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Features of Tabular Iceberg Towing

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Some features of the movement of tabular icebergs during their towing are examined. A tabular iceberg towed in the Barents Sea in 2017, for which surveys of the underwater and surface parts were carried out, was selected for the analysis. As a result of numerical and physical modeling, the hydrodynamic characteristics of the iceberg were obtained for different motion courses; good convergence of the results of these methods was achieved. To determine each component, the numerical simulation, based on the equations of a viscous fluid motion, was carried out. Turbulent fluid flow is described by the Reynolds-averaged Navier–Stokes and continuity equations. The k–ω SST turbulence model is used to simulate turbulence. Numerical differentiation of the equations was performed in the open-source computational fluid dynamics software OpenFOAM. It is shown that the iceberg has several positions of stable and unstable equilibria in terms of the rotation around a vertical axis, and the influence of an iceberg's orientation on additional resistance during rough seas is considered. Obtained results may be used in planning tabular iceberg towing in different regions of the world, as well as in further studies of iceberg behavior under load.

INTRODUCTION

Toward the development of the Arctic, there is a difficult ice situation that requires the development of innovative approaches in its development. Particular attention should be paid to environmental and industrial safety since the ingress of hydrocarbons into the marine environment in the Arctic will lead to severe consequences for the ecosystem of the polar seas.

Exploration and extraction of resources in the Arctic at great depths (more than 100 m) is challenging because of the unpredictability of ice conditions and high ice loads (Hamilton, 2011). The main threats to offshore oil and gas facilities during the development of the Arctic shelf are ice formations of various origins: icebergs (continental ice) and hummocky formations (deformed sea ice).

Icebergs pose a serious threat to shipping, mining, and transportation of minerals in the coastal zone. Ensuring safe human activities on the Arctic shelf requires the development of a comprehensive system of measures to detect, monitor, and predict iceberg drift and assess risks (May et al., 2019a, 2019b). Such works have been carried out both in Russia and abroad (Korsnes and Moe, 1994; Kubat et al., 2005).

One of the most effective methods to prevent collisions of offshore oil and gas structures with icebergs is towing the icebergs. This approach is well known and has been used for more than a dozen years (Kornishin et al., 2019); however, to implement it, it is necessary to correctly predict the behavior of icebergs.

To predict the behavior of icebergs in the open sea, studies are being carried out to analyze the trajectories of icebergs (Buzin et al., 2019), drift models are being developed, and towing experiments are being carried out (Efimov and Kornishin, 2012; Efimov et al., 2019). The development of software for ice management in areas of oil and gas production development is a promising and vital task.

In the work of Bruce et al. (2016), two tools have been developed. One assesses the stability of the iceberg in order to identify the preferential towing directions to reduce the likelihood of rolling the iceberg during a tow. The other allows the user to assess the local shape of the iceberg relative to the towing net to help avoid unfavorable iceberg shapes and slopes. The results of this work and simplified method to numerically determine the most stable orientations for towing will contribute to improving iceberg management efficiency in all regions. Evolved tools have been presented in O'Rourke et al. (2020).

However, as described in Kornishin et al. (2019), an iceberg has an unstable equilibrium: during directional towing experiments in the Barents and Kara Seas, icebergs rotated around a vertical axis

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