ELSEVIER

Advances in Engineering Software 37 (2006) 457–476

ADVANCES IN ENGINEERING SOFTWARE

www.elsevier.com/locate/advengsoft

An initial hull structural modeling system for computer-aided process planning in shipbuilding

Myung-Il Roh *, Kyu-Yeul Lee [1]

Department of the Naval Architecture and Ocean Engineering, Research Institute of Marine Systems Engineering, Seoul National University, Shinlim-Dong, Seoul 151-742, South Korea

Received 1 June 2005; received in revised form 7 September 2005; accepted 15 September 2005
Available online 26 October 2005

Abstract

At the initial stage of ship design, it is difficult for designers to define all design information of a hull structure on 2D drawings. Thus, other designers must undertake the arduous task of translating such information to generate a 3D CAD model of the hull structure which is required at the following design stage such as the initial process planning stage. Since this task needs much time and effort, the 3D CAD model is not being generated at the initial design stage. For solving this problem, an initial hull structural modeling system is developed in this study. The applicability of the developed system is demonstrated by applying it to a deadweight 300,000 ton VLCC (Very Large Crude oil Carrier). The results show that the developed system can quickly generate the 3D CAD model of the hull structure and accurately extract the production material information for computer-aided process planning at the initial design stage.

Keywords: Initial hull structural modeling system; 3D CAD model; Production material information; Computer-aided production planning; Shipbuilding

1. Introduction

1.1. Ship production process

A ship is a huge structure made up of a large number of hull structural parts. Here, a hull structure represents the body of the ship, and a hull structural part represents a part that is placed on the hull structure to secure the structural strength of the ship. As for a deadweight 300,000 ton VLCC (hereafter simply referred to as the '300 K VLCC'), the length, breadth, and depth is about 320, 60, and 30 m, respectively. Thus, contrary to an automobile, the ship cannot be constructed all at once. The ship is first divided into a number of building blocks (block division), For example, the ship is divided into about 200 building blocks in the case of the 300 K VLCC (see Fig. 1). Here, a building block is a unit element for production of the ship. Each building block is assembled in the assembly shop near the dock. Large building blocks, which are called erection blocks, are made by joining several building blocks together. Then, the large building blocks are moved on the dock and welded to each other according to a suitable sequence, which is called the block erection, to complete the final assembly to the ship. That is, the construction process of the ship is similar to the process that a large product is made up of a number of Lego blocks. At this time, to efficiently construct the ship, it should be determined how the ship is divided into building blocks (process planning). This task is performed at the initial process planning stage in shipbuilding design. Fig. 1 gives an example of a block division drawing of the 300 K VLCC. According to this drawing, this ship is divided into about 200 building blocks and then these building blocks are finally constructed together on the dock.

At the initial process planning stage, designers of the shipbuilding company normally determine the work sequences and methods, necessary resources, work duration, etc. based on existing enterprise resources. To perform these tasks, the production material information of the ship is necessary. The production material information includes the weight, center of gravity, painting area, joint length for welding, etc. Basically, this information can be regarded as given in the building block unit at these stages. The most important resources of the shipbuilding company are the docks and cranes that are used to erect the building blocks of the ship. If the ship is divided into a number of building blocks and then constructed on the dock, the dock occupation ratio of the ship increases, and this reduces

* Corresponding author. Tel.: +82 2 880 8378; fax: +82 2 886 4920.
E-mail addresses: myungil.roh@gmail.com (M.-I. Roh), shark@snu.ac.kr (M.-I. Roh), kylee@snu.ac.kr (K.-Y. Lee).
[1] Tel.: +82 2 880 7327; fax: +82 2 888 9298.

0965-9978/$ - see front matter © 2005 Elsevier Ltd. All rights reserved.
doi:10.1016/j.advengsoft.2005.09.005

