Model of the equipment selection of material handling system for large ship

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***Abstract*—The handling equipment optimization problem of material handling system for large ships is discussed in this paper. The optimization models for two supply ways which includes shore-to-ship and vessel-to-vessel are proposed respectively, which are converted to linear programming problems in order to analyze large ship material supply handling system of equipment optimization.**

Keywords-large ship;material handling system;equipment selection optimization

I. INTRODUCTION

Material handling system (MHS) design has a direct influence on the logistics cost. Therefore, how to improve the efficiency of material handling system gets more and more people’s attention. With the rapid development of China's national economy, material handling system is no longer limited to the well known as material handling in factory. The material supplying for large ship before open sea voyage also need an efficient material handling system, so that can be finished inside the shortest time and improve the large ship material handling flexibility. So, the large ship material handling system design is the important context of the design of large ship. The equipment selection problem is the key, because excellent performance and suitable equipment can make the material handling easier.

The research at present about large ship material handling system equipment selection problems at home and abroad mainly focuses on the path algorithm or equipment scheduling problem in court (or reservoir), production line of material handling system. This paper will study the large ship material handling system equipment selection optimization problem based on large ship material handling system characteristic. Firstly, analyze the existing large ship material handling system and sum up the features in section 2. In section 3, according to the large ship material handling system network structure and the actual background, establish the material handling system equipment selection optimization model based on the shore-to-ship supply and vessel-to-ship supply way for different optimization goals. At the end, the full text content to conduct a comprehensive summary.

II. THE ANALYSIS OF LARGE SHIP MATERIAL HANDLING SYSTEM CHARACTERISTIC

The material supply of large ships is mainly divided into shore-to-ship supply and vessel-to-ship supply two ways. The former way, target ship docked at the wharf, shore goods will be handled to ship by all sorts of handling equipment, and then direct transport into the ship warehouse, or unload the goods in temporary area before into ship warehouse by the ship handling equipment to supply the material; By shore-to-ship supply way, the tender ship transport handling equipment with goods directly to the target ship on the sea to finish the material supply for target ship This kind of means need to implement butt between vessels and easily affected by weather conditions and other effect, so it has higher request for the equipment and handling speed. Thus it can be seen, large ships in material supply, the material handling system includes ship's own material handling system (goods temporary area on deck and cabin internal large warehouse), and material handling system of terminal or tender ship. The main features of this kind of material handling system which is different from the material handling system of factory or court are:

- Too many total types material involved in handling, the type and quantity are not sure in each time handling, packaging unitized and handling equipment selection are difficult;
- Handling space on ships usually relatively narrow, handling path design is complex, path optimization problem has the high requirements of the algorithm;
- Material is to be handled to different storage room dispersing the target ship, material handling scheduling command is very important;
- In addition to the handling equipment on the shore, the rest of the material handling equipment can follow ships moving. Equipment selection should consider both the equipment capacity and the energy consumption caused by equipment own weight;
- Material handling system's ability must to meet supply time requirement firstly, the second is considered low construction and operation costs.

III. THE MATERIAL HANDLING SYSTEM EQUIPMENT SELECTION OPTIMIZATION MODEL

The typical large ship material supply handling network structure is shown in figure 1. A stands for supply ship or terminal, B stands for target ship (to be tender) and C stands for target ship's each warehouse. Every warehouse has fixed distribution and storage one certain material. So once material type is determined, the warehouse is established and handling path is mainly determined. Each line in figure 1 stands for a material handling channel.

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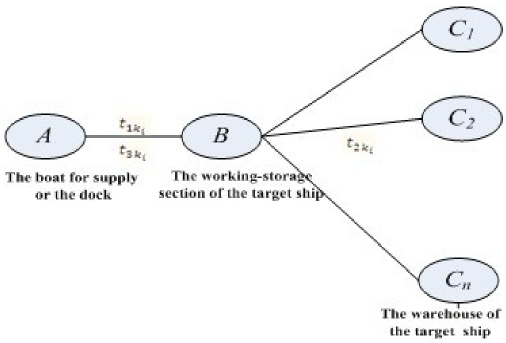

Fig1. The typical large ship material handling system network structure

A. The shore-to-ship supply way

In this way, the handling equipments on the shore are not going with ship, and the material supply time is usually relatively abundant. The handling equipments used on the shore and on ship board are slightly different. The equipment on shore will transport goods to the deck cargo temporary area. Then, there are two ways can be chosen for next step. One needs equipment to get off with no goods by unloading, the other is staying to handle material on the target ship after directly carrying the goods to the warehouse chamber in ship. This paper, aiming at the highest handling speed and lowest comprehensive cost, to consider the shore supply goods whether to need to change equipment after carrying to the ship,, establishes the optimization model.

i =(1,2,3….. ,E):The equipment set used from A to B process in the shore-to-ship supply way;

$i^{\sim}$ =(1,2,3….. ,E):The equipment set used on the target ship for handling material;

Parameters：

H_i ：The cost produced by equipment i to complete one time handling (the whole life cycle cost calculation);

$H_{i^{\sim}}$ ：The cost produced by equipment $i^{\sim}$ to complete one time handling (the whole life cycle cost calculation);

T_i ：The time needed by equipment i to complete one time handling;

$T_{i^{\sim}}$ ：The time needed by equipment $i^{\sim}$ to complete one time handling;

$C_{ii^{\sim}}$ ：The cost of changing material handling equipment form i to $i^{\sim}$ (comprehensive consideration of the time, human loss, etc.)

