International Journal of Offshore and Polar Engineering (ISSN 1053-5381)

Vol. 30, No. 2, June 2020, pp. 194–201; https://doi.org/10.17736/ijope.2020.jc784

http://www.isope.org/publications

Morphometry and Internal Structure of Ice Ridges in the Kara and Laptev Seas

Roman B. Guzenko, Yevgeny U. Mironov, Victor V. Kharitonov, Ruslan I. May, Viktor S. Porubaev and Stepan V. Khotchenkov
Department of Sea Ice and Ice Forecasts, Arctic and Antarctic Research Institute (AARI)
St. Petersburg, Russia

Konstantin A. Kornishin
R&D and Technical Regulations Department, Rosneft Oil Company
Moscow, Russia

Yaroslav O. Efimov
Department of Marine Operations, Arctic Research Centre
Moscow, Russia

Petr A. Tarasov
R&D and Technical Regulations Department, Rosneft Oil Company
Moscow, Russia

The article presents an analysis of the expedition results on morphometry and the internal structure of ice ridges. A regression equation connecting the consolidated layer (CL) thickness of ice ridges with the sum of degree-days of frost is proposed. The issue of the CL distribution inside the ice ridge is considered. It is shown that the largest CL thickness is observed in the zone, combining the maximum sail and keel. The averaged porosity distribution by vertical is derived, and the main regularities of its change inside the ice ridge are shown.

INTRODUCTION

Ice ridges are typical large ice features of the Arctic seas. Having a significant mass and being as a rule in constant motion, ice ridges present a potential threat for marine engineering infrastructure. To determine possible loads on offshore facilities and design appropriate protection, it is necessary to know the main morphometric parameters of an ice ridge for a specific region. They are the crest length, sail height and width, keel depth and width, total thickness, porosity (the volume of voids divided by the total volume of the ice feature; hereafter porosity is referred to as macroporosity), consolidated layer (or CL, the part of the ridge in which the ice blocks were frozen into a monolith), thickness, etc. (Alekseev et al., 2001). Figure 1 presents a diagram of an ice ridge. The CL and porosity refer to the internal structure characteristics of ice features, and it is possible to determine them only by using special equipment.

In different publications, studies of parameters of ice ridge internal structure are frequently based on rather rough measurements using mechanical drilling where the internal structure characteristics in the borehole are obtained practically by touch. The need of using more modern equipment to exclude both the objective technical imperfection of the mechanical method of internal structure investigation and the subjectivity of the drilling system's operator is noted in Ervik et al. (2018). Besides, most articles on the internal structure of ice features present observations of single ice ridges; a study on more than five features is rare (Strub-Klein and Sudom, 2012). Such data paucity is caused by imperfect methodology.

Under the guidance of V.A. Morev, the Arctic and Antarctic Research Institute (AARI) created a technology allowing one to obtain information on the internal structure of large ice features with high productivity and accuracy (Morev et al., 2000). This technology was successfully applied in the expeditions from 2001 and is constantly being improved. Processing and analysis of thermal drilling data made it possible to obtain regularities of morphometric characteristics of ice ridges and stamukhi in the Caspian, Okhotsk, and Kara Seas (Mironov and Porubayev, 2011a, 2011b, 2012).

The present work aims to analyze data on the morphometric characteristics of ice ridges, obtained by improved thermal drilling technology as well as total station and sonar surveys in the Kara and Laptev Seas. Fieldwork was performed by AARI specialists for the Rosneft Oil Company in 2013–2017 during the period of maximum ice cover development (predominantly April–May). During this period, 139 ice ridges were investigated. Analysis and generalization of such a large data volume make it possible to reveal new morphometric regularities and increase scientific understanding of the role of physical processes in the formation of ice ridges.

TECHNOLOGY OF WATER THERMAL DRILLING AS A METHOD TO STUDY THE MORPHOMETRIC CHARACTERISTICS OF ICE FEATURES

To measure the morphometric characteristics of ice ridges and stamukhi, one employs the ice water thermal drilling system with

Received August 13, 2019; updated and further revised manuscript received by the editors January 30, 2020. The original version (prior to the final updated and revised manuscript) was presented at the Twenty-ninth International Ocean and Polar Engineering Conference (ISOPE-2019), Honolulu, Hawaii, June 16–21, 2019.
KEY WORDS: Ice ridge, thermal drilling, internal structure, consolidated layer, porosity, sail, keel.