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New Scheduling Algorithm for Shipping Operation in Steel Works

TOMIYAMA Shinji

Abstract:

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[illegible]

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2. Shipping Operation in Steel Works

Various types of shipping operations exist, corresponding to the characteristics of products and the locations of factories[6,7]. Therefore, this section introduces the common shipping operation in a steel works.

In a steel works, products are moved by specific machines for handling heavy cargos, namely, warehouse cranes, forklifts, quay cranes and vehicles. **Figure 1** shows one example of the shipping operation. After all the necessary manufacturing processes in the works are completed, products are transported to a warehouse near the shipping berth by using special vehicles and

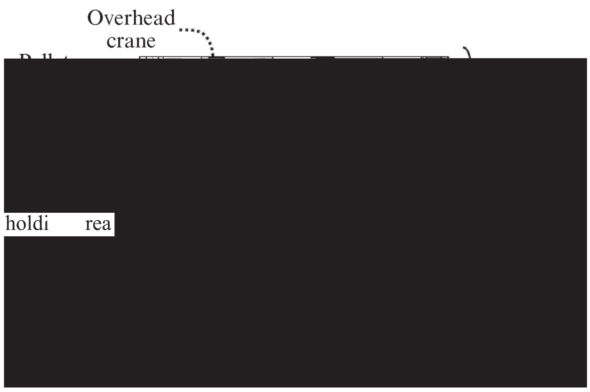

Fig. 1 Outline of shipping operation in steel works

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Senior Researcher Deputy General Manager,
Cyber-Physical System Research & Development Dept.,
Steel Res. Lab., JFE Steel

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pallets, on which plural products can be loaded and received by a warehouse crane. A warehouse holds the received products for some days until instructions for product shipping are issued. When the product shipping time approaches, a warehouse crane moves the products to be shipped from the stockyard to a temporary product holding area. The products in the temporary holding area are carried to berths by forklifts, or if the berth is located far from the warehouse, the products are delivered by a vehicle. A quay crane picks up the products which have arrived at the berth and loads them into a ship.

One product is moved from the factory to the ship by using the above-mentioned machines, as required. Although machines of the same type can deal with different products in parallel, these characteristics of the shipping operation are likely to cause an overload in machine operation. For example, if one warehouse building contains many shipped products which are planned to be loaded by plural quay cranes during the same period, the required workload of the warehouse cranes is likely to exceed their capacity temporarily. Finally, this overload situation leads to a long waiting time for the quay cranes. This research aims to decrease overload, and evaluates the total efficiency of shipping based on the waiting time.

This paper focuses on a schedule for a warehouse building with plural cranes, which results in a quite complicated scheduling problem. Good schedules for the problem must distribute the workload to the cranes in the warehouse building and level the workload of the other machines simultaneously under various constraints.

3. Scheduling Model

In this research, a simplified model of the shipping operation was created because a precise model would

- Receiving product α by warehouse crane [J1]
- Moving product α to temporary holding area by crane [J1]
- Delivering product α to berth by forklift [J4]
- Loading product α into ship by quay crane [J2]

These four items should be processed in order from top to bottom, and conflicting time is not allowed. Therefore, these jobs are assigned to the schedule satisfying the finish-start constraints. Because the warehouses, temporary holding areas, and berths have respective capacity restrictions, early entry of products into an area is sometimes prohibited. **Figure 3** illustrates the lower three of the four items and the relationship to the product positions. The shipped product is

of warehouse cranes because the interference of warehouse cranes produces the complex constraints of the problem. Furthermore, the delay of one crane is likely

Acknowledgement

This paper was created by reproducing and summarizing an international conference paper[8]. The copy-

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