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A Study of 3D Design Data Extraction for Thermal Forming Information

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Abstract

In shipbuilding, diverse manufacturing techniques for automation have been developed and used in practice. Among them, however, the hull forming automation is the one that has not been of major concern compared with others such as welding and cutting. The basis of the development of this process is to find out how to extract thermal forming information. There exist various methods to obtain such information and the 3D design shape that needs to be formed should be extracted first for getting the necessary thermal forming information. Except well-established shipyards which operate 3D design systems, most of the shipyards only rely on 2.5D design systems and do not have an easy way to obtain 3D surface design data. So in this study, various shipbuilding design systems used by shipyards are investigated and a 3D design surface data extraction method is proposed from those design systems. Then an example is presented to show the extraction of real 3D surface data using the proposed method and computation of thermal forming information using the data.
Keywords: hull forming process, thermal forming information, shipbuilding design system, 3D design data, wiseHeating

1 Introduction

Over a long period of time the manufacturing technology in shipbuilding has been improved so that it has contributed to increasing overall productivity of ship fabrication. However, the growth of the hull forming technology is relatively slow compared to other manufacturing techniques. The hull forming is performed manually by a field worker and mainly done based on the worker's know-how as shown in Figure 1. Moreover, there are not many experienced workers who can form curved hulls efficiently and hull forming has been a bottleneck of the whole manufacturing process.

To overcome this situation, what should be done is to obtain standard hull forming information from those workers' know-how. In other words, it needs to be made that any worker or a machine can fabricate a desired curved form only using such standard forming information. This is the first step to automate the curved plate forming process. The standard information may consist of the heating location and heating velocity. Based on this information, the forming process can be performed without workers' know-how and eventually the automation of hull forming can be realized. (Shin 2003, Park 2007b)

Figure 1: Hull forming process by operator (Park 2007b)

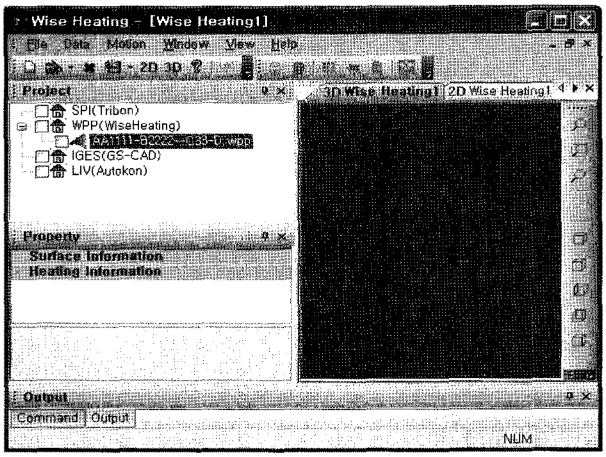

Figure 2: Intelligent thermal forming information computation software

There are many ways of deriving thermal forming information such as by using differential geometry, FEM analysis and an expert system. But for deriving such information like heating location and heating velocity based on those methods, first of all, 3D design data, or the final shape data, are required. The 3D design data can be obtained from a design system used by each shipyard. In a large shipyard, a 3D design system or Tribon(2.5D), which is famous for shipbuilding design, is mainly used. Nowadays the necessity of a 3D design system has increased so most shipyards want to convert their old systems to 3D design systems. In a medium sized shipyard case, they also use Tribon. In a small size shipyard or manufacturing factory case, they use no specific design system like Tribon. So the design is performed just based on 2D drawings. In this case, the operator should Figure out the design shape information from such 2D drawings. Like this there exists a different level of difficulty in design data extraction depending on the design systems being used. If a shipyard uses a 3D design system, the 3D design data can be easily extracted since 3D design data information already exists in the design system. If the design system is not based on 3D data, however, it is not easy to extract 3D data directly from the design system. In this study, an extraction method of 3D design data from Tribon and manufacturing drawings will be explained.

