Insight

Dredging | Mining | Offshore Autumn 2015 | E 7

A helping hand for customers worldwide

COILED TUBING
Integrated solutions for flexible technology

A JOINT APPROACH
Fully integrated DSVs from IHC and Dräger

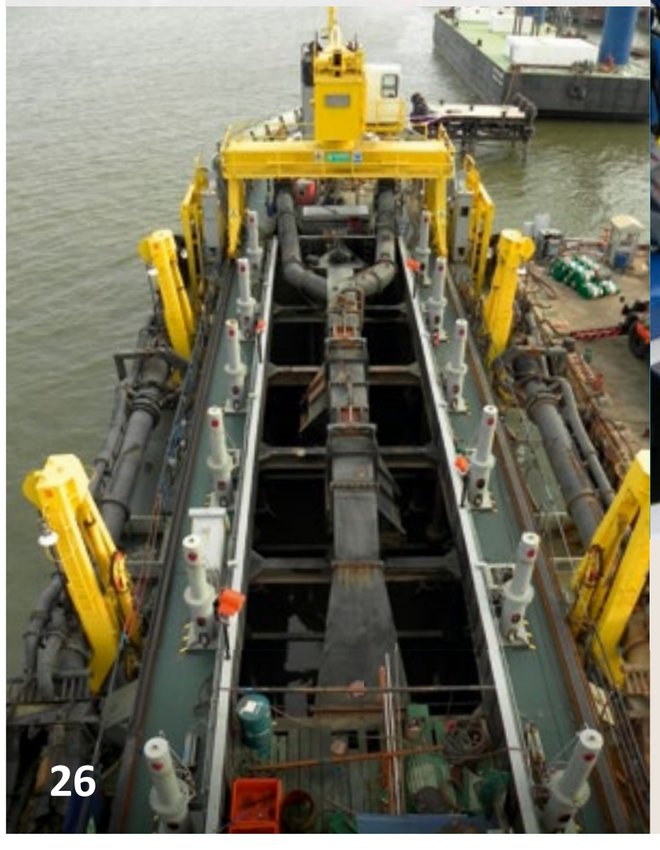
FUEL FOR THE FUTURE
Pioneering LNG dredging vessels

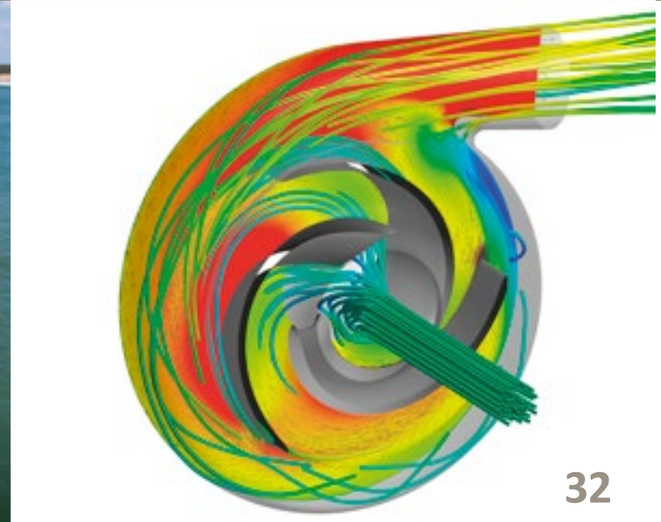
The technology innovator.

Insight

Dredging | Mining | Offshore

Autumn 2015 | E 7





Welcome

Dear reader,

In this issue of IHC Insight you will find a wide range of interesting reports highlighting the current developments and technological advancements within Royal IHC.

IHC's Plumigator I airless overflow is designed to tackle problems related to turbidity and air beneath a vessel. The innovative design incorporates technology from the days of the steam engine as well as equipment from the medical world – find out more on pages 10-15.

Read about the alliance between IHC and safety technology company Dräger on pages 16-19. Through this unique collaboration, the two companies are able to jointly offer owners and operators in the offshore industry fully integrated diving support vessels (DSVs), while minimising the risks and complexities involved.

Coiled tubing is becoming increasingly popular in the offshore oil and gas industries, partly down to its incredible versatility across a wide range of applications. IHC do Brasil is emerging as a market leader in the field through its development of advanced, integrated solutions for the deployment of the flexible product. Find out how on pages 4-9.

IHC's revised Cutter Special Curve offers the market a significant leap forward in efficient and durable dredger pumps. Read more on pages 32-37 and find out how this innovative design combines elements of aeronautical science – with a patent pending on its new blade profile.

Further proof that IHC is leading the way in its field can be found on pages 20-25, with a look at its pioneering liquefied natural gas (LNG) dredging vessel designs. The company has overcome several challenges to make this fuel a viable alternative, with benefits of its use including reduced emissions and lower operational costs for operators.

Finally, take a tour around the world to discover how IHC Services supports and optimises its customers' operations in countries including the UAE, Saudi Arabia, Thailand and China. Read about how customers rely on the company's invaluable expertise and innovative solutions on pages 26-31.

We hope you enjoy the issue!

