©SNAK, 2014

Int. J. Nav. Archit. Ocean Eng. (2014) 6:496~506
http://dx.doi.org/10.2478/IJNAOE-2013-0195
pISSN: 2092-6782, eISSN: 2092-6790

Scenario based optimization of a container vessel with respect to its projected operating conditions

Jonas Wagner, Eva Binkowski and Robert Bronsart

University of Rostock, Germany

ABSTRACT: *In this paper the scenario based optimization of the bulbous bow of the KRISO Container Ship (KCS) is presented. The optimization of the parametrically modeled vessel is based on a statistically developed operational profile generated from noon-to-noon reports of a comparable 3600 TEU container vessel and specific development functions representing the growth of global economy during the vessels service time. In order to consider uncertainties, statistical fluctuations are added. An analysis of these data lead to a number of most probable upcoming operating conditions (OC) the vessel will stay in the future. According to their respective likeliness an objective function for the evaluation of the optimal design variant of the vessel is derived and implemented within the parametrical optimization workbench FRIENDSHIP Framework. In the following this evaluation is done with respect to vessel's calculated effective power based on the usage of potential flow code. The evaluation shows, that the usage of scenarios within the optimization process has a strong influence on the hull form.*

KEY WORDS: Ship design; Hull form optimization; Scenario; Operating conditions; Life-cycle analysis; Potential flow calculation.

INTRODUCTION

At least since the economical crisis the traditional way of designing ships is considered to be outdated. Operating ships at off-design conditions may appear as a good solution in times of a crisis and apparently leads to lower fuel consumption but there is a potential to save even more energy if the vessels would have been designed with respect to more operational conditions. But even without the crisis the process of designing a ship onto one operating condition had to be reconsidered, for the fact that both calculations or prognosis as done by Røe (2010) and analyses of operating profiles of real ships have shown that merchant vessels only operate at their respective design condition (e.g. at 85% Maximum Continuous Rating (MCR)) for a small amount of time.

Despite this fact, the knowledge of a vessels future operational profile is of great interest when it comes to environmental issues as a suboptimal ship design has a higher emission rate than an optimal one.

These problems necessitate a new approach which is capable to deal with future needs and uncertainties and which considers the vessels life-long operating situation. Keeping that in mind, scenario methods seem to be a suitable solution. By linking economical trend analysis with detailed operation profiles the usage of these methods offers the possibility to design ships which are not optimized to one or two particular operational conditions but will be significantly more efficient related to their overall operating time.

Corresponding author: *Jonas Wagner*, e-mail: *jonas.wagner@uni-rostock.de*

This paper has been selected from the Proceedings of PRADS 2013, reviewed by referees and modified to meet guidelines for publication in IJNAOE.

LITERATURE REVIEW

The idea of using a complete operational profile as the basis for the development or optimization of a hull form instead of a single or only a few design points has been adapted within a few projects before. Two of them are in short presented in the following.

As an example, Temple and Collette (2012) have been using probability density functions in order to display the speed range of two vessels (DTMB-5145 naval combatant and KCS container ship) for a following multi-objective optimization of their hull forms. The optimization is done using a Multi-Objective Genetic Algorithm (MOGA) with the lifetime resistance being calculated from the integral over the speed dependant total resistance (estimated using the thin ship theory) multiplied by the Probability Density Function (PDF). The respective PDFs have been generated by applying a bimodal distribution with the two modes representing the vessel's endurance and mission speed in case of the DTMB-5145 and an unimodal distribution with the mode at the vessels design speed for the KCS. As far as the author is aware, those distribution functions are not based on statistics of existing vessels but on the author's consideration.

Statistically based probability distribution functions have been used by Eljardt (2010) in order to assess different vessel types, shipping routes or the commodity flow. Despite the speed distribution, he also considers environmental data such as seastate and wind conditions and other vessel specific data, e.g. the trim. Thereby, the respective distribution functions are taken from statistical analysis and / or prognosis. Within this work the distribution functions are used for sampling a sufficient number of ship operation conditions using the Monte Carlo Method in order to serve for example as the target function for an optimization of a ship's hull form and propulsion system. Although considering a wide range of parameters, this approach differs to the scenario based approach presented in this paper as it does not completely consider the coupled or correlated appearance of different parameters, which can lead to incorrect results in the target function (see next section for details).

GENERAL APPROACH

The basic idea of the scenario based approach is to predict the most probable operating conditions the designated vessel will stay in during its operating time in order to find the most suitable design variant. Fig. 1 shows the flow chart of the complete optimization process as presented in Wagner and Bronsart (2011).

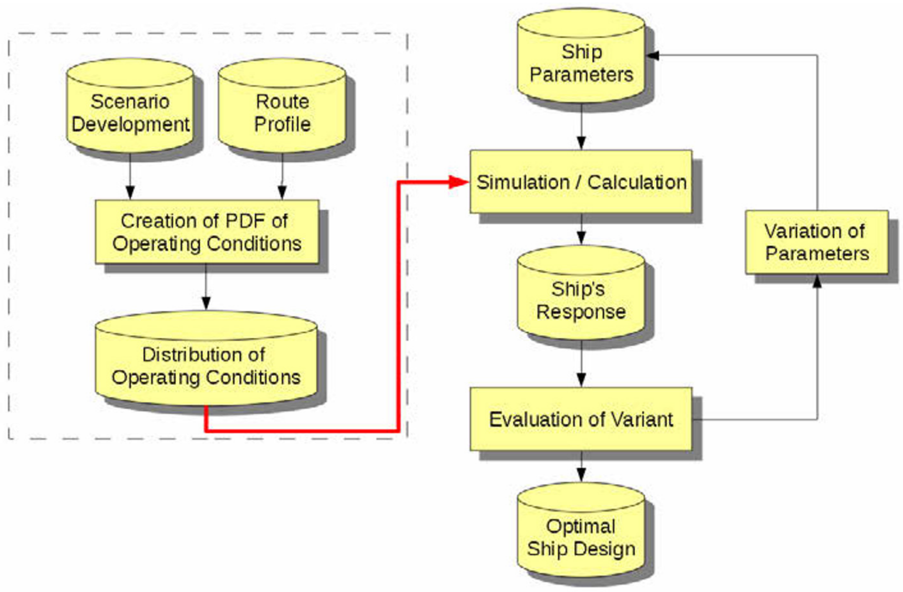

Fig. 1 Flow chart of optimization process.

It can be seen, that the general procedure can be divided into two stages. The first stage consists of the development of a probability density function of operating conditions on the basis of a given route profile and specific scenario development functions. Based on this distribution a target function can be derived, which consecutively will be handed over to stage two - a