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Procedia CIRP 62 (2017) 411 – 416

www.elsevier.com/locate/procedia

10th CIRP Conference on Intelligent Computation in Manufacturing Engineering - CIRP ICME '16

Forming information calculation algorithm of 3-D template for evaluation of curved hull plates

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Abstract

Curved hull plates are essential to the construction of a ship. Moreover, curved hull evaluation is significant during the curved hull plate forming process. Most shipyards use 2D- and 3D-type wooden template to estimate curvature of plates by placing the template on specific positions of curved hull plates. Only the 3-D template can be utilized to evaluate plates that are relatively thick with large radius of curvature. In general, forming plans of the 3-D template, based on the given information, are drawn manually by workers, and the information is only given for plates that may require 3-D templates. These plates are predicted empirically by the designers in the detailed design phase, resulting in the presence of unpredicted plates. For unpredicted plates, workers used to request additional information for manufacturing, and during the process, there exists a complex information exchange between related departments, which is a time-consuming process. To solve the above-mentioned problems, in this paper, a 3-D template forming information calculation algorithm, based on the surface geometric information, was proposed. Moreover, the proposed algorithm was implemented as a computer program in which forming information of 3-D template can be calculated automatically.

Keywords: Computer aided design; Surface evaluation; Geometry; Forming information algorithm

1. Introduction

Curved hull plates are essential to the construction of a ship, and curved hull evaluation is significant during the curved hull forming process. Most shipyards use the curved templates to evaluate the curvature of plates. Curved hulls, in general, can be evaluated using a 2D-type template, which is composed of individual pieces, as shown in

Fig. 1, by putting the 2D-type template on a specifically determined position of surface. In case of curved hull plates with high curvatures, a 3D-type template is used for the evaluation, as shown in Fig 2.

Fig. 1. Evaluation of plates using 2-D template

Fig 2. Evaluation of plates using 3-D template

doi:10.1016/j.procir.2016.06.094

In the field of shipbuilding, various studies have been conducted on the method for evaluating the completion of curved hull plates, mainly utilizing Laser Scanning, Charge Coupled Device (CCD) camera, and templates. For the laser scanning method, Lee, J.M. [1] performed a on the curved hull plate evaluation using laser scanning to construct an integrated software-hardware system. In addition, Shin et al. [2] suggested an algorithm for effective measurement and comparison of the curved hull plates, and developed the algorithm software as well as a hardware equipment for measurement. Park et al. [3] performed a modeling experiment by securing swift and accurate measurement data and comparing it with the designed surface and established automated process for curved plate forming which is applicable to the shipyard. An evaluation system was proposed by Jung et al. [4] in 2009 for in-line completion of the curved hull plates, which able to obtain additional forming information based on currently measured completion of the curved hull plates.

For the study related to curved hull plates evaluation using CCD camera, Kim, B.C. & Lee, S.H. [5] developed a 3-D measuring equipment which capable of measuring the shape characteristics of the curved hull plates in real-time, and proposed a 3-D calibration method for enhancing the measurement precision. Kim, et al. [6] developed an equipment was in 2014 for measuring the shape of curved plates using spot cloud, proposed a shape correction algorithm, and verified it with formula induction. According to status of relevant studies, the method for evaluating the completion of curved plates can be broadly classified into the recent methods of laser scanning and CCD camera, and the traditional template method used in shipyards. As shown in Table 1, the two methods have their distinctive advantages. However, when comparing their pros and cons at large, the traditional method also needs further improvement.

To improve the method for evaluating the completion of curved plates using templates, a template forming process was analyzed, and two issues were identified during the forming process for the 3D-type template. The first issue involved complex information exchange processes between the departments relevant to the 3D-type template. The second issue was that the blueprint of the 3-D template was empirically obtained based on the manual drawings of current workers. Owing to the above-mentioned problems, several hours of dead time is incurred during the manufacturing process, and the manufacturing time of the 3D-type template is ultimately prolonged. To resolve these problems, this study proposed a forming information calculation algorithm of 3D-type template, which capable of calculating the information necessary for manufacturing the 3-D template based only on the geometrical information of the curved hull plates. Through programming the above, the algorithm was applied to an actual curved plate.

This paper is structured as follows. In Section 2, the template's forming process is analyzed to comprehend problems. In Section 3, the forming information calculation algorithm of the 3-D template that can resolve the problems is described. In Section 4, the proposed algorithm is implemented through programming, and is applied to the actual curved plates. Finally, the Conclusion summarizes the finding of this study.

Table 1 Advantages and disadvantages of the two methods

	Recent technology	Traditional technology
	Laser Scanning CCD Camera	Template
Pros	1. Short measuring time [7] 2. High precision [7] 3.No limit in the size of target [7] 4. No error stemming from contact [7]	1. Easy to use 2. Redundant use 3. Short training time
Cons	1. High cost 2. Unskilled automated processing [8] 3. Longer training time 4. Lack of verification for on-site application	1. Requires manufacture of template[9] 2. Requires space for accommodating the template [9] 3. Relatively longer measuring time 4. Measured result cannot be numerically confirmed

2. Analysis of template manufacturing process and derivation of improved method

Template comprises individual template pieces. Fig. 3 shows exemplary 2-D and 3-D template including 4 and 11 individual template pieces, respectively.

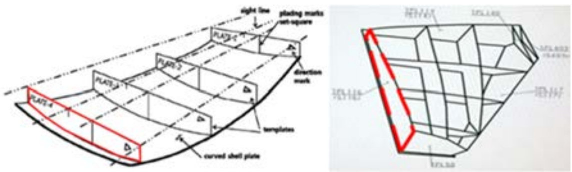

Fig. 3. Examples of 2-D & 3-D templates [10]

To manufacture the individual template pieces included in a template, information regarding the Pin interval, Pin height, etc., are required as shown in Fig. 4. Hereon, the Pin implies the lines that laterally divide a template piece at a predetermined interval. The manufactured template is used as the sole standard for evaluating the completion of curved plates in the curved plate forming workshop.

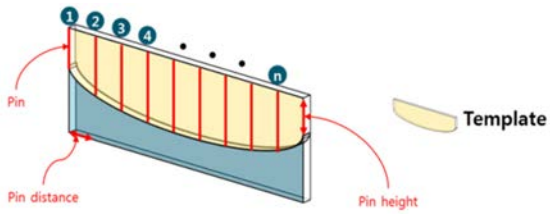

Fig. 4. Pin, pin height & distance on template

2.1. Analysis of template forming process

An analysis was performed on the traditional template forming process, and the results are shown in Fig. 5. In the design department, a curved plate is 3-D-modeled and the work