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ORIGINAL ARTICLE

Weight optimization of offshore supply vessel based on structural analysis using finite element method

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Abstract Ship design process usually relies on statistics and comparisons with existing ships, rather than analytical approaches and optimization techniques. Designers found this way as the best to fulfil the owner's requirements, but better solutions, for both the shipyard and the owner may exist. Assessing ship life cycle cost is one of the most attractive tasks for shipyard during early design stage. Structural optimization can be used to achieve that task. In this paper, a comprehensive study on the structural optimization of an offshore supply vessel (OSV), as a case study, is presented. Detailed structural modeling of the vessel is created. Various environmental loads acting on the ship hull such as still water loads and wave induced loads are briefly explained. Different loading conditions and corresponding structural responses have been investigated to assign the most severe one on the vessel. The basic concept of structural optimization and optimization characteristics is highlighted. Blind search optimization technique is applied and approximately forty-two percent weight and cost savings are found by comparing the weight of various design scenarios together without showing any structural inadequacy.

1. Introduction

At the preliminary design stage, shipyards need to assess the construction cost, to compare fabrication sequences and to find the best frame/stiffener spacing and most suitable scantlings to minimize the life cycle cost of the ship. This can be achieved by performing structural optimization. Structural optimization deals with the application of mathematical optimization to the computer aided optimum design of structures. The task of the mathematical optimization process was to find the optimum point, from any starting point, and to do so with as little computation as possible [1]. A certain number of design variables (e.g. thickness, shape or cross-sectional area of a structure) have to be determined in a way that the objective function (e.g. minimal weight of a construction) is best fulfilled in compliance with the state variables (e.g. strength, stiffness or production). Depending on the design variables, structural optimization can be classified as follows [2]:

- Shape optimization
- Topological optimization

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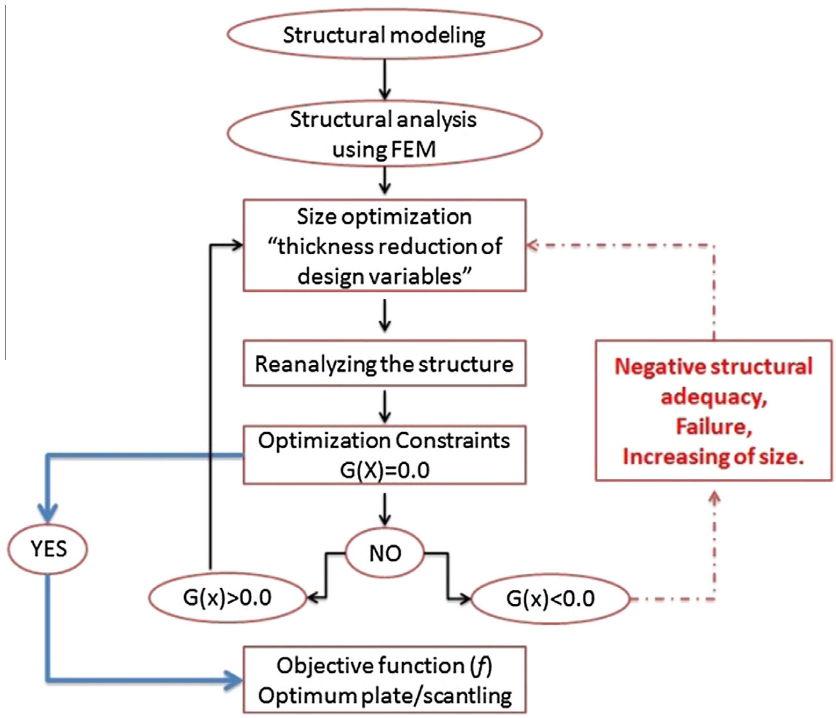

Figure 1 Procedures of vessel size optimization.

Table 1 Offshore support vessel main characteristics and capacities.

Capacities		Characteristics	
Deck cargo	200 tons	Length, overall	44 m
Fresh water	200 tons	Beam	10 m
Fuel oil	200 tons	Depth	3.92 m
Cooler/freezer	6 Cubic meter	Displacements	950 tons
Passengers	19 Persons	Dead weight	610 tons
Crew	10 Persons	Max draft	3.1 m
Passengers	Crew	Light draft	1.45 m
		Frame spacing	0.500 m
– 1 Single rooms	– 2 Single rooms	Bollard pull	25 Ton
– 3 Double rooms	– 1 Double rooms		
– 3 Rooms × 4 beds	– 1 Room × 6 beds		
		Class	BV
		Speed/fuel consumption	
		Cruising speed	12 Knots; 116 l/h
		Max speed	13.5 Knots; 155 l/h

- Choice of material
- Scantling optimization

Ship's main dimensions determine many of her characteristics, e.g. stability, hold capacity, power requirements, and more importantly her economic efficiency. Therefore determining the main dimensions and ratios, as well as coordinating them in such a way that a ship satisfies the design conditions forms a particularly important phase in the overall design. The characteristics desired by a shipping company can be usually achieved through various combinations of dimensions. Such characteristics could have allowed for an economic optimum design to be achieved if it were not for the restrictions imposed by size of locks, canals, slip waterways and bridges and most commonly water depth. Thus, in the marine market, fleet optimization objective is often to find the optimum number of ships, ship speed and capacity without going into further details of her main dimensions. A ship's economic efficiency is usually improved by increasing her size, and accordingly this could lead to the specific cost decreases. In general, the larger the ship, the more economically efficient she is [3].

According to the above-mentioned aspects a perfect ship does not typically exist; however, weight reduction for a well-known design achieving its purpose without shape (main dimensions) alteration leads to a less fuel consumption, increased deadweight, more freeboard, less initial cost, more speed and even better accessibility to channels and harbors