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Resistance and Seakeeping Optimization of a Fast Multihull Passenger Ferry

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A Semi-Small Waterplane Area Twin Hull (Semi-SWATH) ferry is optimized by an automatic procedure with respect to seakeeping and resistance at different speeds. The numeric procedure is based on a fully parametric model of the unconventional hull form, a 3D linear Rankine sources panel method for the steady wave resistance and the seakeeping problem, and a multiobjective global convergence genetic algorithm. Both global and local shape variations are allowed in order to explore highly unconventional hull shapes. Interesting results are obtained from the optimization considering resistance at the two very different speeds and including or not the seakeeping merit functions. Considerable reductions of drag and vertical acceleration can be obtained from the optimization procedure on the order of 15% on drag at high speeds and 30% on vertical acceleration in most exposed passenger areas.

INTRODUCTION

A new research project focused on the design of a high-efficiency, environmentally friendly passenger ferry for commuters and tourists in coastal areas offered the authors the opportunity to develop an optimization study of the hydrodynamic performance of Semi-Small Waterplane Area Twin Hull (Semi-SWATH) hull forms. A new vessel design based on this unconventional hull form optimized for both seakeeping and resistance will be a major step toward a sustainable and resilient littoral transportation in the Ligurian gulf (north Tyrrhenian Sea). The moorings served by the ferries are basically small fishing harbors, sometimes even simple wharfs, located between the main cities of Genoa and La Spezia. The service is currently run with deep V-hull semidisplacement motorboats propelled by direct diesel drives on twin shafts with fixed-pitch (FP) propellers; they are operated at a wide range of speeds, cruising most of the time between 18 and 22 knots (Froude number Fn ~ 0.67) where the hull drag characteristics are surely not optimal.

Also, the behavior in rough seas of these conventional hull forms, although already better than equivalent round bilge hulls, is generally not good enough to ensure continuous service; as a matter of fact, existing vessels are stopped even in moderate sea states (high SS3 and above). In this respect, a SWATH type hull form is expected to significantly enhance the operability of the vessel for its inherent better seakeeping characteristics (Shack, 1995). The Semi-SWATH hull form is a hybrid type of catamaran hull that combines the shape of a SWATH in the entrance body with that of a high-speed catamaran in the run body; hence, it tries to combine the best of the two worlds, such as optimal seakeeping performance, typical of SWATH vessels, with the possibility to install waterjet propulsors to reach high speeds. They were first described by Shack (1995) in the description of the famous design of the Seajet vessel, the predecessor of the Stena HSS high-speed ferry, and adopted by different shipyards around the world, such as Austal. Except for a few other studies about the seakeeping properties of these kinds of unconventional hull forms, such as Doctors (1991) and Holloway (1998), and a single publication by Armstrong and Clarke (2009) on the resistance properties of these hull types compared to conventional high-speed catamarans, little is known.

The goal of this study, then, is to shed some light on the resistance and seakeeping properties of this type of unconventional hull form and to show which type of unconventional hull form shapes may be more beneficial for the reduction in the resistance in calm water and the motions in the waves. This paper capitalizes on the authors' experience in the previous optimization of conventional and unconventional hull forms. Regarding SWATH-like vessels, Brizzolara (2003, 2004) first applied a fully parametric hull form optimization procedure to single-strut SWATH hull forms, based on an original analytical definition of the underwater hull forms and an inviscid free-surface panel method coupled with a thin boundary-layer solver, demonstrating the large gains attainable with such an integrated procedure in terms of total drag reduction. These systematic studies confirmed the early unconventional designs of SWATH hull forms presented by Salvesen et al. (1985) and Papanikolaou et al. (1991), who discussed for the first time the effect of viscosity and systematically approached the optimization design problem in a rational and formally consistent way, using a global convergence differential evolution minimization algorithm and exploring a large number of design variations (order of 1,000). The optimization method for SWATHs was further refined and implemented with a new general B-spline-based parametric geometry model and applied to the optimization of a twin canted strut high-speed SWATH hull (Brizzolara and Vernengo, 2011). The optimum hull shape obtained by the new fully numerical procedure was used and validated by a high-fidelity RANSE solver in the design of an autonomous surface craft (Brizzolara et al., 2011). In parallel, several navy hull forms with bulbous bow shapes (Vernengo et al., 2009) have been optimized with a partial parametric model, and the results were successfully validated by model tests (Biliotti et al., 2011). In these cases, the objective

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KEY WORDS: Semi-SWATH, multihull ferry, multiobjective optimization, parametric hull modeling, wave resistance, seakeeping, Pareto frontier.