Thousand Ships and Thousands of Faces—Research on Navigation Evaluation Software of Curved Channel

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ABSTRACT

The curved channel is the most common channel form in inland rivers. But limited by the circulation and wind of the bend, it is more difficult for ships to navigate accurately. If there is a bridge on the bend, it is not only difficult to navigate, but also easy to cause a bridge collision. So, the ship needs a standard operation when operating in the corners. And most of the research focuses on widening bridge span. It is not applicable to bridges which are difficult to modify the span of bridges. This software starts from theory. First, collect a large number of navigational data in a curved channel. And use the computer to simulate through a series of formulas. Judge whether the passage can be safely passed. Through this method and points out that channel optimal method.¹

KEY WORDS

Curved Channel Intelligent Navigation Bridge Span.

INTRODUCTION

Scholars at home and abroad have done a lot of research on the circumfluence of curved channel and the additional span of curved bridge (the widened width of curved channel). But the ship lateral drift effect caused by different transverse

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velocity, average draught bend circulation ship and ship cornering maneuverability caused by channel width and widening value, the research is not sufficient, there is a study of large blind zone. And because of the flow velocity, the curve bend at the bottom of the nature, factors such as wind speed difference, track bending waterway navigation zone and there is a big error prediction formula. Because the formulas are different for ship type, load and other factors, it is more difficult to predict the curved track. Therefore, it is necessary to study and calculate the widening value of the bend channel width from the aspects of ship form, draft and rudder efficiency, combined with the shape and operation characteristics of each ship and the characteristics of the bend channel. It can not only maintain the navigation safety of the curved channel, reduce the probability of traffic accidents, but also understand the operation characteristics of each ship, which is of great significance to the intellectualization of ship operation.

CHAPTER 1

Research Purpose and Significance

Bending channel is the most common form of inland waterway. Bending channel greatly increases the difficulty of ship maneuvering and has a great impact on navigation safety. However, in the past, limited by conditions, little research has been done on the impact of navigation on such rivers, and ship maneuvering only relies on experience. However, with the development of the times, the use of computers has brought leap-forward convenience to all walks of life. In this paper, from flow, sediment movement, channel evolution to wind-induced offset, a method for evaluating navigation conditions of curved river is proposed. That is, through a large number of tests, collecting a large number of data, using existing formulas, to provide a scientific basis for the planning and design of curved waterways, and to provide a correct direction for ship maneuvering.

Theoretical Basis

Using the ship speed, water speed and wind speed collected by sensors, the theoretical trajectory is calculated according to the formula, and input into the software information database for preliminary processing.

In calculating the required sailing width of a ship passing through a curved channel, the first step is to determine the required sailing width (B1), the flow-induced drift (ΔBL), the yaw (ΔBP) and the wind-induced drift (ΔBf) of a ship passing through a curved channel without the influence of wind and current.

Then, according to the superposition principle, the required width of a ship passing through a curved channel under the influence of wind and current is calculated.
Calculation method of ship width based on ship passing through curved channel. In the absence of wind and current, the width \(B_1\) of a ship passing through a curved channel can be calculated by the following formula\([1]\):

\[
B_1 = \frac{1}{2} b(\cos \alpha_2 - \cos \alpha_1) + P(\sin \alpha_1 - \sin \alpha_2) + 2R\sin\frac{\alpha_1 - \alpha_2}{2}\sin\frac{\alpha_1 + \alpha_2}{2}
\]

\(R\): Curvature radius of ship track
\(\alpha_1\): The initial heading angle of a ship when it enters a curve (The clockwise rotation of the path along the axis of the channel is positive in the direction of the ship's head and tail and vice versa.)
\(\alpha_2\): Heading angle when the ship is out of the curve (The clockwise rotation of the path along the axis of the channel is positive in the direction of the ship's head and tail and vice versa.)

2) The drift size \(\Delta BL\) can be calculated by the following formula.

\[
\Delta B_L = \frac{u^0 R}{v} \sin \beta
\]

3) The yaw rate \(\Delta BP\) can be calculated by the following formula.

\[
\Delta B_P = \theta R \sin \frac{\alpha_1 + \alpha_2}{2}
\]

4) The wind induced offset \(\Delta B_f\) can be calculated by the following formula.[2]

\[
\Delta B_f = K' \left( \sqrt{\frac{B_a}{B_W}} e^{-0.14 v_s} \frac{\theta R}{v} \sin \phi \right)
\]

\(K\): Correction factor, Generally take 0.038~0.041.
\(B_a\): Upper windward area of hull line (m²)
\(BW=\text{L}^*d\) (L is the length of the ship.).
\(v_s\) for ship speed in wind (kn).
\(v_a\) relative wind speed. (m/s).
\(\phi\) The angle between the wind and the axis of the bridge.
\(\theta\) is a bending angle. (\(\theta=\alpha_1 - \alpha_2\)).

