# Research on Dredging and Dewatering Integration Dredger of Inland Main Waterways in Jiangsu Province

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**Abstract.** According to the requirements of environmental protection dredging and the characteristics of inland waterways in Jiangsu Province, the scheme design of a dredging and dewatering integration dredger for inland main waterways is studied. The development trend of the existing dewatering dredger is analyzed, the ship type suitable for the maintenance dredging of inland waterway in Jiangsu Province is selected, and the design idea of the dredger is put forward. At last, the general design of the dredger is given, and the corresponding technical points are analyzed. The dredging and dewatering integration dredger has multiple functions, which is environmentally friendly and practical. It can effectively improve the technical level of inland river maintenance in Jiangsu Province, conform to the development trend of green and low-carbon inland rivers, and it also provide reference for the design and implementation of inland river dredging equipment in other regions of China .

**Keywords:** inland waterway · dredger · maintenance dredging · ship type · general design

## 1 Introduction

Jiangsu province is very rich in water transport resources, and is one of the provinces with the most developed inland river shipping in China. In recent years, its mileage and density of inland river channels rank among the top in China. With the gradual completion of the main framework of the inland waterway in Jiangsu Province, the development of the waterway has gradually changed from the large-scale construction stage to the management and maintenance stage, while the maintenance of the waterway is mainly for maintenance dredging [1]. The inland waterways in Jiangsu Province are busy, with large ship flow in many sections, and the contradiction between dredging construction and navigation is increasingly prominent. In addition, the emergence of landslide danger and environmental protection problems have put forward higher requirements and more severe challenges to the maintenance of waterway dredging, and the dredging method also needs to seek new breakthroughs on the existing basis [2–5].


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## 2 Dredging Vessel Type of Inland Waterway in Jiangsu Province

### 2.1 Development of the Dredging-Dewatering Dredger

Existing for all kinds of dredger in rivers and lakes generally only have dredging function and conveying function, do not have the function of silt treatment. Their corresponding dredging way need to set on the shore large mud field land, which is much difficult for cities and its surrounding implementation, and easy to cause secondary pollution to the environment. In addition, the dredging soil transportation and treatment will need more construction period and cost.

The dredging-dewatering dredger has the function of dredging soil dehydration, and the dehydrated soil can be directly ashore or reused by barge. This disposal method can better solve the problems of the existing river and lake dredger, but at present, there is still little research on the dredger with silt dewatering function in China, and there are still many shortcomings. In 2011, Wu Yan et al. proposed a cutter suction dredging-dewatering dredger, which includes the hull structure and silt treatment device. It made a simple summary of the layout of the hull structure, but did not make a detailed description, let alone the connection mode of various parts on the hull. The dredging ship is a conceptual ship and not practical [6]. In 2014, Qiu Jinxin proposed an automation dehydration dredger of river and its use method. The dredger takes mud by digging or suction, and then separates the solid and liquid in the mud by adding reagents. At last, the solid is made into mud cakes and filter water discharge into the river after [7]. The head of the dredger is equipped with two kinds of dredging tools, including mud digging and suction machine. In practical application, if the suction machine is located inside the hull, it cannot swing and the dredger needs the hull swing to operation, which is difficult to achieve due to the limited inland waters, and the construction accuracy will be limited. In addition, the filtered water from the dredger is discharged into the river, which contains artificially added reagents, and the direct discharge without treatment will affect the original water quality. The water content of the mud absorbed by the dredger is high, and the subsequent mud treatment workload is large.

### 2.2 Suitable Ship Type Determination

The widely used dredgers mainly include suction hopper type, wheel type, grab type, cutter suction type and jet type dredger. The suction hopper dredger is mostly suitable for dredging of large and medium trunk channels. The wheel type dredger is not suitable for the excavation of soft silt and thin sediment in maintenance dredging. The construction quality of grab type dredger is general and there are secondary pollution problems. In addition, for the integrated dredging ships, the grab dredger also has to prepare a mud tank, and the mud in the tank needs to add water and stir it before dewater treatment. The process is not easy to control. Compared to a cutter suction dredger, the excavation section of jet dredger is easier to control, which uses water power to break soil and make pulp, Instead of the more complex and large weight of the cutter mechanism. So the weight and overall size of the jet dredger can be somewhat reduced, it has better cost and environmental protection performance. In summary, it is considered that the jet dredger is more suitable for the maintenance dredging of inland rivers in Jiangsu Province.

Usually jet dredger installs the suction device at the top of the hull bridge. Due to the suction device is more suitable for underwater loose mud and poor for other soil silt, a water knife device is considered to install at the top of the hull bridge at the same time. The dredger is called the jet dredger with water cutter, which can handle not only underwater loose mud but also common silt, and enhances the applicability of the dredger for different kinds of soil.

