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Meshing generation strategy for prediction of ship resistance using CFD approach

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Abstract

CFD is a numerical approach used to solve fluid problems. In the CFD simulation process, the meshing stage is crucial to produce high accuracy. Meshing is a process where the geometric space of an object is broken down into many nodes to translate the physical components that occur while representing the object's physical shape. The research objective was to analyze the characteristics of the mesh technique in the Finite Volume Method (FVM) using the RANS (Reynolds - Averaged Navier - Stokes) equation. The numerical simulation approach used three mesh techniques, namely overset mesh, morphing mesh, and moving mesh. The k-ε turbulent model and VOF (Volume of Fluid) were used to model the water and air phases. The mesh technique approach in CFD simulation s[illegible]owed a pattern under experimental testing. This research showed the difference in value to the expe[illegible]men[illegible] results, namely by using the moving mesh method, the difference in resistance difference w[illegible] 8% at high-speed conditions, the difference in trim value at overset mesh was 11%, and the differen[illegible] in heave value with the moving mesh method was 14% at low speed. The conclusion reported t[illegible]t overset mesh had better than other mesh methods.

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Preface

Papers

Meshing generation strategy for prediction of ship resistance using CFD approach

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Abstract. CFD is a numerical approach used to solve fluid problems. In the CFD simulation process, the meshing stage is crucial to produce high accuracy. Meshing is a process where the geometric space of an object is broken down into many nodes to translate the physical components that occur while representing the object's physical shape. The research objective was to analyze the characteristics of the mesh technique in the *Finite Volume Method* (FVM) using the RANS (*Reynolds - Averaged Navier - Stokes*) equation. The numerical simulation approach used three mesh techniques, namely overset mesh, morphing mesh, and moving mesh. The k-ε turbulent model and VOF (*Volume of Fluid*) were used to model the water and air phases. The mesh technique approach in CFD simulation showed a pattern under experimental testing. This research showed the difference in value to the experimental results, namely by using the moving mesh method, the difference in resistance difference was 8% at high-speed conditions, the difference in trim value at overset mesh was 11%, and the difference in heave value with the moving mesh method was 14% at low speed. The conclusion reported that overset mesh had better than other mesh methods.

Keywords: CFD, Fridsma hull, morphing mesh, moving mesh, overset mesh

1. Introduction

An experiment conducted by G. Fridsma in 1969 has sparked many researchers to conduct similar research related to planing hulls. Fridsma conducted experimental analysis on ships with the planing type, hereinafter known as Fridsma ship, with several L/B configurations, displacement, deadrise angle, LCG (Longitudinal Center of Gravity), and so on [1]. Supported by the ship's simple geometry, until now, there has been much research discussing the Fridsma ship.

The rapid development of technology makes research more effective to do. One technology supporting the research of ships is a numerical simulation method based on Computational Fluid Dynamics (CFD). CFD is a system program that can plan and analyze an engineering product using mathematical solutions. In the analysis using CFD, especially ship type planing, the methods used to predict the resistance and movement of the planing hull included FVM (Finite Volume Method), FEM (Finite Element Method), FDM (Finite Difference Method), and analytical-experimental. According to Yousefi in 2013, the most appropriate method used to predict drag, trim, and heave on ships was FVM because

Experimental study of a ship with the self-righting moment in extreme condition

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Abstract. Patrol vessel is an essential part of offshore security archipelago countries such as Indonesia. The main feature of patrol vessel is operating in rough waves during operation. Ship stability is one of the challenging aspects of patrol vessel because, in extreme conditions, the ship can capsize due to losing a self-righting moment. The present paper carried out a study of a patrol vessel with a self-righting moment in extreme conditions. The condition is a ship with rolling up to above 180^0. Thus, the ship can capsize because of losses of the self-righting moment in rough condition. An experimental study is carried out to model a ship with a rolling angle above 180^0. The principal dimension of ships Lpp, B, H, T, are 13.0 m, 4.2 m, 2.19 m and 1.15 m, respectively. The study was carried out with a physical model of ship 1:27.4. The model is made using 3D printing to maintain the hull integrity. In the present paper, only the full load condition was tested in the experiment condition. It was showed the ship design was proven to have a self-righting moment in the rolling angle above 180^0.

1. Introduction

Patrol vessel is an essential part of offshore security archipelago countries such as Indonesia. The main feature of patrol vessels is operating in rough waves during operation. Ship stability is one of the challenging aspects of high-speed craft because the ship has a small breadth that leads to small self-righting moments in roll motion. This situation could endanger the vessel when a vessel is rolling above 180^0; as a result, a ship can capsize due to losing a self-righting moment. Priohutomo has studied patrol vessels with control manoeuvering ships using an experimental approach in wave basins [1]. The study of the number of bilge keel in patrol vessels was done by Widyatmoko [2]. The study of ship construction and strength of patrol vessels has been conducted by Koostanto [3], moreover CFD simulation was performed by Samuel [4]. The effect of spray strip on on high-speed craft has been conducted by Samuel [5]. Self-righting moment of the patrol vessel was carried out by Putra using a numerical approach. The results showed self-righting moments could be achieved by extending the breadth of the upper deck structure [6]. Previously, the self-righting moment study was done using a numerical method using Hydromax [7]. It shows that the study of a physical model of patrol vessel with a self-righting moment is rolling above 180^0 still few. Thatcher has divided some remarks of self-righting methods into three methods, i.e., inherent stability self-righting, inflatable bag, and ballast movement [8]. Capsize is one cause of marine accidents in the world, as shown in Fig. 1 [9], although it is a very small portion based on Fig.1. Moreover, a patrol vessel is commonly used as a search and rescue (SAR) vessel; as a result,