N_i ：The handling demand of equipment i (in handling times said);

$N_{i^{\sim}}$ ：The handling demand of equipment $i^{\sim}$ (in handling times said);

$L_i \in$ {0,1,2,3,4,5} ：5 means that i is the most suitable equipment for handling materials, 0 means equipment i can't be used to handling material;

$L_{i^{\sim}} \in$ {0,1, 2,3,4,5} ：5 means that $i^{\sim}$ is the most suitable equipment for handling materials, 0 means equipment $i^{\sim}$ can't be used to handling material;

Decision variable：

$Y_{ii^{\sim}}$ ：Equals 1 if change material handling equipment from i on the shore to $i^{\sim}$ on the ship, otherwise 0

Objective function：

$F1 = \sum_{i \in E} \sum_{i^{\sim} \in E} Y_{ii^{\sim}} (H_i T_i N_i + C_{ii^{\sim}} + H_{i^{\sim}} T_{i^{\sim}} N_{i^{\sim}})$ (1)

$F2 = \sum_{i \in E} \sum_{i^{\sim} \in E} Y_{ii^{\sim}} (L_i + L_{i^{\sim}})$ (2)

F1 said the system total cost, the pursuit of minimization, F2 said total fitness, the pursuit of maximization, in the model calculation, the pursuit of two objective function of balance.

Constraint conditions：

$\sum_{i \in E} Y_{ii^{\sim}} \geq 1$ …………..At least choose one kind of equipment for handling

$\sum_{i^{\sim} \in E} Y_{ii^{\sim}} \geq 1$ ………..Each handling equipment is exercised at least once handling

B. The vessel-to-ship supply way

Large ship material supply handling system often uses large supply devices such as a helicopter, high cableway and so on in ship-to-ship supply. Since the target ship can't handle material timely, usually can make goods accumulate. The optimization of ship handling system and speeding up the material handling is very necessary. Handling channel is determined by material type, and the space is relatively narrow. Assumed that the round handling vehicle (full load and no load) is the same number, determining the number of equipment, reducing waste of space and maximum handling flow are the optimization target.

i =(1,2,3….. ,I):The set of supply material types;

j =(1,2,3…..,E):The available equipment set of handling on ship;

Parameters：

$\mathbf{W}_j$ ：The weight of equipment e;

E_{ij} ：The load carrying capacity of equipment e for material i ;

D_i ：The total demand of material i ;

N_i ：The maximum vehicle number in channel i (determined by channel layout, channel width, etc);

M：The maximum weight the target ship can load, here is about 200 tons, or 200000 kg;

I_i ：The capacity of unloading area outside warehouse i ;

O_i ：The capacity of temporary area in warehouse i ;

Decision variable：

$\mathbf{x}_{ij}$ ：The number of equipment e in channel i at one point, assumed flyback vehicle number is the same;

Objective function：

$$maxZ = \sum_{i\in I}\sum_{j\in E} x_{ij} E_{ij} \quad (3)$$

Constraint conditions：

$$0 \le \sum_{j\in E} x_{ij} \le N_i$$

…... Vehicle number does not exceed limit

$$0 \le \frac{D_i}{\sum_{j\in E} x_{ij} E_{ij}} \left(\sum_{j\in E} x_{ij} E_{ij} - O_i\right) \le I_i$$

…... Warehouse i input and output balance

$$0 \le \sum_{i\in I}\sum_{j\in E} x_{ij} E_{ij} + 2\sum_{i\in I}\sum_{j\in E} x_{ij} W_j \le M$$

…... The total load can't more than ship limit

IV. CONCLUSION

Large ship material handling system design as the research background, this paper analyzes large ship material handling system design problems, especially optimization problem and establish equipment selection optimization mathematical model in view of the two supply ways (shore-to-ship supply and ship-to-ship supply). The model is a multi-objective and multi-constraint optimization problem.

The future is worth research direction includes:

(1)Try various ways to solve the model, such as using Lingo tools to solve typical linear programming problem. With the actual numerical example to verify the practicality of the model, the model can be used in the practice of large ship supply equipment selection optimization problem.

(2) Combined with the actual case and comprehensive consideration of various factors, further improvement and optimization of the model and the in-depth application research can be conduct , in order to adapt to a variety of large ship supply system;

(3) To explore all kinds of algorithms which are more efficient and more accurate, instead of using tools computation, intelligent algorithm (such as genetic algorithm, annealing algorithm, particle swarm optimization (pso) algorithm, etc.) can get more optimal solution in a broader solution space to.

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