Among many methods that can derive thermal forming information, one should be selected for this study. Among them the extraction method based on differential geometry, which is proposed by Shin (2002) and Park (2007b), has been selected since it was demonstrated that the validity of the method was shown through application to a real shipyard. For making thermal forming information by using this method, the design data extracted from a design system are provided in WiseHeating(Park 2007b) input format. WiseHeating is software which has been developed to handle 3D shape data and compute forming information. The screenshot of the program is given in Figure 2.

In this study, first the kinds of shipbuilding design systems are explained. The extraction method of design data for making thermal forming information to each design system is also explained. Finally by using this extracted design data, it is shown that thermal forming information can be computed.

2 Shipbuilding design system

In shipyards various kinds of shipbuilding design systems are used. In this section, those design systems are explained by dividing them into three classes in terms of the size of shipyards: large sized one, medium sized one, others

2.1 Design system of large sized shipyards

The design system, which is currently used by a large sized shipyard, has migrated from the existing old design systems like Tribon into a 3D design system. Various companies such as automobile makers, airplane makers and so on, have already used 3D design systems so far. So the level of related technology is mature and there are various kinds of 3D design systems for many purposes. Each system is also adaptable for each manufacturing procedure. Figure 3 is an example of a 3D design system.

On the other hand, 2D or 2.5D systems have been usually used in shipbuilding for a long time and a study of application of a 3D design system to shipbuilding has just been started. So the currently used 3D design system does not cover the whole shipbuilding procedure but most of shipyards try to extend the scope of the 3D design systems for their manufacturing process since there exist many advantages of using the 3D design system as follows: first of all, it is easy and fast to extract 3D design data from the design system compared with other types of systems. Second the modeling result based on the 3D design system is more accurate. Among 3D design data types, IGES (Initial Graphics Exchange Specification) file format is mostly used. IGES can reduce the modeling error compared with other modeling methods. In other words, by using the 3D design system, the extraction procedure is easy and the modeling error can be reduced. Moreover, through accurate shape modeling accurate thermal forming information can be obtained.

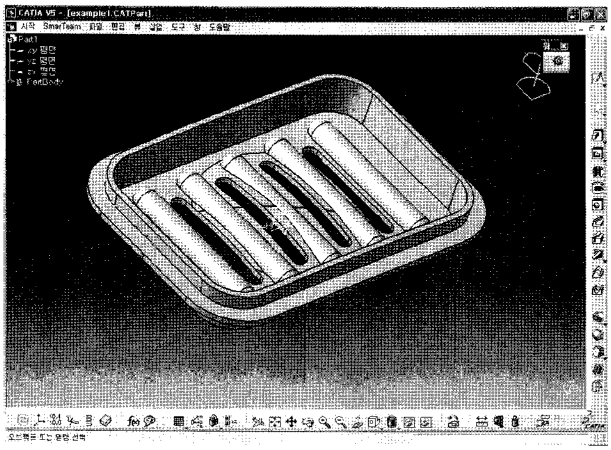

Figure 3: Example of 3D design system(CATIA)

2.2 Design system of medium sized shipyards

In a medium sized shipyard case, various design systems are used but among them, Tribon is the most popular choice. A screenshot of Tribon with an example drawing is given in Figure 4.

