Shape Optimization of a Monohull Fishing Vessel

Riccardo Buiatti, *riccardo_bu@libero.it*

Fabian Pécot, DCNS Research / Sirehna, Nantes/France, *fabian.pecot@sirehna.com*

Camille Yvin, DCNS Research / Sirehna, Nantes/France, *camille.yvin@sirehna.com*

Jean-Jacques Maisonneuve,, DCNS Research / Sirehna, Nantes/France, *jean-jacques.maisonneuve@sirehna.com*

This work aims to ship hull shape optimization for multi-objective purpose - resistance and seakeeping - including extensive CFD calculations. This is carried out on a fishing vessel. Design variations, objectives and constraints are set up according to a naval architect's specifications.

The process starts from the parametric CAD model of the ship made with Catia v5. Global and local geometrical parameters are used, respectively for the hull description and for the bulb shape. The quality evaluation of the hull is made by a frequency-domain seakeeping code (Aqua+) and, two software tools with different levels of modelling for the ship resistance (potential and viscous flow codes - respectively Reva and StarCCM+). The criterion used to evaluate the seakeeping quality of the ship is a combination of the roll and pitch accelerations in one point of the aft part of the ship, for one sea state, and two waves directions (following and beam sea) at zero speed. The second criterion is the ship resistance at 10 kn for a given displacement. The ship resistance can be estimated by a free-surface potential flow code such as REVA with the addition of a frictional resistance assessed by an ITTC'57 formulation. Potential flow methods such as REVA are not accurate enough to correctly rank geometries when their aft parts are changed. For these cases, a RANSE solver (STAR-CCM+) is used. This type of tool is tricky to be involved in an optimization process, and it requires an important preliminary work to create the 3D grid varying with the shape, to determine robust calculation strategies and several settings. Once this work is done, the CFD calculations can be automated. In this case the total resistance is calculated with the Navier-Stokes code which takes huge calculation times. Furthermore, the determination of the Pareto front needs a large number of evaluations because the problem has two objectives. Therefore, the following strategy is used:

- response surfaces are built from a first set of complete calculations (DOE of real CFD calculations). These response surfaces are improved during the optimization process by the results of additional real CFD calculations.
- for the optimization, a multi-objective algorithm mixing virtual calculations based on the previous response surfaces and real calculations is used.

All the previously described tools are integrated in the multi-objective design environment modeFRONTIER to be automatically launched on the appropriate machines; the CFD calculation is done on HPC (High Performance Computing) hardware. The integration also consists in defining the design parameters, their ranges of variation, and the calculation of the optimization criteria from solver outputs. The optimization process requires a large number of design calculations and consequently the overall calculation time can quickly become prohibitive due to the complexity of CFD calculations. To reduce as far as possible the calculation time a specific strategy is retained: a two-level optimization process. This strategy is made of a preliminary hull global geometry optimization, followed by a bow bulb shape optimization.

This process leads to a significant ship resistance reduction with reasonable seakeeping behaviour.

The work was performed by SIREHNA within the French project COCHISE, led by B.E.Mauric as a naval architect, with the support of the French department for fisheries, together with the OMD2 project supported by the National Agency for Research (ANR).

References

[1] GIASSI, A.; MAISONNEUVE, J.J.; BENNIS, F. (2003), *Multidisciplinary Design Optimisation and Robust Design Approaches*, 2nd COMPIT, Hamburg.

[2] MAISONNEUVE, J.J.; PECOT, F.; PAGES, A.; ALBERTELLI, M.; SIDORKIEWICZ, M.; VISCONTI, J. (2007), *Comparison of two approaches for the direct optimisation of a car engine intake port*, 1st Int. Conf. Multidisciplinary Design Optimisation and Applications, Besançon.

[3] PECOT, F.; BESNARD, N.; RIGO, P. (2010), *Ship design goes multidisciplinary*, The Naval Architect.

[4] PECOT, F.; BESNARD, N.; CODDA, M.; UNGARO, A.; TODERAN, C.; KLANAC, A. (2007), *Benchmark on ship structural optimisation*, Int. Conf. Advancements in Marine Structures, Glasgow.