ISSN: 2414-1895 DOI: 10.6919/ICJE.202104_7(4).0025

Block Spatial Scheduling in Shipbuilding Yard Based on Regulation

Jiankun Hu, Jinwen Zhang

School of Shanghai Maritime University, Shanghai 201306, China.

Abstract

In the complex shipbuilding process, block assembly is the key step which consumes a lot of time and resources, unreasonable stacking may produce additional operations, and increase the operating costs. In order to improve the efficiency of shipbuilding, reduce the extra operation in the block movement, this paper proposes the method of location selection of target block moving into the field, path optimization in and out of the field and adjustment the blocks stacking in the unreasonable relevant field based on the formulation of regulation. A large number of numerical experiments on the actual data of a shipyard show that this method is effective to solve practical problems. The results show that the scheduling regulation proposed in the paper achieves the global optimization effect and can reduce more than 20% of additional operations in the block scheduling process.

Keywords

Block Spatial Scheduling; Regulation; Shipbuilding Port; Additional Operations; Yards Utilization.

1. Introduction

In the process of shipbuilding, blocks are the most important intermediate products. As the basic unit of work for the organization, the blocks are built at a site outside the dock, and finally to the dock for the main group. Before the final manufacture of the ship, shipbuilding can be divided into several sub processes. Moreover, many blocks will be produced during these processes. The ship construction of 50000 DWT usually produce 100-200 pieces of blocks, so serious unreasonable stacking of blocks often exists in shipbuilding enterprises.

The scheduling optimization problem of various production resources under the modern shipbuilding mode has received much attention. In recent years, scholars have generally adopted intelligent optimization methods to optimize the shipbuilding process. From the classification point of view, the production resource scheduling problem can be divided into the block shop scheduling problem and the block transportation scheduling problem.

Regarding the scheduling problem of the block shop, Kwon studied the block scheduling problem with time window using multi degree of freedom cycle method (Kwon and Lee, 2015). Caprace proposed a large shipyard space and time allocation problem and modeled it as a three-dimensional packing problem. (Caprace, Petcu and Velarde, 2013). Shang considered the problem as a time-constrained three-dimensional boxing mathematical model and proposed an algorithm. (Shang, Gu, Ding and Duodu, 2017). Zhang established an optimization model to minimum block mobility (Zhang and Xu, 2013). Zhang used event-triggered rescheduling method, combined with block quality and moving distance to establish a mathematical model, taking the cost of moving block as the optimization goal (Zhang, JI F and Zeng, 2015). Chen established a yard scheduling model to minimize segmentation mobility. (Chen, Jiang, Liu and Huang, 2016). Tao proposed a multi-stack

ISSN: 2414-1895 DOI: 10.6919/ICJE.202104_7(4).0025

hull block scheduling method based on process flow with the goal of minimum block mobility (Tao, Jiang, Liu, Sun, Zhu and Li, 2017). Jeong classified and defined the spatial layout planning problems of various shipyards. (Jeong, Ju, Shen, Lee, Shin and Ryu, 2018). Zhuo proposed an enumeration-based search algorithm to solve discrete space optimization problems. (Zhuo, Huat and Wee, 2012). Zheng studied the typical block features and working plates, and obtained the optimal block sequence and spatial layout. (Zheng, Jiang and Chen, 2012).

In the research of the block transportation problem, Zhang used the temporary block scheduling process as the optimization object, and established the mathematical model with the moving distance of the flatbed as the optimization goal. (Zhang and Zeng, 2016). Zeng proposed the evaluation criteria of the block comprehensive movement difficulty by considering the influence of the number of temporary blocking segments (Zeng and Zhang, 2016). Joo considered a block transportation scheduling problem with delivery constraints. It is determined when each block is delivered to the target factory by which the transporter is minimized (Joo and Kim, 2014). Park transformed the shipyard transportation scheduling problem into parallel machine scheduling problem with sequential correlation setting time and priority constraints (Park and Seo, 2012). Dixit studied the problem for 72 shipbuilding projects with uncertain assembly schedules. (Dixit, Verma and Raj, 2018).

Most articles focus on the block transportation problem in a single area, however, the production plan changes continually and the blocks stack all over the yards. So, this paper develops block scheduling regulation, considers the whole area, number of remaining processing cycles and the resistance coefficient of the occupied sites, which has practical significance.

