TRENDS IN DESIGN OF TRAILING SUCTION HOPPER DREDGES; BROWN OR BLUE OCEANS?

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ABSTRACT

In the last decade an enormous increase in scale of trailing suction hopper dredges was used to lower the cost of large dredging projects. Also in the 80’s a large increase in scale can be recognized. It lasted more than 15 years before the next steps were taken. Has this trend of scaling come to an end or not and what will be the new focus?

One major trend is a strong focus on environmental aspects, but there is also focus on lower investment costs and even lower operational costs. Is this a contradictio in terminis or are there opportunities? Is it still possible to find new solutions that create blue oceans?

The design of trailing suction hopper dredges is mostly determined by the investment costs and the operational costs of a vessel. There is a wide spread in philosophies on what is the best design. Dredge Technology Corporation (DTC) / Royal IHC (IHC) as a specialist in designing and building dredge equipment deals with all these different opinions.

Basis for any design is the definition of the mission profile, the types of dredging works and the conditions the vessel will work in. Any good design matches those requirements and delivers optimal performance in varying conditions. New calculation and simulations techniques are available to analyze different designs on aspects like dredging performance, fuel costs and dynamic behavior. Such tools are essential to make the best design for the defined purpose and optimize it for the variety of conditions the vessel will be working in. Besides technical issues also economic and financial considerations need to be taken into account to find an optimal balanced design.

Based on this knowledge DTC / IHC designed a series of designs of modularized dredges. Two series of standardized trailing suction hopper dredges have been developed. The first vessel in the Easydredge series is now being built and will be available ‘from stock’, leading to much shorter delivery times. Because these designs are very suitable and cost effective, these vessels can also be built for the US market.

This paper will present developments in the designs of trailing suction hopper dredges and illustrate this with concrete examples on standard designs and recently built vessels. The paper will also address possibilities for fuel cost reduction and the use of LNG as alternative fuel.

Keywords: Dredging, fuel efficiency, design optimization, design trends, standardization

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INTRODUCTION

Looking at the development of trailing suction hopper dredges an enormous increase in scale has been seen in the last decades. Large Jumbo and Mega hopper dredges were developed for the major land reclamation projects in Singapore and the Middle East. The increase in scale of trailing suction hopper dredges was used to lower the cost price per cubic yard dredge material, enabling the construction of huge land reclamation and making it an economic viable option. Because the US national dredge market has by average different type of dredge projects compared to the global market (far more land reclamation projects), the maximum size of new built dredges is approached in a different way. From an economic point of view (new) dredges have to work at least 35 to 40 weeks per year. This makes it very hard to invest in specialized (or very large dredges) only for the US market. In the US market almost 70% of the fleet is relatively old (> 30 years), as shown in figure 1.

![Fleet of hopper dredges in the US](image)

**Figure 1. Age of US fleet.**

The largest vessel in the US is the Ellis Island of Great Lakes Dredge & Dock Company with a hopper capacity of approx. 15,000 cyd (11,500 m³), currently under construction at Eastern Shipbuilding Group. Outside the US more than 60 hopper dredges with a capacity of more than 15,000 cyd (11,500 m³) have been built as shown in figure 2.

![Hopper capacity built in the US and Worldwide](image)

**Figure 2. Size of US fleet versus world fleet.**
Trailing suction hopper dredges are not only used for land reclamation dredging but also play an important role in the execution of all sorts of dredging projects. It is a vital piece of equipment in harbor development and deepening, maintenance dredging, reservoir dredging, canal and river deepening and maintenance, marine aggregate dredging and coastal protection projects. Trailing suction hopper dredges come in all sizes to fulfil their specific tasks in such projects. Small and maneuverable vessels are used for maintenance of harbors and waterways. Sand and gravel hoppers are used for marine aggregate dredging. The fast mobilization possibilities of a trailing suction hopper dredge makes it a versatile and agile piece of equipment.

Looking at the national US dredging market new trends are becoming dominant, putting their mark on the design of trailing suction hopper dredges. Sustainability is becoming an essential precondition in dredging operations and this will have its effect on the cost price per cubic yard. The dredging industry is facing stricter regulations and legislations on exhaust gas emissions and turbidity. Also legislation on underwater sound emission is likely to be expected in the coming years. Strict regulations on SOx and NOx emissions is already into place and further restrictions are expected in the future (figure 3). USA is leading the world by being one of the first to have implemented Emission Control Areas and Tier 3 emission regulations. IMO is preparing the Energy Efficiency Design Index (EEDI) defining steps in the reduction of CO2 emissions. These developments ask for cleaner engines and will require costly measures for the after treatment of exhaust gas. New types of drive systems and new fuel systems will emerge, for example with the use of LNG for powering trailing suction hopper dredges.

