

# TYPE SELECTION OF SEDIMENT DESILTING MACHINES IN YELLOW RIVER IRRIGATION SYSTEM

Wang Huazhong, Dang Yongliang  
Water Conservancy Bureau of Shandong Province  
250013, Jinan, China

## ABSTRACT

Large amount of water is diverted annually for irrigation along the Yellow River. Owing to the tremendous sediment carried by the river, sediment deposits is an important problem in irrigation and drainage system. The sediment has to be taken out by machines from the irrigation system, otherwise water can not be available in the right place at the right time.

In order to improve the sediment desilting efficiency, the sediments that settle in certain sites of a irrigation system must be removed by different desilting machines with special performance and working conditions. Those certain sites include: the diversion canal in the flood plain, the mouth of inlet, settling basin, irrigation and drainage system. In view of removal sediment above, the paper presents the ideas of type selection of desilting machines applied to certain sites. Proposals of making further improvement on performance for some desilting machines are also put forward.

Key Words: Yellow River Diversion District, Sediment Depoisting, Mechanical Desilting, Type Selection

## INTRODUCTION

The yellow river basin is at once the cradle of the Chinese nation and the "Sorrow of China". Flowing through a loess plateau of 430000 km<sup>2</sup> in the northwestern China, the Yellow River picks up and transports an average of 1.6 billion tons of sediment per year. it rated as the first in the world. A portion of the sediment thus carried is deposited in the river channel downstream causing the bed to aggravate. The elevation of river bed is 3-5 m higher than that of ground nearby. The basin covers a total areas of 725000 km<sup>2</sup>, where 130 million people are living on 18 million hectares of cultivated land. The annual average runoff is 46.4 billion. its average concentration is about 40 kg/m<sup>3</sup> with peak concentration than 100 kg/m<sup>3</sup> in flood season, lasting from June to September.

After the founding of the People' Republic of China, a tremendous amount of river engineering work has been carried out on the Yellow River. In addition, irrigation projects have been completed throughout the basin. Regions along the

lower Yellow River are semi-arid area. The irrigation by the Yellow River plays an important role in the development of agriculture. In recent years the total irrigation area reaches 1.8-2.0 million hectares. The annual diverted water is more than 10 billion m<sup>3</sup> with a maximum of 15.4 billion m<sup>3</sup> in 1989.

With large amount of water is diverted annually for irrigation, tremendous sediment carried by the river settle in the distribution canals. The sediment entering the irrigation area is distributed over the settling basin, the irrigation system, drainage system and field. The proportion is 35.9%, 42%, 14.8%, respectively. There are part of sediment (7.3%) leaving the irrigation area. The sediment has to be taken out from the irrigation schemes before irrigation season starts, otherwise it will cause a series of problems, such as salination in canal system, tremendous dredging, and wind-blown sand, etc. Therefore proper sediment management is the key problem in the long-term development of the agricultural irrigation along the lower Yellow River.

Until recent years, tremendous labors are spent on dredging annually, the dredged sediment volumes in recent years is 9 million m<sup>3</sup> or so. All the dredged sediment is piled up along canal banks with a height of 4-5 m. In windy days wind-blown sand threatens plant in surrounding area and causes severe environment problems.

Today with the local economic development and popularization of desilting machines, the mass urgent ask using the machines to clear the canals and rivers. Owing to the different sediment desilting sites and conditions and the variety of machines type, most of the existing desilting machines cannot find broad application due to reliability and working efficiency. In view of existing situation, the paper presents the ideas of type selection of desilting machines applied to certain sites.

## MATERIALS AND METHODS

The Sediment that settle in certain sites (See Fig.1 ) of a irrigation district must be removed periodically by various desilting machines, such as mud pump, bulldozer, carry-scraper, drag boat, digger, cutter-suction dredge, etc. The operation environment (in water or out of water), the working reliability and efficiency, and the scale of a district are need to be considered too.

## RESULTS AND DISCUSSION

The characteristic and type selection of those desilting machines are given as follows:

### **1. Dredging the Sediment that Settle in Diversion Canal in Flood Plain**

The machines used for silt clearance of this site should meet the demands of :

(1) with small ground specific pressure (within 0.011 Mpa or so) to satisfy the machine's going on spongy ground; (2) possess the performance of amphibious-- it can go on water surface or operating in a certain depth of water body; (3) with large engine power to obtain enough tractive power overcoming the resistance in flood plain; (4) traveling speed not less than 4-5 km/h; (5) better sealing performance for the walking unit, and also of wearability and antitrust; (6) Working unit is hydraulic pressure dipper or cutter suction units.

