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Strength Assessment for Bow Structure of 107k DWT Arctic Tanker under Special Ice Loads

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ABSTRACT

The majority of Arctic class rules have been revised continuously based on collision experiences of small or medium size vessels operating in arctic area. IACS (International Association of Classification Societies) Polar Class Rules was also developed based on collision data for those small vessels with level ice and ultimate hull strength calculated from non-linear FE analysis.
During the design of 107k DWT arctic tanker, which is much larger than the vessels utilized in rule development, several collision scenarios were provided through co-work between ABS, BMT Fleet and DSME to consider possible ice loads which IACS Polar Class does not cover.
Three different collision scenarios were suggested for bow structure strength assessment. They are based on actual ice characteristics in Barents Sea. Besides level ice, ice floe and semi-ramming, which are not considered in IACS Polar Class, were also considered in collision scenarios. For each collision scenario, ice loads were directly calculated. Direct strength assessment through non-linear FE analysis was followed to verify bow structure design of 107k DWT arctic tanker.

KEY WORDS: Arctic Tanker; IACS Polar Class (PC); Barents Sea; Popov ice model; DDPS; bow structure analysis

NOMENCLATURE

DDPS	Direct Design for Polar Ships Computer Program by Prof. Daley for Ice Load Calculation
KE	kinetic energy
IE	indentation energy
PE	potential energy
PC	IACS Polar Class

INTRODUCTION

Vast reserves of oil and gas are expected to be exploited in the Russian Arctic including the Barents Sea, the Pechora Sea and the Kara Sea. To transport crude oil, large crude oil tankers, which should be prepared for ice collision, are required.

In structural point of view, ice loads as well as wave and current loads should be considered in hull design. However, ice loads are not familiar with ship designers since market demands were not so strong yet. With the increase of market requirement, lots of joint research works are under progress to consider the ice loads in design stage. IACS Polar Class released in 2007 is a fruit of such joint work and the ship for service in Arctic area will be designed in accordance with the IACS Polar Class and/or Other Arctic rules.

Vessels operating in the Arctic region are exposed to a number of unique demands. However, current operational experience in the Arctic is limited to much smaller vessels than those that are envisaged. A key design issue at the conceptual and detailed phases is the integrity and safety of hull structures under ice interaction. So, we have researched the features of the Barents Sea and then we have developed ice load models based on these data.

ABS and BMT Fleet Technology have developed DDPS – new ice load model which can consider various hull geometry, ice thickness and ship speeds. DSME recently designed 107k Arctic tanker. To verify newly developed ice load model as well as Arctic tanker, three parties, i.e., ABS, BMT Fleet and DSME started joint research work.

Among several scenarios in DDPS, three most possible collision scenarios were selected for strength assessment of bow structure. Ice loads calculated using DDPS were compared with IACS Polar rule and non-linear FE analyses were followed for strength verification.

The Barents Sea

The Barents Sea which has many oil and gas fields is a marginal sea bordering on the Arctic Ocean in the north, the Greenland and the Norwegian Seas in the west, the Kara Sea in the east and the coast of the Kola Peninsula in the south.

The Barents Sea has open water for most of the year. In some years in the mid march to mid May time period, incursions from the ice pack can occur and thin locally grown ice can extend in a narrow fringe off the South West coast of Novaya Zemlya. The ice pack, when it occurs in the region is very mobile and large ice floes can occur in this region.