Ocean Engineering 144 (2017) 305–319

Contents lists available at ScienceDirect

Ocean Engineering

journal homepage: www.elsevier.com/locate/oceaneng

Feature-based estimation of preliminary costs in shipbuilding

Cheng-Kuan Lin *, Heiu-Jou Shaw

Department of Systems and Naval Mechatronic Engineering, National Cheng Kung University, Tainan, Taiwan, ROC

ARTICLE INFO

Keywords:
Feature-based
Cost estimation
Ship design

ABSTRACT

Accurate cost estimation is crucial for obtaining ship owners' orders in shipyards. The classic preliminary estimation methods of ship costs provide only rough estimates of the labor, materials, and equipment based on the overall ship parameters and do not reflect further specifications. This study develops an innovative cost estimation method called the feature-based estimation method that is based on the preliminary specifications to estimate ship costs, including the steel, other main materials, engine, power generator, other core equipment, and labor hours.

The method mainly establishes the topology of the relationships between the features by linking the general dimensional parameters and detailed features of the specifications of the designs and cost information to estimate the main cost items of the ship. The features are extracted and transformed into a quantifiable structure. The definitions of the features contains the core context using a small amount of information for the preliminary estimation.

Empirical formulas are derived based on the configured cost items in the preliminary design stage. The errors of the estimated total costs are less than ±7%. Hence, the estimation model is suitable for modern ships. The applications of the model may be more robust for new ships in a future study.

1. Introduction

The purpose of this research is to outline the preliminary stage of cost estimation of ships. Because the growing worldwide shipbuilding capacities, global crises, and overcapacity in shipping have led to significant decreases in construction prices, shipyards must decrease ship costs to respond to new orders with minimal profit margins and limited production time.

Accurate cost estimation is a crucial task. During the preliminary ship design phase, the design is temporary and subject to change based on variations in the ship owner's requirements. Rapid and flexible responses are important competitive advantages (Son et al., 2011). However, the specifications for a new design at the beginning of a project are typically incomplete and imprecise. Thus, the total costs are generally established through decisions made in the initial design phases (Fischer and Holbach, 2011).

Using the limited design parameters causes difficulty in developing an accurate budget. In this study, we take into account the preliminary design and preliminary cost estimation to improve the issue.

1.1. Discontinuous cost estimates at different stages

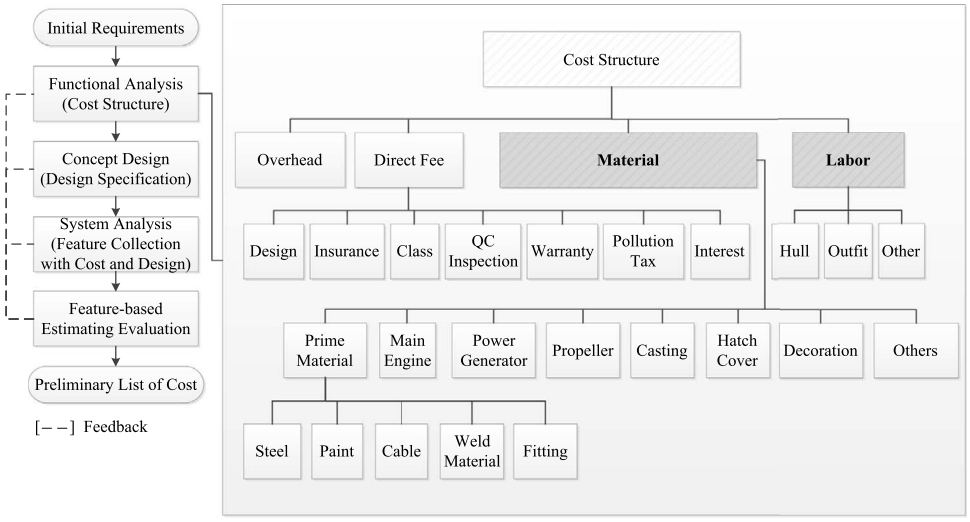
Cost estimates for the main items of merchant ships, including the labor, materials, and overhead costs of shipyards, typically evolve over three levels of detail, including the concept design, the ready preliminary design, and the completed contract design.