These trends have their impact on the design of trailing suction hopper dredges. Designing a trailing suction hopper dredge is a very complex process in which many different requirements have to be balanced and operational, economic and technical considerations have to be made. The outcome of this process strongly determines the competitive and economical value of a dredge, expressed in parameters like cost per cubic yard, cost of ownership, etc. As a developer and builder of dredging equipment Dredge Technology Corporation (DTC) / Royal IHC (IHC) has many years of experience in designing trailing suction hopper dredges. DTC / IHC is continuously investing in extensive research and development programs in order to prepare for upcoming challenges and to be able improve the performance and cost effectiveness of trailing suction hopper dredges.

This paper will address new developments in the design of trailing suction hopper dredges. Recently delivered vessels will illustrate the state of the art in trailing suction hopper dredge design. The advances in DTC's / IHC's research on fuel cost reduction and the application of LNG will be described. The paper will also zoom in on the development of a new series of standardized off-the-shelf trailing suction hopper dredges, the Easydredge series.
DESIGNING TRAILING SUCTION HOPPER DREDGES

The design process of a trailing suction hopper dredge usually starts with a definition of the mission profile of the vessel. What are the types and sizes of work that the vessel should be able to carry out? At which locations will the vessel be working and what are the water depths and ambient conditions? What are the soil conditions at those locations and how should the vessel be able to handle these soils? With such questions a mission profile can be defined, which is the basis to define specific characteristics of the vessel, like hopper volume, draught, dredging depth, speed, etc.

Based on this information the design process of a new vessel can start. When designing a new trailing suction hopper dredge many different requirements have to be balanced. A trailing suction hopper dredge is a complex, integrated system with many different disciplines involved (figure 4). Hydro mechanical expertise is needed to define the hull shape and optimize it for sailing in shallow water. The hull resistance defines the propulsion power needed to propel the vessel with the required speed. Hydro mechanical expertise is also needed to determine the (damage) stability of the vessel. Ship design expertise is needed to construct a robust hull structure accommodating the hopper and all relevant equipment that is needed to fulfil different functions. Dredging specialism is needed to select the right dredge pump, draghead and other dredge components. Mechanical engineering expertise is needed to define the energy supply system and power distribution to propellers, dredge pumps and other main components. Control and automation expertise is needed to couple the different systems and make them work as one integral system. Even ergonomic expertise is needed to make sure the vessel can be operated safely and the operator gets essential information presented in a clear and logical way.

Figure 4. A complex integrated system with many subsystems and components.
During the design process of a new trailing suction hopper dredge important design choices have to be made. Each choice will have its influence on the performance and cost price of the vessel, so it is a delicate process to balance all the different requirements. Important design choices are for example:

- type of drive trains (direct driven, diesel-electric, hybrid)
- number of diesel engines
- type of propulsion (fixed pitch propeller or controllable pitch propeller)
- number of dredge pumps
- jet pressure and jet flow
- bottom doors or conical valves
- type of draghead and draghead control
- level of automation

The outcome of the design process strongly determines the performance of a trailing suction hopper dredge. The performance of a vessel is usually defined by parameters like cycle production, loading times, unloading times, suction production, utilization, etc. During a design process the performance is continuously balanced with the costs of providing certain functionality and performance. A very important key performance indicator is cost per cubic yard dredged material, relating production rate to cost price. Another important key performance indicator is the fuel consumption per cubic yard dredged material, indicating the amount of fuel that is needed to realize a certain production. Such key performance indicators are essential to compare different designs in order to make the right choices and deliver the most optimal design.

**STATE OF THE ART TRAILING SUCTION HOPPER DREDGES**

DTC / IHC has many years of experience in designing and building trailing suction hopper dredges. The knowledge and expertise is developing continuously and the designs of trailing suction hopper dredges are evolving over time. To illustrate the state of the art in trailing suction hopper dredge design some of the latest vessels are described.