To meet the demands above, the dredger suitable are list below:

### *1.1 Amphibious Hydraulic Excavator*

There are two types for this kinds of excavator: one is "green turtle" type, another one is called "caterpillar with floating box" type. The dredge method of original design for both unit is with backhoe. In order to meet the different width of a canal, the dipper may be replaced by suction, cup wheel, sword wheel, etc. The green turtle type excavator use backhoe to dig. It has 4 lateral legs, and can sailing by itself. When working on land, the 4 legs would act, it can working on one side or both sides of a canal. When working on a large scale canal, the dump barge need to be equipped. Several excavator had been developed with different capacity of heaped bucket and different length of arm. The main indexes of technical performance is: producing capacity, 45-60 m<sup>3</sup>/h; engine power, 48.5-60 kW; rotating speed, 1500 rpm; weight, 11-13 t; excavator depth, 3-6 m; climbing capacity, 15°; radius, 7-9 m; operating depth, 1.5-3.5 m.

### *1.2 Amphibious Impact-suction Dredger and Amphibious Cutter-suction Dredger*

The walking unit of both sets is caterpillar with floating box. They can travel on ground or sail in water. The operating procedure for impact-suction dredge is: The water flow pass the high pressure pump, eject from the nozzle of water giant with high speed and high pressure. It can cut and shiver the silt, form the liquid mixed with silt block and mud, then use the mud pump and flow pass the mud tube, transport the mud to other place for filling, dumping, etc. The main specifications of GQY-40 type made in China is : producing capacity, 40 m<sup>3</sup>/h; engine power, 73.5 kW; rotating speed, 2000 r/m; weight, 14 t; depth of dredge beneath the surface, 2.3m; working speed, 120 m/h; lift, 10m; transporting distance, 150m; mud concentration, 10 % (sediment content 270 kg/m<sup>3</sup>). The working procedure for cutter-suction unit: The mud (concentration 10%-20%) sucked by the device is ejected to the banks of a canal directly or transported to far place by pipe. The specification of cutter-suction dredge is: working capacity, 20-60 m<sup>3</sup>/h; weight, 20-32 t; excavate depth, 3 m; max. transporting distance, 300-400 m; lift, 15-26 m; engine power, 88-147 kW; rotating speed, 1800-2200 r/m; traveling speed, 3 km/h on land and 2 km/h in water. Dropping anchor or stake auto-changing may be used.

### *1.3 Engine Power Boat for Pull the Deposition*

By the theory of sediment movement, we know silting occurs when the sediment concentration is bigger than the sediment carrying capacity of local water flow. But if a way of making the coefficient of silt bigger than income sediment content are adopted, scouring would occur. For supersaturated flow, the sediment transporting distance (L) is concerned with flow velocity (v), settling velocity (w) and the initial height from the bed (h). That is :

$$L=Kvh/w \quad (1)$$

where K is a comprehensive coefficient.

From the Eq. (1) above, we can find in the same condition, the transporting distance of sediment in the upper layer of flow is far than that of in the lower layer, and measures should be taken to enlarge the traveling distance of sediment in the lower layer by making the lower sediment floating to the upper layer. Thus we can use a boat and its silt stirrer, such as spray run, roller and rake to let the silt full suspension, prolonging the traveling distance of sediment to reduce the sediment accumulation. On the other hand, for the sediment that has been deposited on a canal, using roller and rake to make the sediment to start, with the help of hydraulic power, enlarging the concentration, the sediment accumulation would be dropped too. In a word, it is workable to use an engine power boat and its stirrer to minus sediment accumulation.

## **2. Dredging Sediment that Settle in the Mouth of Inlet**

At this site, sediment deposits occur when we reduce the diversion discharge or stop to draw water. In order to prevent the sediment silting, some small machines are used to scour this site, form the mud slurry as well as adjusting the diversion discharge.

### *2.1 Screw Propeller Dredger in Water*

The screw propeller device had been applied on transporters overseas. It belongs to initiation to use the screw propeller device for dredger in water in domestic product. This device is with super lower ground specific pressure and can walk both on muskeg swamp and operation in water, accomplish the walking, turning, run wild on non stiffen ground. The dredger can come automatically in or out of water, has a good climbing capacity. It is controlled by electric system by the operator on bank. The working device is rake-suction unit. When operation begins, the mud was mixed, forming thick liquid, then use the mud pump, transport the mud to far place. This unit is suitable for constantly dredging within the small range at the mouth of inlet.

### *2.2 Suction Dredger in Water*

This machine often selected to use for small area of an entry. The suction slurry pumps directly driven by the motor in water, the cutter in the fore part of the pump form the slurry mud, and the mud will be transported to given place. When silting clearance operation begins, the whole unit is hanged on a movable car, and the car can travel along the banks to and fro on the track. The working

depth is 10-15m, the distance of transporting is 50-60m, slurry mud concentration is 25-40%.