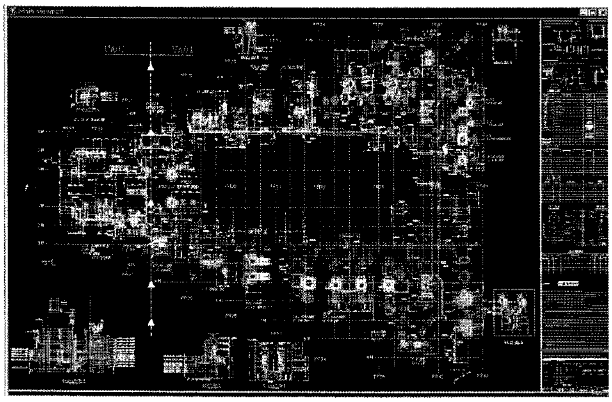

Figure 4: A screenshot of Tribon

Tribon has been used since 90s. In the early days it was usually used for manufacturing design more than initial design. Tribon is a group of programs that create and control the DB which stores the design data of various ships. Shipbuilding information can be extracted using commands by contacting Tribon_DB through various subprograms. Tribon has been used for a long time in shipbuilding but there are some advantages and disadvantages. Firstly Tribon was developed as a shipbuilding design system. Therefore, without much effort, it cannot be used for any shipbuilding process quite easily. Plus since it has been used for a long time, much know-how has been accumulated in using it in ship design. It also provides many additional options that can be added or modified according to the needs of each shipyard. But there are also some disadvantages. Firstly Tribon is a command based program so when specific data are extracted from the DB, the extraction procedure is complex and it takes too long time. And Tribon is a 2.5D design system so it is less accurate compared to a 3D design system in handling data. In addition, visualization is not intuitive using 2.5D data.

2.3 Design system of small sized shipyards and others

In a large sized or medium sized shipyard case, each shipyard uses various design systems. But some small shipyards or independent manufacturing factories which take orders from shipyards do not use popular design systems. So extraction of necessary 3D data is not standardized and difficult for them. Therefore, the hull forming process is performed purely based on manufacturing plans or drawings which are provided to a 2D CAD system like AutoCad. In this case there is no accurate method to extract 3D design data for making thermal forming information.

3 3D information extraction from design systems

In this section, methods of extracting 3D design data are explained for three cases: 3D design systems, Tribon, and manufacturing drawings.

3.1 3D information extraction from 3D design system

In general, it is easy to extract 3D design data from a 3D design system. The design data stored in the 3D design system are already given in 3D so the 3D design data are just obtained without any modification or transformation. IGES is a representative example of the 3D design data type. IGES file can be obtained by exporting data from the system. One example of the IGES file is shown in Figure 5, where various types of data are specified.

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WISE UNFOLDING for HHIC Author:XINNOS all rights reserved - http://xinnoS      1
s.com Filename:HN2222-A11S0--44V-P_1_1.igs 11:34AM Sep 12 2006           S      2
1H,,1H;,,27HHN2222-A11S0--44V-P_1_1.igs,23HWISE UNFOLDING for HHIC,,32,7G      1
5,6,75,15,,1.000000,2,2HMM,1000,3.200000,13H060912.113413,0.000001,0.000G      2
000,5HJ_KIM,,8,0;                                                       G      3
     128       1       0       1       0       0       0       00000000D      1
     128     156       4      15       0               Surface        0D      2
128,3,3,3,3,0,0,0,0,0,0.000000,0.000000,0.000000,0.000000,            1P      1
1.000000,1.000000,1.000000,1.000000,0.000000,0.000000,0.000000,       1P      2
0.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,       1P      3
1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,       1P      4
1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,1.000000,       1P      5
-0.573362,0.005655,1069.814205,205.860418,-0.324899,750.698123,       1P      6
331.333356,-0.038225,379.998608,351.836180,0.165855,-0.238889,        1P      7
255.430334,147.112173,1069.889426,451.087032,120.320215,              1P      8
746.593724,553.977559,105.526612,376.389571,565.533666,               1P      9
93.868585,-0.194788,509.981586,293.422085,1069.487097,                1P     10
696.617211,236.276868,744.751367,776.646677,211.337221,               1P     11
373.891003,775.106863,191.576205,-1.010470,771.902520,                1P     12
430.525534,1070.513318,924.947877,390.980005,734.734219,              1P     13
1000.870367,313.746079,368.517722,994.176519,275.004295,              1P     14
0.497423,0.000000,1.000000,0.000000,1.000000;                         1P     15
S      2G      3D      2P      15                                     T      1
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Figure 5: IGES file format

3.2 3D information extraction from Tribon

In this study Tribon_M3 which is the latest version of Tribon is considered. It is possible to extract specific 3D design data that the operator wants to obtain from Tribon. But it takes a lot of time and the procedure for extraction is relatively complex. For example when the design data of a curved panel consisting of eight plates are extracted, it is necessary to carry out eighty one procedures which are diagramed in Figure 6.