2. Problem Description

Shipyards have different types of codes depending on the shipbuilding operation. Prior to final assembly, the hull blocks place and process in more than one area. The capacity of yard is limited in number and its function is fixed, shipbuilding process stages required for each block are different, so it is necessary to move the blocks between the yards according to the shipbuilding process. The site is divided into a plurality of isolated secondary sites according to the spatial location, that is, the process, and each small square is a three-level venue that accommodates the blocks. Every day, the shipbuilding department puts forward the blocks' moving list, due to the blocks are densely placed all over the yard, and it is necessary to remove other blocks on the platform's driving path before moving out or moving into the yard, which leads to additional operations. Therefore, not only we have to complete the block move list, but also need to reduce the additional operations.

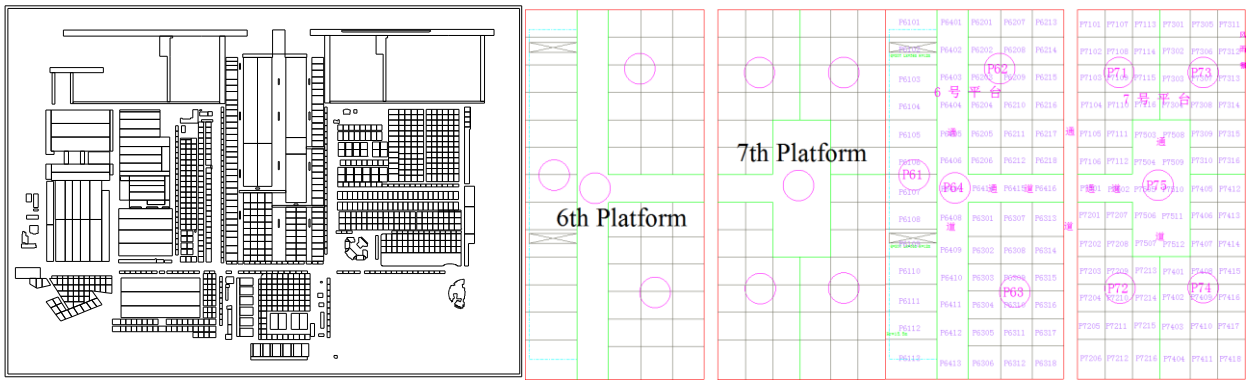

Figure 1. The first level yard, the second level yard and the third level yard

2.1 Level of Yard

A shipyard can be called a first class yard. Due to the difference of operation types, some independent operation areas are called secondary yard. The block area containing several secondary yards is called tertiary yard.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202104_7(4).0025

2.2 Yard Features

According to the shipyard production management system, the features of the third level yard are divided into two categories features. The invariant features: yard code, priority, operation choices, coefficient of stacking. The dynamic features: Block stacked identification, Remaining time for stacking due to the plan.

Coefficient of stacking can be set by the spatial layout of the third level yard. The coefficient of the tertiary yard stacking close to the street is zero, and the coefficient of stacking will be 1 if there is a tertiary yard between the yard and the street, and so on.

3. Spatial Scheduling Algorithm and System

1. Sort the Move List of Blocks. The movement list includes the following information: moving block identification, yard name of the block moved in, yard name of the block out, operation choices, the periodic intervals of the moving block. The blocks with backward shipbuilding technology or short process cycle have a high priority. The blocks at the back of the process flow can be done first, so as to get closer to the assembly, and the space left after moving can be used by the blocks ready for operation, thus reducing the number of additional operations.

2. Determine the idle yard. Before moving the blocks, it is necessary to determine the idle secondary yard, including the existing and to be demolished.

3. Calculate the resistance value of the whole third level yard. The resistance value refers to the resistance of the flat car. When the flat car passes through a certain third level yard, the value of the empty yard is 0, and the resistance value of the third level stacking yard is a specific value.

The relationship between stacking coefficient and shipbuilding time should be considered. Those with shorter shipbuilding period should be stacked in the peripheral yard, while those with longer shipbuilding period should be stacked in the yard with high stacking coefficient, so as not to hinder the passage of other blocks.

If the number of the third level yard is [10,8,8] the stacking coefficient is 0,1,2. Sort the blocks according to the number of days remaining in the shipbuilding cycle. If the remaining shipbuilding cycle days of a block in the secondary yard is 12 days, the stacking coefficient of the stacking yard is 0.By comparing the days of shipbuilding cycle and stacking coefficient, if it is found that the location of the block is not appropriate, the resistance value of the block is set to a ($a<1$), and $a<1$ means that if an extra job is generated to move a segment, the inappropriate segment is moved first. If the remaining shipbuilding cycle days of a block is 15 days and the stacking coefficient of the yard is 1, then the placement of the block is appropriate and the resistance value of the yard is set to 1.

4. Calculate the best path. In order to reduce the extra operation times of block material moving in and out of the yard as much as possible, the optimal path of each three-level yard should be calculated. The key point is to form a network for each secondary yard. That is,each three-level yard is taken as the vertex to connect two adjacent yards, and the weight is expressed by the resistance value of the yard. Dijkstra method is used to calculate the optimal path, which is represented by three-level yard identification.

