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Research paper

Drag-Reduction Study and its Dynamic Characteristics on Recreational Speedboat Utilizing Simplified Shark Skin Design

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Abstract

Inspired by the structure of the shark skin denticles, our team has carried out a study on the attempt of improving the hydrodynamic design of marine vessels through design modification on the hull form by applying simplified imitation of shark skins. Speedboat models used in this study were designed using computer-aided design (CAD) software and computational fluid dynamic (CFD) simulations were then carried out to predict the hydrodynamic effect of the bio mimicry application on the hull form, mainly focusing on the wave profile produced by the models as well as the total drag experienced by it under two different Froude value; Fr≈ 0.39 and Fr≈0.47. Interestingly, the design modification on the hull gave encouraging results with a reduction of 12% and 10.4% at Fr≈ 0.39 and Fr≈0.47 respectively on the total drag coefficient. Furthermore, the modified speedboat provides better wave pattern compared to unmodified hull form. The reduction of drag force could contribute to a more efficient vessel with better cruising speed. Thus, this provide better impact to marine industry in order to help improve their vessel dynamic performances.

Keywords: *Biomimetic shark skin, hull modification, simulation, marine vessel.*

1. Introduction

Shipping industry has grown into one of the largest scale economy in the world concomitant to the development on the size of the marine vessels which has escalated rapidly [1]. Various studies have also been actively carried out today to create a more efficient vessel, less polluting and better in performance. The turbulent flows of ship's motion is a difficult fluid mechanics problem. Drag force is an example of physical phenomenon which normally due to air or fluid that flows through either moving or static objects. Hence, it is good to have a better understanding on external flow in designing of numerous engineering systems including automobiles, watercrafts, aircrafts and all varieties of turbines [2]. Reducing the resistance experienced by the vessels may help in improving the cruising speed and reduces the consumption of fuel simultaneously [3]. Prediction on viscous flow around the ship is commonly carried out through computational fluid dynamic (CFD) activities. A free surface flow plays an important role in predicting the ship hydrodynamic and ship wave resistance [4]. This present paper discusses on the effect of the implementation of biomimetic shark skins on hull of a speedboat focusing on hydrodynamic effect which includes drag resistance and the flow pattern produced around the model. Mimicking nature such as shark's denticle is a learning process on how natural occurring of living creatures can inspired us to come up with designs that has functions similar to them.

As explained by most researchers, it is proven that the unique structure of the shark skin denticles gave hydrodynamic effects that can help in reducing drag. Primarily, the water that drifts along the body of the shark will flows smoothly due to the presence of these denticles. It retains the fluid to flow in laminar pattern and helps to speed up the fluid which closes to the body surface of the shark. This will help reduce the velocity difference for fluid near the body surface and fluid which flows away from the body surface. Fluctuation in the fluid's velocity will retain the pattern of the flowing fluid throughout the entire body and later splits off into turbulence flow. Narrower wake or vortices produced behind the shark leading to a more efficient swim, less drag and faster speed [5]. The main aim of this research is to study the effect of modified hull design on marine vessel with the implementation of simplified biomimetic shark skin denticle.

2. Materials and Methods

2.1 Model Development

The marine vessel models were designed using computer-aided design (CAD) and simulated using CFD. Two speedboat models are drafted which include a default model and a model which were added with simplified biomimetic riblet shark skin (BSS) denticle on its hull. The dimensions of the models are as follows: length L = 0.65m, width W = 0.2m, height h = 0.1m, and the parameters of the biomimetic shark denticle and the geometry of the body is shown in Figure 1. Figure 2 shows the structure for the biomimetic riblets and the dimensions are as follows: riblet height, h= 2.0cm, riblet length, s1= 2.0cm, s2= 4.0cm, s3= 6.0cm, =1.0cm, r2= 2.0cm and distance between riblet, d = 1.0cm.

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