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Optimal Heuristics Algorithm of Single Job-order for Mobile Racks

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Abstract **–**Recently, an automation in logistics industries has focusing the high efficiency operation of warehouse system for small quantity batch order. Especially, the effectiveness of the storage space in warehouse was improved by change the fixed rack into mobile rack. In this paper, we propose a simple algorithm of single job-order scheduling algorithm for effectiveness operation of mobile racks. Due to the difference between loading and shipping schedules in warehouse, generally a single job-order schedule should be performed. To operate a mobile rack efficiently, a movements of mobile rack and a moving distance for loading/discharging a cargo should be minimized. By considering the performance index, we proposed a simple rule to decide the job-ordering schedule and it will be verified by simulation results.

Keywords**:** Optimal, Heuristics, Single works, Mobile rack

1. Introduction

An automation for warehouse system is an important elements in logistics area for increasing the storage capacity and operation efficiency. Especially an AS/RS is required high technology for loading, unloading and order-picking to reduce the travel time and save an operation energy.

To increase the efficiency of the AS/RS, first travel-time model was shown by Husman et al. (1976) and Bozer and White (1984) presented an analytical models for single and dual command cycle for non-square-in-time racks. Recently, modelling the travel time and simulation skill for mobile racks with AS/RS(M-AS/RS) are proposed by Hakim Guezzen et al. (2013). In the above reference, they show a new concepts Mobile Rack type AS/RS which are a variation of the multi aisles AS/RS and presents discrete model of travel time for M-AS/RS.

On the other hands, the job order scheduling is firstly induced to minimize the length of a job on the shop floor in manufacturing. Also it would be important for just-in-time (JIT) production systems to accommodate the condition with minimize the inventory.

Also in manufacturing system, the job shop scheduling will be effected by dynamic environment with unexpected new orders. For these problems, recently Surjandari et al. (2015) are proposed a scheduling algorithm for multi-item multi-level products with the objective of minimizing total actual flow time. However, these job shop scheduling is only focused on minimize the inventory and/or flow time. To apply these algorithm for mobile rack in warehouse, it still required to be modified.

In this paper, we are focused on the minimizing the movements of mobile rack and moving distance of transport equipment (ex, forklifts) for loading and discharging the pallet cargos from the gate of storage area to the allocated stock positions in mobile racks.

First of all, we will define the warehouse system for mobile rack and the symbols for explain the notations. Second, a mathematics model for calculating a move distance of transport equipment and movement of mobile racks will present. Also the move group for mobile rack will be shown. Last, a simple job order scheduling algorithm is proposed and it will be verified by simulation results.

2. Definitions of Mobile Rack in Warehouse

Normally, when a cargo is loaded into receive area from trucks docks, it should be put a way into the mobile rack area. For the operation of mobile rack in warehouse, a single job-order flow will be shown in Fig. 1. To efficiency operation of mobile rack, the following rules would be considered as:

1. To minimize the moving distance of picking trucks for loading and discharging
2. To minimize the movement of mobile rack
3. To consider the works priorities

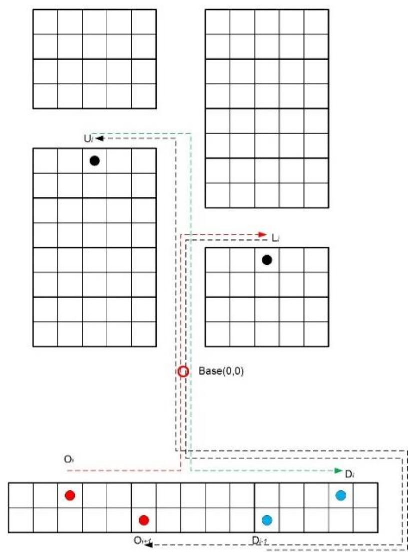

Fig. 1 Single job order flows

The gate of mobile rack area will be given as a base coordinates (0, 0). By base on the base coordinates, the notation will be given as:

$O_i(O_{x_i}, O_{y_i})$: loading place for i number of cargo

$D_i(D_{x_i}, D_{y_i})$: shipping place for i number of cargo

$L_i(L_{x_i}, L_{y_i})$: loading position for i number of cargo in mobile rack area

$U_i(U_{x_i}, U_{y_i})$: discharging position for i number of cargo in mobile rack area

The receive area for loading and shipping from/to trucks will be assigned previously by considering the trucks schedules. But, all of cargos for mobile rack should be passed the base coordinates. Thus, we just consider the distance between the loading/discharging position and base position to determine a job-order scheduling.