**Equipment Base**

**ELECTRONIC CHART SYSTEM**

It is a spatial data technology system based on computer technology. In a sense, the electronic chart system is an integral part or an aspect of the geographic information system. Electronic chart technology mainly uses computers to quickly
calculate and produce chart data and display them on designated equipment. By connecting various positioning devices, radio communication devices and other network interface devices, it plays a key role in the improvement of navigation safety and the development of ship navigation intellectualization. In addition, the most important function of the electronic chart system is to display data transmitted by other devices. That is, the software can be directly installed on the electronic chart system without updating the equipment.

**AIS Information:**

1. Static information: Information that will not change within a certain time interval. Such as Maritime Mobile Service Identification Code (MMSI), call sign, ship name, ship length, ship type, GPS position on board, etc.

2. Dynamic information: Constantly updated information at certain intervals. Such as the location of the ship, UTC time, ground speed, heading, navigation condition, steering rate and so on. The software provides the length and type of ships needed and the navigational status of the ship. Research on Intelligent Collision Avoidance System Based on AIS and electronic chart [3] AIS information can be described by binary. That means that it can be imported into the computer system for statistics. And research and application of ship trajectory analysis based on AIS. [4] The AIS system can be used for preliminary prediction of ship trajectories. This shows that the existing equipment of ships and fairways can fully support the operation of the software.

**THE SECOND CHAPTER DESIGN PRINCIPLE**

**Software Overview**

The electronic chart system has the following obvious advantages: Use color pictures to display information such as charts, tracks, navigation aids and so on. When navigating sensor information such as GPS, radar and ARPA can be connected, route design can be carried out. Record navigation information, understand ship's posture etc. The preliminary study on the application of Wu Yongjun's ECDIS in the Yangtze River waters shows that electronic charts can be connected with other equipment. This forms one of the hardware foundations of the software. [5].

**Construction Principle**

| Fu Jiangsha channel | depth (m) | width (m) | current (m/s) | wind speed (m/s) | wind direction (°) | center point (°) |
|---------------------|----------|-----------|---------------|------------------|-------------------|-----------------|
| the south channel   | 10.5     | 200       | 10.5          | 2.0              | 3                 | 60              |
| the middle channel  | 12.5     | 260       | 150           | 10.5             | 2                 | 65              |
| the north channel   | 8        | 220       | 1300          | 10.5             | 2                 | 55              |
DATA COLLECTION

Water speed, wind speed, speed, track and rudder angle are recorded. Taking Fujiang sha waterway as an example, some parameters can be provided by the marine bureau to avoid duplication. Collect tonnage, length, weight, rudder angle, ship track record and so on. The collected data are transmitted to the software background database to record the ship's navigation data, and the data are fitted by mathematical formulas. The theoretical rudder angle, speed and turning point are calculated, and the track is preliminarily calculated. According to the calculated track results, the influence factors of the bend on other factors (shoal, depth) of the ship are found out by comparing with the actual track.

TRACK MODELING

After a series of calculations, an estimated data has been preliminarily formed, and the initial track model has been formed. However, the initial model is not closely integrated with the ship because of the lack of data, so it needs to be combined with the screening process before it can be used.

OPERATION MATCHING AND SCREENING PROCESS

In this paper, before matching and screening operations, the historical information of ship operation in a curved channel is collected and saved as a database that can be extracted at any time. Then, the matching results are further screened according to the ship's characteristic parameters and the ship's characteristic data in the database, so that the screening results are most in line with the ship's requirements. The key to this matching process is the richness of the database. Because the more data, the more comprehensive, the more can reflect the sailing tendency of the front ship. The more secure operation is, the more times the data is used by the software. The more data, the more filterable operations will be added, which will be more conducive to matching and screening the most suitable and safe operations. Operation speed requirement: Because this software is based on a certain number of historical data of ships, the number of data is very large, which requires high processing capacity of computers. At the same time, the data storage capability of EXCEL will also become a problem restricting the computing power of the software. Besides, the requirements for screening conditions are very high in this experiment, and the priority setting is very strict. Requirements must be entered to meet the required format conditions, and pay attention to case, condition setting range and other elements. Strict requirement limits show that the experiment is not inclusive.
IMPROVED PARAMETER VALUES