5. Put the block into the designated yard. Putting blocks into a designated yard involves two steps. Firstly, the target t3rd level should be selected and the optimal path should be determined. In the process of selecting the target yard, it is necessary to pay attention to the constraint conditions,which include mandatory constraints such as process operation requirements and soft constraints such as yard priority and stacking coefficient. Second, calculate the order list. The sequence should be: prepare the secondary storage yard to be moved in, determine the secondary storage yard to be moved out, and then move it. It should be noted that the shortest path of each tertiary yard should be recalculated after each move operation.

The total algorithm flow is shown in Figure 2.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202104_7(4).0025

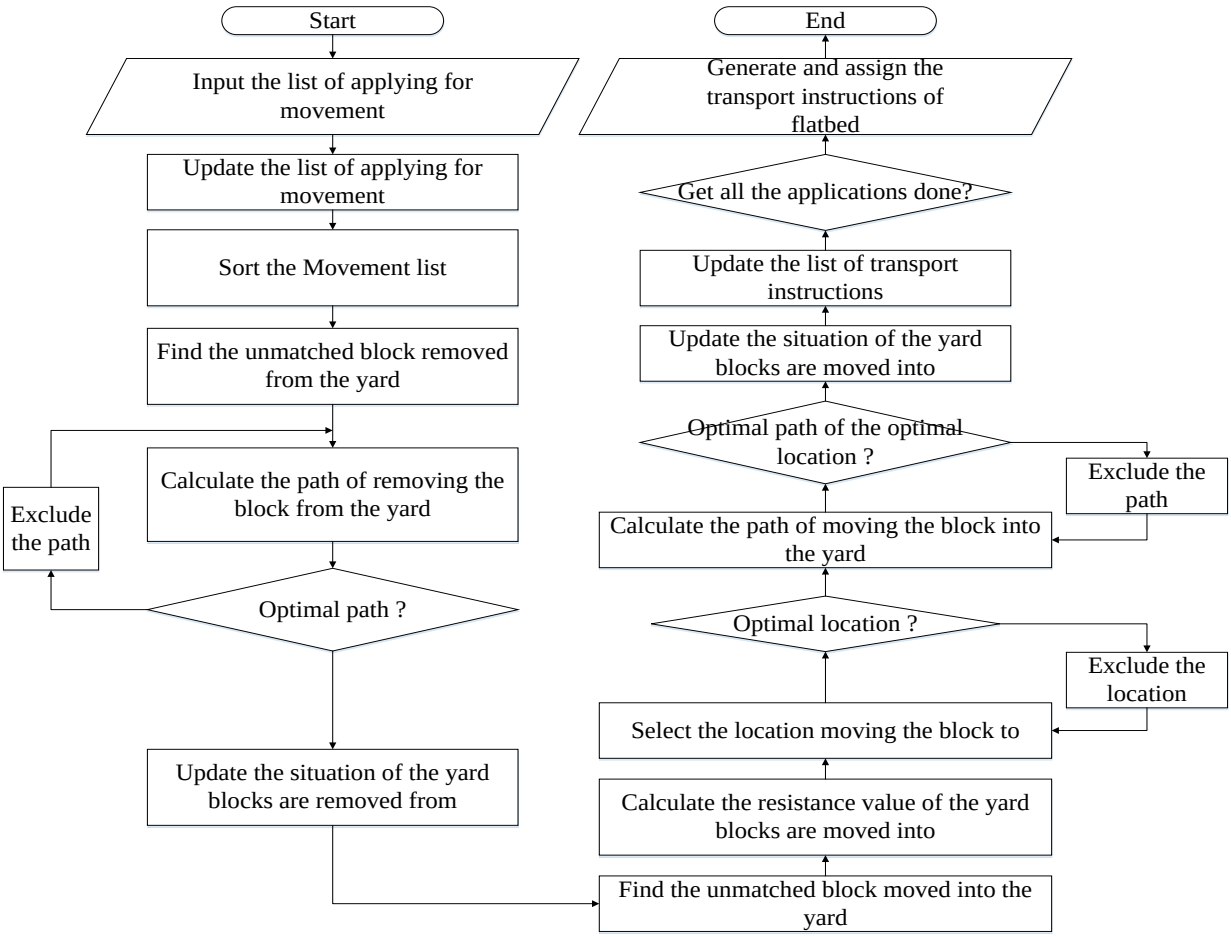

Figure 2. The flowchart of schedule

4. Realization

Through the application of the data of a shipbuilding enterprise, in order to verify the effectiveness of the algorithm, the data are simulated in different yards. The order operation number is 20.