**DCI DREDGE XIX, XX and XXI**

Recently DTC / IHC has built 3 identical 7,200 cyd (5,500 m³) trailing suction hopper dredges for the Dredging Corporation of India (DCI). The vessels are designed as general purpose trailing suction hopper dredges and can be deployed for maintenance of the harbours that DCI is responsible for. The vessels have been optimized for dredging in the Hoogly River, the main entrance to the port of Kolkata. The Hoogly River is known for its large tidal differences, its shallow water and strong currents, sometimes reaching current speeds of seven knots. In order to maintain enough groundspeed in such high current velocities the vessels have two large diesel engines installed with a total installed power of 9,294 kW. The sailing speed of a loaded vessel is 14.1 knots. When designing the hull shape special attention has been paid to the performance in shallow water, leading to an optimized bulbous bow design (figure 5) and a modern twin gondola aft ship shape. This results in low resistance of the vessel and incurred high bow waves are avoided, as shown in figure 6. The optimized hull shape has a combined low draught and a high block coefficient in order to maximize the hopper volume within the boundaries of the hull dimensions.
The vessels are propelled with two controllable pitch propellers in fixed nozzles and are equipped with twin fishtail-type rudders for optimal maneuverability. The vessels are equipped with two suction pipes reaching a maximum dredging depth of 82 feet (25 m). The suction tubes can also be converted to stationary suction pipes. The bow thrusters and jet pumps are driven electrically with controlled variable frequency drives. A modern dredging control and automation system is installed and the SCADA interface can be operated with touchscreen interfaces.

Figure 5. Optimized bulbous bow.

Figure 6. Low hull waves due to optimized hull shape.
ALBATROS

The Dutch company Baggerbedrijf De Boer operates a fleet of trailing suction hopper dredges varying from small trailing suction hopper dredges with hopper volumes around 650 cyd (500 m$^3$) up to middle sized trailing suction hopper dredges with hopper volumes around 5,200 cyd (4,000 m$^3$). Baggerbedrijf De Boer is a professional player in the market, mainly focusing on maintenance dredging works. Recently IHC has delivered the 2,000 cyd (1,500 m$^3$) trailing suction hopper dredge ALBATROS to Baggerbedrijf De Boer. The ALBATROS is a twin-screw trailing suction hopper dredge with one suction tube and a IHC single-walled dredge pump installed. The maximum dredging depth of the vessel is 98 feet (30 m). The vessel is especially designed for shallow draught and as well as an extremely low air draught (the profile above the waterline). The low air draught is not only realized by its low profile, but also by a wheelhouse that can be lowered and a tiltable deck crane and mast. The extremely low air draught enables the dredge to pass bridges without delay, providing quick access to dredging areas further inland that can normally not be reached with larger trailing suction hopper dredges.

The vessel was built in Eastern Europe under strict supervision of representatives of Baggerbedrijf De Boer and IHC. The design objective was to minimize the investment by keeping things as simple as possible, while striving for maximum performance. This resulted in some principle design choices like:

- fulfilling specified functionality with as few components as possible and thereby reducing investment costs and maintenance time/costs
- installing components that are easily understandable and maintainable by dredge operators and board engineers
- reducing energy conversions and thereby increase efficiency
- operating the vessel with a small complement of crew

These design choices led to a straightforward and competitive design. For example all major energy users, like propulsion, dredge pump, jet pump and bow thrusters, are driven directly by their own diesel engine. This results in a total installed power of approx. 3,500 kW. The vessel is equipped with a modern control and automation system.
FUEL SAVING OPPORTUNITIES FOR TRAILING SUCTION HOPPER DREDGES

Fuel costs are a significant part of the total operational costs that a dredging company is facing when operating a dredge. Despite the fluctuations in oil price, reducing fuel consumption is always a focus point for dredging contractors. Operating fuel efficient is essential to stay competitive in the market and operate in a more environmental friendly way.

Exploring the possibilities of fuel reduction starts with thorough insight in the operational profile. Trailing suction hopper dredges have a specific operational profile which is different from many other vessels, as described in [Boer, 2013]. During dredging a trailing suction hopper dredge does require high propulsion power at low speed, but also high propulsion power at high speed when sailing. Depending on the dredge project a trailing suction hopper dredge is working on, sailing distances will vary, soil characteristics will vary, the dredge might discharge via the bottom doors or via the discharge pipe and there might be restrictions on maximum sailing speeds. All these conditions and restrictions will have their influence the operational profile of the trailing suction hopper dredge.

