FACTS ABOUT
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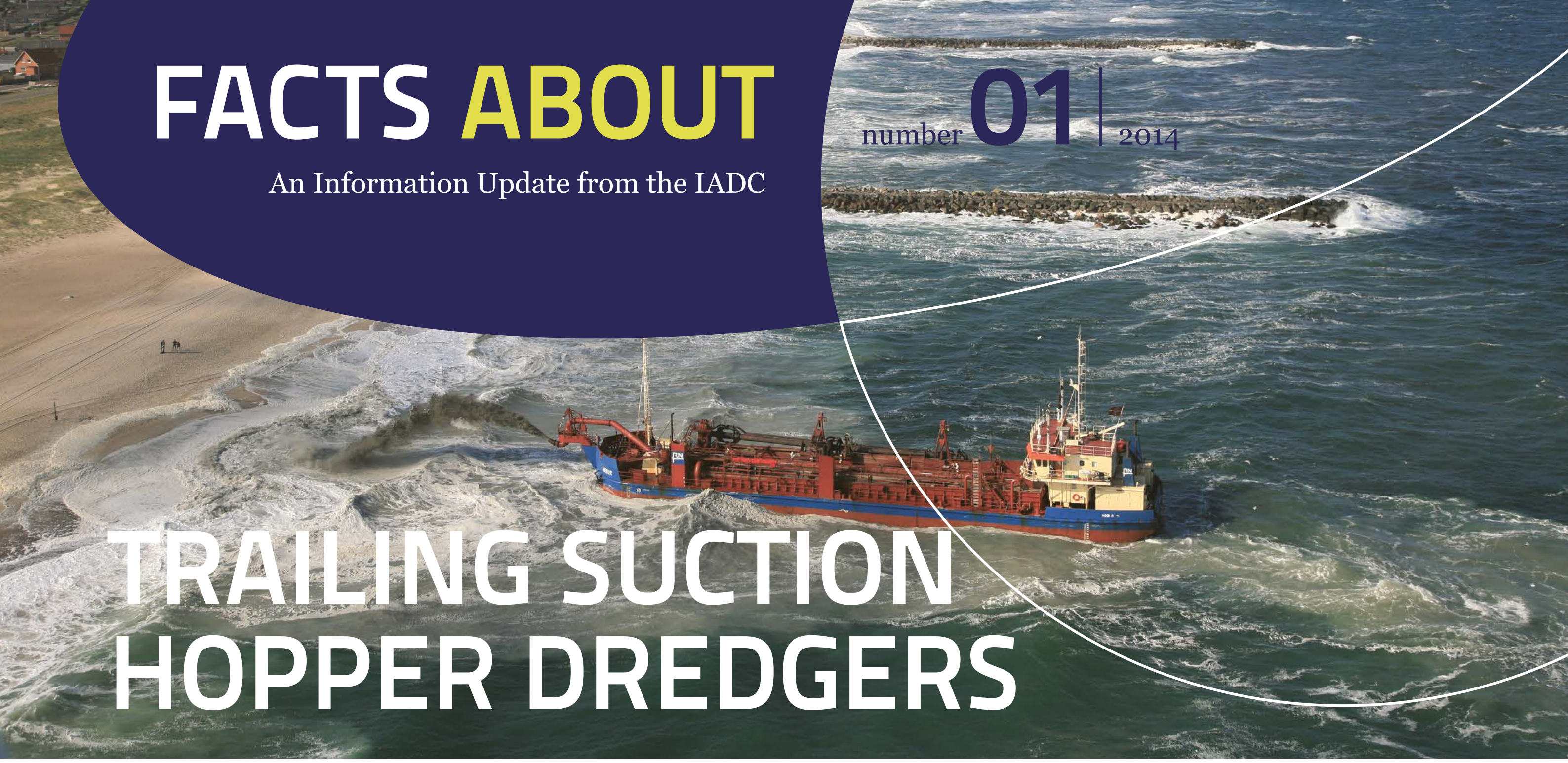


TRAILING SUCTION HOPPER DREDGERS

WHAT IS A TRAILING SUCTION HOPPER 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. Trailing suction hopper dredgers (TSHDs) are classified as hydraulic 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.

