CFD APPROACH TO RESISTANCE PREDICTION AS FUNCTION OF ROUGHNESS

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ABSTRACT

Computational fluid dynamics (CFD) is an effective tool to analyse the flow within turbulent boundary layer and it has become very popular to assess the resistance and power performance of marine vessels including dynamic fluid-structure interaction. Resistance of a marine vessel is mainly divided into frictional resistance and residuary resistance. Frictional resistance is induced by shear stress around hull which is dominated by hull form and hull roughness, both could be investigated using CFD software.

Roughness of surfaces affects the flow properties and causes a reduction in velocity profile in turbulent boundary layer which turns in to an increase of shear stress and frictional resistance. The frictional resistance of a ship has paramount importance to ship speed, power requirements, fuel consumption and greenhouse gas (GHG) emissions. Smoothing the hull surfaces using antifouling marine coatings is a prevalent method to reduce frictional resistance to a degree. Hence, it is very desirable to investigate ship coating's roughness effect on flow and frictional resistance particularly by using a CFD approach.

This paper aims at presenting a CFD approach to predict resistance as function of surface roughness by performing CFD simulations of towing tests of coated flat plates. Following a brief description of roughness and the roughness effect on turbulent boundary layer, different types of roughness function model and flow regimes are discussed in details. The CFD approaches to represent smooth and rough velocity profile as well as roughness function and frictional resistance are presented with illustrations. Then, a validation study is carried out to obtain frictional resistance coefficients (C_F) of flat plates with different surface roughness conditions using the existing CFD approach, namely uniform sand roughness function approach, and the numerical simulation steps and the cruxes of the procedure are identified clearly. The comparison of C_F values shows this model works very well to represent surfaces roughened with uniform sand whereas it is not suitable to predict the effect of coating roughness on ship resistance.

Therefore Grigson's roughness function model, a more appropriate function for antifouling ship coatings' roughness, is employed in the CFD software and the simulations are repeated. The results obtained by using the new roughness function model are compared against the experimental data given in the literature. The new approach shows a very good agreement with the experimental data and it is able to predict the resistance of ship coatings as function of roughness height. The results are presented in both graphical and tabular forms and discussed in details.

Keywords: Computational Fluid Dynamics, Roughness, Resistance, Ship Coating

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