The top priority of the estimation process is to provide an approximate cost for the concept design before any details of the ship design and manufacturing processes are fully considered. The level estimations are developed based on the main parameters, such as ship's weight, principal dimensions, size and other general performance parameters. Most shipyards derive these cost estimates based on the costs per ton or man-hours per ton, which are typically obtained from records of recent construction projects (Watson, 2002). Thus, determining an accurate estimated weight is the first task. Additional details of weight estimation of preliminary cost items are presented in this study.

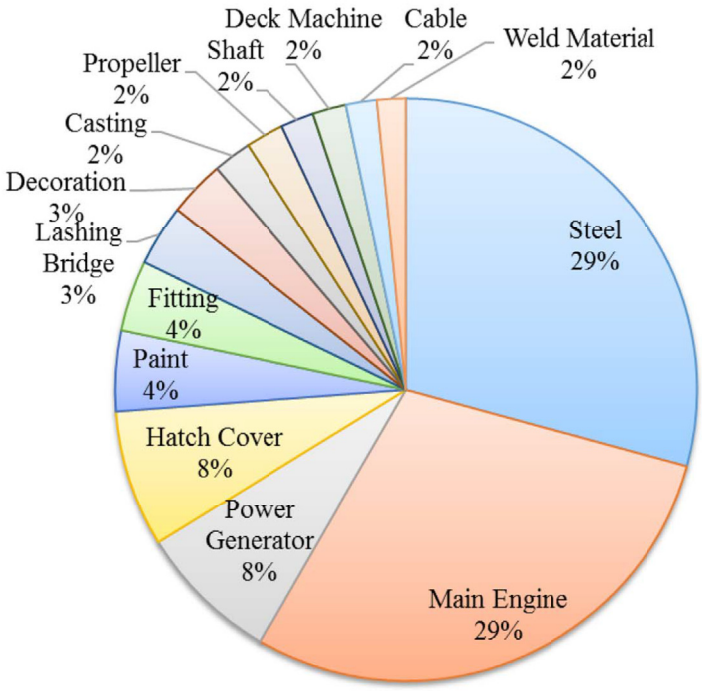
The next level is when a preliminary design has been prepared, and a system weight has been estimated to support the main estimation based on the owner's requirements (Lamb, 2004). The preliminary offer provides a basis to determine whether a project will continue until the contract negotiations between the shipyard and owner. In practice, the estimate is used to establish the cost by comparing critical factors in a

* Corresponding author.
E-mail addresses: libiru@gmail.com (C.-K. Lin), nmshaw@mail.ncku.edu.tw (H.-J. Shaw).

https://doi.org/10.1016/j.oceaneng.2016.11.040
Received 17 May 2016; Received in revised form 11 October 2016; Accepted 26 November 2016
Available online 9 September 2017



(a)



(b)

Fig. 1. **(a)** Cost structure. **(b)** Costs of the main materials and equipment.

new design with the characteristics of previously delivered vessels. It may take several weeks to obtain an accurate result because many design factors affect the cost. The owner prefers to acquire the estimate early to conduct a follow-up assessment and negotiation. Hence, rapid and flexible responses are critical during this phase. However, no existing systems support the shipbuilding tendering process due to the different design and engineering methods of ship construction. Although commercial software platforms for shipbuilding are available, the shipyard must identify the design parameters and cost items at different levels to support the cost estimation.

A more detailed estimate typically follows the completion of the contract design with a pricing process that operates within the work breakdown structure (WBS) format. The WBS provides a format by which a shipyard can collect, organize, and manage costs that can be used to estimate prices for new ships. The North Atlantic Treaty Organization (NATO) provides the Expanded Ship Work Breakdown Structure (ESWBS) that defines a hierarchy of the components of ships (NATO, 2006). Although the structure is based on the practical work of shipyards, it traditionally requires a list of common ship system components, including the hull structure, outfit, equipment, piping, electrical system, paint and furnishings, to support production. Thus, this study presents a list of preliminary critical cost items that are collected using the WBS database. The preliminary estimates that have the greatest impacts on the ship's total cost establish the base-line costs at different stages.

1.2. *Relative methods*

The major cost estimation methods in the literature are classified into