ABSTRACT

This article presents the methodology of determination of ice loads acting on ice belt of a ship. This method is also eligible for stern of the modern double-acting ships. Calculated parameters of ice loads make it possible to check strength of ship hull operated in different ice conditions depending on its speed. The design methods are verified including comparison with the results of the full-scale measurements of ice loads. Results of the analysis show that the designed ice loads (with an accuracy needed for the practical use) correspond to the calculations of the results of full-scale measurements.

KEY WORDS: ice, double-acting vessel, hull, methodology, ice loads.

INTRODUCTION

Development of the arctic shipping and shipbuilding is a remarkable issue of the present. Economic practicability raises the necessity of the improvement of technical and operational characteristics of ice ships. Improvement of ice capability is one of the way of solving this problem. The latter led to the development and implementation of extreme bow hull lines (with large entrance angles of waterline and frames) which make it possible to decrease the force of the resistance between hull and level ice. Double-acting ships fitted with azimuth thrusters also make it possible to improve the operational characteristics. In heavy ice conditions double-acting ships are operated astern and this reduces the force of the resistance between hull and level ice. Double-acting ships are also eligible for stern of the modern double-acting ships. Ice load is calculated in dependence with the speed of a ship, characteristics of ice cover (first-year, multi-year ice, level ice, characteris tics of ice formations). The results of the calculation of local loads needed for hull strength check are calculated: value of ice force perpendicular to the surface of hull; sizes of hull/ice contact zone, i.e. height and length of ice force application zone, average ice pressure along the contact zone, parameters of ice loads acting on an element of hull corresponding to a frame spacing (ice force, average contact pressure). Impact between bow (stern) bilge and ice sheet edge (channel edge) is assumed as a main scenario for the determination of the ice impact parameters. Ice load is determined by the condition of breaking down of the ice edge by bending. Possibility of the interaction between wall-sided board and ice cover without breaking down by bending is considered also. The latter scenario is the governing for assigning of the parameters of ice impact on the wall-sided area of bulbous bow. Ice load is calculated in dependence with the speed of a ship, characteristics of ice cover (first-year, multi-year ice, level ice, hummock, strength characteristics of ice formations). This methodology includes specified determination of strength characteristics of ice formations. The results of the calculation of local loads parameters can be used for the hull strength check (area AI, ice belt) and for the assignment of the admissible conditions of ice navigation respectively.

Main Approaches of Determination of Ice Loads Acting on Ice Belt of Bow and Stern of Ice Ships Including Icebreakers

CNIIMF, RS and Peter the Great Saint-Petersburg Polytechnic University have developed the methodology of calculation of the local ice loads acting on the elements of hull (stern part of double-acting ship) along ice waterline AI (ice belt). The following parameters of the local loads needed for hull strength check are calculated: value of ice force perpendicular to the surface of hull; sizes of hull/ice contact zone, i.e. height and length of ice force application zone, average ice pressure along the contact zone, parameters of ice loads acting on an element of hull corresponding to a frame spacing (ice force, average contact pressure). Impact between bow (stern) bilge and ice sheet edge (channel edge) is assumed as a main scenario for the determination of the ice impact parameters. Ice load is determined by the condition of breaking down of the ice edge by bending. Possibility of the interaction between wall-sided board and ice cover without breaking down by bending is considered also. The latter scenario is the governing for assigning of the parameters of ice impact on the wall-sided area of bulbous bow. Ice load is calculated in dependence with the speed of a ship, characteristics of ice cover (first-year, multi-year ice, level ice, hummock, strength characteristics of ice formations). This methodology includes specified determination of strength characteristics of ice formations. The results of the calculation of local loads parameters can be used for the hull strength check (area AI, ice belt) and for the assignment of the admissible conditions of ice navigation respectively.

General Points Provisions of the Methods of Ice Strength Characteristics Determination

The methodology includes determination of the following distributions: temperature, salinity, porosity and strength of ice, unconfined compressive strength across ice sheet and consolidated part of hummock in