WHEN ARE TSHDS USED?

TSHDs are used on a wide variety of maritime construction and maintenance projects. These range from maintenance dredging of ports and access channels to remove sand to bring them to necessary depths to capital dredging projects such as giant land reclamation projects that require millions of cubic metres of sand. The performance efficiency of a TSHD has a direct influence on the costs of a project. Consequently, research and development on TSHDs is an ongoing endeavour to improve cost-effectiveness.

WHAT CHARACTERISES A TSHD?

TSHDs or hoppers are self-propelled ships that contain a hopper or hold inside their hulls. They are primarily used for dredging loose material such as sand, clay or gravel. The main features of a TSHD are drag heads, suction pipes, swell compensators and gantries. Typically a TSHD is equipped with one or two suction pipes to which the drag heads are attached. A drag head is often compared to a giant vacuum cleaner. The suction pipes are lowered underwater and the drag heads are “dragged” over the seabed, sucking up material as the ship slowly moves forward, i.e., trails.

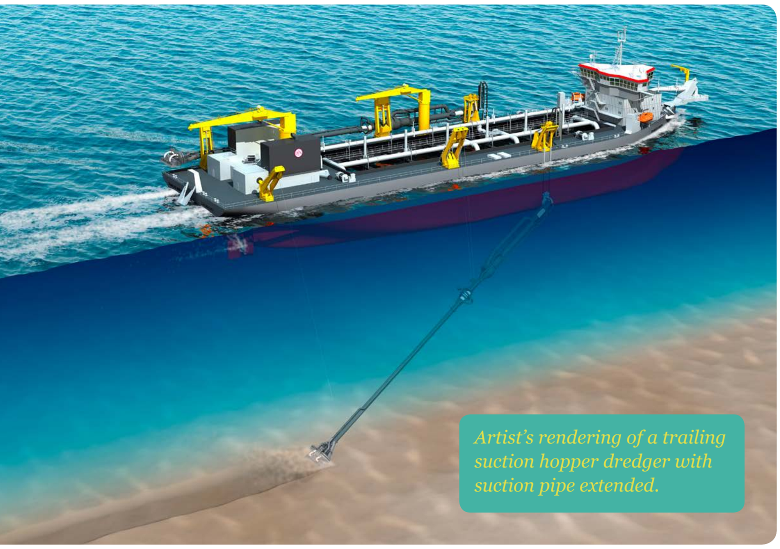
The suction pipes and drag heads can be positioned according to the performance needs of the intended dredging operation so that they can be transported to the hopper. Through a pump system the sand/water mixture, called slurry, is drawn upwards to the hopper or hold of the vessel. Gantries and winches operate the suction pipes, moving them either overboard or bringing them back inboard. A swell compensator is used to control the contact between the drag head and the seabed when dredging in waves. In addition, the TSHD must have an overflow system to separate the slurry and discharge excess water. The efficiency of each of these elements will have a direct effect on the productivity of the TSHD.

WHAT TYPES OF DRAG HEADS ARE AVAILABLE?

Although all TSHDs have drag heads attached to suction pipes, drag heads can differ. The job of the drag head is to excavate the seabed material and to mix this material with water to create slurry. The drag head is the first ‘touchdown’ place for contact with the soil. In general, the force that makes the points of the drag head penetrate into the soil is the weight of the drag head and the suction pipe. When dredging hard soils, however, if this weight is not sufficient, the drag head will not penetrate enough and will drag on top of the surface without cutting the soil. This results in a low mixture density which lowers the production of the hopper dredger. The higher the density of the mixture created by the drag head, the better the performance.

Continuing research has resulted in the development of drag heads that excavate with high pressure water jets assisted by teeth. They loosen the material and increase the productivity to form the slurry. To improve the efficiency of the water jets, sometimes the nozzle is integrated into the points of the drag head so that the water jets cut the soil moments before the point penetrates the soil. As a result the forces needed to penetrate the soil are reduced, and the cutting efficiency is increased. The suction power of the pump then captures the seabed material and allows the slurry to be transported hydraulically. The sediment is hydraulically transported through suction lines by the centrifugal pump

Above: Trailing suction hopper dredgers (TSHDs) are flexible and can work in shallow waters even during heavy seas.



