Fatigue Strength Assessment of the River-Sea Bulk Carrier Based on Spectral Analysis Method

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ABSTRACT

This paper focuses on the fatigue strength of river-sea direct link ships based on spectral method. A 45000 DWT river-sea bulk carrier is taken as an example, hydrodynamic analysis method and finite element analysis method are adopted using SESAM software to study its wave induced loads and bending-torsional strength of whole ship structure. Fatigue check points are chosen according to the stress and deformation distribution of hull structure. The spectral-based fatigue analysis is applied to gain four typical nodes’ fatigue strength in two loading conditions, and their accumulative fatigue damage and life are obtained. Hot spots’ stress response spectral and fatigue life spectral in per sea state are drawn to analyze the effect of different sea states on fatigue damage. Sub model technique is applied and fractions of time in loaded condition and ballast condition are taken into account during analysis process.

KEY WORDS: River-sea bulk carrier; fatigue strength; spectral-based fatigue analysis; SESAM software.

INTRODUCTION

River-sea through transportation refers to goods that are transported from the starting port directly to the destination port by the same ship through rivers and ocean waters without transshipment (B. Bao, S.Y. Qin, T.Z. Cheng, 1991). The river-sea direct link ship can directly sail into the sea from the river or directly sail into the river from the sea, thereby reducing the transit shipment link of goods transportation, which has the advantages of high efficiency, short period and less damage. It is an ideal vessel for river-sea joint transportation.

In recent years, the number of river-sea direct link ships has grown rapidly. But the technique of structural safety is still imperfect and need to be improved and verified, and the construction expense and consumption has great optimization space (Y.S. Li, C.Y. Niu, 2008). Due to restrictions of the port berths draft and waterway, the river-sea direct link ship is a kind of shallow draft full ship forms. Only this type of ship can solve the contradiction of inland waterway draft restriction and cargo capacity as large as possible.

River-sea direct link ships are different from inland boats and sea-going vessels, which directly cross the river and sea, two different meteorological and hydro-logical conditions, and must be able to withstand the structural safety test of two different navigation areas. Wide and flat features of river-sea-through ships have a great effect on strength and stiffness of the hull structure. When river-sea-through ships sail in the river and sea, they suffer different wave loads, whose periods and wave heights are different. When calculating their design loads, directly using existing empirical formulas in rules for inland ships or rules for sea-going ships is inappropriate.

The ship structure is subjected to wave loads and inertial forces repeatedly during the voyage. They are dynamic loads and constantly changing, which cause alternating stress inside the structure, resulting in fatigue damage. The insufficient fatigue strength of ships’ typical node sites is one of the main causes of the hull structure’s damage. Especially for large-scale ships, constructed with high-strength steel, the problem on ship hull structure’s fatigue damage is more outstanding. The cracks found in the ship structure need to be repaired in time, otherwise their propagating to a certain stage will result in the hull structure’s catastrophic damage. The cracks detection and repair will cost a lot of money and manpower. So in the ship design stage the hull structure should be ensured to meet fatigue life requirement. How to reasonably assess the fatigue strength of ships is becoming more imminent.

At present, there have been some fatigue strength evaluation methods for ship structures. But fatigue strength evaluation is very complicated, which involves many aspects, including load calculation of hull structure, stress analysis, dealing with stress concentration of nodes, determination of the S-N curve, and the fatigue cumulative damage calculation, etc. (Y.H. Peng, J.H. Liu, F.H. Wang, 2011; Ahmet Tasdemir, Serkan Nohut, 2012). Besides, there are many uncertainty factors. The fatigue damage has great randomness. To establish a simple and reliable method of fatigue strength assessment, we still need to do a lot of work.

Besides, there is less study on river-sea direct link ships’ fatigue strength. This paper focuses on this type of ship. The structural strength of the global model with coarse grids is analyzed by finite element method. Then the sub models with refined mesh grids of the fatigue check locations are established. Stress and displacement boundary conditions are extracted from the global model to calculate the sub models’ stress distribution corresponding conditions. Finally the fatigue spectral analysis method based on the S-N curves is used to assess fatigue strength of refinement sub models. The calculation results provide the basis for improving structure node design to ensure that the hull structure have enough fatigue life.