

A Ship Lockage Scheduling and Organization Method under Multi-Plan Collaboration

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Abstract: At present, inland river ship locks in China generally adopt a standard scheduling and organization process centered on remote ship declaration, automatic registration and queuing, joint safety inspection of waiting ships, ship lock arrangement, and lockage scheduling, which effectively ensures fair, impartial, standardized and orderly ship dam passage. With the annual growth of the throughput of inland river shipping hubs, the overall qualification rate of ship safety inspection has remained steadily high for a long time. To reduce the times of "schedule adjustment" operation of waiting ships and enhance navigation safety and stability, this paper introduces the concept of rolling planning combined with the actual lock scheduling scenarios, and develops a ship lockage scheduling and organization method under multi-plan collaboration. It can provide a reference for the scheduling and organization optimization of large inland river ship locks.

Keywords: Ship Lockage; Multi-Plan Collaboration; Rolling Plan; Ship Scheduling and Organization Mode

1. Introduction

In recent years, the freight transport demand along the Yangtze River trunk line and high-grade inland waterways in China has continued to expand, and the throughput of shipping hubs has climbed steadily year by year. The contradiction between the insufficient throughput capacity of ship locks and the demand for ship dam passage transport has become increasingly prominent. Large water conservancy hub ship locks feature extensive waiting water areas, a large number of stranded ships, long scheduling chains and complex navigation environments. [1]

Currently, inland river ship locks in China generally adopt the standardized scheduling and organization mode of "remote declaration –

automatic queuing – waiting and joint safety inspection – ship lock arrangement – lockage scheduling", which relies on standardized scheduling rules to guarantee fair and orderly ship lockage as well as stable and controllable navigation operation. [2] Under the new situation of strict safety production management and control, the overall qualification rate of ship safety inspection has gradually stabilized and remained at a high level. [3] To reduce the schedule adjustment frequency of waiting ships and continuously improve navigation safety and operational stability of ship locks, this paper explores and researches a multi-plan collaborative ship lockage scheduling and organization method based on actual ship scheduling scenarios. By introducing the concept of rolling planning, the existing ship scheduling and organization mode is optimized, and the connection among ship anchorage, ship safety inspection and lockage operation plans is strengthened, providing a reference for the scheduling and organization optimization of large inland river ship locks.

2. Analysis of the Existing Scheduling and Organization Mode

At present, the ship scheduling and organization mode of inland river ship locks in China mainly includes links such as remote ship declaration, automatic registration and queuing, waiting and joint safety inspection, ship lock arrangement, and lockage scheduling.

Remote Ship Declaration: Ships submit lockage applications through the remote declaration system, filling in information including ship name, dimensions, draft, cargo type, dangerous goods status and estimated arrival time, providing basic data for subsequent scheduling. [4]

Automatic Registration and Queuing: The scheduling system automatically generates a waiting ship queue according to the declaration time, registration time, ship type, priority and relevant rules. [5]

Waiting and Joint Safety Inspection: Ships enter the waiting water area in accordance with scheduling arrangements, choose anchorages to drop anchor for lockage waiting independently, and sail towards the dam-front water area in sequence. Relevant departments conduct joint safety inspections on ship seaworthiness, crew allocation, loading status, equipment operation and dangerous goods declaration in the dam-front water area, mostly in the form of random inspection. [6]

Ship Lock Arrangement: Ships passing safety inspection enter the lock arrangement link. The scheduling department formulates lockage arrangements by comprehensively considering ship dimensions, draft, lock chamber conditions, upward and downward directions, water regime flow, ship priority and other factors.

Lockage Scheduling: The scheduling department issues lockage operation plans and organizes ships to enter, pass through and exit the lock in designated lock times, sequences and time schedules.

This mode has achieved remarkable operational results with steady growth of ship lock throughput and efficient and orderly navigation organization. However, as the overall qualification rate of ship safety inspection remains steadily high, strengthening the connection among ship anchorage, joint safety inspection and lockage operation plans is conducive to reducing the schedule adjustment frequency of waiting ships and enhancing navigation safety and stability.

3. Exploration of the Optimized Scheduling and Organization Mode

Based on the existing process of remote ship declaration, automatic queuing, joint safety inspection, lock arrangement and lockage scheduling, this paper introduces the concept of rolling planning, strengthens information sharing, dynamic verification, connection linkage and closed-loop feedback among ship anchorage, ship safety inspection and lockage operation plans, reduces the schedule adjustment times of waiting ships from the source of the process, and continuously improves the navigation organization efficiency and safety stability of ship locks.

3.1 Rolling Plan

On the basis of ship queuing, the rolling plan is a preliminary lockage operation plan formulated

under constraint conditions including ship priority, flow control standards, draft control standards, ship lock operation status and lock chamber throughput capacity. Rather than the final executable ship lockage plan, the rolling plan serves as an important basis for predicting the ship lockage order, safety inspection demand and operation arrangement in the future period in advance. The rolling plan is dynamically updated at a fixed cycle, adopting hourly rolling or daily plan rolling according to actual conditions, which maintains relative stability while adapting to changes in water regime, ship lock operation and ship arrival status. By introducing the rolling plan into the existing scheduling and organization mode, the connection among ship anchorage, ship safety inspection and lockage operation plans is strengthened to explore a multi-plan collaborative scheduling and organization method.