Artist's rendering of a trailing suction hopper dredger with suction pipe extended.

into the hopper. There the solids settle out and are held awaiting transport and subsequent placement.

WHAT IS A RIPPER DRAG HEAD?

A more recently developed drag head is "the ripper ", a drag head with teeth. Usually rock is dredged by a cutter suction dredger (CSD), equipped with a special head that bores through hard material. But when sea conditions are rough, or a waterway has high vessel traffic, a cutter is not suitable. A ripper drag head can be placed on a traditional TSHD, and combines cutting power of a CSD with the flexibility and stability of a TSHD.

WHAT DOES A SUCTION PIPE DO?

Suction pipes perform several important tasks. They are the conduit through which the slurry is transported to the hopper. In addition, the suction pipe, directed by the dredge master, controls the movement of the drag head on the seabed. By directing the trailing force from the drag head to the vessel, the suction pipe ensures that good contact is maintained between the drag head and the seabed. Working with swell compensators, the optimal height of the drag head in relation to the seabed can be regulated. If the drag head is too high it create a mixture with too much water, but if it is too deep or its weight is pressing down too much it will create too much trailing force. The suction pipe and swell compensators compensate for the vertical motion of the ship as well as the possible irregularities of the seabed and help maintain the proper balance for the position of the drag head in relation to the seabed. The dredge master is actually able to see and adjust all these actions via sophisticated instrumentation. Done correctly, this will clearly improve performance.

WHAT IS AN OVERFLOW SYSTEM?

The slurry that is dredged by a TSHD is a mixture of water and solids, such as sand. Since the ultimate purpose of the TSHD is to collect sand for reuse elsewhere or disposal somewhere, a TSHD must have a system which maximises the retention of these solid dredged materials and minimises the water that stays in the hopper. The extra water must be separated and released overboard. The solid, sandy part of the slurry will sink to the bottom of the hopper, but it needs time for this process to take place. An overflow system provides the means to separate the solids and the water by reducing the turbulence of the slurry mixture and allowing sufficient time for the solid part (sand, gravel) to settle to the bottom. Then the water separates out and this overflow is drained overboard.

HOW DO TSHDS OFFLOAD OR DISCHARGE DREDGED MATERIAL?

TSHDs are very flexible and can operate independently of other equipment and, since they are self-propelled, are able to transport the dredged material over long distances. Once fully loaded, the vessel sails to the unloading or placement site where the dredged material is offloaded. Depending on the type of project, the dredged material will be offloaded/discharged in one of three ways:

- material is either deposited at the placement site by opening the hatches in the bottom of the ship;
- it may be pumped ashore through pipelines, which may be submerged or floating; or
- the material may be propelled by heavy duty pumps into the air, a process known as rainbowing.

The method of offloading or discharging is directly related to the type of project.

WHEN TO DISCHARGE THROUGH BOTTOM DOORS?

When material is dredged out of a harbour or access channel and the material is clean, the TSHD will sail out to sea to a designated location and deposit the dredged sediment by opening its bottom doors (hatches). Discharging through bottom doors allows quick, direct and total offloading of dredged material at a selected location. This is a reliable and effective method, but only in certain specific circumstances.

WHEN TO DISCHARGE THROUGH A PIPELINE?

During large land reclamation or beach nourishment projects, the TSHD will navigate to a selected borrow area, which may be many kilometres away from the construction site. At the borrow site the dredger will load up its hopper with sand and then sail to the site where new land is being built. This material is then either rainbowed into place or pumped on site through floating or submerged pipelines. To connect the pipeline to the vessel requires a special link known as the bow coupling. If the distance from ship to shore is rather long, then booster pumps as an extra source of power can be added along the pipeline. The nozzle for rainbowing is also a part of the bow coupling.

A submerged pipeline is less sensitive to weather conditions, and provides no obstacle to other ships that may be crossing in the area. It is usually assembled on shore and then pulled out until the open end is positioned correctly on the beach. Sections may be added if necessary. Floating pipelines, although more sensitive to rough seas, have the advantage that they are visible above the surface of the water and can be reached easily if in need of repair.

