Shape optimization of the superstructure of ships with an automated framework based on CFD tool

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Ships, especially VLCC (Very Large Crude Carrier), encounter the resistance from the wave and wind. Generally, the wave resistance under water should be discussed prior to the wind resistance to the ship. Therefore many kind of research are reported concerning about it [1]. On the other hand, in case of the high wind environment, the wind resistance cannot be neglected, particularly for VLCC. The way of reduction of the wind resistance is mentioned in some of few researches [2, 3] with the aim of energy saving. In this study, the wind resistance is focused on and the optimal shape of the superstructure of ships, which has low wind resistance, is explored by the optimization method.

In the present study, the automated framework (shown in Figure 1) for shape optimization of the superstructure of ships (shown in Figure 2) is constructed. In the part of numerical flow simulation of automated framework, instead of commercial software, OpenFOAM is utilized so as to reduce the simulation time with the large number of parallelization. The meshing process for numerical analysis is also performed in parallelization. Therefore this automated framework is not only what achieved full automation but has high efficiency in searching for optimal solution. In the field of general industry, this time reduction has a beneficent influence especially on the designer in the early-stage of design.

Before the exploration of the optimal design, the initial cases are sampled by following the LHD (Latin Hyper Cubic Design) method, which extracts the sampling point statistically and equally within the design space. At the optimization step, the objective function is investigated on the response surface, which is interpolated by the Kriging method generated by using the initial evaluated resistance values from actual CFD.

As the objective function in the shape optimization of the superstructure of ships is the resistance, which is sum of viscosity resistance and pressure resistance, these resistances were output in every calculation time steps and monitored its convergence for the assurance of accuracy. And in this optimization, the wind flow direction is considered as one of the design parameters. This changing of the wind flow direction is produced by the rotation of the superstructure of the ship. Some examples of numerical results are shown in Figure 3, which express the total pressure distribution of various kind of superstructure of ships. The

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optimization with OpenFOAM is currently working. We expect to obtain lower resistance of optimal shape of the superstructure of ships than that of the original.

Parallel computation of OpenFOAM is very effective for performing hundreds of cases. OpenFOAM would take an important role of the optimization tool because of the low cost availability and customization flexibility, which are the advantages of open source software.

REFERENCES