Kitty de Hey-Maas
Strategy and Communications Director

IHC Insight
Coordination:
C. de Hey-Maas
Strategy and Communications Director

Layout:
S. Duijvelshoff, Corporate Communication

Editorial committee:
E. Bos, H.J. Cornegé, C.J. van der Harst, C. de Hey, S.C. Ooijens, J. van Overhagen, E. Peters, E. Put, M. de Rover, RED International Communication

The articles were published with the cooperation of:
CHEC Dredging Co. Ltd. (CHECD), DEME, Dräger Safety AG & Co. KGaA Engineered Solutions, Dubai Drydock World, Eerland Shiprepair BV, Port Authority of Thailand

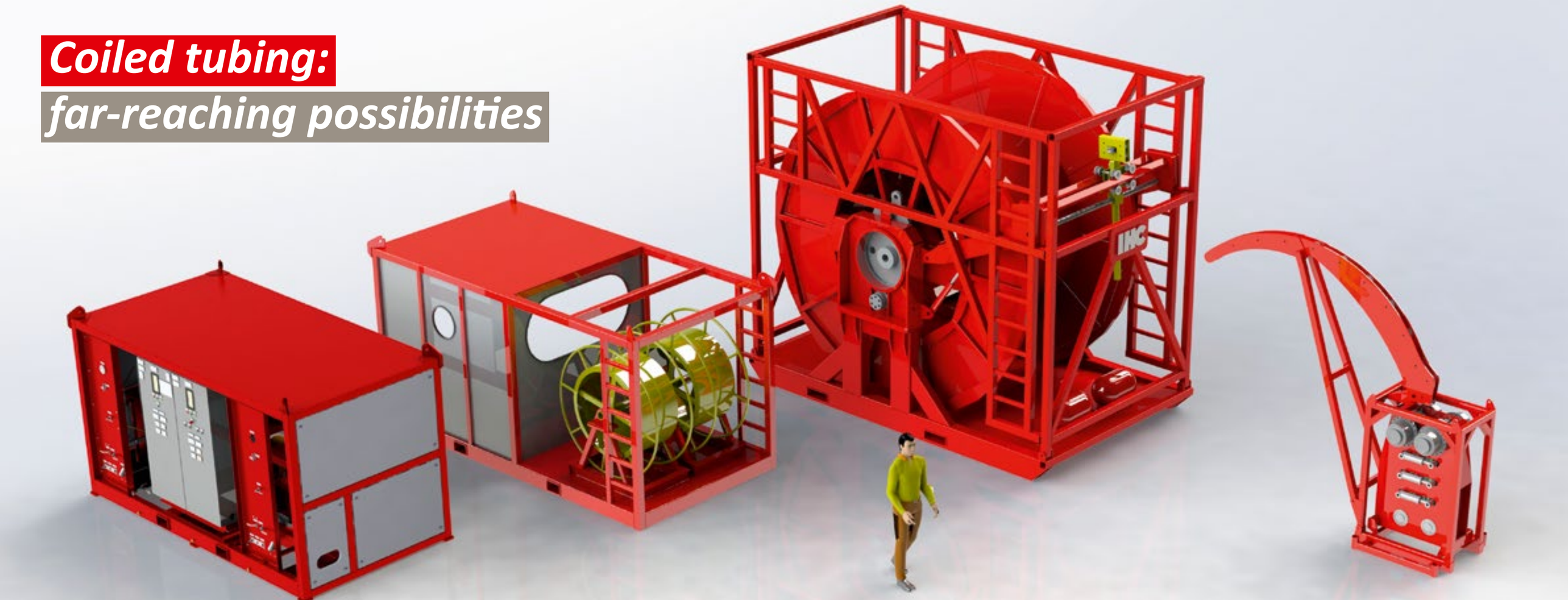
IHC Insight is published by Royal IHC.

Editorial and correspondence address:
Royal IHC
P.O. Box 204
3360 AE Sliedrecht
The Netherlands

ISSN: 0166-5766

For more information about any article, please contact **Royal IHC**.

Coiled tubing: far-reaching possibilities



Adaptable to a wide range of useful and cost-effective well intervention operations, coiled tubing is used all around the world by the offshore oil and gas industries. Find out how IHC do Brasil, which designs and manufactures the integrated equipment required to deploy this flexible technology, is now playing an important role in this rapidly evolving market.

Specialising in the design and manufacture of well intervention equipment for local and international oil and gas markets, IHC do Brasil began operations in April 2013 with a team of five. Since then it has tripled in size and gained a number of high-profile customers, including Petrobras and Halliburton.

From its offices and manufacturing facilities in Rio de Janeiro, the company has the capability to offer complete solutions with a high percentage of local content. Its experienced team is strategically located to provide a fast service, either inland or offshore, with its high-quality after-sales support proving a key factor in its success.

An interesting and important focus for the company is the development of high-end solutions for coiled tubing operations. As a result of IHC do Brasil's multidisciplined skills, lean engineering process and integrated approach, it is now proving to be a leader in this exciting field.

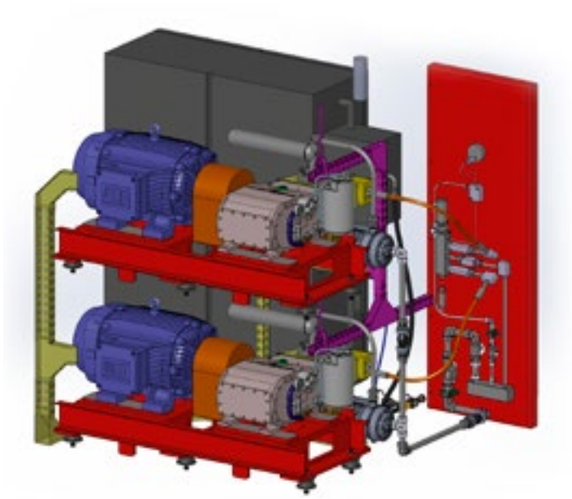
Durable and versatile technology

Coiled tubing (CT) is a continuously milled tubular product manufactured in lengths that are supplied spooled onto a take-up reel. The CT is straightened prior to insertion into the wellbore before being recoiled for spooling back onto the reel after use. The diameter of CT ranges from 19 to 100mm, and tube lengths in excess of 9,000m have been commercially manufactured.