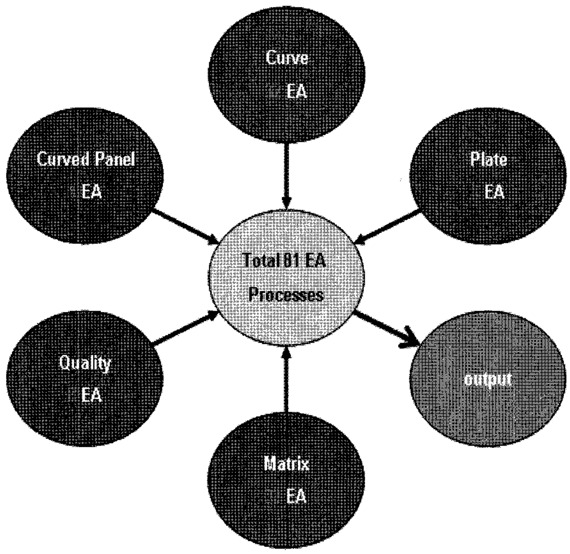

Figure 6: Extraction procedure of 3D design data from Tribon

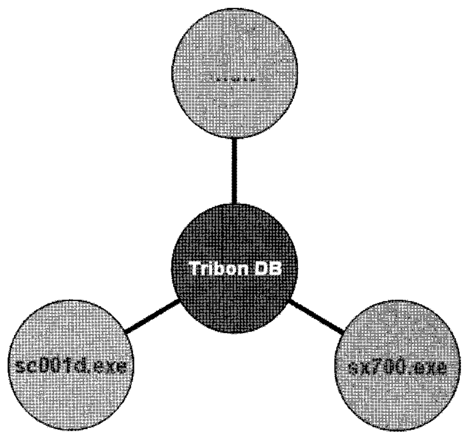

Figure 7: Execution file for contacting Tribon DB

In other words, even though necessary 3D design data can be extracted from Tribon now, the procedure for extraction is not intuitive and straightforward and it takes time to complete the procedure. For some plates, it can happen that data cannot be extracted from Tribon due to incorrect input data in the Tribon DB caused by mistakes of designers. Except for this case, the new extraction method can decrease the time for extraction by doing this process automatically. For this, a software module is developed that makes the manual and command-based extraction process fully automatic. This module simplifies the complex extraction process as one automatic procedure by avoiding direct access to Tribon DB by the designer to get each part information. This means that the operator selects a target by using the proposed software and all the complex extraction procedure is performed internally, producing the necessary results. This software accesses Tribon DB using two execution files and gathers information necessary for design data for extraction. This operation is illustrated in Figure 7.

The proposed software is denoted as WiseHeating_Pre, whose UI (User Interface) is shown in Figure 8.

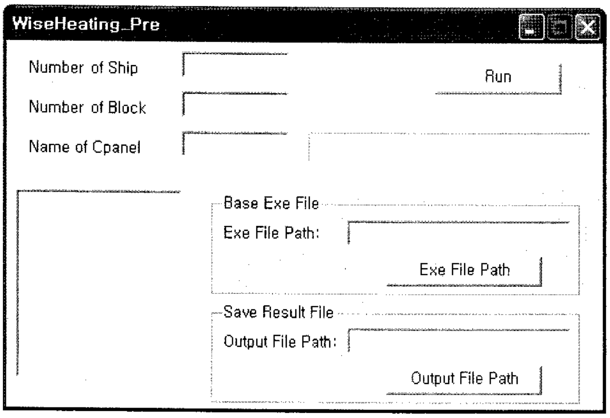

Figure 8: WiseHeating _Pre UI

Extraction of design data using WiseHeating_Pre from Tribon can be performed through the following steps: first, the project number of a ship whose design data need to be extracted is selected in Tribon. Then WiseHeating_Pre program is executed and after providing the names of blocks and curved plates the necessary design data can be extracted. The extracted results are stored in a file named HCI_SPI. The format of this file conforms to the input format of WiseHeating(Park 2007b), a program for computing forming information, which consists of information of edges, vertices and inner points. Using such 3D design data, forming information can be computed.