The operational profile is a result of the dredging cycle. Every trailing suction hopper dredge runs a cycle of sailing, dredging, sailing and discharging. During this cycle for example the ship speeds varies. The vessel has low speed during dredging and discharging activities and high speed during sailing. An example of measured speed variation during an dredging cycle can be seen in figure 9. The speed and the amount of time that the vessel is sailing at a certain speed depends on the location of the dredging project and the type of dredging cycle. But also other preconditions, like for example speed restrictions, will have their influence on the sailing speed of the vessel and thus the operational profile.
The variations in sailing speed will influence the level of power being used. When sailing at full speed a high power level is needed, but when sailing at lower speed only partial power will be needed. The amount of time that a certain power level is needed can be plotted, the so-called operational profile. An example of a measure operational profile is shown in figure 10 (not matching to speed profile in figure 9). The figure shows the deviation in power levels (from 0 to 100%) and the amount of time that a certain power level is used. From this particular figure, based on a particular measurement, it can be concluded that the maximum propulsion power is only used for a small amount of time and the propulsion drive is operated most of the time on a partial power level.

![Figure 9. Variation in sailing speed during a dredge cycle.](image)

![Figure 10. Example of a measured operational profile of propulsion power (source [Boer, 2013]).](image)

In the past years IHC has carried out many measurements on operational profiles. Operational profiles were measured on different vessels, working on different projects and in different conditions. Although operational profiles vary case by case, in general it can be stated that there is a gap between the maximum design point and the average operational point. This insight provides the basis for fuel saving opportunities. Knowing that a certain drive train is operating on partial power level provides several opportunities for fuel saving, like:

- actively controlling the speed of a drive train
- temporarily shutting down of engines
- using energy storage systems
- alternative drive train options
Especially in the design phase of a new trailing suction hopper dredge the insight provided by an operational profile is very valuable. For example the choice between a Controllable Pitch Propeller (CPP) propulsion or a Fixed Pitch Propeller (FPP) propulsion is an important one. Or the choice between integrated drive trains or separate drive trains (figure 11). Such design choices have large influence on the total vessel design. These choice can be based on required functionality and cost price, but they can also be based on the expected fuel consumption. Knowing the gap between average and maximum propulsion power, other choices might be made when fuel consumption is considered as one of the major design criteria.

![Alternative drive train designs.](image)

As research continues it becomes clear that there is no single answer to the question: 'What is the most optimal drive train?' No dredge project is the same, soil characteristics are different every time and the dredging cycle will be different for each project. So, the 'optimum' is different every time. However, the operational profile helps in generalizing the variations and makes it able to calculate the effect of certain design choices. For this, IHC has developed a Fuel Consumption Calculation Tool. This tool is described in [Heggeler, 2014]. The Fuel Consumption Calculation Tool has proven to be a very valuable tool when designing new drive trains. With this tool the fuel consumption for a specific dredge with a given operational profile can be calculated by combining data and characteristics of the diesel engine, propulsion, electric efficiency, dredge pump and operational profile. The calculation tool results in fuel consumption per cubic yard dredged material and the total cost per cubic yard for the dredge. Using the Fuel Consumption Calculation Tool in an early design stage gives the opportunity to compare different drive train designs on their fuel consumption and the costs per cubic yard dredge material. This enables a designer to choose the optimal drivetrain and give specific advice to customers when building new vessels, comparing alternatives on both the cost and fuel consumption per cubic yard dredged material.
POWERING DREDGING VESSELS WITH LNG

Stricter regulations on NO\textsubscript{x}, SO\textsubscript{x} and CO\textsubscript{2} emissions are providing a huge challenge for the global dredging industry. This will also affect the design of dredging equipment in general and trailing suction hopper dredges in particular, as most vessels are operating on Heavy Fuel Oil and Marine Diesel Oil. Meeting the stricter emission levels with diesel engines operating on Heavy Fuel Oil will be very tough. Costly measures are needed, for example the installation of scrubbers to filter sulfur out of exhaust gasses. Although such systems are available on the market, at the moment it is uncertain what the reliability and effectiveness is of these systems when working in dredging conditions. Switching to Marine Diesel Oil is an viable option, but there is significant cost price difference involved.

