A Consideration on Bow Design of Arctic Tanker Transiting in Thin Level Ice and in Broken Ice Channel

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ABSTRACT

Arctic tankers are classified into two categories, namely, 1) ice strengthened tanker with bulbous bow and 2) self-propelled icebreaking tanker with ice breaking bow. Ice strengthened tanker navigates in both open sea and sea ice. In sea ice the tanker usually follows icebreakers as a convoy system. The tanker must navigate in both full load condition and ballast load condition in sea ice and interaction between bow part with large bulbous bow and ice also becomes severe.

Ship resistance in sea ice is extremely large compared to open sea so reduction of icebreaking resistance by bow form optimization is a very important subject from the viewpoint of transportation efficiency in both open sea and sea ice.

In this paper, after reviewing design parameters of bulbous bow tanker in sea ice compared to icebreaking tanker, hull shape analysis is as made using typical conventional tanker lines and several problems on icebreaking characteristics are pointed out. Finally, a proposal for bow form is described.

KEY WORDS: arctic tanker; bulbous bow; icebreaking resistance; open sea; bow form optimization; hull shape analysis; change of draft in sea ice; proposal of bow form configuration

INTRODUCTION

Due to the increase of amounts of crude oil and LNG produced in the Southern Barents, the Far East Sakhalin etc, the needs of arctic tanker are increased for exporting the natural resources from Russia. Many arctic tankers were built and are under construction in Korea, Europe and Japan.

The special feature of the sea route is having both sea ice and open sea. The ratio of sea ice depends on navigating route and season. The self-propelled icebreaking tanker and DAT(Double Acting Tanker) are often used when the ratio of sea ice is large and ice feature is severe.

But in case that ice feature is light and the distance of sea ice navigation is relatively short, conventional tanker designed for open sea navigates in the sea ice under convoy of icebreakers. These tankers are called “ice strengthened tanker”, installed with engine power based on specified ice class to withstand ice load.

Generally, icebreaking resistance is extremely larger than open sea resistance. Many research studies on icebreaker hull form have been made for a long time and today’s icebreaking bow was developed. On the other hand, as hull form of ice strengthened tanker is designed exclusively for open sea navigation, ship resistance in sea ice, as a matter of course, increases extremely as compared with icebreaker-like hull. Thus, it becomes very important and interesting subject to investigate and find out the optimum bow form from the viewpoint of both performances in sea ice and open sea, for obtaining the desirable speed in the permissible range of the ship safety speed diagram needed in ice. But there are a few published papers about this subject.

In this paper, following items are discussed.
(1) Design target and parameters of conventional bulbous bow tanker in sea ice
(2) Hull shape analysis of bulbous bow tanker, several problems on icebreaking characteristics in ice and consideration for its improvement
(3) A proposal of bow form to improve icebreaking performance without deterioration of open sea performance

DESIGN TARGET OF CONVENTIONAL BULBOUS BOW TANKER AND ICEBREAKING TANKER

Design Characteristics of Both Tankers

Design characteristics of both tankers having full and ballast load conditions, and navigating in both open sea and sea ice are summarized in Fig.1. Generally, as for performance design of tanker, the fore part (bow and bulbous bow) and the after part of the tanker can be designed independently by separability principle of ship form. The former is mainly designed from the viewpoint of wave resistance and the latter is mainly designed from the viewpoint of viscous resistance and self-propulsion performance. In this paper, only bow part is discussed due to the problem of icebreaking phenomena.

Design parameters in open sea performance are stem shape, sectional area curve, water line curve, frame line, form of bulbous bow, etc. In case of tanker selected reasonable sectional area curve, bulbous bow design is subsequently important for wave making resistance. Wave making resistance is separated into wave pattern resistance and wave breaking resistance. Wave breaking resistance at ballast condition is dominant. The large bulbous bow is necessary to reduce wave breaking resistance so most tankers have large bulbous bow.