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Adoption of a Radiused Hopper Knuckle: Recommendations for Design and Fabrication

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The use of a radiused or bent hopper knuckle with no offset between the longitudinal girder and the knuckle line (aligned radiused hopper knuckle) was proposed by DAEWOO Shipbuilding and Marine Engineering (DSME) as a design alternative to a conventional welded hopper knuckle for a Very Large Crude Carrier (VLCC). Extensive numerical and experimental studies were carried out within Phase I of a Joint DSME/Lloyd's Register Project to ensure good fatigue performance of the aligned hopper knuckle.

INTRODUCTION

A Very Large Crude Carrier (VLCC) is a tanker with Deadweight Tonnage (DWT) between 200,000 tonnes and 315,000 tonnes and up to 470 m long. The welded connection between the hopper tank sloped plating and the inner bottom plating has always been a matter of concern because of the very high local stress concentrations in the area. Considerable efforts have been made to optimise the design of the connection and to improve the fabrication process with the intention of achieving quality welds and accurate alignment during construction.

The use of a radiused hopper knuckle as a design alternative to a conventional welded hopper knuckle for a VLCC will increase productivity by reducing fabrication time during construction, and it will provide easy maintenance in service. The work described in this paper was carried out to confirm that a fatigue standard equivalent to that normally achieved for a welded hopper knuckle could be assumed.

FINITE ELEMENT STUDY: EFFECT OF OFFSET OF LONGITUDINAL GIRDER FROM KNUCKLE LINE

The objective of the study was to identify the effect of an offset of the longitudinal girder from the knuckle line on the hot-spot stress at the critical location. Fig. 1 shows the position of the knuckle line in relation to the longitudinal girder for a radiused hopper knuckle.

Analysis Scheme

A numerical study on the effect of an offset of the longitudinal girder from the knuckle line was carried out. Three types of hopper knuckle were considered: welded knuckle; radiused hopper knuckle with an offset of 100 mm between the longitudinal girder and the knuckle line (referred to below as eccentric radiused hopper knuckle); and radiused hopper knuckle with zero offset between the longitudinal girder and the knuckle line (referred to below as aligned radiused hopper knuckle). Fig. 2 shows the 3 types of hopper knuckle design.

Numerical analyses were performed for a 300,000 DWT double-hull VLCC. Table 1 shows the 3 levels of finite element analysis that were carried out. Fig. 3 shows the global finite element model; Fig. 4, the first and second level zoom models.

Finite element analysis for the global model was performed for the internal pressure dynamic load case according to DNV's guidance (DNV, 2003). The ABAQUS finite element package was used to perform finite element analyses for the global and zoom shell element models.

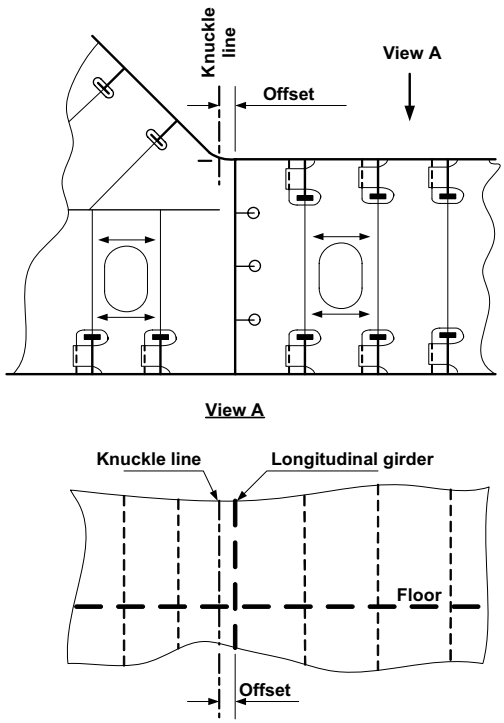

Fig. 1 Position of knuckle line in relation to longitudinal girder for a radiused hopper knuckle

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