"The biggest use of CT technology is currently in the onshore market, particularly in the United States and Canada, however the technology is now seeing a migration into the offshore world," says IHC do Brasil Project Manager Rafael Vorcaro. "This is partly due to the activity in large oilfields in Brazil and Africa, but also due to technological developments which have increased the durability and versatility of the equipment."

CT is incredibly useful to the oil and gas industries as it allows operators to introduce a wide range of elements, for example chemicals, into the well. This has a number of benefits for activities such as workovers, scale removal and production, among others.

IHC do Brasil is now establishing itself as an important player in the market. It has achieved this through the design, manufacture and supply of efficient, high-end equipment required to deploy CT and take advantage of its multipurpose capabilities through the use of a single set of tools.



High precision engineering capabilities at IHC do Brasil

The complete package

"Where possible, customers prefer to buy a complete, integrated package of equipment from a single supplier," Rafael explains. "This keeps things simple, with IHC do Brasil responsible for the service and maintenance of all the elements. It also means the customer is communicating with just one company."

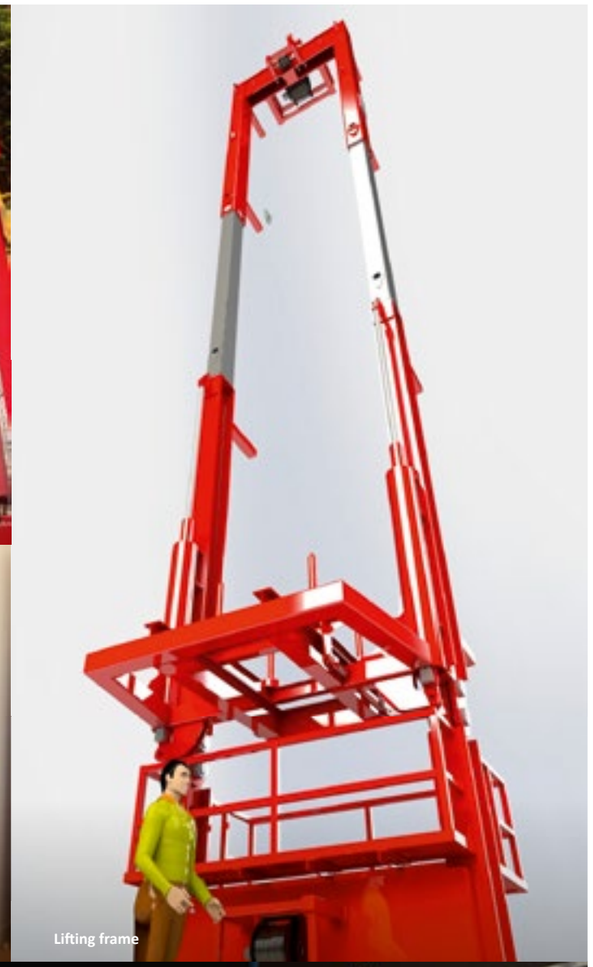
The key elements of an integrated CT unit are the reel, injector head, power pack, control cabin, high pressure pump unit and power hose reel. This is the complete set of equipment required to perform standard, continuous-length tubing operations in the field. All are certified for use in classified areas, for example in conditions where explosive gas is present.

Throughout operation, CT is spooled on a drum in reels with a hydraulic drive train used for rotation. The drum is mounted on a skid frame, and fluid or other materials can be transmitted into the tubing while it is spooled. Pressure inside the CT can reach 1,000 bar during injection. To minimise downtime, the drum can be removed and sent directly to a CT supplier for new product, with a secondary drum on standby for immediate replacement.

The CT is inserted and retrieved from the wellbore with the use of an injector head. Tensioners are used to conform and straighten it before entry. During this process, the CT is gripped and held in place. The two tracks are able to support weights of up to 55t

High pressure pump unit

IHC do Brasil Engineering Manager Bernardo Jaccoud (left) and Project Manager Rafael Vorcaro (right)



Lifting frame

Well intervention rellers

in order to prevent the CT unspooling itself, while an in-built encoder counts the length of tubing inserted into the riser during intervention work.

IHC has designed and manufactured the lifting frame for the injector head, which is size adjustable for multiple functionality. This extremely durable IMO or DNV-compliant frame can support weights of up to 350t, which means the injector head can be moved while still connected to the riser and provides valuable free space on the deck for other operations.

