FACTS ABOUT
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CUTTER SUCTION DREDGERS

WHAT IS A CUTTER SUCTION DREDGER?

Although systems for describing dredgers vary, in general three broad classifications are recognised based on the means of excavation and operation. These are known as mechanical dredgers, hydraulic dredgers and hydrodynamic dredgers. Hydraulic dredgers include all dredging equipment which makes use of centrifugal pumps for at least part of the transport process of moving the dredged materials, either by raising material out of the water or horizontally transporting material to another site. Cutter suction dredgers (CSDs) are classified as hydraulic dredgers and are the most common vessels in the hydraulic/mechanical category. CSDs have the ability to dredge nearly all kinds of soils (sand, clay, rock) and are used where the ground is too hard for trailing suction hopper dredgers.

WHAT CHARACTERISES A CSD?

There are two types of cutter suction dredgers:

- CSDs which have a pontoon hull without the means of propulsion (non-propelled), and
- self-propelled CSDs that are shaped like a ship and are seagoing.

Although non-propelled CSDs are more common, even with self-propelled CSDs, the dredging operation takes place with the CSD in a stationary position, that is, even a self-propelled CSD will be moored with spuds or anchors while at work.

HOW DOES THE CSD WORK?

All CSDs are equipped with a rotating cutter head, which is able to cut hard soil or rock into fragments. The cutter head is a rotating mechanical device, mounted in front of the suction head and rotating along the axis of the suction pipe. The cut soil is then sucked in by dredge pumps. CSDs cut the soil according to a pre-set profile. The dredged material is then pumped ashore using pumps and a floating pipeline or loaded into a split hopper barge moored alongside, which in turn can then offload the dredged sediment at the designated location. The cutting action of a CSD is powerful and, combined with the suction action, the material can be ‘cut’ into suitably sized pieces. These pieces are then sucked into the suction pipe as a solid/water slurry and pumped to the surface using pumps mounted on a structural device which extends towards the seabed known as ‘the ladder’.

ARE CSDS FLEXIBLE?

