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The implementation of the integrated design process in the hole-plan system

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ABSTRACT: *All current shipyards are using the customized CAD/CAM programs in order to improve the design quality and increase the design efficiency. Even though the data structures for ship design and construction are almost completed, the implementation related to the ship design processes are still in progress so that it has been the main causes of the bottleneck and delay during the middle of design process. In this study, we thought that the hole-plan system would be a good example which is remained to be improved. The people of outfitting division who don't have direct authority to edit the structural panels, should request the hull design division to install the holes for the outfitting equipment. For acceptance, they should calculate the hole position, determine the hole type, and find the intersected contour of panel. After consideration of the hull people, the requested holes are manually installed on the hull structure. As the above, many processes are needed such as communication and discussion between the divisions, drawings for hole-plan, and the consideration for the structural or production compatibility. However this iterative process takes a lot of working time and requires mental pressure to the related people and cross-division conflict. This paper will handle the hole-plan system in detail to automate the series of process and minimize the human efforts and time-consumption.*

KEY WORDS: Hole-plan system; Hull and outfitting design; Process automation.

INTRODUCTION

In the traditional design environment, the designers had been satisfied that the CAD/CAM system could provide the drawings for products. However, the expectation of the shipbuilding CAD/CAM has been updated around these days (Mistree et al. 1990). Many major shipyards are deploying 3D product model to support the variety of requirements, such as factory automation data, reproduction of the data and the detail product information.

Among the current issues for the development of integrated design support system, this paper focuses on the process automation (Andritsos and Perez-Prat, 2000) which, in general, are occurred between the related several divisions. For this, the design information management system which can reflect the ship design process and solve the process conflict is certainly needed. The generation process of outfitting holes is the typical example which needs the co-work between the outfitting and hull design divisions. The difference of design-time, work scope of each division, and the numerous revisions are the main reason why the hole-plan system should be automated.

To solve this complicated process on the outfitting design, a Bill-of-Material (BOM) approach has been introduced and suggested by Lee et al. (2010) and Lee (2010). However there are a few studies directly related to the hole plan system. The

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related studies had been implemented by Ye and Kim (1992), Lee and Kim (1992) and Suh and Lee (2006). At that time, the outfitting division did not have the same CAD system with the hull structure division. These researches, therefore, had tried to solve the interface problem between the two different systems. For reference, the major shipyards are recently using the unified CAD system. So we are going to focus on the process automation which includes the generation of virtual holes, the management of holes history, the insert of automated hole on the panels, and the hole visualization connecting with CAD system, instead of the interface problem. Based on the concept of this article, we have developed the hole-plan system and the detail processes are explained on the remaining chapters.

THE CONCEPT AND DEFINITION OF HOLE-PLAN

Holes on the hull structure

There are many kinds of holes on the hull structure. They are used for the various purposes which include the passage usage (Access hole, Man hole), the discharge usage (Drain hole, Air hole), the welding or assembly usage (Scallop, Slot), and lightening usage (Lightening hole) or the special usage (Lashing hole, etc.). Here, the lashing hole is used for tightening the cars on the Pure car and Truck Carrier (PCTC) ship, and the lightening holes are also made for the load dispersion, passage usage, besides the weight reduction. Additionally, the outfitting holes which are the main theme of this article consist of the pipe holes, the ventilation holes, and cable holes. Fig. 1 shows the outfitting pipe network on an engine block.

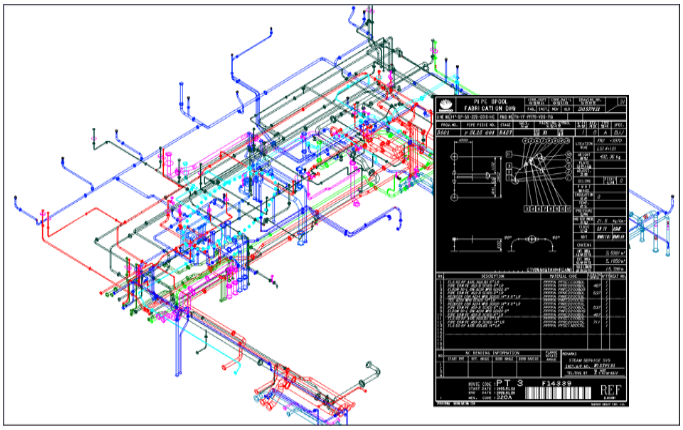

Fig. 1 A piping network on the engine block.

