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SIMULATION-BASED WORKLOAD FORECASTING FOR SHIPYARD BLOCK ASSEMBLY OPERATIONS

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ABSTRACT

The shipbuilding industry faces challenges in simulation-based production forecasting due to custom design requirements, design-to-production variability, labor-intensive processes, and complex scheduling. Increasing labor shortages and cost pressures highlight the need for a data-driven operational framework. A discrete-event simulation model tailored for ship block assembly planning is presented, defining standardized work units and deployment criteria to forecast labor and equipment workload and schedule delays. The simulator significantly shortens planning and load analysis time, improves delay forecasting accuracy, and visualizes load distribution and bottleneck patterns through a user-friendly interface. These capabilities enhance management efficiency and decision-making confidence in practical shipyard operations.

1 INTRODUCTION

The block assembly process in shipyards involves the simultaneous fabrication of multiple blocks; however, flow-line production is infeasible. Task configurations and execution sequences for each block are dynamically prioritized according to operational needs, and labor and equipment are flexibly allocated. Consequently, some blocks receive concentrated staffing while others endure extended idle periods, resulting in highly variable cycle times per block. Such operational complexity challenges the forecast accuracy of conventional data-driven planning and basic DES (Discrete Event Simulation) simulation models. Previous studies have shown limitations in modeling fine-grained block workflows (Jeong et al. 2016), quantifying workload differences between blocks (Jeong et al. 2020) and aligning simulation systems with actual site practices (Lee et al. 2020). To address these gaps, this study develops a DES model that integrates real workload data with flexible resource deployment logic. The proposed system is designed to forecast workload distribution and schedule delays at the block level in an operationally realistic context. By closely reflecting real-world assembly dynamics, the resulting simulator enhances the precision of planning and supports proactive decision-making in shipyard block assembly operations.

2 WORKLOAD FORECASTING METHOD FOR BLOCK ASSEMBLY

This study reflects the realistic workflow of a shipyard's grand assembly process by standardizing detailed operation units and configurations for each block, based on actual process data. We established a dedicated coding system for major work groups (such as fitting, welding, and erection) and defined more than 50 detailed operation types based on the equipment used and the timing of the tasks. Each of these tasks was then combined to align with the design and performance characteristics of each block, closely simulating the actual assembly sequence. In addition, a workload calculation model based on the welding length of each block was utilized to precisely calculate the workload by considering the type of work and welding position, thereby estimating the processing time for each detailed operation (Figure 1). The logic for allocating workers and equipment was designed based on block-level priorities and workload information. This system automatically assigns manpower when a specific block has an excessive workload and automatically identifies delayed blocks in case of labor shortages. To further enhance forecast accuracy, the system moved beyond traditional daily management by implementing a function for hourly worker allocation. The data structure and operational logic are designed to closely resemble the actual on-site environment, providing a foundation for analyzing and forecasting block-specific workload distribution and potential schedule delays. This approach serves as an effective, practical forecasting tool for managers in complex production environments.

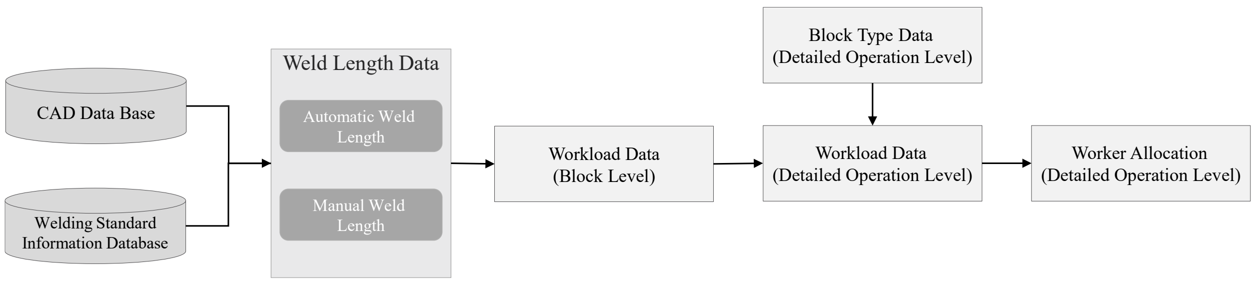

Figure 1: Detailed operation workload and worker allocation methodology.

3 DEVELOPMENT OF A SIMULATION MODEL FOR BLOCK ASSEMBLY OPERATIONS

A DES system was implemented to support data-driven decision-making and provide forecasting of operational risks during production planning and management. This system reflects the actual shipyard environment, including factory layout, block assignments, and workforce information, enabling rapid analysis of potential issues such as labor shortages, parallel block assembly, and schedule delays. The model automatically allocates labor and equipment based on block-specific priorities and workload estimates derived from weld-length metrics. To improve accuracy beyond traditional daily practices, workforce allocation is adjusted at hourly intervals. In cases of resource constraints, priority-based rules dynamically identify blocks at risk of delay. A dedicated user interface presents intuitive visualizations of role-specific workload, hourly production output, and delay status. The operational logic is designed to closely resemble the actual on-site environment, providing a foundation for high accuracy forecasting of workload distribution and schedule delays. This simulation serves as an effective, practical tool for managers, tailored to the complex workflows of shipyard block assembly.

4 CONCLUSION

This study defined a workload calculation method based on detailed operation information and developed a simulation model for forecasting production plan loads. The model incorporates features such as worker and equipment allocation and hourly task distribution, which enables more accurate forecasting of worker load and block delays. This approach has significantly reduced the time for production planning and load analysis, while supporting proactive decision-making by forecasting potential schedule delays. Furthermore, the intuitive visualization of simulation results enhances management efficiency and the practical applicability of the system.

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