Analysis of Factors Affecting Safety Navigation of Inland River Bending Channel

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ABSTRACT

Curved channel is the main channel form that ships are facing in inland navigation. The scale and flow conditions of curved channel are the key points to restrict the navigation of ships. It is necessary to study the safe navigation of curved channel. From the point of view of safe navigation in curved channel, this paper mainly discusses the influence of flow condition in curved channel on safe navigation of ships, and expounds the influence of curvature radius of curved channel, operator level and ship maneuverability on safe navigation of ships, and puts forward some suggestions.

KEYWORDS

Inland river; Curved channel; Safe navigation; Current situation; Ship handling level.

INTRODUCTION

With the development of China's economy, shipping industry has ushered in a new period of opportunity. The opening of new curved waterway and the transformation of old curved waterway make the navigation safety of ships face a great test. The large-scale, modern and professional ship itself also requires a higher navigation environment. However, most inland waterways are curved ones. The key to restrict the navigation of ships in curved waterways is the channel size and flow conditions. It is very important to study the safe navigation of curved waterways.

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How to make ships pass through curved channels safely and efficiently under certain conditions of bending channel scale and navigation capacity has attracted the attention of scholars, and a lot of research has been done on it. The research shows that the ship's navigation in curved channels is not only affected by the flow characteristics, ship size, and curvature radius of the curved channel, but also related to the level of maneuver.

**THE IMPACT ON SAFETY NAVIGATION OF SHIPS**

The flow environment of the curved channel is complex, not only has the longitudinal velocity, but also has the circumfluence flow pattern of the curved channel in the cross section, which is extremely complex [1-2], as shown in Figure 1. When a ship is traveling in an inland river, the influence of current on the safe navigation of the ship should be fully considered.

The curved channel belongs to the non-uniform spoon flow field, and the flow pattern is complex. The concave bank is scoured by the current, and the velocity is higher than that of the convex bank. Small, and there is siltation phenomenon. Mainstream, backflow, and crossflow of curved rivers have certain effects on ship navigation, and bank wall effect makes maneuvering more difficult. Because the mainstream and backflow in the local area of the bend belong to the non-uniform flow field, the bow and stern of a ship may be affected by the flow in different directions when passing through the bend, so the hydrodynamic force will change.

![Figure 1. Bend flow diagram.](image)

**The Top Flow Passes Through The Bend**

When the ship's top flow enters the bend, the steering moment is opposite to the action moment of the bow flow. When the rotating moment of rudder force is less than that of current and the speed of ship is lower, it is easy for the bow of ship to touch the bank wall of the concave bank under the action of cross flow, as shown in Fig. 2 (a).
Before entering the bend, the ship should adjust its position so as to keep the ship on the slightly concave bank side of the channel axis, turn its head to the direction of flow, steer ahead, turn slowly along the bend of the concave bank, make the curvature radius of the track less than the curvature radius of the channel axis, and keep the heading direction on the inner side of the channel axis all the time. To prevent too late or too early steering near the curved vertex to cause excessive transverse displacement. Once the bow offset is found, the helix should be added in time to increase the speed and energy efficiency to correct it. When the measures are ineffective, double anchors should be dropped decisively and the car should be reversed quickly to prevent the accident of touching the bank wall.

**Go Straight Through the Bend**

Compared with top-flow bending, downstream bending is riskier. When a ship enters a bend along the river, the rotating moment of the rudder force is in the same direction as the action moment of the stern current. When the rudder is steered too early and the ship's speed is low, it is easier to touch the side wall of the concave bank under the action of cross flow, as shown in Figure 2 (b).

Before entering the bend, the ship should adjust its position so as to keep the ship on the axis of the channel and turn its stern to the direction of flow, then steer ahead, and turn slowly along the bend of the concave bank, so that the curvature radius of the track line is slightly larger than that of the axis of the channel, so that the bow direction of the ship is always placed outside the axis of the channel to prevent the bending vertex. The large rudder angle is used in the vicinity to cause excessive transverse displacement. It is difficult to control the speed and rudder efficiency of the ship passing along the bend. It is necessary to decelerate in time before entering the bend and increase the speed before reaching the bend, so that the ship can have a larger rudder force when passing through the bend.