Generation process of outfitting holes

Fig. 2 describes the overview of the developed hole-plan system which compares “As-Is” and “To-Be” being developed. In case of “As-Is”, the people of outfitting division should make the complicated hole drawings (refer to Fig. 3, Ye and Kim, 1992) which could indicate the exact position, type of holes and the target hull panel. For reference, the hole drawing had been used as

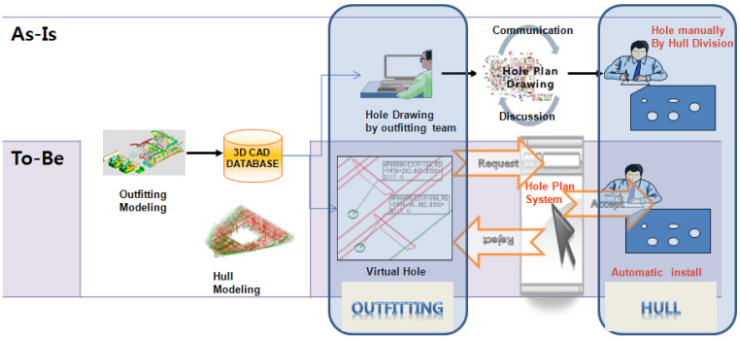

Fig. 2 Overview of the hole-plan system.

main medium between outfitting and hull division, and the designated hole-plan system generates this drawing only for the evidence material. This drawing job is executed in repeating way every time with revision works as well as the initial work. On the other hand, the people of hull division must manually add the actual outfitting holes after review and consideration about the requested holes.

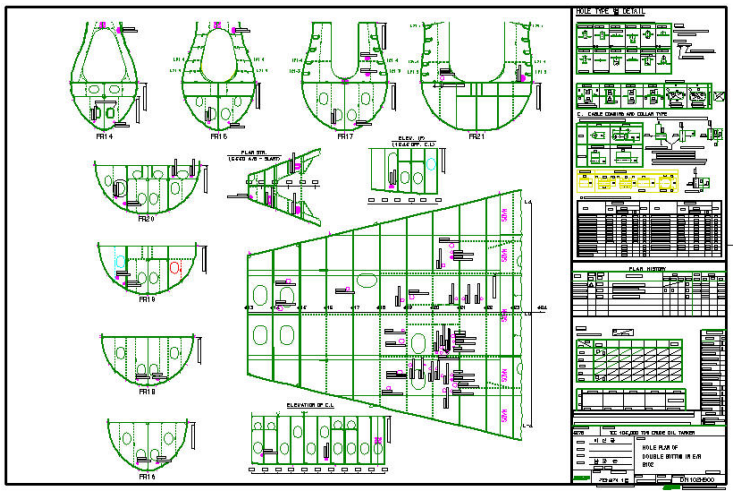

Fig. 3 An example of hole drawing.

However, all requested holes cannot be approved with the several reasons, which will be explained later. In that case, the relevant holes will be sent back to the outfitting division. It could, therefore, be expected that a lot of confliction would be generated between the relevant divisions. Naturally, discussion and meetings are frequently needed to settle down such problems. In conclusion, it seems that the current mechanism has a lot of problems.

Meanwhile, "To-Be" process does not require drawing works. The hole-plan system covers for its role, and the designers of two divisions are not necessary to leave their seats and go to the meeting room.

In detail, the designers of outfitting division could make the virtual holes which are the temporary ones calculated by the system, not the actual hole. (Refer to Fig. 4) The hole-plan system generates all virtual holes which are located at the intersection point between the hull panel and the outfitting equipment. In addition, their shape is determined by considering the installation. For example, a separated pipe has the flanges or sleeves at the both ends for connection with the other pipe. The size of corresponding virtual holes, therefore, should contain the larger one. For reference, all virtual holes have already fixed depending on the outfitting components at the stage of installation. When the virtual holes are generated, the system checks their compatibility conditions on the structural or production view. Main checking items are the distance between the designated hole and

