Simulation Study of Ship Traffic Efficiency of Inland River Combined Hub

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ABSTRACT
At present, the research on the efficiency of inland river vessels passing through the hub is mainly focused on single-stage or multi-level ship locks, but few studies have been conducted on the passage efficiency of ships under the new type of inland river junctions. Compared with the former, the latter needs to consider more constraints. Based on Anylogic software and considering the above constraints, this paper proposes a method for constructing a ship's traffic efficiency simulation model of such a combined hub. Finally, taking Wujiang River Silin's proposed hub as an example, the ship's traffic efficiency under different operating modes is evaluated.

KEY WORDS: Ship traffic efficiency; constraints; combined hub; Anylogic

INTRODUCTION
In order to meet the needs of the development of domestic river cargo transportation, the level of waterways needs to be improved urgently, and higher requirements are naturally set for navigation facilities. The construction of a new type of combined navigation hub has become an inevitable trend. The corresponding operation mode of the ship is no longer limited to the traditional self-propelled mode, and the passage efficiency of the ship under the new mode is a question worthy of attention and research. Taking the Wujiang River Silin’s section as an example, a navigation tunnel is planned to be excavated in the cliffs on both sides of the river, and then a 1000t class ship lock-navigable tunnel-ship lift joint navigation hub is constructed, and a traction system is planned for the ship Towing mode, it is necessary to evaluate the ship's traffic efficiency under this mode.

A lot of researches have been done on the issue of the traffic efficiency of hub ships at home and abroad. Smith, LD (2009) and others constructed a discrete event simulation model to study the congestion of some navigation hubs in the upper Mississippi River. The results of the study indicate that giving priority to the ship with the shortest average handling time and the shortest fixed time during the ship crossing process can improve the passage efficiency of the ship lock, especially during peak hours; Wu, ZR (2013) proposed a flexible time for ship crossing time The calculation problem is based on the actual ship crossing data of a hub on the Beijing-Hangzhou Canal, combined with the ship parameter ratio and the theoretical model of traffic flow, and a kinematic calculation method for this problem is given. Liu, Y (2015) used SIVAK software to construct Three Gorges simulation model. From the simulation results, it is concluded that the FCFS scheduling method can improve the service level of ship locks compared with the orchestration scheduling method. The methods studied above can be divided into two types: mathematical modeling, optimization algorithm solving and simulation modeling. None of the objects studied involved a combined hub composed of multiple navigation facilities.

This article first analyzes the factors and constraints that need to be considered in the inland waterway complex hub system, then clarifies the logical flow of ship traffic based on its characteristics, and builds a logical simulation model of the ship's traffic efficiency in the inland waterway complex hub. Finally, the Wujiang River Silin’s hub system The parameters are used as input to complete the ship's traffic efficiency evaluation under this system.

SYSTEM SIMULATION ELEMENTS
Before simulating the inland river complex hub system, it is necessary to clarify the internal elements of the system and their corresponding relationships (Xue, MJ (2019)). Based on the analysis of the inland river ship passing through the lock process and combining the characteristics of the target hub, it is summarized into five parts: ship elements, channel elements, anchorage and berth elements, navigation facilities elements, and traction system elements.

Ship Elements
Ships are the most important active individuals in the system. They are

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