![Figure 2. The influence of bending channel on ship motion.](image-url)
THE EFFECT OF DRIFT ANGLE ON SHIP NAVIGATION

Drift Angle

When a ship is sailing in a bend, it is affected by many factors to make complex and irregular curves. Its track is a curve belt with serpentine edge. Because the ship moves in curves, it not only needs to move forward, but also makes different degrees of rotation. For the transverse displacement caused by the transverse flow and centrifugal force during rotation, the ship must make its longitudinal axis intersect with the tangent of the trajectory, which is the drift angle[3-6]. The greater the transverse velocity, the greater the transverse force of the ship's current, the greater the moment the ship will be subjected to. At the same time, the faster the ship's cross-shore speed will be, the greater the inertial centrifugal force will be, the larger the transverse displacement will be, and the larger the drift angle will be. Because of the appearance and change of drift angle and the corresponding change of track, with the increase of drift angle, the track bandwidth increases accordingly.

The Influence of Speed on Drift Angle

According to the law of curvilinear motion, the faster the speed of motion, the greater the centrifugal force produced. The ship must sail at a larger drift angle to offset the transverse displacement caused by the centrifugal force [7-9]. When the velocity is equal, the greater the ship's speed to the ground, the greater the inertia centrifugal force produced. Therefore, the larger the lateral displacement produced, the larger the drift angle required. But the test results show that the change is not obvious, which shows that the effect of speed on drift angle is not sensitive enough.

The Influence of Current on Drift Angle

Flow mainly affects drift angle through velocity and direction. In the case of roughly the same ship-to-ground speed, the greater the current speed, the greater the inertia centrifugal force produced by the ship, the larger the lateral displacement, the larger the drift angle produced by the ship to offset the lateral displacement, and the smaller the drift angle when the ship is sailing against the current.

The transverse diversion of water flow will inevitably occur when it flows through a bend, which will lead to the transverse displacement of ships when they sail along the bend. The larger the transverse velocity, the larger the transverse displacement and the larger the drift angle.

THE IMPACT OF NAVIGATION ENVIRONMENT ON SHIP NAVIGATION

In order to ensure the safe navigation of ships, the curved channel must have a certain width and depth. At the same time, the curvature radius of the channel should
not be too small. The research shows that the smaller the channel width, the greater the probability of accidents, and the more unfavorable it is to the navigation of ships. On the contrary, the wider the channel width, the smaller the probability of accidents, and the more conducive to the navigation of ships. The bigger the radius of curvature is, the easier it is for the ship to cross the bend; the smaller the radius of curvature is, the more difficult it is for the ship to cross the bend. When the draft of a ship is constant, the deeper the water depth, the smaller the probability of accidents; the shallower the water depth, the greater the probability of accidents. That is to say, the greater the water depth, the easier the ship to pass through the bend. The smaller the water depth, the more difficult it is for the ship to pass through the bend. Therefore, in order to make ships safely pass through the curved channel, the channel should have certain water depth conditions and certain width, and the radius of curvature should be as large as possible. Only when the above three are satisfied at the same time, can the ship pass through the curved channel safely and efficiently.

When a ship is sailing in a bend, due to the uneven distribution of the current and the existence of the circumfluence in the bend, the ship will move horizontally and possibly produce the shore wall effect. The wider the ship's track band, the wider the channel it occupies. The higher the requirement of channel width is.

THE LEVEL OF CREW OPERATIONS AND THE IMPACT OF MACHINERY

For a ship, the machine is the heart of the ship, and the man who operates the ship is the brain of the ship. If the machine fails, the ship's power system will be paralysis and the ship will lose control. At this time, the ship will be uncontrolled, drift with the waves, and the possibility of accidents will be greatly increased. Therefore, it is very important for ships to check the condition of machinery and equipment frequently and keep them seaworthy all the time.

The driver is the brain of the ship, which controls the action of the ship. A series of operations will directly determine the direction of the ship. If the level of maneuvering as a pilot does not meet the requirements, it will be a great test for the pilot to maneuver frequently when the ship is sailing in bends. Once an emergency occurs, the ship will be in extremely dangerous situation because the pilot's maneuvering level does not meet the requirements and he does not maneuver the ship in time. Therefore, the driver should be proficient in the skills and basic knowledge of ship maneuvering. When a ship is sailing in a curved river, it can issue correct instructions and maneuver the ship at the first time.

CONCLUSIONS

The flow pattern of curved channel is complex, and it is the main form of inland waterway. The water depth, channel width and curvature radius of the bend must
meet the navigation requirements. If not, dredging should be done in time. Because
the navigation environment is complex and there are many ships in inland waterway,
there are higher requirements for the ship's own conditions and the driver's
professional level. In order to make the ship safely pass through the curved channel,
the driver should pay attention to improving the professionalism and the level of
ship maneuvering. When entering a bend, the driver should pay more attention and
inform the relevant personnel to monitor the operation of the machine and
equipment in real time. Ships sailing in curved rivers should minimize the factors
that may affect the safe navigation of ships. Only in this way can ships pass through
curved rivers safely and efficiently.

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