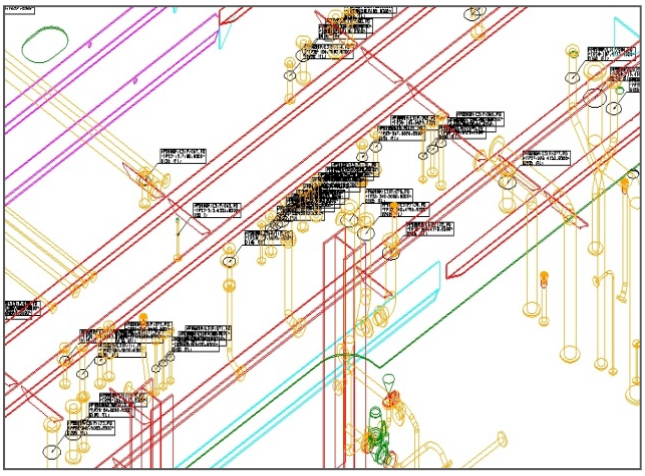

Fig. 4 Virtual holes made by the outfitting division.

the periphery parts which are sensitive to the strength. It will be explained in detail at the next chapter. Anyway, the allowable holes and the intended holes are transferred to the hull division for the approval. The hull person in charge decides whether the hole should be approved or rejected. The approval hole would be inserted on the hull panel. On the other hand, the rejected hole would be returned to the outfitting with the proper opinion.

The series of this process on the hole-plan system proceed without any drawings or the meeting. Without the sweat of outfitting people, they can achieve the virtual holes and get the approval through the intranet or web system and finally all related results can be shown on the CAD/CAM system. Meanwhile, the hull people have only to check the request virtual holes and determine whether to give their approval or not.

Definition and necessity of hole-plan system

If we try to define "Hole-plan system", it could be said that the requested holes by outfitting division would be automatically inserted on the hull panel with the approval of the hull division with the foundation of the hull structure and the outfitting model on the CAD/CAM DB. In addition, it ought to be comparatively easy to modify the holes' position and its type and to insert and delete.

Most of the holes on a hull structure are treated by the hull division and they are planned at the relatively early stage of design before node of the product design on Fig. 5. However, the outfitting holes are a little different to other holes. There are so many of variability during the ship construction. The periods of installation are spread over the construction schedule. For reference, the outfitting installation is possible to be divisible in the precedent (Shin et al., 2009), the dock, and the quay installation with the time when outfitting equipment is established. In case of the precedent installation, it can be subdivided by "Hull structure outfitting," "Unit outfitting," "On-block outfitting," and "Pre-Erection outfitting". There is therefore a lot of probability of revision on account of the change of equipment and facilities, incompatibility with the predesigned structure and some inevitable situation. For these reason, all design information of outfitting holes cannot participate in the preliminary structural drawings. Hole-plan system has to handle these unexpected holes.

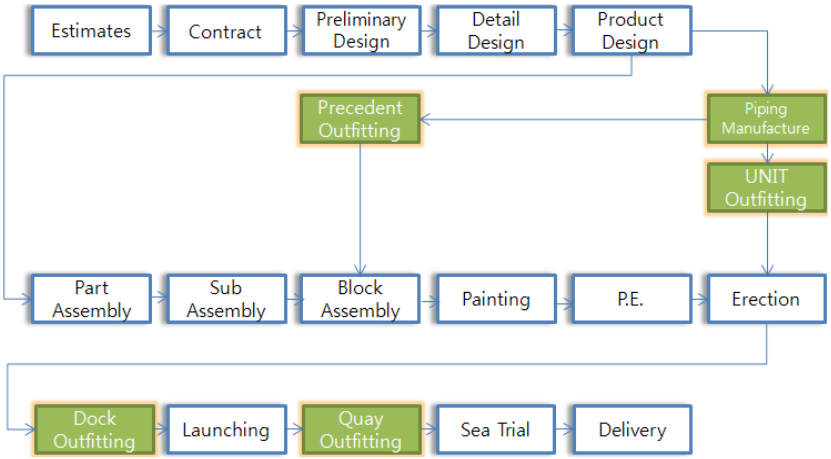

Fig. 5 Various stage of outfitting erection during the ship construction (Wijnolst and Wergeland, 2008).

Expected effect of hole-plan system

It is possible to expect the following effect by the application of Hole-plan system. First of all, this system can reduce the human error. Considering the installation constraints and the characteristics of outfitting equipment, all outfitting components are assigned and have the proper hole's size and type before this system is implanted on the CAD/CAM software. Secondary, the generated holes get to have their history which contains the generation date, time, designer, and inspector information. So this management system can clarify where the responsibility lies. Thirdly, it can reduce the working hour. All related jobs are connected to the CAD/CAM DB. So, the users can find the exact position of each hole using the hull and outfitting model, verify the hole shape and position with the CAD system. In addition, people of hull team can automatically make the real and approved hole on the hull structure. To reinforce the panel having the several holes, it is usual

that the hull team insert the additional structures such as "Coaming" or "Carling" around the hole. This system also supports to insert automatically. Finally, this system is very helpful to increase the rate of design standardization. There are a lot of people who execute the outfitting design. Depending on the designers, the installed holes can have various types and sizes without this system.