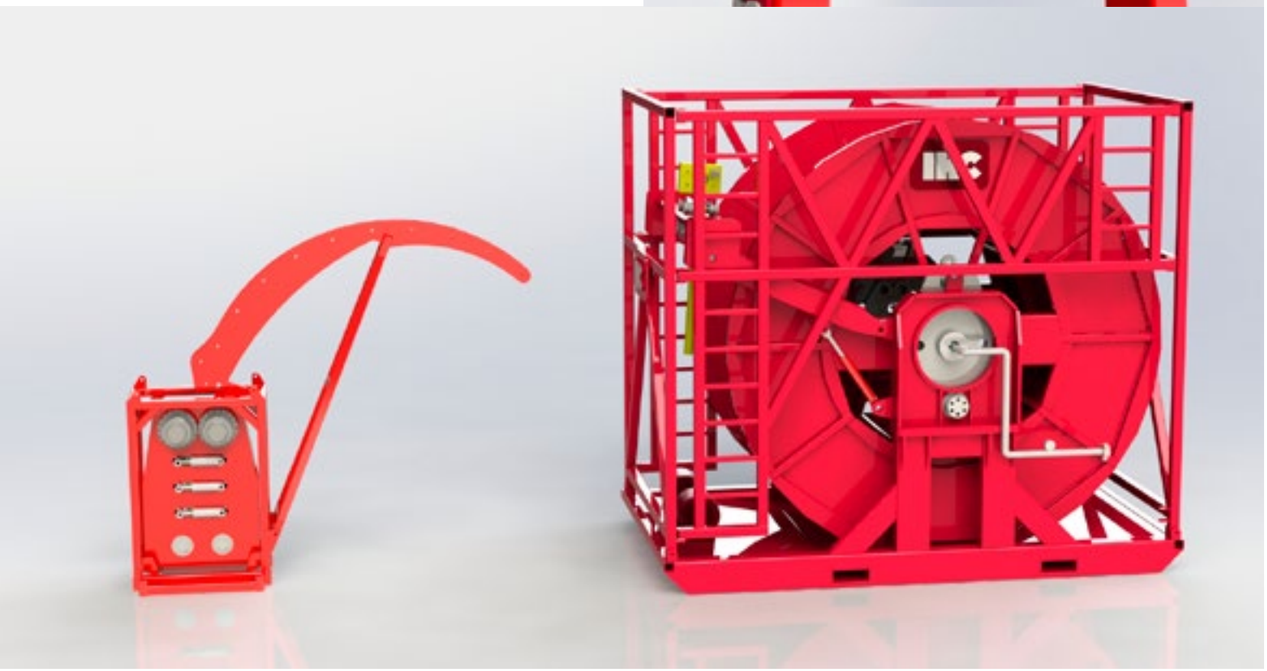
The control cabin is a complete, integrated IHC solution that allows full management of the entire operation. This includes parameters such as the pressure inside the CT, the load applied to the tensioners, and the length of the tubing inserted into the well. In order to generate the hydraulic and pneumatic power required to operate all systems on the CT unit, IHC do Brasil supplies a skid-mounted diesel-driven power pack that meets Zone 2 certification.

A wide range of capabilities

"With this complete set of equipment, a customer can perform a number of important tasks that would normally require different tools," says Bernardo Jaccoud, IHC do Brasil Engineering Manager. "That's the biggest advantage of IHC's integrated approach, which is becoming very popular on the market."

Examples of these applications include: removing sand or fill from a wellbore; fracturing or acidising a formation; unloading a well using nitrogen; gravel packing; and scale removal. However, the opportunities are far greater, with the possibility to attach cameras or sensors to the CT for logging and gathering information.

"Deploying CT for the removal of sand or fill from a wellbore is a common application for the technology," explains Bernardo. "It is incredibly important, as the removal of accumulated particles from the wellbore ensures an unimpeded fluid flow and an increase in well productivity."



The procedure involves the injection and circulation of fluid via the CT, which transports material out of the wellbore. Similarly, it is possible to improve the productivity of an oil or gas well through the injection of acid, which dissolves lodged materials or formations.

Nitrogen can be injected into the well in order to displace high-pressure hydrostatic fluid columns. This allows the reservoir fluid to flow normally, and the operation is cost-effective and straightforward from an operational perspective.

A reliable alternative

CT can be used as a reliable alternative to conventional drill pipes. This method requires much less effort and expenditure than traditional techniques due to the flexibility of the tubing, and the ease of inserting and removing it from the well. CT can also be used as a conduction pipe in order to analyse new oil deposits.

Other useful applications include zone isolation, which enables invasive workover solutions to be executed in a live well, and gravel packing to prevent the accumulation of formation sand. Issues related to hydrocarbon scale formations, wax and hydrate plugs – all of which represent a threat to production – can also be cost effectively eliminated.

Furthermore, CT can be used to assist with fishing activities in order to retrieve damaged or fallen equipment. It is also an ideal tool for pumping small amounts of cement into a well with a high degree of accuracy for recompletion work. The use of CT for well logging also has advantages, particularly in inclined or horizontal wells, where the rigid nature of the equipment becomes highly beneficial.

Looking to the future

CT does not last forever, and so one of the key future demands of the industry is to increase its longevity. As Bernardo explains, "The lifetime of CT material is defined because of the fatigue that results from bending it – it's steel, not a hosepipe! As a result of several factors, including radial bends and internal pressure, the amount of times CT can be used effectively is limited."

As a supplier of advanced equipment, IHC is working with CT manufacturers to develop solutions in order to resolve these issues. Primarily, this involves finding ways to reduce the stress of loads, which would result in lower levels of CT fatigue.

"If the weight of the tubing and the equipment used can be reduced, then CT will last longer and cost less," says Bernardo. "IHC do Brasil also aims to make the technology involved easier to use and transport. These developments only further strengthen IHC's position as a competitive supplier and a reliable solution for customers."

"CT technology actually represents a combination of equipment that IHC already produces," says Rafael. "With such a wide range of resources and a vast amount of knowledge available, we have everything we need in-house."

IHC's integrated, multidisciplinary approach enables it to respond to the industry's demands, as businesses continue to use coiled tubing solutions as a key part of their operations. It also ensures that the company possesses the knowledge required to support its customers throughout the life-cycle of their products.