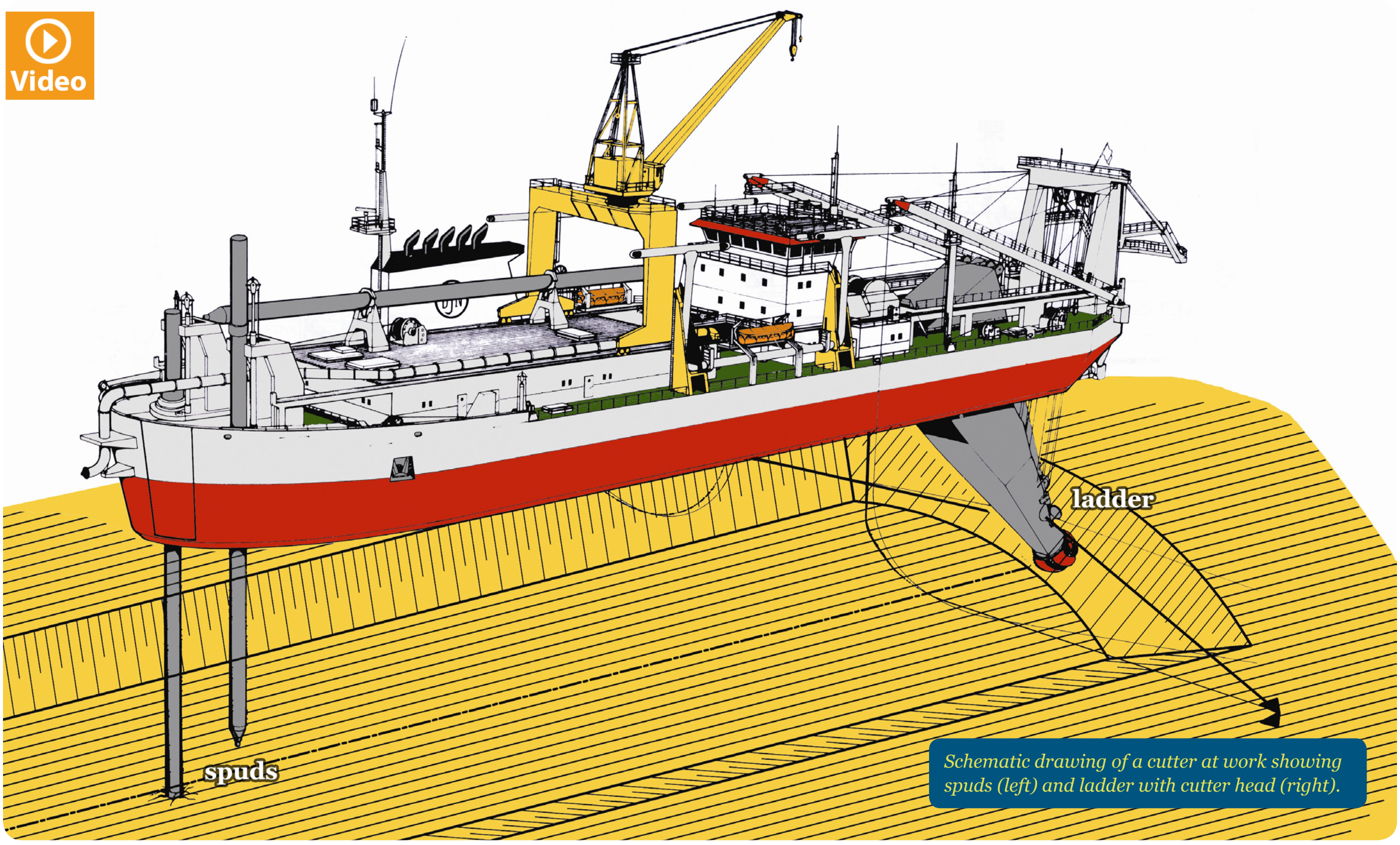
CSDs are sensitive to rough seas and are not easily moved whilst working. They are however characterised by high production rates and the ability to effectively handle a wide range of materials – silts, clays, sand, gravel, cobbles, and fractured and solid rocks. The most powerful cutters can dredge strong rocks effectively on a continuous basis. In addition, the self-propelled CSDs can travel long distances and be deployed in remote locations, far from their home port. They can work in shallow waters and they also have flexible discharge alternatives: They can transport the dredged material between dredging and disposal sites without the need for other equipment. They can then discharge material through pipelines to the placement site and with the use of booster pumps in the discharge lines, they can do this at considerable distances from the work site. Of course they can also discharge into barges. The decision of which method to use will be determined by where the dredging is taking place and what the final destination of the material is.

WHEN ARE CSDS USED?

CSDs can be used for land reclamation, for deepening harbours and for the construction and expansion of ports and navigational channels or for pipeline trenching in the seabed. When the dredged material is being used for land reclamation, the distance between the dredging and disposal areas is usually shorter than the distances covered by trailing suction hopper dredgers. CSDs can tackle almost all types of soil, although of course this depends on the installed cutting

Above: Self-propelled cutter suction dredgers are versatile and can travel long distances to dredge hard materials in shallow waters.

Video



Schematic drawing of a cutter at work showing spuds (left) and ladder with cutter head (right).

power. CSDs are built in a wide range of types and sizes; the cutting head power ranges between 20 kW for the smallest to around 6,000 kW for the largest.

In fact, dredging sites are not always easily accessible by water. When access is very shallow, an area may have to be 'pre-dredged' prior to the actual dredging. In the case where there is no water access, a small demountable cutter may have to be brought to the site by road.

HOW DO CSDS WORK?

The working principle of the CSD is that it disintegrates or breaks the cohesion of the soil to be dredged mechanically by a rotating cutter head. The suction tube and cutter head are attached to the so-called ladder as described above. The ladder with cutter head is positioned at the fore of the vessel. To begin with, this ladder is lowered under water, then the dredge pump(s) are started and the cutter head set in motion.
The ladder is then moved down until it touches the seabed, or until it reaches the maximum depth. If the required dredging depth has not been reached at the end of a swing, the ladder is set more deeply and the ship will move in the opposite direction. Step by step one or more layers of the water bed are cut away as the ladder is lowered one cutting thickness at the end of each swing. The thickness of the layer that can be removed by one swing (cut thickness) depends both on the diameter of the cutter head and the type of soil.

