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Automation of block assignment planning using a diagram-based scenario modeling method

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ABSTRACT: *Most shipbuilding scheduling research so far has focused on the load level on the dock plan. This is because the dock is the least extendable resource in shipyards, and its overloading is difficult to resolve. However, once dock scheduling is completed, making a plan that makes the best use of the rest of the resources in the shipyard to minimize any additional cost is also important. Block assignment planning is one of the midterm planning tasks; it assigns a block to the facility (factory/shop or surface plate) that will actually manufacture the block according to the block characteristics and current situation of the facility. It is one of the most heavily loaded midterm planning tasks and is carried out manually by experienced workers. In this study, a method of representing the block assignment rules using a diagram was suggested through analysis of the existing manual process. A block allocation program was developed which automated the block assignment process according to the rules represented by the diagram. The planning scenario was validated through a case study that compared the manual assignment and two automated block assignment results.*

KEY WORDS: Ship block assignment methodology; Midterm scheduling; Automation; Ship block assignment.

INTRODUCTION

In shipyards, scheduling is carried out with a focus on the dock plan. Therefore, when there are sufficient orders, the load level of a dock has little slack, if any. Even though the shipbuilding industry is in a recession due to the aftereffects of the global economic crisis, the large shipyards in Korea are managing to maintain a sufficient amount of orders for production, and the docks are still running at the maximum load level. Instead, due to the excessive amount of orders, the quays or predecessor processes such as block assembly are overloaded at times. If the block manufacturing process is overloaded, blocks can be outsourced. Many shipyards actually outsourced quite a few blocks when business was booming. However, more efficient utilization of internal resources is necessary for a better profit structure. Thus, research on the scheduling of block manufacturing processes needs to be carried out.

Large Korean shipyards have already built their own scheduling and planning systems. However, for certain tasks, the backbone system only handles the data storage; the actual task is done manually without the backbone system. Block assignment planning is one such task. The load level of these tasks can be reduced by automation or optimization, and they can be integrated and managed by extending the existing scheduling/planning system.

Block assignment planning is one of the midterm planning tasks; it assigns a block to the facility (factory/shop or surface

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plate) that will actually manufacture the block according to the block characteristics and current situation of the facility. It is one of the most heavily loaded midterm planning tasks. Reducing the overall load of the task is important along with appropriate assignment. In this paper, a diagram-based scenario modeling method is suggested to systematize the block assignment rules and automate the task to improve the block assignment planning efficiency.

LITERATURE REVIEW

There have been few studies that directly studied block assignment planning. Extending the range of interest to scheduling produces various studies of interest. Studies on shipbuilding scheduling can largely be divided into those either establishing the schedule or verifying the established schedule. The former includes many optimization studies, and the latter includes many simulation studies. Establishment and verification of the schedule are closely related.

Lamb et al. (2006) defined entities of production process and production logics through analyzing a shipyard fabrication/forming shop. Furthermore, they suggested a method that enables us to grasp problems that a production process has by modeling & simulation. Song et al. (2009) analyzed the schedules of small- and medium-sized shipyards and verified that planned ships can be built while the established schedules are followed using simulation technology. Lee et al. (2009) constructed a simulation-based production execution system where the execution schedule was verified by the simulation method. Zhao et al. (2010) studied the hybrid parallel algorithm for scheduling job shop-type processes. Shin et al. (2008) studied layout planning of the ship assembly process using the differential evolution algorithm. The present study has similarities with the work by Shin et al. because they were essentially creating schedules while considering the capacity constraints of space resources. Layout planning of the assembly process is a detailed scheduling activity that is established after block assignment planning, which was the main focus of the present study. Guldogan (2011) studied how to optimize operation allocation to machines. When there are operations and machines with different characteristics, he determined the suitability of a machine to each operation based on expert opinions and assigned the most suitable operation to each machine through optimization using the genetic algorithm. The present study is similar to the procedure in their study, in that they assigned processes (operations) to resources, while block assignment planning assigns resources to products. Studies on scheduling so far mostly dealt with the optimization of the schedules subject to some constraints. However, changes in the constraints or in the model itself were difficult to be reflected. This study defines how to model constraints and automates the block assignment planning. Therefore, the proposed block assignment planning method can respond to the changes promptly.

In the present study, a diagram-based modeling method was used for automation of the block assignment planning in order to visualize the logical flows. Diagram-based methods are often used in process design or in the design of signal processing for the control of mechanical instruments because the logical flow is very important in these activities (Kiritsis and Porchet, 1996; Ramaswamy et al., 1997; Manesis and Akantziotis, 2005). Petri nets are widely used in process planning because they can describe not only the relationships between processes but also the product per se using a token, and a simple simulation can be carried out (Cecil et al., 1992; Venkatesh and Ilyas, 1995; Kiritsis and Porchet, 1996; Ramaswamy et al., 1997; Kiritsis et al., 1999). The Petri net has a wide range of applications; it is also used to model optimization processes (Reddy et al., 2001). Meng (2010) modeled a reconfigurable manufacturing system (RMS) using colored timed object-oriented Petri nets. An RMS is a manufacturing system to cope with the rapidly changing manufacturing environment, which includes both hardware and software. As in the above methods, diagram-based modeling methods play an important role in simplifying existing circumstances or in defining the rules that are written in a natural language in a systematic way. Furthermore, models defined by a diagram can be made into a library and can have high reusability. This study utilizes the advantages of the diagram-based modeling methods and establishes a block assignment planning method.

Process planning defines the process and determines the sequence of processes in order to optimize the efficiency of the manufacturing process plan. Hence, the process definition and sequence determination are separate processes. Once the processes are defined, the relationships and sequences between the processes become important. The Petri net can describe the relationships and sequences between processes very well and can also describe the status change of products using tokens (Kiritsis and Porchet, 1996; Kiritsis et al., 1999). The state diagram is a modeling method that focuses more on the change in states. In the present study, however, the diagram being defined carries out block assignment rule definition and sequence determination at the same time, and the change in states is less important. In contrast, true/false conditions are very important. Thus, a new diagram-based modeling method was defined in this study that considers the aforementioned characteristics and automates block assignment planning.