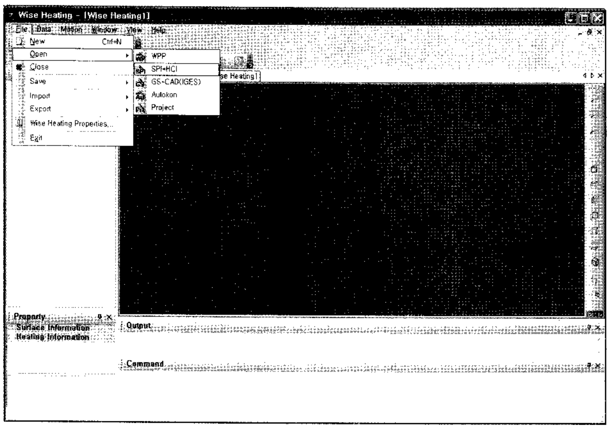

Figure 9: Input file format of WiseHeating

3.3 3D information extraction from 2D drawings

When a design system is not available for extracting 3D design data directly, the 3D data should be extracted from 2D drawings representing the shape of a ship hull. At least, two pieces of information are needed to extract design data from 2D drawings: one is called the landing body plan, and the other the shell expansion. The landing body plan shows a family of frame-by-frame hull lines in a 2D plane generated by a 2D CAD system as shown in Figure 10. The shell expansion is a drawing which shows the expanded shape of the outer curved hull with SEAM BUTT lines as shown in Figure 11.