Go with the flow: a new dredging solution

The latest innovation to emerge from Royal IHC tackles the long-suffered problem of turbidity and air beneath a vessel. The new solution is associated with storm drains and technology from the days of the steam engine. Pressure gauges from the medical world were used to make it a reality and it was named following a unique internal competition at IHC. Introducing the Plumigator I airless overflow.

The formation of turbidity and related air pockets underneath a vessel has been an issue within the dredging industry for many years. It not only causes damage to the vessel, but also produces harmful effects for local marine life and the environment.

IHC Innovation Manager Dredging Erik van der Blom explains: “When a trailing suction hopper dredger [TSHD] starts dredging and overflowing, air gets enclosed within the overflow and is pumped underneath the vessel, which can result in damage. Air pockets are sucked up again by jet pumps and other pumps, and can cause damage to these systems. The air gets sucked through the propellers too, which can lead to cavitation and possible damage of the propeller blades – that’s also a huge problem for our customers.”

The effect on the environment is due to more concentrated sedimentation of the overflow material, as IHC Business Development Manager Joost Koevoets explains: “When air mixes with the sand, the air bubbles become so small that they cling to the sand particles and make them float. This results in a large plume of brown-coloured water around the dredger and additional sedimentation. It interferes with, and can suffocate, local marine wildlife.”

Taking air out of the overflow equation therefore has clear benefits: eliminating air pockets under the vessel; and limiting the deposit of plume material directly on the dredging works and thereby reducing the environmental impact of the dredging process.

There is both a commercial and environmental impetus for a new solution. Environmental requirements are becoming increasingly tough for dredging operators, and legislative bodies reward those capable of operating with a smaller environmental impact. Reducing the plumes as much as possible also makes dredging feasible in more environmentally sensitive areas. “We observed this in Australia, where a large ore export port and the related dredging works collided with the delicate ecosystem of the Great Barrier Reef,” says Joost.

Until this recent airless overflow innovation by Royal IHC, the only available solution was an environmental valve, which is installed below the waterline and requires active management. Now more than 30 years old, however, it is less reliable and is facing changes in legislation that will affect its suitability for use.

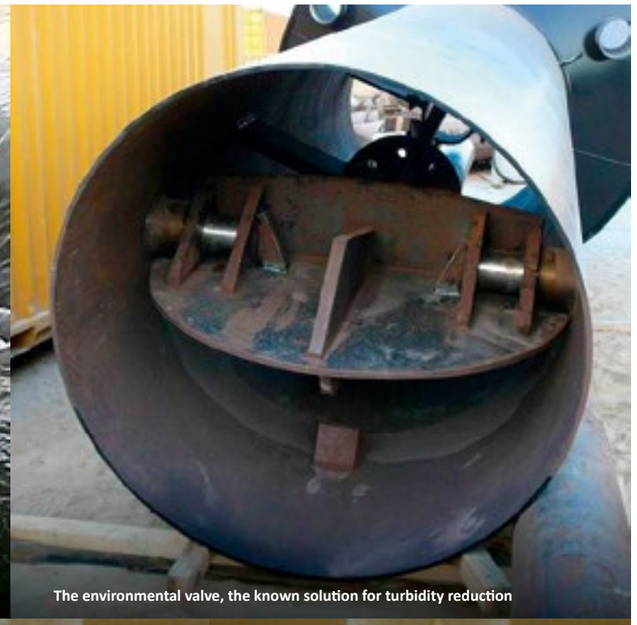
“In the past we have tried various solutions,” says Joost, “with valves on the bottom of the vessel. Although everything works, it’s still experimental and under water. With the Plumigator I airless overflow, we aimed to create a solution with as few moving parts as possible and no expensive active control mechanisms.”

The process

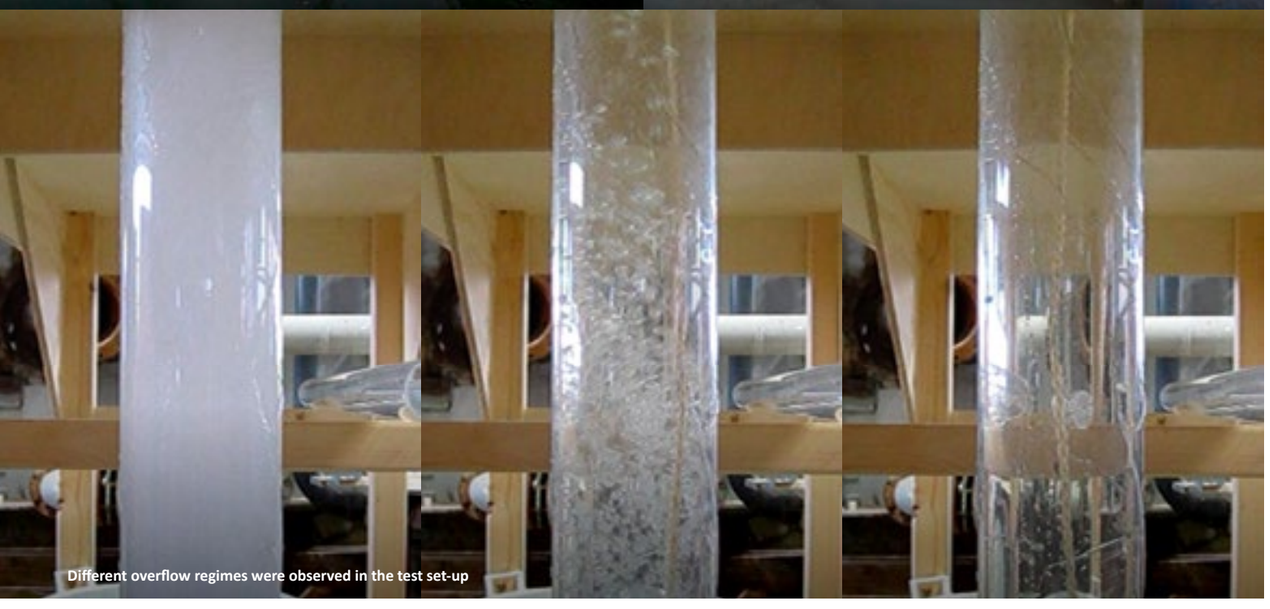
Research into an alternative solution began with some simple observations by IHC employees. One of them was during testing of the TSHD, ISANDLWANA, built in 2010 for the Transnet National Ports Authority in South Africa. “A guy from R&D saw that in certain conditions there was no plume in some operations, and in other conditions there was,” says Erik.