### 2.3 Ship Design Objectives

In view of the problems existing in the dredging of inland waterway in Jiangsu Province, a suitable dredger is designed and constructed namely self-propelled jet-type dredging and dewatering integration dredger. The design adopts the principle of ejection suction, which combines the independent sludge dehydration device with the hull, so that the working ship has multiple functions such as dredging, sorting, overflow, dehydration and tail water treatment. The working ship can carry out environmental protection dredging. Its accuracy and efficiency meet the dredging requirements. It can ensure the quality of the project, and effectively reduce the contradiction between construction and navigation.

Thousand-ton ship is the mainstream ship type of inland river operation in Jiangsu Province, so the dredger is designed according to thousand-ton class, and can dredge level 3 channel and take into account level 4 channel, and the design and construction output is 250 $m^3$/h. The dredger scale shall meet the requirements of reaching the inland river construction area in Jiangsu Province. Considering that the inland water transport in Jiangsu province is more developed, the ships can sail to each construction site by waterway. The channel conditions in Jiangsu Province include 40 m bottom width and 2.5 m water depth for level 4 channels; 230 m long and less than 10 m wide for Yunxi lock in Yangzhou; many small bridges across the river which net height is less than 5 m.

## 3 Overall Design of Self-propelled Jet Dredging and Dewatering Integration Dredger

The self-propelled jet dredging and dewatering integration dredger adopts single deck, single bottom, full electric welding and horizontal skeleton structure. The head and middle parts are flat bottom lines, the tail is double tunnel lines, and the navigation area is Class A inland river. The dredger equips the jet dredging bridge mechanism with the water knife at the head, sets up driver control room at the front and deck room on the left rear.

The main measures are:

| | |
|---|---|
| Maximum captain | ~53.5 m |
| Total length | 40.0 m |
| Waterline length | 40.0 m |
| Length between two columns | 38.9 m |
| Type-width | 9.5 m |
| Total width | 9.8 m |
| Type-depth | 2.8 m |

| | |
|---|---|
| Design draft | 1.6 m (navigation), 2.0 m (work) |
| Host power | 2 × 220 kW |
| Speed | 14 km/h |
| Auxiliary engine power | 1 × 110 kW, 1 × 40 kW |
| Navigation area | class A inland river |
| Fixed staff members | 2 people |

The dredger is mainly composed of jet and suction system, mud tank and overflow system, dredging and dewatering system, drainage system, ship moving positioning system and intelligent control system. The suction system is composed of water knife, suction pump, bridge structure, oil cylinder, pipeline and plate sieve, etc. It inhales the sediment, and then transmits to the mud tank and overflow system. The mud tank and overflow system is composed of mud tank, overflow tank, filter net, etc. The silt and liquid are separated from the sucked mud, and the mud water is precipitated, stratified and overflow treated. The sediment dewatering system is composed of sedimentation tank, dewatering machine and soil processing machine, etc. The mud is first flocculated and primary filtered, and then dehydrated, and finally the soil is made into mud blocks and sent to the barge through the belt conveyor. The drainage system is composed of sewage treatment equipment, drainage pipes, etc. The sewage generated by the sediment dewatering and curing system is purified and discharged into the river together with the overflow water from the mud tank and overflow system. The ship moving positioning system changes the plane position of the hull in the water to meet the needs of dredging. The intelligent control system is used to monitor the operation, working condition and output of the ship. The general layout of the dredger shown in Fig. 1, whose maximum operating depth is 6 m underwater.

The working method of the dredger is to locate the ship first and start the suction equipment. When the silt operation within the scope is completed, the dredger shifts. At the same time the suction equipment stops working and the dehydration and curing equipment can work continuously. The ship repeats repositioning and dredging. In the circulation process of positioning, dredging, moving ship and positioning, the ship completes the whole dredging work of the channel. The workflow is seen in Fig. 2.

The dehydrated and solidified soil in the dredger dredging is transported to the shore through the barge or directly ashore. During the construction process, the silt does not occupy the area on the ground, which saves the land resources, reduces the project cost, and avoids the secondary pollution. See Fig. 3 for the dredger construction flow chart.

