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AN INTEGRATED SYSTEM OF SCHEDULING AND DIGITAL TWIN FOR ORE TRANSPORTATION INSIDE-OUTSIDE STEELWORKS

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ABSTRACT

JFE Steel Corporation has developed an ore logistics optimizer to reduce transportation costs. Because the Japanese steel industry imports large quantities of raw materials, the huge cost of ship freight and demurrage fees has become a problem. This work presents the ore carrier scheduler which was developed using metaheuristics methods to minimize logistics costs. A strategy of consolidating various iron ore brands at a junction spot that super-large carriers can enter is suggested. A digital twin that represents the stockyard in the steelworks is developed using a discrete simulator to verify the feasibility of operations, confirming the possibility of reducing costs by more than 10 % by utilizing this system.

1 INTRODUCTION

A steelworks carries out raw material planning such as ore carrier scheduling to assign carriers to ensure a stable supply of raw material brands from mines to each steelworks and blending scheduling to achieve the desired composition of the various iron ore brands. Some systems for optimizing planning were discussed in the past (Ito et al. 2019). As a new strategy, this work examines the cost reduction effect by consolidation of raw material brands at a junction spot using super-large carriers.

2 ORE CARRIER SCHEDULER

It is difficult to draw up ore carrier schedules with transportation-related restrictions because a comprehensive judgment of the total schedule is necessary. If computerized planning using an exhaustive calculation approach is considered, the number of candidate plans will increase exponentially with the number of variables, and the time required will be excessive, even with a supercomputer. As a result, experienced staff must still create schedules manually.

To address this problem, we developed a scheduler engine that efficiently supports schedule preparation tasks utilizing optimization technology. As the base of the algorithm, we applied a method for planning truck deliveries (Ibaraki et al. 2005), which first enumerates the delivery route patterns and then selects the optimal patterns that satisfy the constraints. In the ore carrier schedule, the voyage routes include loading and unloading ports, carrier size, arrival time, and the contents of unloading, as shown in Figure 1 a). A large number of voyage routes are listed in advance, and a 6-month schedule is created by combining the routes. The engine takes into account constraints such as berth size and upper inventory limits, while requirements include transportation costs and trends of inventory. These items are formulated, and metaheuristics methods are applied to develop the optimal schedule.

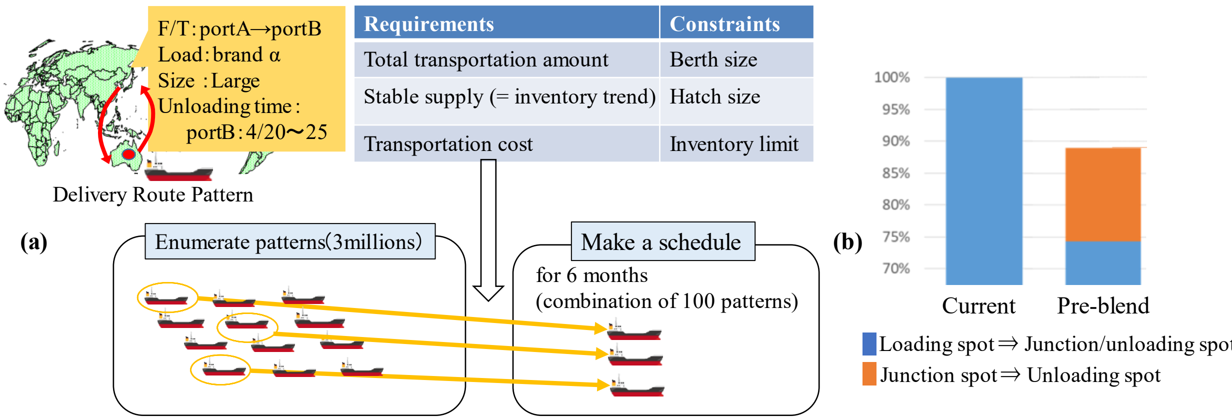

Figure 1: a) Model of algorithm applied to scheduler ; b) effect of strategy on transportation cost.

3 DIGITAL TWIN OF ORE LOGISTICS INSIDE STEELWORKS

To further reduce logistics costs and expand the use of super-large carriers, which are more economical per transport lot, we considered a strategy of consolidating iron ore inventory at a junction spot that super-large carriers can enter. This strategy not only enables reduction of transportation costs, but also consolidation of iron ore inventory by advance blending (pre-blending) of ore brands for easy use at each steelworks, which is expected to improve stockyard operations at the steelworks. Based on a comparison of two schedules output by the scheduler described in Chapter 2, Figure 1 b) shows that this strategy can reduce transportation costs by more than 10 % .

However, if this strategy is implemented, storage and loading of iron ore will be required at the junction spot in addition to conventional operations, and the possibility of these operations must be confirmed in advance. Therefore, we developed a digital twin for ore logistics at the junction spot that can implement the strategy by using a discrete simulator. The ore carrier schedule from the scheduler is utilized as input data for this digital twin. The execution results are shown in Figure 2, and show that the inventory trend is within the operational range, indicating that the ore consolidation strategy is feasible.

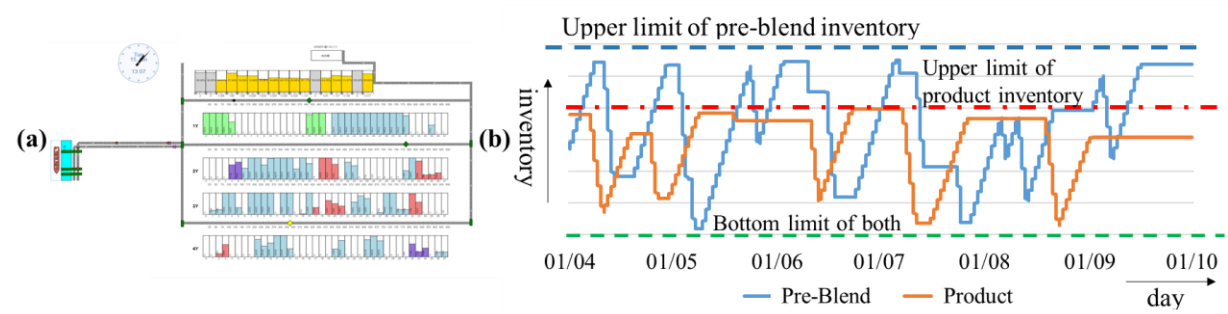

Figure 2: a) Screen of executed simulation as function of digital twin model; b) results of inventory trend using the strategy in this work.

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