HOW DOES THE CUTTER HEAD WORK?

The cutter head, with a half dozen 'toothed blades', is one of the most crucial parts of this unique type of equipment. These teeth come in a variety of types, like wide or narrow chisels which are used for cutting sand, peat and soft clay or teeth with pick points which are used for cutting rock. The wear and tear on these teeth is a significant factor in the cost-efficiency of a cutter head, because they influence the frequency with which operations must stop to change the teeth of the cutter head.

In addition, the dimensions and speed of the cutter head as well as the diameter of the cutter head influence production rates. The cutter head speed will influence the amount of spillage – material that is cut but not sucked up by the suction pipe. Spillage reduces the productivity of the cutter suction dredger and therefore needs to be minimised. To work efficiently, a balance has to be found between the cutter speed and the pump capacity to optimise the particle size of the rock dredged and reduce spillage.

WHICH CUTTER HEAD IS SUITABLE FOR WHICH TYPE OF SOIL?

Different cutter heads are designed for different types of soil, for instance, hard soil, non-cohesive or cohesive soils have different requirements:

- For hard soil, a cutter head should be used that can withstand impact forces on its teeth. It should be heavy but have a small contour with replaceable teeth so that it can withstand extreme wear on both the cutter head itself and on the teeth. Often more teeth (or chisels) are used for hard soil and good, accurate tooth positions are necessary.
- For non-cohesive soil it should be possible to achieve high production rates. A good mixture formation with replaceable chisels or cutting edges will be able to withstand wear. Here as well, good, accurate tooth positions are needed.
- And, for cohesive soil, a primary concern is that the cutter head does not become blocked. For this reason, the cutter head should be round in contour and large enough. It may require fewer blades with different types of edges (e.g., plain, adapter, toothed or serrated) on multiple smaller teeth.

WHAT INFLUENCES A CSD'S PRODUCTION RATE?

The desired production rate of a CSD will determine the design, size and type of soil the vessel can dredge. CSDs have a high accuracy and a continuous rate of production whether they are standard vessels or custom-made, whether they are being used for dredging rock or sand and gravel, or for construction and reclamation works or environmental dredging. The production capacity designed is directly related to the hardness of the material that the CSD is going to dredge.

Also when designing a CSD, the maximum and the minimum dredging depths must be considered since these influence the viability of the dredger. Often the need for a greater dredging depth leads to a pontoon with deeper draught and thus to a reduction in the minimum dredging depth. And obviously when dredging at minimum depths, the dredger or the pontoon must have sufficient clearance. When dredging in shallow waters, the ladder may also need to be adapted.

Other factors influencing the production rate, besides the type of soil being dredged, include the minimum and maximum width of the cut. This will influence the installed cutter head side winch power, the strength of the ladder, the spuds and the pontoon. Also the type of CSD used is dependent on the accessibility of the work site by water. In some cases only a smaller CSD will be able to reach a site.

WHAT IS A SPUD POLE?

CSDs are always stationary when they are working – even if they are self-propelled. To lock the vessel into a stationary position, a CSD generally has two spud poles. One spud pole (the auxiliary spud) passes straight through the vessel, whilst the other, the working spud, is mounted on a movable spud carriage, which can be moved lengthwise along the vessel or

CSDs can discharge dredged material either via a floating pipeline to shore (above) or by discharging it into a barge with a special loading system (below).

Dredging in hard soils causes wear and tear so that cutter teeth need to be replaced regularly.

pontoon. Steel cables are used to move the ladder or cutter head from side to side, with the spud in the spud carriage as the centre of each concentric circle that it describes.

Although the vessel is stationary, moving the spud carriage causes the dredger to move. This is known as 'stepping'. In this way, the CSD describes an arc round a fixed point – the spud pole or working pole – and the radius of the arc is increased by 'stepping' ahead with the spud carrier. In many CSDs this pole is mounted on a movable carriage, the spud carriage. A second pole, the auxiliary spud, is set out of the centreline, usually on the starboard side of the stern of the pontoon. This auxiliary spud is used to keep the vessel in position, when the working spud is raised, and the spud carrier is moved back to its initial position. Since spuds are literally dropped into the soil, they have pointed ends to make sure that they penetrate the soil deeply enough to be secure. They are hoisted out of the seabed and that requires specialised hoisting wires and systems.