Table 1. Actual case result.

Serial number	Stacking rate	Number of additional operations	Rate of additional operations
1	52.2%	6	23%
2	56.3%	5	20%
3	63.8%	8	28.6%
4	67.5%	10	33.3%
5	70.5%	10	33.3%
6	76.9%	12	37.5%
7	82.5%	13	39.4%
8	86.9%	15	42.9%
9	90.2%	28	58.3%
10	96.3%	42	67.7%

According to the common sense, when the utilization rate of the storage yard less than 80%, the rate of the additional operation achieves about 50%, and when the utilization rate of the storage yard more than 90%, the rate of the additional operation achieves more than 80%.

Therefore, as shown in Table 1, the scheduling regulation proposed in the paper can effectively reduce the number of additional operations, thus saving the fuel cost and improve work efficiency.

ISSN: 2414-1895 DOI: 10.6919/ICJE.202104_7(4).0025

5. Conclusion

The scheduling regulation proposed in the paper can effectively improve the yard dilemma of shipyards Combining the processing flow and processing cycle of the block. It integrates the distribution of packing coefficient, considering the unreasonable block, thereby reducing the number of processing in the planned task, improving the logistics efficiency of the shipyard, and, in addition, the conductive management code area. In practice, more than one block can be placed in a 3rd yard, and more complex problems can be studied in the future.

Acknowledgments

This paper is supported by National Natural Science Foundation of China (71801150) and Shanghai Scientific Research Foundation (19511105002).

References

[1] Kwon B, Lee G M. Spatial scheduling for large assembly blocks in shipbuilding. Computers & Industrial Engineering, 2015, 89(C):203-212.

[2] Caprace JD, Petcu C, Velarde M G. Optimization of shipyard space allocation and scheduling using a heuristic algorithm. Journal of Marine Science and Technology, 2013, 18(3):404-417.

[3] Shang ZY, Gu JA, Ding W, Duodu EA. Spatial Scheduling Optimization Algorithm for Block Assembly in Shipbuilding. Mathematical Problems in Engineering, 2017

[4] Zhang ZY, Xu JX, J F. Shipbuilding Yard Scheduling Approach Based on Genetic Algorithm. Journal of Shanghai Jiao tong University, 2013, 47(07):1036-1042.

[5] Zhang ZY, JI F, Zeng JZ. Block stockyard scheduling approach based on an improved genetic algorithm. Journal of Harbin Engineering University, 2015, 36(08):1103-1108.

[6] Chen K, Jiang ZH, Liu JF, Huang YW. Ship building Yard Scheduling with Block Inbound Time Window. Journal of Shanghai Jiao tong University, 2016, 50(09):1390-1398.

[7] Tao NR, Jiang ZH, Liu JF, Sun XJ, Zhu YL, Li JT. Multi-stockyard scheduling problem considering technological process of hull blocks. Hebei Journal of Industrial Science and Technology, 2017, 34(01):12-17.

[8] Jeong YK, Ju SH, Shen H, Lee DK, Shin JG, Ryu C. An analysis of shipyard spatial arrangement planning problems and a spatial arrangement algorithm considering free space and unplaced block. The International Journal of Advanced Manufacturing Technology, 2018, 95(9-12): 4307-4325.

[9] Zhuo L, Huat DCK, Wee KH. Scheduling dynamic block assembly in shipbuilding through hybrid simulation and spatialoptimisation. International Journal of Production Research, 2012, 50(20): 5986-6004.

[10] Zheng JL,Jiang ZB,Chen Q. Block spatial scheduling modelling and application in shipbuilding. International Journal of Production Research, 2012, 50(10): 2744-2756.

[11] Zhang ZY, Zeng JZ. Obstructive block stockyard scheduling and optimization based on heuristic rules. Journal of Harbin Engineering University, 2016, 37(10):1416-1423.

[12] Zeng JZ, Zhang ZY. Block stockyard scheduling and optimizing based on an intelligent algorithm. Journal of Harbin Engineering University, 2016, 37(01):41-47.

[13] Joo C M, Kim B S. Block transportation scheduling under delivery restriction in shipyard using meta-heuristic algorithms. Expert Systems with Applications, 2014, 41(6):2851-2858.

[14] Park C, Seo J. A GRASP approach to transporter scheduling and routing at a shipyard. Computers & Industrial Engineering, 2012, 63(2):390-399.

[15] Dixit V, Verma P, Raj P&Sharma M.Resource and time criticality based block spatial scheduling in a shipyard under uncertainty. International Journal of Production Research, 2018, 56(22): 6993-7007.