Secondly, during the development of the Easydredge vessel – a product line also created by Joost – it was decided in the early stages that a controlled overflow system was required for less turbidity. “One of our testing captains for the vessel’s maiden trips, Walter Beij, had the idea to change the overflow in order to solve the problem of air pockets,” says Joost. “So, with a number of

Air enclosed in the overflow during dredging

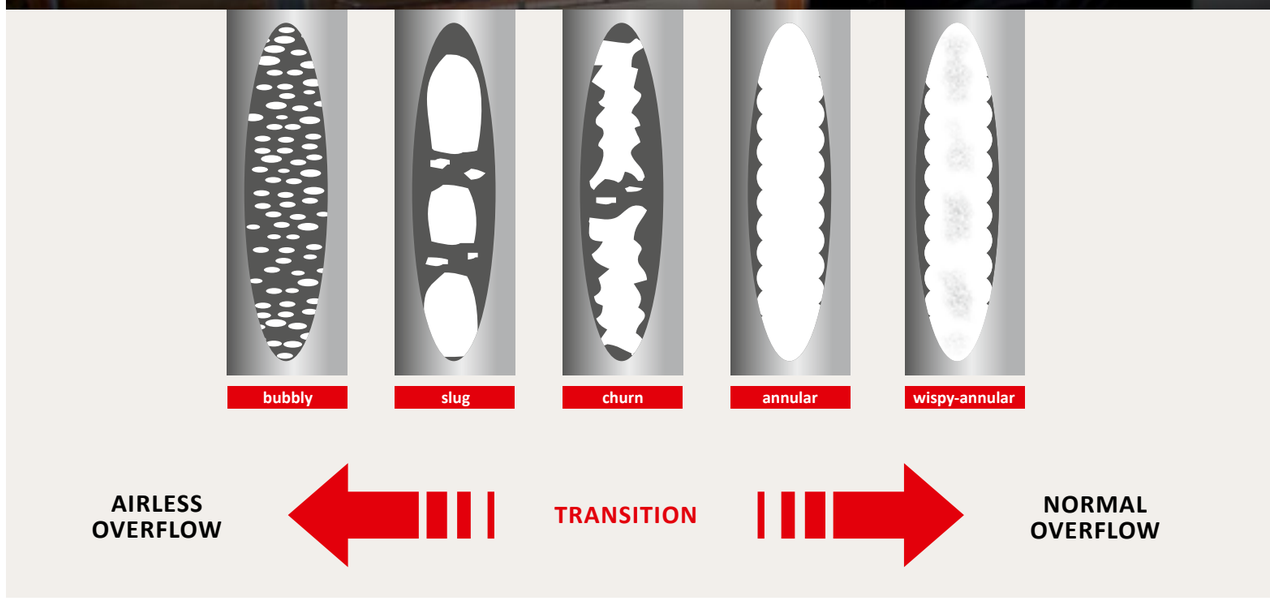


The environmental valve, the known solution for turbidity reduction



Different overflow regimes were observed in the test set-up

Inventors working on the small-scale test set-up



indications from the market, and ourselves, we realised we could do something to tackle this."

With a perfect opportunity in the development of the Easydredge (which is built to stock), the subject of airless overflow became a reality as a research project at the IHC laboratories in Kinderdijk.

The innovation

Joost and his colleague, Arjen van der Horst, started work approximately 18 months ago to create some ideas on how to tackle the issue of air in the overflow system. "The short-term goal was the reduction of air and the more long-term aim was reduction of turbidity," confirms Erik. "We had a very hands-on test, with a simple wooden box, a water pump and some transparent pipe sections," says Joost. "We simulated flow patterns, which occur in the overflow. By making small adjustments, we could observe and deduct what was actually happening in the overflow."

"We found out in the flow patterns that if you separate air from the water, the overflow speed increases three to four times," says Joost, "therefore we had to increase the capacity. So, if we kept the capacity at the same level, we could reduce the diameter of the overflow. That meant we could overflow in this process with half the diameter size and still have a higher exit speed. For the same capacity, the spoil goes deeper under the vessel, so doesn't interact with the vessel shape itself."

Joost and Arjen then built an overflow from plastic and used 3D-printed parts to influence the flow. "By making small changes, we worked out how we could manipulate the flow so that it behaved as we wanted it to. At a certain point, we could control the bubbles in the flow, increasing and reducing their speed. Then we started working on the solution. By keeping the overflow transparent, we could see what was required to get the process in the right order."

"The small-scale tests enabled us to get an understanding of the physics in the process and how it works. This was the basis of the new concept but it was also linked to the past. The physical processes we saw in the overflow were comparable to steam tube technology from the 1950s," says Joost.

