Proceedings of the 2024 Winter Simulation Conference
H. Lam, E. Azar, D. Batur, S. Gao, W. Xie, S. R. Hunter, and M. D. Rossetti, eds.

PRODUCTIVITY EVALUATION OF INTRODUCING NEW WELDING METHODS IN DECK HOUSE BLOCK FACTORY USING DISCRETE EVENT SIMULATION

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ABSTRACT

This study introduces a discrete event simulation-based modeling approach to evaluate productivity impacts when new welding techniques are introduced in deck house block production for shipbuilding. The hull manufacturing process is divided into stages including steel storage, fabrication, assembly, pre-outfitting, painting, and erection, with a focus on deck house blocks in this study. Four key factors—welding speed, welder movement speed, setup time, and finishing time—are used to evaluate the effectiveness of new welding methods, which may not always outperform existing methods. Discrete event simulation is used to analyze these factors, accounting for production volume characteristics and manufacturing logistics complexity. The developed simulation model incorporates welding times and processes to assess productivity, analyzing indicators like total welding length, crane utilization, and cycle times, along with sensitivity analyses of welder numbers.

1 INTRODUCTION

In the shipbuilding industry, the process of designing and manufacturing the hull involves a complex set of processes. To analyze the impact of changes in unit operations like welding operation on a block production amidst complex processes, it is necessary to use discrete event simulation methods that can simulate the dynamic production environment. In the shipbuilding industry, the hull manufacturing follows job-shop approach, where the limited number of welders acts as a constraint. Welders are dispersed across the large factory area, performing tasks in different locations. Discrete event simulation is an effective tool for simulating these complex processes, where welding operations are carried out simultaneously across multiple locations. This study suggests a discrete event simulation-based modeling approach to analyze the impact on productivity when new welding techniques are introduced in the production of deck house blocks for shipbuilding.

2 ASSEMBLY PROCESSES FOR BUILDING DECK HOUSE BLOCKS

The hull manufacturing process for shipbuilding is broadly divided into the following stages: steel storage, fabrication, sub-assembly, indoor/outdoor block assembly, pre-outfitting, painting, and erection. Stiffeners are welded onto flat plates in the sub-assembly process, while web frames are welded onto shell plates in the sub-block assembly process. Assembled components and sub-blocks are welded together to form a much larger unit in the block assembly process. Among the various blocks that make up the hull, this study focuses on the production of deck house blocks that constitute the ship's accommodation areas.

3 DISCRETE EVENT SIMULATION TO ANALYZE A NEW WELDING METHOD

This study uses discrete event simulation to evaluate productivity when introducing new welding techniques in a factory that produces deck house blocks. In shipbuilding welding operations, four key factors are used as criteria for evaluating the introduction of new welding methods. The first factor is welding speed, the second is the welders' movement speed while carrying and transporting the equipment, the third is setup time, and the last is finishing time (or grinding time). The new welding method introduced may not be superior in all four factors compared to the existing method; in some aspects, it may result in greater losses than the current method. For example, although welding speed may improve, the welder might face slower movement speeds while transporting the equipment or longer setup times as drawbacks. Therefore, considering the characteristics of the production volume and the complexity of the manufacturing logistics flow, a multifaceted analysis is needed to determine whether the new welding technique is effective in improving productivity. Discrete event simulation has been used to enhance the accuracy of process and production planning according to shipyard process plans and enables productivity analysis that accounts for the characteristics of the volume and internal logistics flow of the factory.

4 DISCRETE EVENT SIMULATION MODEL CONSIDERING WELDING TIME AND PRODUCTIVITY EVALUATION OF DIFFERENT WELDING METHOD

We developed a simulation model that incorporates welding times based on welding positions and techniques. By inputting information such as welding lengths and fitting lengths for each assembly of deck house blocks, along with the block's Bill of Materials (BOM), the simulation performs preprocessing to calculate the required fitting lengths and welding lengths for each process. Using this simulation model, we analyzes the effects of welding techniques by examining productivity indicators such as the total welding length per process, crane utilization rates, and the average cycle time of assemblies. Additionally, sensitivity analyses based on the number of welders are performed to assess the impact of welding techniques on factory productivity from multiple perspectives. Future research will focus on developing a discrete event simulation-based modeling approach that considers the welding times of robots.

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