An option that looks very promising is Liquefied Natural Gas (LNG). The application of LNG will reduce emission drastically. SO\textsubscript{x} emissions and Particulate Matter (PM) will be almost be eliminated when using LNG. NO\textsubscript{x} emissions can be reduced by approx. 80% and CO\textsubscript{2} emissions by approx. 20%. Compared to other measures for emission reduction, LNG is also economically a viable option. The availability of LNG in the US and worldwide is improving and the LNG infrastructure developing rapidly. Major engine manufacturers are developing new ranges of gas engines for the maritime industry. Especially the development of LNG Dual Fuel engines is proceeding rapidly with power levels that are high enough for marine applications. The ability to operate both on LNG as well as diesel fuel makes it a flexible solution.

The benefits of LNG makes it an interesting option for powering trailing suction hopper dredges. IHC is performing research on the application of LNG on trailing suction hopper dredges and other dredging equipment. There are quite some challenges when applying LNG on trailing suction hopper dredges. Some of the challenges that were identified in the research project are:

- LNG storage requires approx. 1.5 times more volume than diesel oil storage, leading to spatial consequences
- autonomy is an important design condition, since there is a trade-off between requested autonomy and space required for LNG storage
- LNG storage tanks have more weight than diesel oil storage tanks, which has consequences for stability and trim
- LNG Duel Fuel engines have a smaller operational window, limited by the risks of engine knocking and misfiring
- LNG Dual Fuel engines have longer response times to load fluctuations than regular diesel engines
- LNG Duel Fuel engines have relatively high fuel consumption at partial load conditions
- placement of the LNG tank has huge impact on the ship design, but is also subjected to safety restrictions
- many safety restrictions apply on engine room configuration, pipelines, fuelling, etc.
- rules and regulations for gas systems and LNG tanks are still under development
- using boil off when the vessel is idle

All these difficulties provide a huge design challenge when designing a trailing suction hopper dredge powered with LNG. The challenge is to fit all necessary gas storage and treatment equipment within the overall ship dimensions, while meeting all necessary safety restrictions and maintaining high production performances. Due to the research carried out, it is a challenge IHC can cope with. Recently IHC has secured an order for two LNG powered trailing suction hopper dredges for DEME (figure 12).
One of the major challenges in the application of LNG onboard of trailing suction hopper dredges is the response of LNG Dual Fuel engines to load fluctuations while dredging. Drive trains on trailing suction hopper dredges are always experiencing fluctuating loads, due to the many disturbances acting on dredging vessels. Disturbances from wind, waves and current and variations in soil conditions and sea floor profile lead to strong load fluctuations in for example the dredge pump drive train and the propulsion drive train. But also more regular load fluctuations, for example caused by starting up a dredge pump, can be a challenge for a LNG Dual Fuel engine. A gas engine is a lower load acceptance capability than regular diesel engines. The operational window in gas-mode is limited by the possibility of knocking on one side and the possibility of misfiring on the other side, as shown in figure 13. Large fluctuations in load can cause exceedance of the operating window. Engine manufacturers have developed engine controls that are guarding this process and will automatically actively switch to diesel-mode. The engine will continue to deliver the same power without any interruptions. The challenge however is to avoid switching in modes as much as possible because otherwise the potential benefits of LNG will be lost.

![Figure 12. LNG powered 10,400 cyd (7,950 m³) trailing suction hopper dredge.](image)

In the research project IHC has together with engine manufacturers carried out extensive tests with load fluctuations. This has provided insight in which engines are capable of handling load fluctuations and what are the essential preconditions to avoid switching to diesel mode. In some cases additional measures have to be taken to limit the effect of load fluctuations. A possible measure is the installation of a temporary energy storage system that dampens
the load fluctuations. Another useful measure is the application of intelligent dredging automation that reduces load fluctuations, as described in [Osnabrugge, 2013] and [Blom, 2014].

EASYDREDGE SERIES

The total cost of ownership of dredging equipment is not only determined by operational cost like fuel costs but also by capital costs. The high investment costs of trailing suction hopper dredges can be an economic barrier for small dredging companies and new entrants to the market. Reducing the investment costs of trailing suction hopper dredges is therefore an important focus point in IHC’s research & development program. One way to reduce investment costs is standardization and modularization, as described in [Blaas, 2012]. Although DTC / IHC is well known for building custom-build dredging equipment, the company also has a long track record in the production of standardized dredging equipment like the IHC Beaver® series Cutter Suction Dredges. IHC has now developed a new series of standardized trailing suction hopper dredges.