We define L_i is a distance for loading i number of cargo from the base position and it will be calculated by perpendicular distance of x and y coordinates from base (0,0) as

$$C_i = 2 \times (|L_{x_i}| + |L_{y_i}|) \quad (1)$$

Also, the discharging distance U_i for i number of cargo will be given as

$$C_i = 2 \times (|U_{x_i}| + |U_{y_i}|) \quad (2)$$

For loading/discharging the cargo into the mobile rack, it will be divided into two cases: for same rows in mobile rack and for opposite rack. Let us define L is a unit distance for mobile rack module and W is the width of mobile rack. The left side and right side of blocks will be defined as M_1 and M_2 respectively. And M_{ij} will be denote the mobile rack which located in i block and j rows. After finish the works at position P_i, the mobile rack should be moved for next works at position P_{i+1}. At this time, we can define the mobile racks M_{ij} for moving P_i position into P_{i+1} position as

$$M = \{ M_{kj}, k \in 2, j \in n\} \tag{3}$$

Where, n is maximum row for block and

$$k = \begin{cases} 1, & M_2 \rightarrow M_1, M_1 \rightarrow M_1 \\ 2, & M_1 \rightarrow M_2, M_2 \rightarrow M_2 \end{cases} \tag{4}$$

In case of $l(P_{i+1}) > l(P_i)$, j will be given as

$$j = \begin{cases} l(P_i)+1, \cdots, l(P_{i+1}), if\ S(P_i) = A\ and\ \ S(P_{i+1}) = A \\ l(P_i)+1, \cdots, l(P_{i+1})-1, if\ S(P_i) = A\ and\ \ S(P_{i+1}) = B \\ l(P_i), \cdots, l(P_{i+1}), if\ S(P_i) = B\ and\ \ S(P_{i+1}) = A \\ l(P_i), \cdots, l(P_{i+1})-1, if\ S(P_i) = B\ and\ \ S(P_{i+1}) = B \end{cases}$$

And in case of $l(P_{i+1}) < l(P_i)$, j also given as

$$j = \begin{cases} l(P_i), \cdots, l(P_{i+1})+1, if\ S(P_i) = A\ and\ \ S(P_{i+1}) = A \\ l(P_i), \cdots, l(P_{i+1}), if\ S(P_i) = A\ and\ \ S(P_{i+1}) = B \\ l(P_i)-1, \cdots, l(P_{i+1})+1, if\ S(P_i) = B\ and\ \ S(P_{i+1}) = A \\ l(P_i)-1, \cdots, l(P_{i+1}), if\ S(P_i) = B\ and\ \ S(P_{i+1}) = B \end{cases}$$

Here, $l(P_i)$ denotes the row number of mobile rack on P_i position and $S(P_i)$ shows the side of mobile rack on P_i position

From the above equations, the moving mobile rack group for i job-order works will defines M_{kj} and the number of mobile rack which moving for i job-order works is defined $N(M_{kj})$.

Thus, the total movement distance of mobile rack for i job-order works R_i will be calculated as $R_i = W_A \times N(M_{kj})$, where W_A is denote the aisle width between mobile rack.

3. Optimal Heuristics Job Ordering Algorithm

In this section, a job ordering algorithms will be suggested by considering the job-order priority, movement costs for mobile rack and picking trucks.

Let us define that the priority for i job-order E_i ($0 < E_i < 1.0$) and the high priority is set near 0. Then the performance index for optimal job-order scheduling will be given by job-order priority, movement of mobile rack and distance of transport equipment as

$$\min f\left(\sum_{i=1}^{2} E_i \times (\alpha \times C_i\ + \beta \times R_i\ )\right) \tag{5}$$

Where, α and β are weight coefficients (or denote the cost for unit distance)

If there are cost relation 10:1 between mobile rack and transport equipment, the coefficient will be given $\alpha = 0.1 \times\ \beta$ and the above equation will be modified as

$$\min f\left(\sum_{i=1}^{2} E_i \times (0.1 \times C_i + W_A \times N(M_{kj}))\right) \quad (6)$$

For the optimal job-order scheduling, a simple heuristics algorithm is suggested as
Step 1: Sort the job order by mobile rack rows for loading/discharging job-order
Step 2: Sort the job order by same mobile rack block.
Step 3: Move down to next mobile rack and go to Step 1, if Step 2 is finished. Else exit.