When the ship has experienced many bends, or when the software collects enough times for the ship to pass through the bend, the software can preliminarily infer the influence of the unchanged factors in the bend (such as water depth, shoal, etc.) on the ship's track. According to the above conditions, the formula is optimized to obtain more secure data for assisting the driver to operate.

ANALYSIS OF STORED DATA

After more than a few times, more accurate information has been obtained for the specific ship corners. It is also possible to directly select the optimal method for indicating the operation of a ship without using a large amount of data for calculation.

RESULT

The calculation formula has also undergone a lot of data collection and modification by the software and has been amended by adding the regional factors of this bend. The ship has recorded a lot of data and got a track equation which is close to safety and effective and is suitable for the ship.

Software features. After a long period of data collection, a large number of mathematical data processing and track model simulation are carried out. According to the characteristics of each ship, it is judged whether the ship can pass through the bend, and it is pointed out that the best rudder angle, the best course, the best turning point and the best speed through the bend can be fed back to the pilot. This software collects data first, finds out the correction factor, and then brings in the simulation method to predict the ship's curved track. With the increase of time and the increase of data, the predicted results will become more and more safe. It makes the navigation of ship's curved channel more data-based, accurate and single-vessel, instead of captain's experience or ability, and makes the navigation of curved channel safer. There are one thousand operation methods for the one thousand ships. There are one thousand operation methods for the one thousand ships. We call this Thousand boats and thousands of faces.

THE THIRD CHAPTER PRACTICAL APPLICATIONS

Manipulate

It helps to understand ship maneuverability.

① Combined with various navigators and other instruments, the functions of the system are enriched. So as to play a better navigation function. At present, it is becoming more and more important to make full use of all kinds of advanced...
navigation equipment to promote navigation safety. The advent of this software greatly improves the reliability and safety of navigation in the Yangtze River and inland rivers. With the development and improvement of electronic chart navigation technology, it will play a more important role in ship navigation.

② This software collects the basic data of every ship. It is not only useful for guiding the ship's maneuvering in inland river bending channel, but also plays a key role in narrow waters, port maneuvering and windy weather maneuvering.

③ Intelligent navigation direction. Every ship has its own unique core. Every ship has its own "behavior habits". We understand the "behavior habits" of the ship. Artificial intelligence can control every minute change more accurately and accomplish more tasks safely and reliably. In the context of the rapid development of AI, it is particularly important to change technology to achieve safer and more efficient results. This round of scientific and technological revolution and industrial transformation has given impetus to the shipbuilding industry.

Data Purpose

① For ship structure research: a large number of ship data are collected in the database. These data can be used to calculate ship characteristics besides ship tracks. They can optimize ship structure in combination with actual conditions, and provide a large number of data basis for ship upgrading and transformation.

② Research on curved channel: In addition to the study of ship structure, the influence of bends on ship navigation can also be studied, and the characteristics of various bends can be analyzed, which will bring more convenient methods or treatment methods to the widening of channel regulation in curved reach.

THE FOURTH CHAPTER CONCLUSION AND PROSPECT

Epilogue

① Due to the time is too short, this paper only proposes a concept, does not carry out actual software development and testing, and early data collection needs to be negotiated by the maritime department, there are many difficulties in the implementation.

② This paper takes into account as many factors as possible, but does not consider the impact of other ships in the past, the actual situation of ships with tugboat assistance and so on.

③ It is incomplete to study the navigation conditions of a river only from the point of view of flow, sediment movement and river course evolution. Each bending channel has its own characteristics. We can't calculate all the impacts completely. We only need to collect data as much as possible to make navigation safer.
Expectation

①The navigation of ship's curved channel has always been a difficult problem, and the bridge's curved channel needs more precise steering technology and precise control of ship. This software is to digitalize and standardize the operation. It is not only of great help to the navigation of curved channel, but also of great significance to the optimization of ship's operation and the maintenance of ship's safety.

②This software assists the ship in all kinds of complex operations and is of great significance for intelligent shipping.

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