3.2 Multi-Plan Collaborative Scheduling and Organization Method

Under constraint conditions such as ship priority, flow control standards, draft control standards and ship lock operation status, combined with automatic registration queuing, the method compiles ships within a certain time range into a rolling plan, i.e., a preliminary lockage operation plan. The scheduling department conducts overall arrangement of joint ship safety inspection according to the rolling plan. Subsequently, the rolling plan is dynamically verified and adjusted combined with real-time water regime flow, ship priority, ship draft, safety inspection results, ship arrival status, ship lock operation status and on-site navigation conditions. Finally, the official lockage operation plan is formulated for ships in the rolling plan that pass safety inspection and meet relevant navigation requirements, so as to organize orderly ship dam passage as planned.

The basic process is as follows:

Remote Ship Declaration → Automatic Registration and Queuing → Generation of Preliminary Rolling Plan → Compilation of Rolling Plan → Joint Safety Inspection and Verification → Formulation and Execution of Lockage Operation Plan → Plan Feedback and Dynamic Correction

4. Operation Mechanism of Multi-Plan Collaboration

To realize information sharing, dynamic verification, connection linkage and closed-loop feedback among ship lockage waiting, ship safety inspection and lockage operation plans, and ensure the efficient operation of the multi-plan collaborative scheduling and organization method, corresponding operation mechanisms must be established.

4.1 Information Sharing Mechanism

Information sharing is the foundation of multi-plan collaboration. [7]Relying on the ship scheduling information system, real-time sharing of ship declaration information, registration queuing information, ship dynamic information, lockage waiting status information, safety inspection status information, ship lock operation status and water regime information shall be realized. [8]Information sharing avoids disconnection among ship anchorage, ship safety inspection and lockage operation plans [9], and improves the accuracy and consistency of plan compilation.

4.2 Dynamic Verification Mechanism

Ship lockage scheduling is affected by multiple factors such as water regime flow, meteorological conditions, equipment operation, ship arrival and on-site traffic conditions, so plans must be dynamically verified. The scheduling department shall focus on verifying whether ships arrive as planned, whether safety inspection is completed, whether the draft meets control standards, whether water regime flow meets organizational conditions, whether ship locks operate normally, and whether priority ships are temporarily inserted, so as to adjust the rolling plan and lockage operation plan accordingly.

4.3 Plan Connection Mechanism

A clear connection relationship shall be established among automatic ship registration queuing, rolling plan, joint safety inspection plan and lockage operation plan. Automatic registration queuing provides basic data, the rolling plan forms operation prediction, safety inspection completes safety confirmation, and the lockage operation plan realizes on-site execution. Plan connection eliminates breaks in all links of scheduling organization and improves the continuity of ship lockage organization.

4.4 Closed-Loop Feedback Mechanism

After the completion of lockage operation, information including actual lock entry time, lock exit time, plan fulfillment status, causes of abnormal adjustment, ship waiting time and on-site safety conditions shall be fed back to the scheduling system. The scheduling department revises subsequent rolling plans and ship lockage operation plans according to feedback results, forming a closed-loop management of "plan compilation – safety inspection organization – operation execution – feedback and revision".

4.5 Abnormal Disposal Mechanism

An abnormal disposal mechanism shall be established for situations such as ships failing to arrive on time, unqualified safety inspection, sudden water regime changes, ship lock equipment failures and temporary insertion of special task ships, clarifying the authority of plan adjustment, ship replacement rules, information release methods and on-site organization requirements, so as to ensure safe and orderly scheduling organization under abnormal conditions.

5. Feasibility Analysis

5.1 Technical Feasibility

At present, the remote ship declaration system, Beidou ship positioning system, ship lock operation monitoring system and water regime information system are relatively mature [10], which can provide data foundation and technical support for multi-plan collaboration. Through system function integration and data sharing, automatic generation of ship queuing, compilation of rolling plans, generation of joint safety inspection plans, release and dynamic adjustment of lockage operation plans can be realized.

5.2 Management Feasibility

The existing ship lockage scheduling and organization has formed a sound management system covering declaration, queuing, safety inspection and lockage operation [11]. The multi-plan collaborative method strengthens the connection among all links on the basis of the existing process without changing the basic current scheduling rules, possessing good promotion conditions.

5.3 Safety Feasibility

This method improves the predictability of plans, strengthens the connection among ship lockage waiting, joint safety inspection and lockage operation plans, and reduces disorderly movement and temporary schedule adjustment frequency, helping enhance the traffic organization stability of waiting water areas. Meanwhile, a ship can be included in the official lockage operation plan only on the premise of passing safety inspection, meeting draft control standards, satisfying water regime flow requirements, normal ship lock operation status and available on-site navigation conditions, without lowering safety management standards.

6. Conclusion

By introducing the concept of rolling planning into the existing scheduling and organization mode, this paper proposes a ship lockage scheduling and organization method under multi-plan collaboration. It strengthens information sharing, dynamic verification, connection linkage and closed-loop feedback among linkage control, ship safety inspection and lockage operation plans, which helps reduce disorderly movement and temporary schedule adjustment of ships in waiting water areas, enhance navigation safety and stability, and improve the service level of ship lock scheduling. Subsequent research can be carried out combining the actual operation data of specific ship locks on the setting of time window for rolling plans, allocation of safety inspection resources, compilation rules of lockage operation plans and plan execution evaluation index system, so as to promote the practical application of the multi-plan collaborative scheduling and organization method in large inland river ship locks, and provide support and reference for the digital, collaborative and intelligent development of inland river hub ship scheduling.

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