Development of Strength Evaluation Methodology for Forward Structures of a Container Ship

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ABSTRACT

In recent years, the local structural damages on forward structures of Container ships have been reported by accidents. During the initial design stage, global direct strength analyses are generally performed for evaluation of yield and buckling strength using net dimensions of primary structure of container ship. Generally, the seakeeping and stochastic analysis are performed for the target ship to calculate the linear external wave and dynamic loads based on 3D linear potential theory. However, this method calculates external loads only on the wetted surface of the ship and thus additional strength evaluation is required to ensure the safety of the forward part of the container ship located above the draught line. In this study, the strength analysis considering the max. bow pitching case and bow impact effect are performed to evaluate the primary structures of forward holds of a container ship in addition to traditional global strength analysis. The max. bow pitching analysis is based on nonlinear external wave loads and considers the maximum bow pitching acceleration condition, while bow impact analysis is based on rule-based patch loads. Both analyses are performed using Finite Element Analysis (FEA) and applying Korean Register classification rules. The strength is evaluated in terms of yield and buckling capacity. The analyses procedures are thoroughly analyzed and presented with applied examples. The insights of this study will be helpful for the safe design of a container ship.

KEY WORDS: Structural damage, Forward structure, The Max. bow pitching, Bow impact effect, Container ship

INTRODUCTION

Recently, local buckling and cracking damages are frequently reported in the bow area of container ships built in large shipyards. Damages to the hull cause not only its own risk, but also the expenditure of repair costs and the loss of time due to repair, ultimately causing a significant reduction in the safety and economic efficiency of the ship. Also, as a results, this signifies that the strength evaluation method currently applied is insufficient to predict the structural strength of the fore and aft parts of container ships. In general, the strength evaluation procedure in the design stage proceeds with scantling check that satisfies the prescriptive rule, and the structural integrity of the ship is evaluated through cargo hold analysis, global structural analysis, and fatigue analysis.

Recently, a simplified evaluation method based on rule load has been proposed to evaluate the structural strength against impact loads such as slamming. In the IACS Common Structural Rule (IACS, 2022), simple formulas are presented for the pressure generated for bottom slamming which occurs when the hull is exposed to the surface of the water and then re-entered and bow flare slamming caused by incident waves at the bow of the ship. In addition, classification societies such as Lloyd register guideline (LR, 2018) suggest a method for calculating the bow's immersion state based on the deterministic formula. However, it is not necessarily applied at the design stage depending on the type and size of ships such as container ships and small and medium-sized tankers, and there are limitations in application because accurate analysis procedures or tolerances are not presented.

The study on the evaluation of the ship's bow structure has been studied for a relatively long time and mainly conducted on the slamming impact loads. However, despite long-term research, the impact phenomenon itself is very complex in nature and it is very difficult to apply in the actual design stage as the respective hydrodynamic analysis and structural analysis is also very complicated.