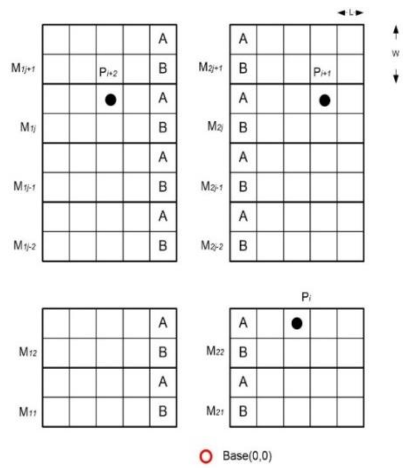

Fig. 2 Definition of warehouse

4. Simulation and Results

In simulation, we assume two fixed rack for each blocks and 8 mobile rack with 20 bays in Fig. 3 (cm unit), and generate 10 job-order lists by using random function.

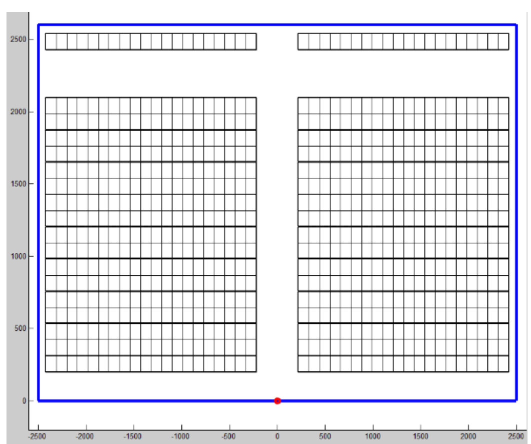

Fig. 3 Warehouse layout

In the simulation results, the top figure shows an average movement distance of transport equipment for loading/discharging, middle figure explains an average movement number of mobile rack and bottom shows the performance index; blue is total value, red is for mobile rack and green is for transport equipment.

In the results, the average distance for transport equipment is same due to single job-order. But, the average movement of mobile rack will be decreased dramatically and it will be effected into the total performance index.

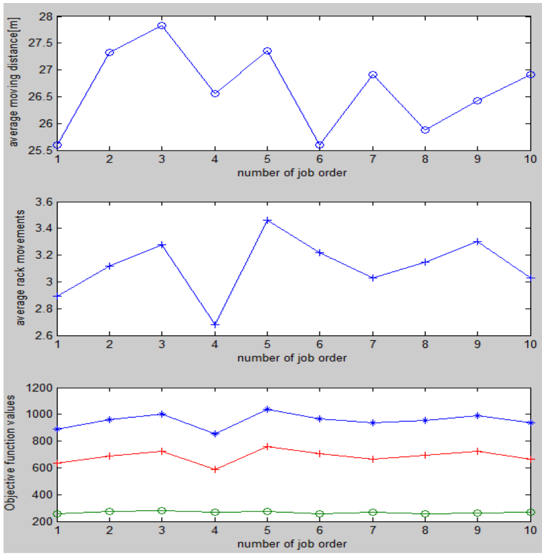

Fig. 4 Conventional job ordering results

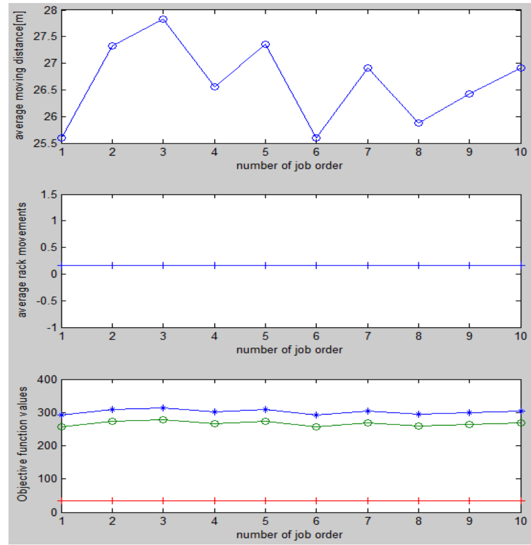

Fig. 5 Optimal job ordering results

5. Conclusions

In this paper, we dealt with an optimal job order scheduling algorithm for mobile rack in warehouse. The algorithm was proposed based on a simple job-order procedure and it was verified by 10 times simulation. By compare with conventional simulation results, the suggested algorithm will reduce about 68% of performance index. Thus, the algorithm is expected to use to operate the mobile rack in warehouse in future.

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