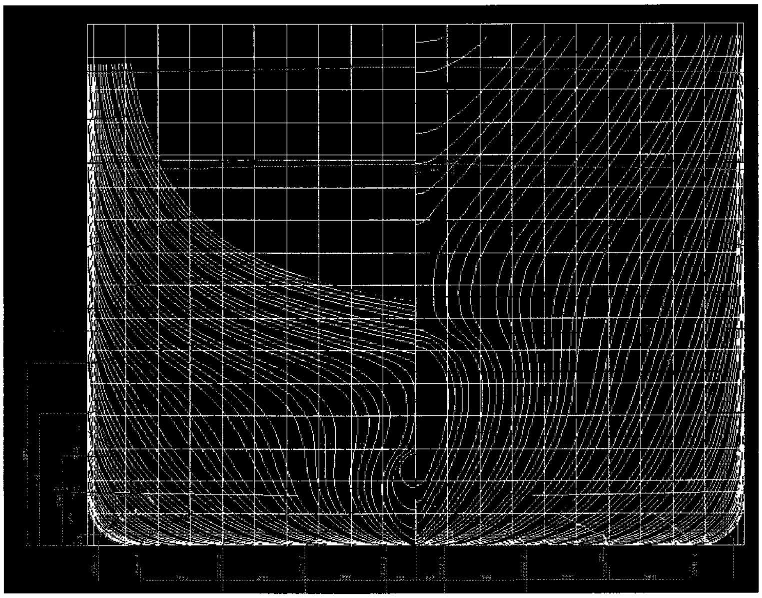

Figure 10: Landing Body Plan

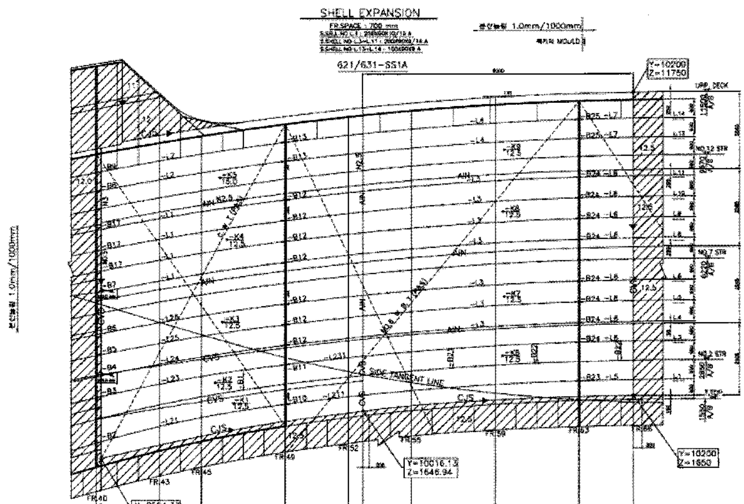

Figure 11: Shell expansion

Using these two drawings, a set of 3D design data can be extracted. First, the position of a frame line and the height of a plate whose design data are required are located from the shell expansion. Then, based on this information, the location of the plate can be found in the landing body plan and the boundary of the plate can be extracted from the same drawing.

For example consider a plate named K1 whose boundary is indicated using circles in Figure 12. The frame line and the height information can be obtained from the shell expansion as shown in Figure 12. It is found that the frame numbers that the K1 plate covers are from 40 through 52 and the height of the plate runs from 1650 through 2750 as illustrated in Figure 13. Using this information, the K1 plate is located from the landing body plan as shown in Figure 14.