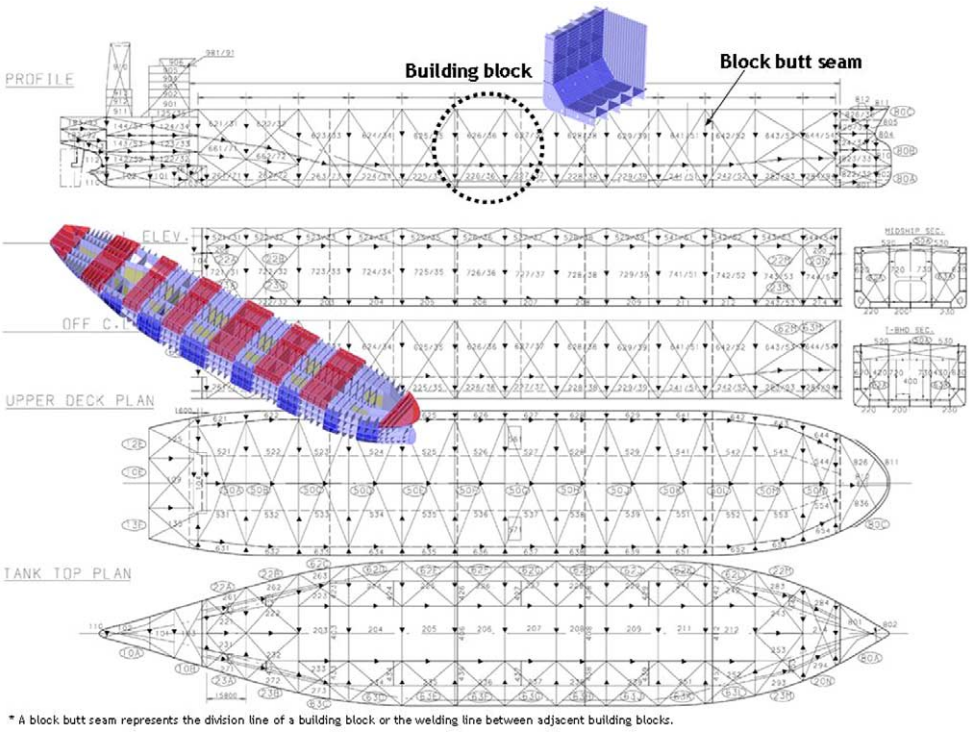

Fig. 1. Example of the block division drawing of the 300 K VLCC.

productivity of the shipbuilding company. Therefore, it is important to set an optimal number of the building blocks considering the maximum capacity of the cranes. Here, the most important factors that need to be considered are the accurate weight and center of gravity of the building blocks. The painting area of the building blocks needs to be known to calculate the amount of paint and the number of man hours required for painting the building blocks on the painting shop. The joint length between the building blocks is necessary to calculate the number of man hours required for erecting the building blocks on the dock, and the joint length in the building block is required to calculate the number of man hours required for assembling the building block in the assembly shop.

1.2. The current state of hull structural modeling in shipbuilding

At the initial process planning stage, various design information of the hull structure such as the placing position of bulkheads, number of decks, frame space, placing position of equipments, etc. are obtained from 2D drawings such as the lines, general arrangement, midship section, construction profile, etc. Then, the hull structure, that is, the ship is divided into a number of building blocks using these information, taking into account the capacity of the assembly shops and cranes, and referencing the data of parent ships. Finally, the production material information of each building block is estimated and manually calculated from hull structural parts, which are included in the corresponding building block, as shown in Fig. 2. Since, currently, this calculation is manually performed based on the 2D drawings, data of parent ships, and design experiences, the accuracy and reliability of the calculated information is quite low. This calculation is possible only if the data of the parent ships are available, and it is very difficult to perform such calculation for building an entirely new ship where there is no existing data.

If a 3D CAD model of the hull structure at the initial design stage, that is, the initial hull structural model can be generated and such model can be divided into a number of building blocks, the production material information of a building block

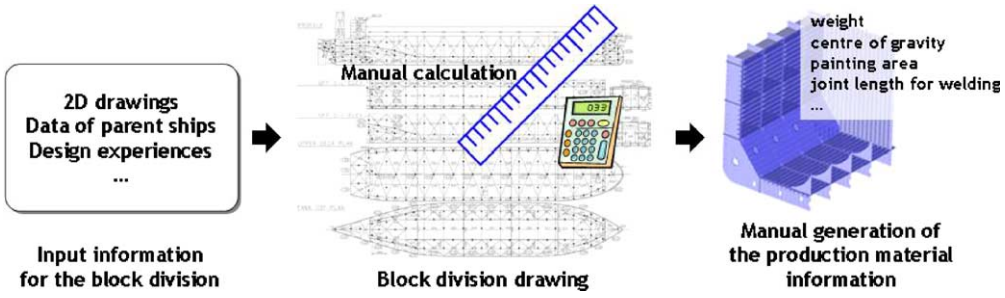

Fig. 2. Existing procedure of manually generating the production material information at the initial process planning stage.