Development of hydrodynamic shape optimization framework for integrated Energy Saving Devices (ESD)

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ABSTRACT

Recently, various Energy Saving Devices (ESD) have been developed and applied to improve the propulsive performance of the vessel. Each ESD such as rudder with rudder bulb, Pre-Swirl Duct (PSD) and Flow Control Fin (FCF) have been being individually optimized based on the hydrodynamic analysis. Though each ESD has a considerable effect on other ESDs, there is not enough researches related to the shape optimization method considering the interaction effect between ESDs. Within this context, the integrated ESD shape optimization framework is dealt with in this paper. ESD includes pre-swirl duct, rudder with rudder bulb and flow control fin that have been already applied to the shipyard are selected for shape optimization. The integrated ESD shape optimization framework is embodied in three modules, Computer Aided Design (CAD) program that generates each ESD based on design variables, Computational Fluid Dynamics (CFD) solver that computes the propulsive performance of the vessel with ESD and optimizer that assesses the outcome of CFD solver to reach the optimal point, respectively. As a design variable, all major design parameters of each ESD are chosen to figure out the interaction between design variables. As a optimization method, hybrid optimization method that combines advantages of the global and local search algorithms is used to obtain the optimal solution. This optimization framework can give a considerable benefit to overcome the dependency on engineer‘s physical intuition and experience. Both CAD and CFD automation enable us to avoid human errors during the repeatition of the CAD and CFD processes and reduce the engineering hours about 25%. To demonstrate our optimization framework, the ESD optimization process is carried out on the single and twin skeg vessels respectively. Throughout the integrated optimization, the physical relavances between ESDs are identified and about 2% or more additional improvement on propulsive performances is carried out than the conventional process that optimize each ESD without considering an interaction effect.

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