HOW DO CSDS OFFLOAD OR DISCHARGE DREDGED MATERIAL?

When the material is loosened or pulverised, it is then sucked up and transported through a pipeline by centrifugal dredge pumps. A suction inlet located beneath the cutter head (known as the suction mouth) is connected by a suction tube directly to one or more centrifugal pumps. The vacuum force at the suction inlet sucks up the loosened material. The CSD will discharge the dredged material to the disposal site either via a floating pipeline to shore or by discharging it into a barge with a special loading system. The choice of which to do depends on the distance that the dredged material has to go to the disposal site and what is more economical. If the distances are too great, barges may be more cost-efficient than hydraulic pipelines.

HOW BIG ARE CSDS?

CSDs come in a variety of sizes and types with a total installed power ranging from 200 kW on the smallest dredgers to some 30,000 kW for the largest. The dredging depth depends on the size of the dredger. Smaller ones can dredge in less than 2 metres depth, whilst some of the biggest CSDs can reach depths of more than 35 metres. The minimum dredging depth is usually determined by the draught of the pontoon.

Both large and small CSDs are important parts of the dredging fleets of the major dredging companies. For instance, medium-powered dredgers fall in the 10,000-15,000 kW power range but are often not self-propelled. Recently, a number of very large CSDs have been built – some measuring 130 metres long – with some of the largest having a total installed power of 24,000 to 28,200 kW. Amongst these state-of-the-art CSDs some are fully diesel-electric powered dredgers. They have uninterrupted power supply units (UPS) to feed the vessel's computers and essential navigation/nautical equipment.

WHAT ARE THE DISADVANTAGES OF A CSD?

In general, the larger, most modern CSDs are generally self-propelled and can be mobilised over long distances to a project. They can also be easily relocated during the project. However, as said above, when at work the CSD is stationary with at least two side anchors that are necessary for the dredging process. Because of these anchors they may obstruct shipping movement in a harbour or access channel. Therefore, since even self-propelling CSDs operate in "quasi-stationary" mode, they are particularly vulnerable when working in shipping channel. They are also sensitive to wave conditions and rough seas. When working under offshore conditions with waves or swell, they clearly have more limitations than trailing suction hopper dredgers even if equipped with swell compensators. Smaller cutters are limited as to their dredging depths.

WHAT ARE THE ADVANTAGES OF A CSD?

The primary advantage of a CSD is that it is able to dredge hard materials that most trailing suction hopper dredgers cannot handle. In addition, self-propelled CSDs are almost as flexible as a trailing suction hopper dredger, because they too can use their propulsion systems during mobilisation to a dredging site. This makes them cost-effective. In addition, they can be moved from one place to the other in the channels or when the dredging area has to be left, for instance, when inclement weather is expected.

Although stationary CSDs cannot do this, small to medium sized stationary CSDs can often be supplied in a demountable form. This makes them suitable for transport by road to inland sites that are not accessible by water, for example, to lay a sand foundation for a road or to dredge sand and gravel for the building industry.

WHAT SAFETY FACTORS SHOULD BE CONSIDERED?

Nowadays safety and sustainability are considered part and parcel of every seagoing vessel and CSDs are no exception. The newest CSDs take advantage of the high-tech possibilities to insure technical and constructional features that comply with the highest standards. For instance, because of the type of work they do – breaking hard rock and soils – CSDs are known for their high sound and vibration levels. The intensity of sounds varies depending on the amount or hardness of the material to be removed. To ensure that the crews have comfortable working environment and living quarters, new ships have better insulated living areas.

WHEN IS A CSD THE APPROPRIATE CHOICE FOR DREDGING?

CSDs are largely used in the dredging of harbours and fairways as well as for land reclamation projects when harder material needs to be dredged. They are also used when the distance between the dredging and disposal areas is shorter than the distances covered by trailing suction hopper dredgers. CSDs also have the advantage when an accurate profile has to be dredged. CSDs can dredge almost all types of soil if the installed cutting power of the cutter head is appropriate. Because of the availability and versatility of a wide range of large and small cutter suction dredgers, the most diverse projects can be tackled.

FOR FURTHER READING AND INFORMATION

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