be tested using numerical, model and full scale research, until an economical and successful blend of capability and safety has been found.

7 REFERENCES

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