A study of interceptor performance for deep-v planing hull

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Abstract. The acting on the planing hull is the most complex hydrodynamics simulation. Therefore, an analysis was done to evaluate drag, lift force, and seakeeping in two degrees of freedom (2-DOF) which is heave and trim. It was fundamental aspects of the overall high-speed vessel. This article focused on the hydrodynamic performance of a complete interceptor configuration that could control the motion behavior of deep-V planing hull in calm water conditions. The benchmark study was undertaken by comparing numerical results with experimental study by Park at al. Models with and without interceptors had been analyzed by numerical simulation performed using Reynold Averaged Navier Stokes (RANS) to describe turbulence model with k epsilon based on computational fluid dynamic (CFD). In this study, the interceptor proper applies at a speed of less than Froude number 0.87. Interceptor reduce by 21% drag at Froude number 0.87 and also reduce by 16% trim and 6% heave at Froude number 0.58. Nevertheless, applied interceptor in high Froude number such as more than Froude number 1.16 caused interceptor lose effectiveness due to producing a decisive moment which made negative trim (bow-down) and increase total drag.

Keywords: CFD, drag, full interceptor, heave, lift force, planing craft

1. Introduction

The interceptor is a thin rectangle mounted on the vessel's transom to modify local flow near the stern. The interceptor generates substantial additional pressure towards the vessel’s stern. This concept is adopted from an aerodynamic device called a gurney flap on race cars to increase down-force on the car's rear wing. The interceptor mechanism aims to increase the lift to drag ratio pressure on the vessel, which is slightly different from the situation on race cars. The aerodynamic aspect of a racing car does not affect drag friction. However, drag friction is significantly affected even in steady flow on the vessel. The interceptor will modify the pressure distribution in the same way as the gurney flap. However, the interceptor can affect the balance, which impacts the generation of the stern wave system and the resistance due to the waves. In addition, the increase in lift force also reduces sinkage and wetted surface areas as well as frictional resistance to the hull.

An experimental study conducted by Day and Cooper reported that the interceptor could reduce drag on sailing yachts [1]. Furthermore, Van Oossanen conducted a 45 m motor yacht with an interceptor dimension of 50 mm using the CFD approach. The study resulted in a reduction in the trim of 1 degree and decrease in drag of 7% at Froude number 0.6 [2].

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Dynamic Safety Modelling for Ship Management Performance

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Abstract. Recent development and projection of ship operations as a sociotechnical system is getting more complex. In order to successfully emulate a high-reliability organization with a balance between operational efficiency and safety, the shipping companies have to grab a well understanding of the operating performance. However, because the teams are distributed spatially and temporally, a misalignment of shared situation awareness casually exists. We extended Rasmussen's dynamic safety theory and adjusted it in the context of ship management performance. A modelling study using system dynamics was done to illuminate how the feedback loops construct the interaction between safety, efficiency, and workload. The simulation result shows that the operations behave following the safety and efficiency pressures created by existing goals and boundaries. The model is also able to capture these trade-offs in different variety of operation scenarios. Application such modelling may provide the managers with a better understanding and valuable insight to implement the strategies to sustain safe operations.

1. Introduction

Balancing between efficiency and safety in ship operation is common practice, as well as other general industries. While doing it, each level of the organization's components in ship operation frequently makes a trade-off between efficiency and thoroughness to manage the available resources [1]. Naturally, an organization such as a shipping or ship management company based their decision to pursue optimum cost-effectiveness, but on the other hand, it also prepares the stage for the accident [2]. In a sociotechnical system where safety is viewed as a control problem, an accident occurs whenever this control system cannot handle component failure or external troubles [3]. Therefore, examining the behaviour in each interaction between components becomes more prominent.

Ship management operation has a characteristic of the distributed team between shore staff and onboard seafarers. Different time operations make the team distributed not only geographically but also temporally [4]. Even the accident number in maritime operations is decreasing, human error, especially the failure of situation awareness, remains dominant [5]. The failure to attain situation awareness occurs not only because the difficulty in communicating mental models between the team members onboard, but also between onboard and shore side [6]. The overall situation awareness is perceived differently by an individual based on incomplete and inaccurate information. Such condition makes the team remain locked into a false picture of the situation until accidents or incidents occur [4].

The interaction between onboard seafarers and shore management and its behavior in terms of efficiency, safety, and workload needs to be closely observed in a feedback loop environment.