

# Assessment of Frictional Drag on Ship Advancing in Ice Floes

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## ABSTRACT

The estimation of drag exerted on a ship operating in arctic region has recently been of interest; however, the quantitative methods have still been investigated and mostly relied on the experiment in the ice tanks. Among many components of ice drags on ships, the breaking resistance is known as dominant one while the others including frictional drag are unclear in estimation. In general, the frictional drag is estimated based on the buoyant force on the ship exerted by ice floes in contact with the hull; however, the hydrodynamic pressure effects are not yet considered.

In these perspectives, this study describes a hybrid method to assess the frictional drag on a ship operating in the ice floes. Considering the friction between the ship hull and the ice floes depends on the normal force on the ice floes in contact with the hull surface, the hydrodynamic pressure around the hull is computed to be considered as normal forces on the ice floes in addition to the buoyant forces.

A set of full 3D Navier-Stokes equation is employed to compute the hydrodynamic pressure on the ship hull in steady and turbulent flow without free surface. It is assumed that the portions of hull surface under positive hydrodynamic pressure experience the friction by the normal force caused by the pressure force and the buoyant force on the ice floes. By summing up the individual frictional force on the discretized hull surface, the total frictional forces for model ships were compared those of experimental values. The results show that this method provides a good assessment of the frictional drag within reasonable errors.

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