AUTOMATED PROCESS OF OUTFITTING DIVISION

Virtual hole

Table 1 Various hole types.

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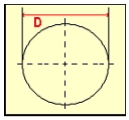
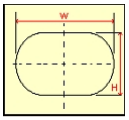
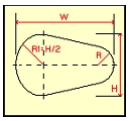
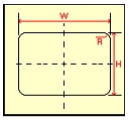
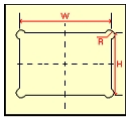
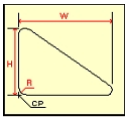
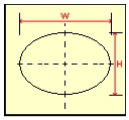
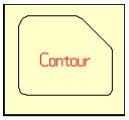
			
HRM	**HT**	**HE**	**Contour**
			

The virtual holes are already introduced at the previous chapter and Fig. 4. The reason that these holes are referred as the virtual hole not the regular hole, is that the hole-plan system temporarily made for the purpose of the approval of the hull division. Fig. 6 shows an enlarged virtual hole which contains the pipe component. All generated holes have the D-type shape for the efficiency of automation. Later, the user can change the holes' type with easy using this system. Each virtual hole displayed on the CAD view has its own annotation which consists of a hole name (ship project name + division name / block name / serial no. constraint status), hole position (X/Y/Z), and hole type (D / HO / HOR / HR / HRM / HT / HE / Contour-refer to Table 1).

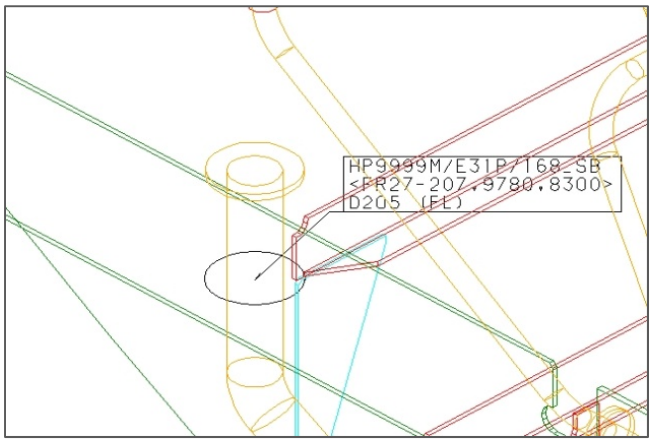


Fig. 6 Detail of a virtual hole.

Constraints of virtual holes

All virtual holes must get through the several compatibility constraints which generally consist of "interference with the other structures" and "the distance with the main components of panels". These constraints have relevance to the local structural strength and the construction reasons which are usually determined with division or company rules.

Table 2 Compatibility check items of the virtual holes.

Constraint type	Reason
Stiffener Approach (SA)	Structural strength
Seam Approach (SM)	Structural strength & Production
Overlap (OL)	Production
None Spec.	No data

The hole-plan system classifies the verification result by the specific name which was explained as the "constraint status" at the previous sub-chapter. If a virtual hole pass all constraints, it has the "Stand-by (SB)" mark on their note dimension. Table 2 shows the checking marks when the virtual holes violate the compatibility conditions.

Note that the verification is implemented at the stage of outfitting process not the hull stage. The system intends to check in advance and the people of hull to check only the virtual hole which has passed all compatibility condition. The outfitting people also must identify whether the relevant virtual hole has passed, and then request for approval.

Table 3 shows the representative case of violating the constraints. The first shows a hole approaches the stiffener too closely, the second is located on the seam line, and the last get close to other holes very much. In the last case, the user must combine near holes so as to make them one hole.

