Numerical Analysis of Stress and Strain for Ship Decks with Wide Hatches

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ABSTRACT

The cases of the appearance of increased deformations of deck structures are typical for the ships with wide cargo hatches. These deformations could appear in conditions of simultaneous action of vertical, horizontal bending moments and torque as well as due to ship increased flexibility. This investigation was motivated by numerous damages in hull structures of ships with wide deck openings that are operated in the Far East Basin. In this research we offer to use calculation procedure, as well as formulas limiting the width of the hatches. This will allow to choose the width of the deck opening corresponding to the allowable level of combined stresses and deformations under torsion in the deck structures, at early design stages.

KEY WORDS: Torsion; combined stresses; contour of openings; limiting; hatch width.

INTRODUCTION

Increased deformations of deck structures typically appear in ships with wide-open decks. These deformations can lead to an increase in stresses and warping of a hatch openings contour. The latter is especially unwanted because of the possibility of violation of hatch cover watertight integrity. Increased stresses in the deck structures in most cases are caused by bending of deck stringer in its plane, which can happen under bending and torsional moments, and local loads. This fact was reported by many researches and operators. The accidents in old vessels during the storm, when detachable hatch beams were falling out from its places, are known to be caused by the deformation of longitudinal coamings (Barabanov, NV, 1993).

An example of side structures deflections towards center line under transverse loads is the incident on board of m/v «Seatiger», which occurred due to the incorrect loading of the ship with the coal. Hatch cover rollers moved outside of the guiding device because of the significant deformations of the deck stringer and longitudinal coamings. Tape measurements of diagonals of the rectangular hatch openings have not shown any difference with original dimensions, while longitudinal hatch coamings have moved closer by more than 100 mm (Fig.1).

Calculations of strain-stress state of a cargo hold and stepwise measurements of cargo hold deformations during loading of the vessel have been carried out in order to check the strength of the hold. (German, AP, Novikov, VV, and Shemendyuk, GP, 2013).

Figure 1. Dislocation of hatch cover rollers, m/v «Seatiger»

The finite element method was used as a tool in the calculations. The calculations and measurements have shown that ship’s hull has relatively low rigidity, which is due to excessive deck opening. As result an excessive bending of deck stringer in its plane together with longitudinal coaming occurred, followed by side structures deflections towards center line under operational loads.

A lot of damages and cracks are observed on the mixed navigation vessels, which hulls have relative low flexure-torsion stiffness. For example, on vessels type “Ladoga” (length L = 77.6 m) a number of typical damages have been detected (Fig.2). The possible reason for these damages could be low rigidity of deck stringer when ship sides are exposed to the external pressure (Goretyi, OA, and Surov, OE, 2014).

Given examples of the damages are typical. Further studies are required to look into stresses and strains in structures of ships with wide-open decks.