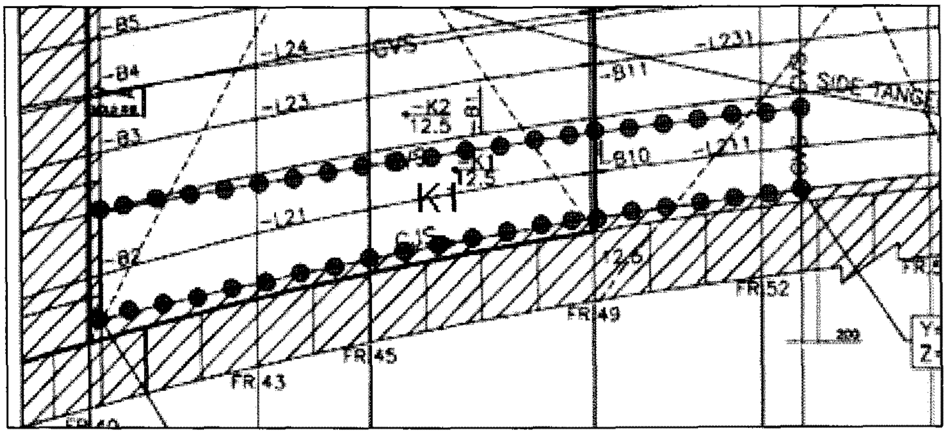

Figure 12: Plate K1

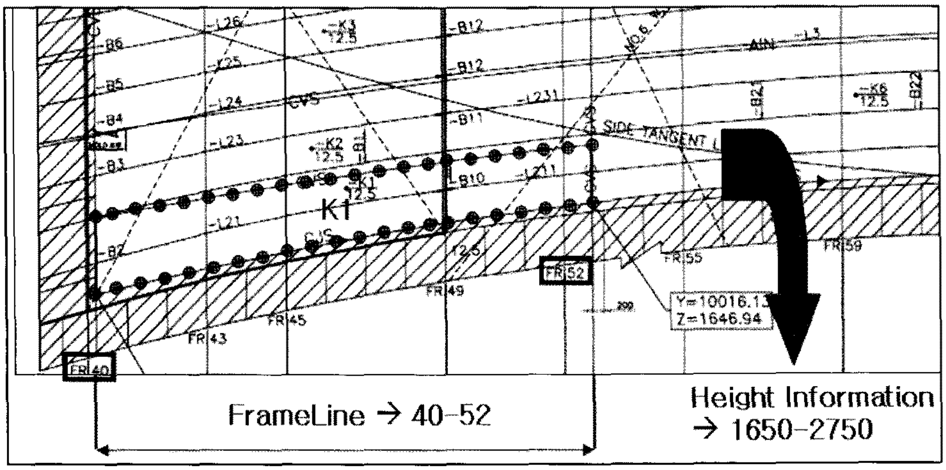

Figure 13: Basic information extraction from the shell expansion

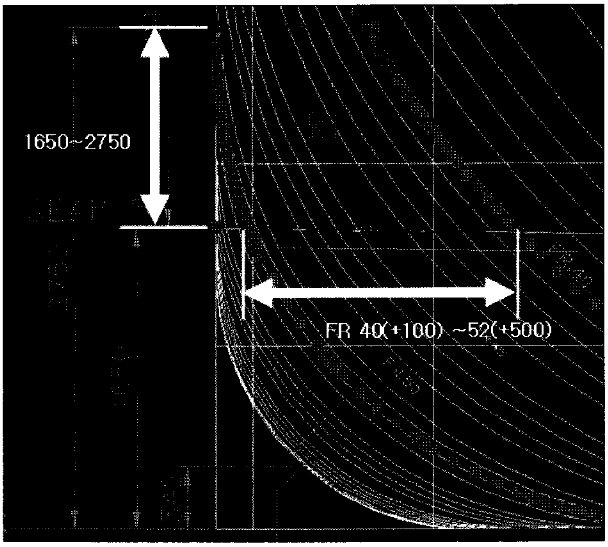

Figure 14: Data extraction from the landing body plan

Now the edge point data can be extracted from the landing body plan using 2D CAD systems. This extracted data are compiled in a format called the wpp, which indicates the number of edges, the number of points in each edge and the position of each point. This type of data is the basic format which can be provided as input to the program, WiseHeating(Park 2007b) that computes the thermal forming information. Figure 15 shows a screenshot of WiseHeating which reads a wpp file.

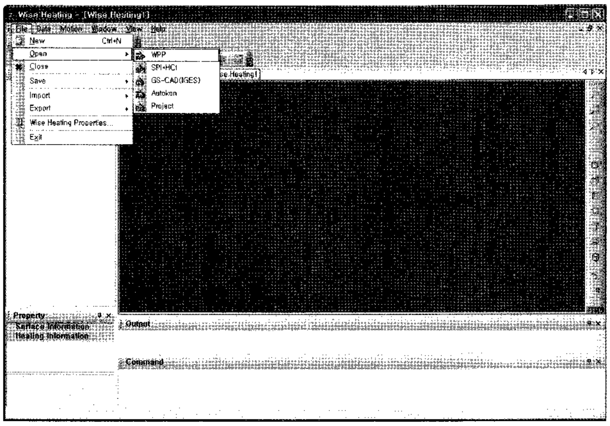

Figure 15: Input file format of WiseHeating

4 3D design data extraction and forming information generation

In this section it is shown that based on the proposed extraction process 3D design data of a plate are extracted using real ship data and forming information for the plate is computed. The target of this work is not to extract 3D design data for a shipyard which uses a 3D design system but to propose a procedure for extracting design data from Tribon system, to show how such design data are extracted and forming information is computed. Therefore, it is not discussed how to extract design data and compute forming information from a 3D design system in this section.

Using the program WiseHeating_Pre, necessary data are extracted from Tribon, which are then stored in the HCI_SPI file. Then using the data of this file a designed plate is modeled and based on the model, forming information is computed. If 2D drawings are used for data extraction, the landing body plan and the shell expansion are used to estimate necessary data and by modeling them, forming information can be computed.

In this section, the same curved plate K1 (621-SS1A) is provided as an example to demonstrate two proposed methods for extracting necessary data from Tribon and 2D drawings.

4.1 3D information extraction from TRIBON and thermal forming information computation