Automated process

This system is mainly implemented using "Python" (ver. 2.6, http://www.python.org/) which is the only language for calling the API functions inherent in Tribon M3 system (http://www.aveva.com/). The designer of outfitting division starts with selecting the outfitting components (② on Fig. 7) and the related hull blocks (①), and then makes the virtual holes using the button ③. That result would be listed up at the ④ which includes all generated virtual holes, their name, and the compatibility status. The view button(⑨) displays the 4 views which include the hull structure, the outfitting network, and the virtual holes. Fig. 8 displays only a plan and ISO view among 4 views about an engine block. After solving the violation of compatibility condition, the button ⑥ enables to request the selected virtual holes to the hull division by e-mail or intranet. In addition, the users can verify the hole history using the button ⑦ and make the hole drawing using the button ⑩. If the hull team accept the requested holes, this list can be checked on the ⑤ list box. If not, the rejected holes are listed on the ④ list box.

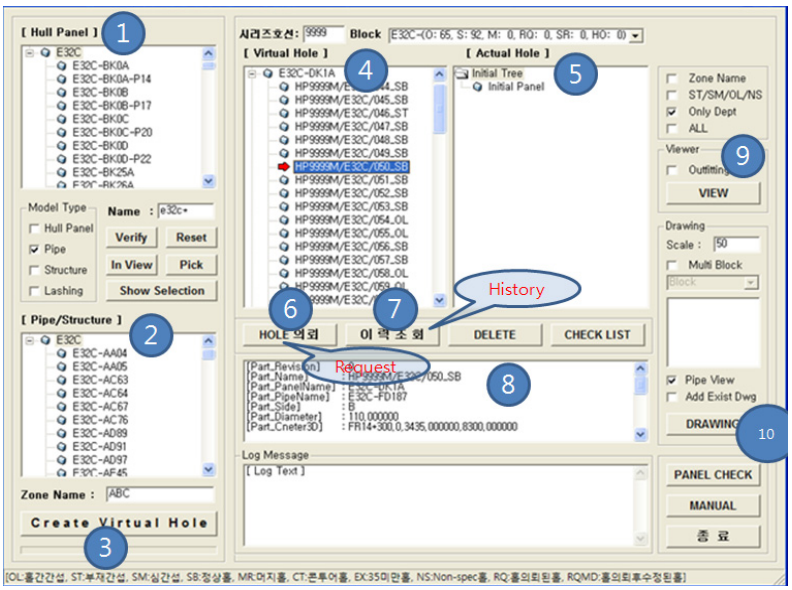
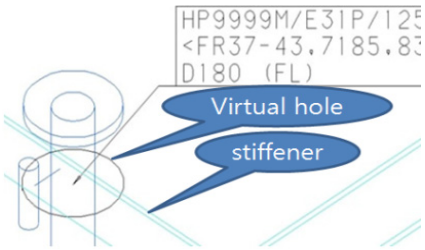
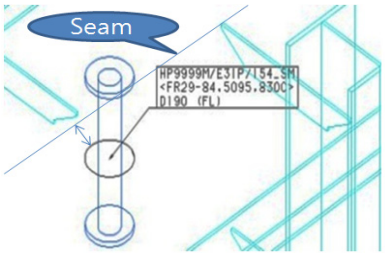
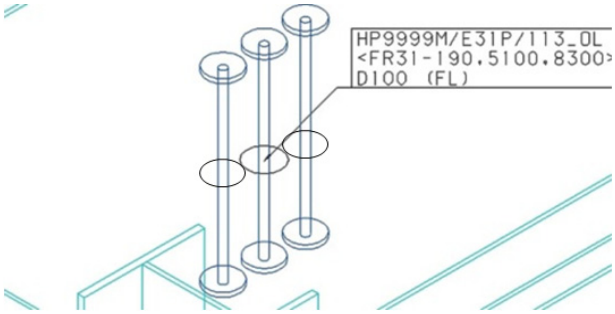


Fig. 7 The detail process of outfitting division.

Table 3 Violation cases of virtual holes.

SA	
SM	
OL	

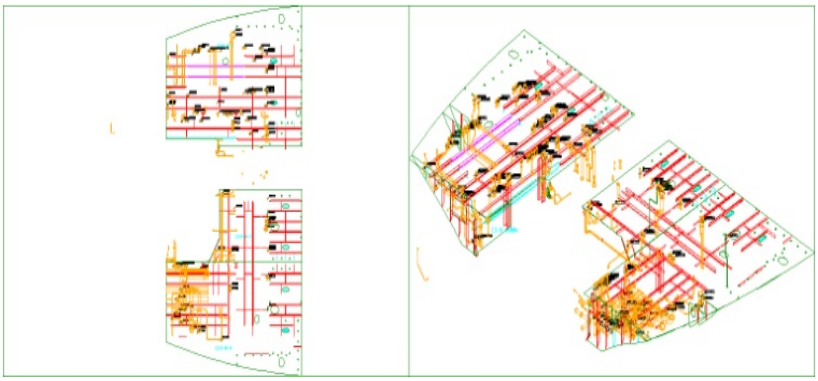


Fig. 8 The involved hull, outfitting, and generated virtual holes.