### **3. Dredging sediment that Settle in Settling Basin**

There are two types of settling basin, that is, laces basin, strip basin. The strip type settling basin can achieve good results. It is of 5-10 km length, 100-200 m width, 2-5 m water depth, 0.2-3.0 km transporting distance. The laces basin usually belong to natural concave or hole. The “Silting -clearance-silting-clearance” operation method can be selected.

#### *3.1 For Alternative Settling Basin*

After the water diversion, lower ground specific pressure or amphibious bulldozer, carry-scraper can be used to dredge. These machines can travel and operate both on spongy and in shallow water. The damp-land bulldozer is used when the transporting distance is less than 100m. When the distance of silt transporting is bigger than 500 m, the economic method is use the lower ground specific pressure excavator supported by the transfer car.

#### *3.2 For Settling Basin with Water*

The cutter-suction and impact-suction dredger can be use for the settling basin with water. The often adopted type is FJ series cutter-suction dredger, it is developed by importing the technology of “Beaver” dredger made in Northerlands. The dredger is suitable for our country’s condition, it is advanced in its performance and maneuverability, fit for all kinds of settling basin.

The amphibious dredgers used in flood plain are also suitable for settling basin.

### **4. Dredging Sediment that Settle in Irrigation and Drainage System**

Some influence factors, such as width of bed, flow depth, slope length, distribution of trees and structures on two banks, is there a place of mud filling or not, etc., must be comprehensive considered due to the complicated conditions of the canal and drainage river at different levels.

#### *4.1 For Small Scale Canal*

The excavator on land can be adopted to dig the mud and unload to bank, it is with 8-10 m long arms, and 0.4-1.0 m<sup>3</sup> budget capacity. The hydraulic excavator can be considered when the land of bank is spongy. The amphibious excavator can be used when there are some pounding water in canals.

#### *4.2 For Large Scale Canal*

A long arm hydraulic excavator and a pull-excavator being developed can be used. There are 3 specifications-- 15 m, 20 m, 30 m. This machine possess double characteristics -- backhoe and pull shovel: long arm, larger capacity of heaped bucket, and strong digging capacity. A high-bank press-drainage mud transfer machine can also be combined with dig machines system. It have the characteristics followed: transporting distance, 50-100m; lift, 15 m; mud concentration, 5%-60% (weight ratio); with good mechanical property.

#### 4.3 For Drainage Channel or River

The drainage system often have overgrown-weeds, mud, and pounding water. It is hard to use manpower to clear. There are some difficulty when using machine to dredge. For large scale drainage ditch, the land excavator such as bulldozer and slurry pump can be use to clear the parts above the water. The rope shovel, seizheaped bucket, back digger can used for mud beneath the water surface. The chopper excavator is suitable for ditch with weeds. Only one side of the banks can plant trees, the other side is specially for going of machines.

### CONCLUSIONS

Regions along the lower Yellow River are semi-arid area. The irrigation by the Yellow River plays an important role in the development of agriculture. With large amount of water is diverted annually for irrigation, tremendous sediment carried by the river settle in the distribution canals. The sediment entering the irrigation area has to be taken out by machines from the irrigation system, otherwise water can not available in the right place at the right time.

Today with the local economic development and popularization of desilting machines, the mass urgent ask using the machines to clear the canals and rivers. Owing the different sediment desilting sites and conditions and the variety of machines type, most of the existing desilting machines cannot find broad application due to reliability and its working efficiency.

By analysis and contrast, we can find different machines are suitable different conditions. In the operation of silting clearance, we should distinguish the dredge occasion, select the most suitable dredger machines and its working methods.

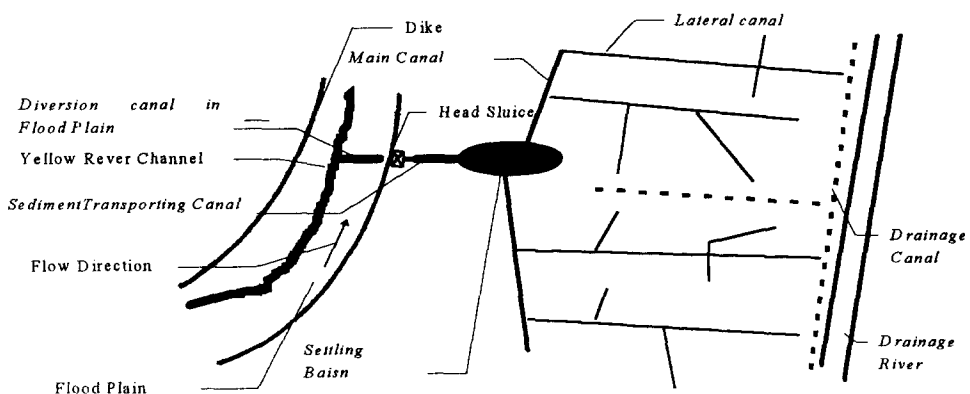


Fig.1 Diagram of a Typical Yellow River Diversion District