WHAT IS RAINBOWING?

Rainbowing is the name given to the technique by which a TSHD pumps the sand that has been claimed from the seabed in a high arc placing it at the reclamation site. These locations can vary from a beach which is being shored up to prevent erosion for coastal protection or recreation (or both) to a reclamation site where new land or islands are being built for port expansion, recreation or multiple other purposes.

To begin with, the TSHD creates a so-called slurry mixture, which because of its liquid qualities, can be forced as a projectile through the air in an arc onto the beach or released into the deposit area. Rainbowing is often the best method for discharging huge quantities of sand in shallow locations close to shore, for land reclamation projects or beach replenishment. Since rainbowing does not require floating or submerged pipelines, boosters or landlines, it is often the most economical method.

WHAT FACTORS INFLUENCE A TSHD WHEN RAINBOWING?

Many factors influence the productivity of a TSHD when rainbowing, but especially the characteristics of the nozzle should be considered. To start, consider the vertical angle of the nozzle. A decade ago a 45° angle was typical. Nowadays, the vertical angle of a nozzle is 30° because research demonstrated that this was the most efficient angle to project slurry over a long distance. At this angle less backflow to the dredger is created and the craters that form in the fill area are smaller.

The diameter of the nozzle is also of utmost importance. The smaller the diameter, the lower the flow, making the production output lower, but because the exit velocity is higher, sand can be projected over a greater distance. Take the modern jumbo trailers: Although the discharge time increases by about 30 percent, they can rainbow and reach distances of 150 metres. Still these jumbos can work at peak rates of 25,000 m3 per hour to start. Recently, TSHDs have been overcoming the production rate vs. distance challenge by being equipped with two nozzles working together to maximise output.

Another important factor is the height of the rainbow nozzle in relation to the waterline. The shape of the nozzle is also significant, with the more state-of-the-art nozzles resulting in better flow and a higher exit velocity of the sand, which means more efficient production rates.

WHEN IS RAINBOWING APPROPRIATE?

In order to rainbow, the loaded draught of the trailer must be such that the vessel can be brought close to the rainbow site. This shallow draught may limit where the ship can sail to reach the borrow area. Usually this can be compensated by spraying huge quantities of sand in the first few minutes alleviating the forward draught, so the ship can then push closer to the beach. Beaching the ship is an option but this may compromise the hull over time and the bow must be reinforced.

HOW BIG IS A TSHD?

TSHDs vary widely in size. Their size is expressed in the hopper volume capacity, length and pump power. They can range from between a few hundred m3 up to 45,000+ m3. Recently several international dredging companies have commissioned some very large TSHDS. For instance, one of the largest in the world has a hopper capacity of 46,000 m^3, a deadweight of 78,500 tonne and is approximately 223.0 m long, with a loaded draught 15.15 m. She has a maximum dredging depth of 155 m with suction pipes having a diameter of 1,300 mm. Her trailing pump power is 2 x 6,500 kW, a discharging pump power of 16,000 kW and a propulsion power 2 x 19,200 kW. Her total installed diesel power is 41,650 kW and she can sail at a speed of 18.0 knots.

A TSHD rainbowing with two nozzles to maximise output.

In contrast, one of the smallest TSHDs has a hopper capacity of only 3,400 m^3, a deadweight of 4,800 tonne with a length of only 93.3 m and a loaded draught of 5.0 m. Her maximum dredging depth is 26.5 m with a suction pipe diameter of 800 mm, a trailing pump power of 1,250 kW and a power when pumping ashore of 2,000 kW, and a propulsion power 2 x 1,000 kW. Its total installed diesel power is 4,100 kW and she has a speed of 11.5 knots.

WHAT ARE THE ADVANTAGES OF TSHDS?

