Optimization Scheduling Model of Double Line Shiplock Based on Nonlinear Goal Programming

Q. H. Pang*[1] and X. Y. Wu[1]

[1] School of Business Administration
HoHia University
Changzhou, China
*pangqh77@126.com

ABSTRACT
The scheduling method of shiplock has a strong influence on the improvement of shiplock capacity. On the condition that the number of the ships waiting for the lock was relatively stable, the paper constructed an optimization model for joint scheduling of double line shiplock based on the nonlinear goal programming. The hard constraints included that the number of ships arranged in the shiplocks couldn't exceed the number of the ships waiting for the lock. The soft constraints included arranging the ships with the priority and time limit as far as possible, and maximizing the utility of the lock chambers. Then the objective function was constructed. Considering the characteristics of the nonlinear goal programming mode, the Hooke – Jeeves algorithm was used to solve the model. In the end, a double line shiplock of Jiangsu province was taken to verify the scientificity and feasibility of the model.

Keywords: Double line shiplock, optimization of joint scheduling, nonlinear goal programming model, Hook- Jeeves algorithm.

1. Introduction

Shiplocks are the major influence factors which will restrict the navigation capacity of waterway [1]. With the rapid development of social economy, as infrastructure of logistics network, the inland waterway is valued more by people. But the shiplocks still affect the efficiency of inland waterway transport. The optimization of shiplocks' scheduling is very important to improve the throughput of shiplocks and the utilization of lock chamber. According to the number of ships sailing parallel on the channel the shiplocks can be divided into singel line, double line, three line etc. As the number of double line and three line locks increases gradually, the study of how to realize joint scheduling of double line locks and giving full play to the advantages of the combination is of great significance.

There're many researches on the shiplock scheduling made by domestic and overseas scholars. Kim et al. [2] proposed the general Packing aggregating model for the arrangement of ships and analyzed the two main advantages of this method. Wang et al. [3] investigated a ship lock scheduling problem and proposed a data-driven approach, which is a typical optimizing and decision-making problem. Siswanto et al. [4] presented a ship inventory routing and scheduling problem with undedicated compartments, and their objective of the problem is to find a minimum cost solution while satisfying a number of technical and physical constraints within a given planning horizon. Andersson et al. [5] introduced and solved a planning problem faced by shipping companies operating in a special segment of tramp shipping called project shipping. Guo [6] set up a dynamic model on the traffic capacity of the three gorges ship lock based on the structural and dynamic method to obtain the potential capacity, which describes the dynamic relationship between the cargo-boat tonnage, operating time, ship number, efficiency of using area with traffic capacity. Xu et al. [7] analyzed the concepts and features of symmetric shiplock, designed a dispatching model of secondary symmetric ship lock with high feasibility and applicability, constructed an open symmetric shiplock's dispatching model contains information model, queue model, ship combination in lock chamber model and joint scheduling model. Li et al. [8] established a mathematical scheduling model considering the two goals of the utilization rate of lock chamber and the first come first serve

and made the Xiangjiang as an experiment. Shang et al. [9] analyzed influential factors of multiple-lane lock's joint scheduling for Changzhou hydro-junction project and then built a computer simulation model based on the lockage operating procedures, which included anchorage, channel & approach channel, parallel four-lane ship lock, ship's joint scheduling, etc. Zhao [10] proposed a new model of lock service satisfaction degree which is constructed by the method of structural equation modeling based on the analysis of the lock service theory and the satisfaction theory. Wang [11] made a simulation research on the scheduling of shiplock from the perspective of quality of service. Liu [12] studied on how to reduce two-dimensional packing problem to one-dimension, the mathematical model is constructed and then algorithm for the problem based on greedy algorithm. With the technology development, the scheduling simulation is also studied [13-15].

The above-mentioned studies mainly carried out for single ship lock, rarely researched on specific model of double line lock operation. In fact, with the increasing demand for shipping, double line and three line shiplock have become a very common phenomenon. Double line shiplock scheduling problem is not a simple combination of single lock scheduling. It includes not only the design of single lock queue rules, the reasonable arrangements of lock chamber, but also how to realize the two lock joint scheduling to take advantage of the combination and realize the maximization of the lock throughput.

Basing on the situation that the number of ships waiting in line lock at a certain time is relatively stable, the paper aims at using the nonlinear goal programming model to study the double lock joint optimization scheduling model ,. It also uses a global scheduling strategy based on the analysis of the double line shiplock [16].

2. Description of the problem

2.1 Design for the ships in the waiting queues

The ships are divided into four types according to the width in order to facilitate to realize the optimization of scheduling. And the ships that arrive at the dispatching station queue according to the four types. The four types are: extremely large-sized (T, W>7m), large-sized (D, 6m<W≤7m), medium-sized (Z, 5m <W≤ 6m), small-sized (X, W ≤ 5m), where "W" represents the width of the ships.

2.2 Rules design for the queuing ships

In combination with the practical operation scheduling of shiplock, the paper consider mainly four modes.

Mode1: The first service for the first arrival way. The principle of "first service for the first arrival" is applied to the common ships in the waiting queues.

Mode2: The single service way. The principle of "single service" is applied to the ships (such as the ships with hazardous articles on it) which accord with the condition to pass the ship lock separately. It should be noted that the number of ships which can meet this way is small, and usually corresponding ship lock can be directly pre-arranged according to the size of the ship. Therefore, in the later discussion of the model, related symbols are in the situation that ships which meet this way have been arranged in addition to the number of locks.

Mode3: The priority service way. The principle of "priority service" is applied to the ships (such as the ships which transport national emergency supplies) which accord with the preferential condition to pass the ship lock.

Mode4: The time limit service way. Define the "waiting time limit" according to the different ships, and once the waiting time of some ships exceeds the limit, these ships should be arranged to pass the ship lock as soon as possible.

The ships that do not meet Mode 2 to Mode 4 should be orderly arranged to pass the corresponding ship lock according to mode one.

3. Methodology

3.1 Related conditions and variable hypothesis

(1) To make general significance, we assume that ships meet the requirements of draft. The paper sets that two shiplocks are available in