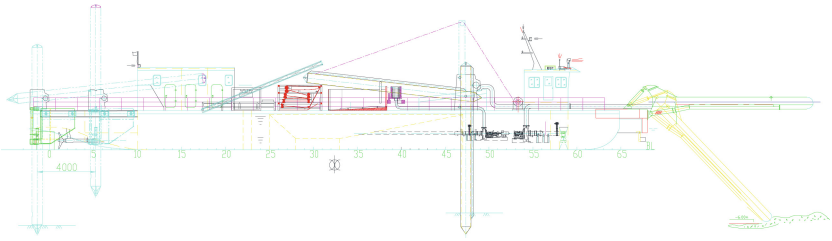

**Fig. 1.** General layout side view

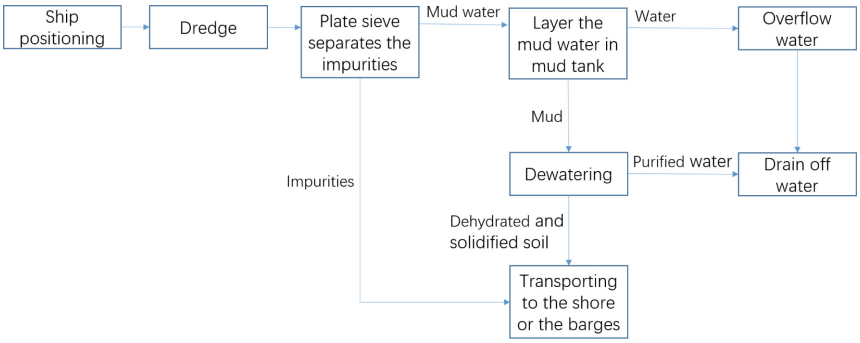


**Fig. 2.** Dredger workflow schematic

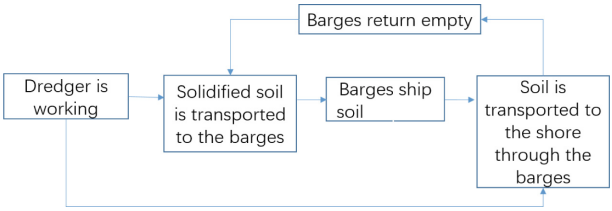


**Fig. 3.** Dredger construction flow chart

# 4 Special Devices

## 4.1 Jet and Suction System

The mud collecting machine is the jet and suction system. The dredger installs suction pump and water knife device on the top of the bridge structure. The working pump 1 on the ship provides the working water for the suction pump, and the working pump 2 provides cutting water for the water knife device. The working pumps inhale the clear water outside the ship, and jet into the mixing room with high speed through the working water pipe and nozzle to form the sand water mixture. Then, the sand water mixture is inhaled along pipes and discharged into the plate sieve, which is connected with the suction system. After separating impurities through the plate sieve, it enters the mud tank. For different constructions, the staff can determine whether to run the working pump 2 according to the soil condition, or adjust the flow head of the water knife working pump to reach the working state equipped with the soil characteristics. The flow of working pump 1 is ~1000 $m^3$/h, flow head is ~70 m, and power is ~250 kW. The flow of working pump 2 is ~800 $m^3$/h, flow head is ~70 m, and power is ~ 200 kW. The flow of suction pump is ~1250 $m^3$/h, and the average concentration is about 20%.

## 4.2 Mud Tank Setting

The design output of the dredger is 250 $m^3$/h. Due to utilization rate and structure size limit, the output of dewatering equipment is about 100 $m^3$/h. The two outputs

are inconsistent. Even if the two outputs are completely consistent in constructions the environmental influences can also lead to asynchrony, thus mud tank is set to coordinate operation, to store the surplus mud, and to keep dewatering operation during ship moving operation or without mud suction.

The moisture content of the mud water formed by the suction dredger is relatively high, generally about 85%, thus the subsequent mud treatment workload is large, and the cost is significantly increased. If the mud tank is set, it can initially precipitate and layer the mud water. In the mud tank, the upper part is water and the lower part is mud. The water in the upper part of the mud tank overflows and discharges, which can greatly reduce the subsequent mud treatment capacity and reduce the construction period and cost.

The capacity of the mud tank can be determined according to the hull size of the ship and the operation of the ship. It should be suitable for the operation that the dewatering equipment can complete the dehydration work of the dredging amount within a period of dredging and ship positioning. The mud tank capacity of this dredger is about 112 $m^3$.

### 4.3 Tail Pool Setting

The dehydration and curing equipment on the ship is to filter and dehydration the mud by adding reagents. The water produced by dehydration can not be directly discharged into the river. In order to prevent secondary pollution, it is necessary to purify the water produced after dehydration and then discharge it. Therefore, the tail pool is set on the dredger. The size of the tail pool is related to the purification capacity and purification water quantity. In the case of limited space, the tail pool can be set as irregular shape. The tail pool capacity of this dredger is about 15 $m^3$.

## 5 Conclusion

Jiangsu province has high density of ships, many hydraulic structures such as ship locks and docks, and many towns, dwellings, scenic belts and factory areas along the rivers. The dredging characteristics of inland river channels in Jiangsu province are remarkable. According to the characteristics and environmental protection requirements of trunk channels in Jiangsu province, the dredging ship type study is carried out. It not only can enhance the technical level of Jiangsu province inland river maintenance, promote the development of inland green low-carbon, but also can provide reference for the design and implementation of inland river dredging equipment in other areas of our country.

The dredging and dewatering integration dredger designed not only has the advantages of the existing sludge dehydrated dredger, but also is more environmentally friendly and low consumption, easy to realize. The dredger maintenance is simple, dredging efficiency is high, dredging cost is low, the excavation section is easy to control, and the construction quality is good. It can be widely used in inland river dredging and ecological dredging projects.

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