"Sometimes you have to look to the past for the future. Somebody who worked on steam engines encountered a similar problem. When we found that out, it made life a little simpler. We also found comparable notes on storm drains from more recent times."

How it works: flow control

The natural vertical flow of water through a pipe means it will always cling to the periphery. In the middle, air gets sucked in and mixes with the water. As the flow increases, it mixes more intensively.

"The mixture of air and water has a lower density than water itself, or a mixture of water and sand," says Joost. "That means that the lower density mixture will tend to rise and this reduces the efficiency of the flow."

Therefore, the more air entering into the overflow, the less efficient it will be. The next step was to fill the core with another tube, so the air couldn't get in and mix with the sand or water. "What then happens is the flow increases so much, at such high efficiency that it starts to suck air in from in between the two pipes," says Joost. "You can only control the flow entering the overflow. It's flow control. Once you can control the flow, you can prevent the air from entering the overflow tube."

During the three months spent in the lab, two of the difficulties encountered by the team related to measuring – how they could measure and what they were actually measuring.

"We couldn't measure air bubbles in water using the normal measuring techniques we had within IHC," says Joost. "We had to build an arrangement of pressure tubes so we could use very small pressure gauges to get the correct pressure ranges. These were borrowed from the medical world, where they are usually used for blood pressure measurements. They were small enough in the model to measure the pressure differences over the entire flow pattern."

A matter of scale

Following a series of tests and observations, Joost and Arjen had to make an assumption and prove it. This involved measuring a certain number of different factors in order to scale it up. The same test results would have to be found on the full-scale Easydredge as on their small set-up in the lab.

"The hardest thing was to come up with the correct measuring techniques in this small-scale set-up, which could be compared to the scale on the Easydredge," says Joost. "However, sometimes the larger it becomes, the simpler it is. Pressure differences in the model were much smaller than on the Easydredge."

However, scaling up also had its challenges. Working on the Easydredge site involved huge parts of steel weighing approximately five tonnes as opposed to easily modified 3D-printed parts on the small-scale model. The team had to adapt to the existing dimensions of the Easydredge 2800, which was largely finished by this point. Nonetheless, the first prototype of the airless overflow system was installed on the vessel and tested in May 2015 at the shipyard in Varna, Bulgaria.

"It worked practically straight away," says Erik. "It solves the problem of air underneath the vessel, and we expect it to reduce the overflow plume. There might be additional advantages, but this requires further research and testing over a longer period of time." Additional tests of the overflow are planned during dredging trials of the Easydredge. These are set to determine the differences in plume and plume shape.

A major advantage of the new airless overflow system over the old environmental valve is that it can work without any form of control or involvement from the crew. "The old system required continuous adjustment," says Joost. "This system is governed by the dynamics of the process. So that means if you increase the flow of the pump, the system automatically corrects itself. Once installed, nobody has to check it – it just works without adjustments, on flow dynamics."

Erik adds: "The benefits of the airless overflow are two-fold. Firstly, it means less damage to the pumps, propellers and other systems on board which draw water from outside of the vessel. Secondly, it's beneficial from an environmental point of view."

First prototype installed on the Easydredge

The prototype worked perfectly on the Easydredge

The effect of the airless overflow

Part of the bigger picture

The airless overflow is the latest innovation by IHC that highlights the company's ability to produce practical solutions to problems experienced in the market. Designed to fit on every vessel, the new system has potential for both new-build ships and existing fleets. It also has potential for other markets. "We have already had some enquiries from a company in the mining industry to see what would work in that sector," says Joost.