The Easydredge series is a range of cost effective and cost efficient trailing suction hopper dredges which can be tailored by various optional packages. The Easydredge is available in hopper volumes of 2,100 cyd (1,600 m³), 3,500 cyd (2,700 m³) and 4,800 cyd (3,700 m³). Each vessel can easily be extended with optional packages and high-quality dredging equipment, both in new building phase and even after years of operation. The option packages currently available are the Easydredge Port Special, Easydredge World Dredging and Easydredge Marine Aggregates executions. The Port Special execution has a dredging depth of approx. 50 feet (15m) and comes with bottom doors for offloading. The World Dredging execution has a dredging depth of approx. 82 feet (25m) and besides offloading via bottom doors it also has a shore connection and rainbow nozzle for offloading purposes. The Marine Aggregates execution comes with a long suction tube and submerged underwater pump, enabling to dredge up to approx. 165 feet (50m) water depth. The package can be extended with options like a dry sand discharge installation, a barge loading installation and telescopic spud poles.

Figure 14. Easydredge trailing suction hopper dredge.

The entire design process of the Easydredge series is focused on reduction of investment costs. A unique design approach led to significant cost saving opportunities, like:

- standardization throughout the whole range
- rationalization of functionality and components
- fully engineered option packages
standardized and interchangeable components
long term agreements with preferred suppliers

The focus on cost price reduction makes the Easydredge an ideal vessel for port authorities and for start-ups in the dredging industry. This is supported by the fast availability of the vessel, as the Easydredge will be available for the International market 'from stock'. The first vessel, an Easydredge 2700, is currently under construction at a shipyard in Eastern Europe (figure 15). The vessel was launched in December 2014. Currently it is ready for delivery (figure 16). For the US market DTC / IHC developed a design and component package. DTC is working together with a US based shipyard and can provide newbuilding prices, delivery lead time and a customer finance package. Design choices were focused on making it an easy understandable and maintainable vessel. Propulsion and the dredge pump are direct driven with diesel engines that can easily be maintained. The electric and hydraulic installations are basic and reliable. The vessel is operated with ergonomically designed control consoles and simple touchscreen controls.

Figure 15. Construction of Easydredge 2700.

Figure 16. Launch of the first Easydredge 2700.
CONCLUSIONS

The design of a trailing suction hopper dredge strongly determines the competitive and economical value of the dredge. A high quality design approach is needed in order to find the optimal balance between required functionality, performance and costs. Ensuring the lowest cost per cubic yard dredge material is needed to make the dredge economically viable.

The design of a trailing suction hopper dredge is not only based on functional requirements, but is also influenced by other considerations. Besides operational and economic considerations also sustainability is of importance. Sustainability is one of the major trends in the dredging market and leads to stricter regulations, for example on exhaust gas emissions. This influences the designs of trailing suction hopper dredges, putting the focus on production optimization, fuel efficiency, the use of alternative fuels and optimization of drive train systems.

Insight in the operational profile provides a basis for fuel saving opportunities. Although operational profiles vary case by case, in general it can be stated that there is a gap between maximum installed power and the average power level being used during operations. IHC designs its dredges for optimal fuel consumption by considering alternative drive train designs and calculating the effect of certain design choices on fuel cost per cubic yard dredged material.

LNG is developing rapidly as a viable alternative for powering trailing suction hopper dredges. With LNG exhaust gas emissions are reduced significantly and strict emission regulations can be met. The use of LNG comes with tough design challenges, for example accommodating large LNG storage tanks and the response to dredge pump load fluctuations.

The Easydredge series is a series of cost effective trailing suction hopper dredges with short delivery times and is available for the US dredge market. The Easydredge is specially designed for smaller dredging companies, port authorities and new entrants to the market. The Easydredge is designed in such a way that optional equipment packages can be added both in design phase or later when the vessel is operational. This way the Easydredge will enable contractors to deal with the varying dredge projects in the US and abroad by either a 'fit for purpose' Easydredge execution or a versatile multi-tasking one.

REFERENCES


Blom, E.C. van der, et al. (2014). “Modern design of trailing suction hopper dredges, how research leads to opportunities.”, *WEDA/TAMU 2014*, Toronto, Canada


Osnabrugge, J. and Bergh, P.M. van den (2013). “Optimizing manpower and reducing fuel consumption while maintaining maximum dredging production” *WODCON XX 2013*, Brussels, Belgium

CITATION