TSHDs can be deployed for a great number of operations, because they are amongst the most flexible dredging plant available. This flexibility is evident in the types of material they can dredge, where this material can be placed and where they can work. For instance, they can dredge sands, clays, silt or gravel, and nowadays even some kinds of rock. They can work in calm, protected waters or more turbulent waters such as at entrance channels or far out to sea where weather and waves may be more active. Unlike stationary vessels, TSHDs can work in busy harbours because they are have no anchors or cables and are self-propelled so they can move about freely. In addition, they can work at very great depths or in shallow areas. The larger vessels have the economic advantage of being able to dredge materials in borrow sites at a great distance from the reclamation area. They have relatively high production rates although these can vary depending on the type of material, the depth of the seabed and weather conditions.

HOW ACCURATE IS A TSHD?

TSHDS are not especially accurate and therefore are not particularly suited to removing thin layers of (contaminated) sediment. But because a TSHD is basically scratching the seabed horizontally and not digging into it, only limited quantities of soil are loosened. The spill residual is generally small and although water is added during the suction stage of the operation, nowadays this too can be limited and monitored.

WHAT ARE ENVIRONMENTAL CONCERNS WHEN USING A TSHD?

A number of environmental concerns should be mentioned when using a TSHD. Given the difficulty of regulating a suction pipe, accuracy can be challenging and needs to be scrutinised by high-tech monitoring and steering equipment. Although working with a TSHD creates limited suspended sediments and turbidity compared to cutter suction dredgers, it can occur when loading takes place with an overflow of excess water containing fines. This creates a plume of fine-grained elements causing an increase in suspended sediments in the water column at the dredging site and an increase in turbidity or reduction of the light penetration through the water column may occur. Because this can have a negative impact on the benthic life, this turbidity must be carefully monitored. Nowadays, turbidity can be reduced with a number of new technologies such as using green valves, recycling (part of) overflow water, overflow with a bottom exit, or reducing the overflow.

WHAT SAFETY FACTORS ARE CONSIDERED?

In all dredging projects, the safety of the crew must be assured in all aspects of their jobs. However, special attention is spent when crew members come in contact with dredged material. If the material has particularly high gas content, certain de-gassing procedures may need to be followed as a precaution. In addition, the TSHD is required by international maritime laws to meet certain standards of strength and stability. The strength of the vessel has to meet criteria based on its loading according to the allowed draught in flat water as well as in water with waves. The stability of a seagoing vessel, which a TSHD is, is also stipulated as the ability of the ship to return to equilibrium when affected by outside forces like winds and waves.

IS SOUND A FACTOR WITH A TSHD?

The TSHD is equipped with powerful engines generating significant sound levels. For those in close proximity to the TSHD, the sound levels can be expected to be high. However, a few hundred metres away from the vessel, the sound is quite a bit less and generally reduced to acceptable levels. Since TSHDs are often working at great distances from populated areas this is not often an issue for people.

Underwater sound is a separate concern and the effects of machine-made sound on marine life have recently been the subject of considerable study. Acoustic modelling and measuring has helped to monitor sound and make appropriate adjustments. In general, TSHDs generate less sound than some other types of dredgers and vessels.

WHEN IS A TSHD THE APPROPRIATE CHOICE FOR A DREDGING PROJECT?

Each project must be evaluated on its merits and the decision about what equipment to deploy will be based on the type and quantity of the material to be dredged as well as a where the borrow area and the reclamation area are located. Nowadays the larger international dredging companies often order custom-designed TSHDs which suit specific dredging requirements. Vessels are completely computerised and often a minimum of crew are needed because the dredging process can be regulated from the bridge.

Because TSHDs are self-propelled, seaworthy vessels they are ideal to be used in major land reclamation projects where enormous quantities of fill are needed and suitable sand must be brought in from distant borrow areas. This self-sufficiency allows them to dredge the material and discharge it where it is needed without any other support equipment. This also means they can be used in busy ports where shipping traffic is an issue. For the same reason, they can be mobilised efficiently to any part of the world and get there under their own steam. All these qualities add up to a highly cost efficient piece of dredging equipment.

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Facts About is presented by the International Association of Dredging Companies whose members offer the highest quality and professionalism in dredging and maritime construction. This information is part of an on-going effort to support clients and others in understanding the fundamental principles of dredging and maritime construction.

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