AUTOMATED PROCESS OF HULL DIVISION

The hull team needs only to determine whether the requested hole is acceptable or worth refusing. He can comment his opinion about the rejected ones on its history record. He will start with the input of his own ID and check the requested hole at the each block(① on the Fig. 9). When click the designated block, the list of corresponding virtual holes listed on the box(②). Anytime he want, he can check the selected hole information from the view button(⑦). The button ⑥ enables the selected virtual holes to be the confirmed holes and automatically reflect on the real structural DB and they are also listed on the ③. Fig. 10 depicts the confirmed holes on the structural panel. Note that all resultant holes on the Fig. 10 have not passed the given constraints and generated for just example. As soon as the user presses the button ⑤, the reject result will be sent back to the outfitting person in charge. In addition, he can check the hole history from the ④ box.

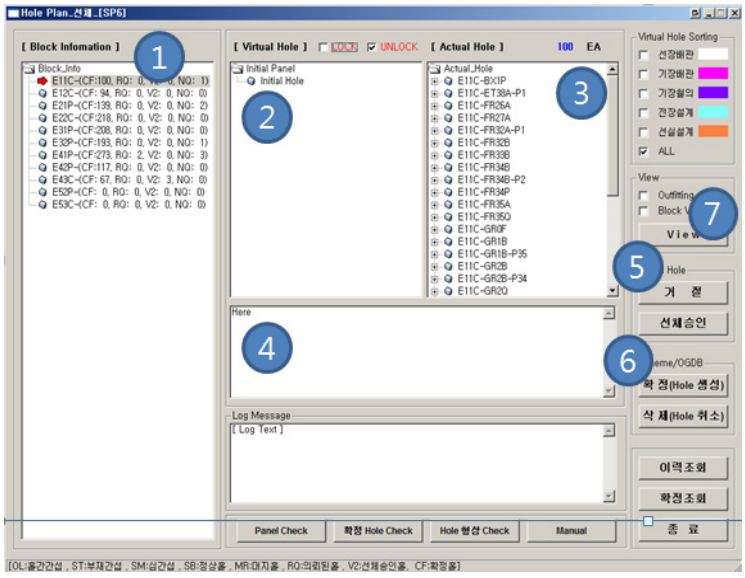


Fig. 9 The procedure of hull division.

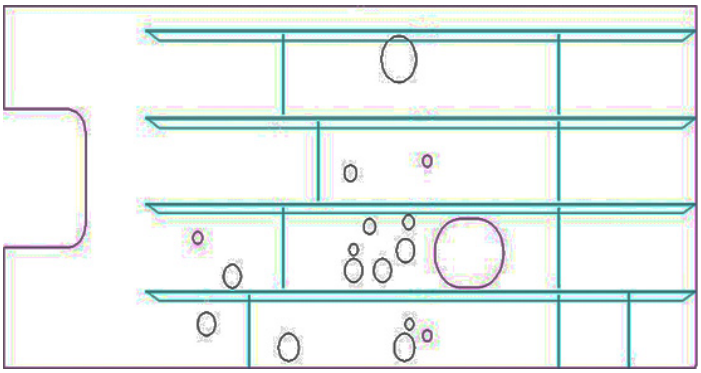


Fig. 10 The confirmed outfitting holes.

CONCLUSIONS

After the preliminary ship design, the detail design is generally carried out by the two major divisions. One is the hull division and the other is the outfitting design. It is fact that the efficiency of these divisions has been increased and their own processes get to be increasingly smooth by help of the CAD/CAM system. However, it is an exception to generate the outfitting holes on the structural panel. It is easy to image that there could be the meeting point where two division must cooperate to make the outfitting hole which satisfy the space of outfitting equipment and also the compatibility condition of structural behavior.

This article tries to automate the all design process of the outfitting holes by two division points of view. The automatic generation of virtual holes, the linkage with the CAD system, the communication using the intranet or E-mail, the holes' history management and the automation of compatibility checking are the developed catalog at the outfitting division side. On the other hand, the automatic scheme, the hole verification using the CAD system, and the information management system are the advantages at the hull division side.

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