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Hydrodynamic Optimisation of High-Speed Trimaran Hull Forms

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ABSTRACT

This paper presents experimental data and numerical computations for two trimaran hull forms for high speed transportation: one with round bilge component hulls and one characterized by a hard-chine main hull. The experimental data concern residual resistance results systematically collected for a grid of configurations of both hull forms. The numerical analysis, carried out on the same grid, is aimed to the assessment of the capability of a boundary element method to comply with the physical results related to a complex marine vehicle as the trimaran which involves appreciable interference problems of the free surface pattern around the component hulls. In addition a numerical optimisation is presented which was attempted to individuate the best position of the side hulls by coupling the boundary element method with a stocastic optimisation process similar to genetic algorithms. The search of the best configuration had the objective of minimizing wave resistance in the two-dimensional space describing the side hull positions

KEY WORDS: Multi-hulls; wave resistance; optimisation

INTRODUCTION

Trimaran hulls have recently been subject of interest for some marine applications. In fact they have been considered as alternative to mono-hulls in high speed transportation and in naval applications. In fact, this solution seems to offer good enough hydrodynamic performance and consequently better economy, larger deck area and adequate stability characteristics. A recent example regards the design of a naval vessel which led to the building of a prototype and to the publications of several studies (Royal Inst. of Naval Arch. 2000). Another significant design example has also performed for a fast ferry 126 *m* long which has recently been built(Armstrong, 2003) For this reason, reference data about their measured hydrodynamic performance or reports about applications of numerical methods for their evaluation may be useful for people involved in the design of such vehicles.
As far as hydrodynamic behaviour of trimaran ships is concerned literature sources reporting systematic data and information useful for design are relatively few when compared with those concerning catamarans and mono-hulls. Studies regarding hydrodynamic trimaran behaviour are of course complicated by the fact that, in addition to the influence of the form parameter of the main hull, further variables are added as the form and dimensions of the side hulls and their relative position with respect to the main hull. For this reason a systematic experimental investigation becomes particularly onerous. However some useful examples have been reported (Ackers, 1997). Some research has also been carried out by the research group of the authors (Brizzolara et al. 2005a, 2005b).
An important aid can be offered by numerical investigations that presently allow to examine, in relatively short time, several possible forms and mutual positions of the component hulls. The recent availability and development of three dimensional boundary element methods can supply an useful and adequately economic tool to assess some hydrodynamic characteristics and, even though free surface RANSE methodologies can determinate the complex flow field more completely they still require long times for computation and analysis to be systematically employed to several cases. Three dimensional free surface boundary element methods, based on potential flow approximations, could be more suitable for a massive application.
The study presented in this paper is part of the activity of a national research project dedicated to the study of modern and efficient multi-hull vessels for fast sea transportation. It deals with a high speed trimaran hull suitable for medium range routes and intends to analyze the hydrodynamic behaviour and the interference effects in different configurations and with two different forms for the main hull: a round bilge and a deep-V hull. The paper is concerned with the ship resistance, which, in addition to the results deriving from the towing tank tests, is also evaluated numerically. The numerical investigation is carried out to assess the possibility of complementing the inevitably limited number of experimental investigations, implied by the necessity of considering a higher number of configurations determined by the longitudinal and by the transverse position of the side hulls. As a necessary premise to the latter aim, the accuracy and stability of the results deriving from the application of a free surface potential flow method to these new multi-hull typologies is studied and verified.
Further motivations of the present study regard the enhancement of the experience in the application of parametric optimisation algorithms to the design of fast ship hulls with improved powering characteristics, that brought already interesting results in another study (Brizzolara, 2004).