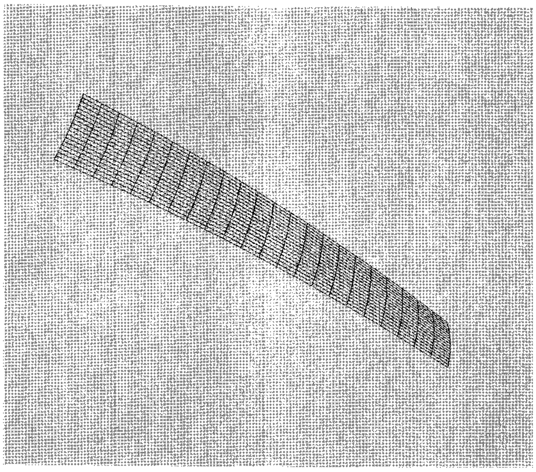

Figure 16: 3D design data of K1

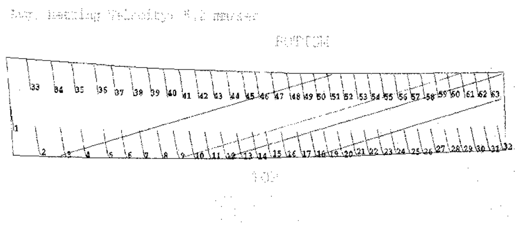

Figure 17: Thermal forming information of K1

In this section, it is shown that 3D design data are extracted from Tribon and they are modeled as a surface (Park 2007a) as given in Figure 16. Using this surface data, forming information is computed whose results are given as heating curves shown on the plate as shown in Figure 17.

4.2 3D information extraction from plans and thermal bending information generation

In this section, using the same part the necessary 3D design data has been extracted for the plate K1 from 2D drawings, the landing body plan and the shell expansion. As shown in Figures. 18 and 19, the similar results are obtained as those in Figures 16 and 17.

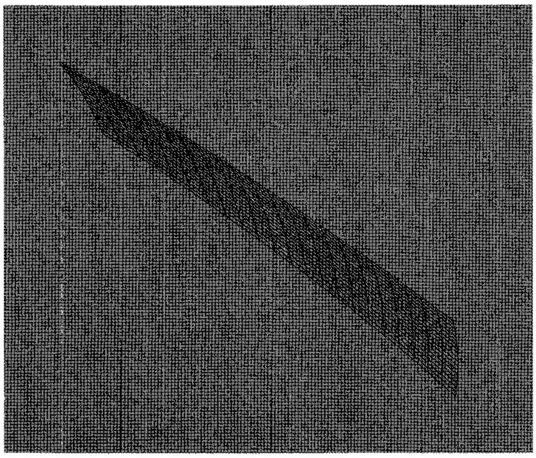

Figure 18: 3D design data of K1

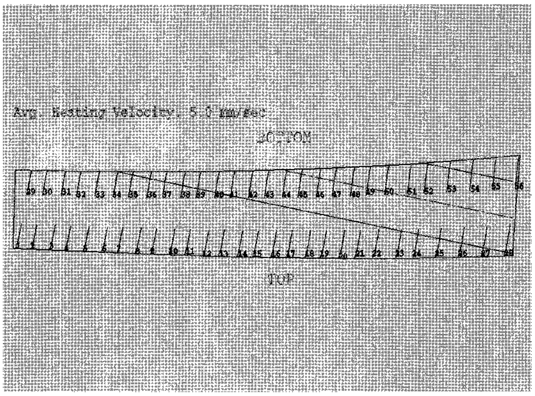

Figure 18: Thermal forming information of K1

5 Conclusion

In this paper, how to extract 3D design data is discussed, which is necessary for providing the standard forming information for curved hull forming that has been recognized as a bottleneck of the whole ship production. At first, 3D design systems which are used currently are investigated and then extraction methods and procedures for each typical design system are explained. In particular, the main target of this paper includes Tribon and 2D manufacturing drawings and it is shown that from those two cases 3D design data are successfully extracted and heating information for forming is computed. Through this work, the methods and a procedure to extract necessary 3D design data for forming are proposed and it is verified that standard forming information can be computed from a system which does not provide 3D design information directly such as Tribon and 2D drawings.

Acknowledgements

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Shin, J.G. and J.H. Lee. 2002. Nondimensionalized Relationship Between Heating Conditions and Residual Deformations in the Line Heating Process. Journal of Ship Research, **46**, **4**, 229-238.

Shin, J.G., C.H. Ryu, J.H. Lee and W.D. Kim. 2003. A User-friendly, Advanced Line Heating Automation for Accurate Plate Fabrication. Journal of Ship Production, **19**, **1**, 8-15.