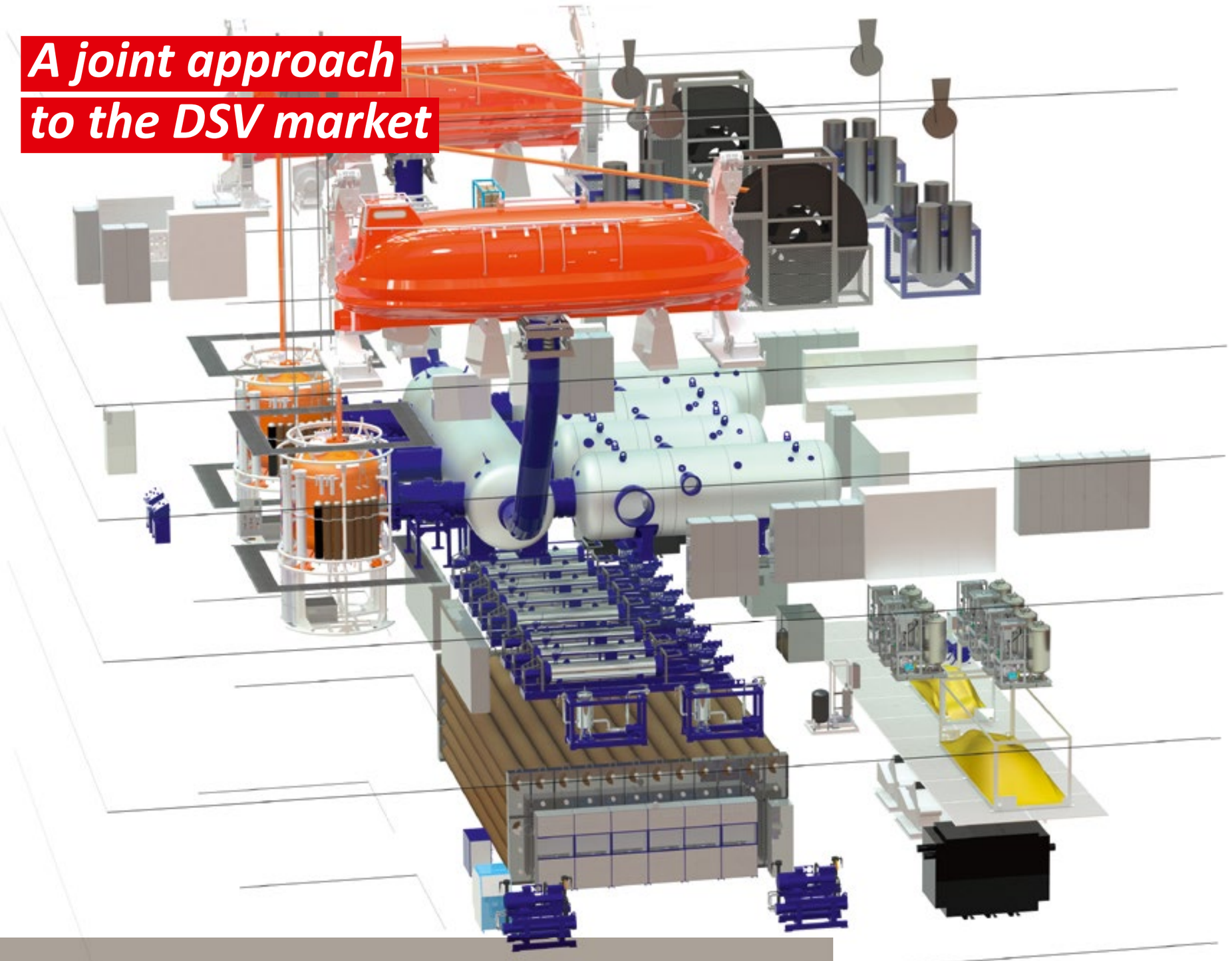
The Plumigator I is just one of several improvements planned for IHC vessels, in order to make them more efficient, more environmentally friendly and easier to use. "We are looking at all aspects of dredging and aligned markets, in which we can apply the same technology with simple small changes to the execution," says Joost. The airless overflow innovation is therefore part of the bigger picture at IHC.

It also highlights new ways of working within the company. In order to find a suitable name for the innovation, IP Consultant Mireille de Regt-Schippers, responsible for registering brand names, proposed that employees submit suggestions as part of an internal competition – the first of its kind for IHC. "It is difficult to come up with a unique brand name for a product," says Joost, "and so inviting our colleagues to come up with a good name is innovative too!"

By August 2015, the judging panel had received more than 100 entries. With a patent pending on the design, they had to select a name that would help with registering the airless overflow system for a trademark. Joost and Mireille were members of the panel, with Product Director Hopper Dredgers Andre Kik, Strategy & Communications Director Kitty de Hey and Marketing Manager Hanno Smits.

They selected a winner in early September according to three criteria: the name should enhance IHC's image as the technology innovator; it should refer to the sustainable and environmentally friendly benefits of the airless overflow; and it should be easy to pronounce in English. Plumigator I was chosen because it emphasizes the plume reduction capabilities of the airless overflow and has a powerful connotation. The best ideas flow naturally, it seems.

A joint approach to the DSV market



Impression of an 18-man, four-chamber diving system

A strategic alliance between Royal IHC and safety technology company Dräger has made it easier for owners and operators in the offshore industry to acquire a fully integrated diving support vessel (DSV). The two companies explain how they can offer a unique proposition to the market, minimising commercial risks and complexities for customers.

Highly experienced in the design, build and commissioning of diving support vessels (DSV) with integrated saturation diving systems, Royal IHC and Dräger announced their intention to join forces for this buoyant sector of the market in May this year.

IHC is renowned for delivering the larger and more complex custom-built DSVs, as well as the ready-to-build IHC Supporter® class portfolio. The company also has in-house experience with offshore diving technologies, a wide range of (SAT) diving equipment, and the full integration of Classification Society approved diving systems, to the extent of delivering vessels with full DSV SAT notation.

Known for its breathing protection and detection technologies, Dräger is responsible for the world's most advanced automated saturation diving systems. Its dedicated team of engineers and software experts specialise in meeting the bespoke demands of customers in compliance with existing and forthcoming industry regulations.

The combination of two leading suppliers in their respective fields undoubtedly brings benefits to the market, namely high-quality state-of-the-art technical solutions at a competitive price. Having cooperated on various projects over several years, IHC and Dräger mutually arrived at the idea to join forces to address the DSV market after experiencing the challenges encountered by their customers.

Potential for conflict

"Traditionally, an operator or owner would search the market for a dive system and a vessel separately, which would result in a myriad of responsibilities and commitments between the suppliers of the vessel and the system," says Henk Cornegé, Senior Business Development Manager Offshore at Royal IHC.

The customer, shipyard and dive system manufacturer would be bound by commercial and technical contracts. More often than not, however, the customer wouldn't be able to confirm the order for the dive system until the last minute, in order to maximise the optimisation to his needs or maybe just to limit cash-flow issues. The shipyard wouldn't be informed of the system interfaces or the components selected until after engineering had started. Integrating these into the vessel's design or production process could require re-engineering, causing the project to overrun.

In addition to time and cost overruns, DSVs have proved difficult to build due to regulatory, logistic, integration, interfacing and commissioning issues. More often than not, vessel owners and operators customise subsystems, which then result in unplanned re-certification outside the DSV's delivery planning.

Ultimately these components have to be integrated. Equally, having a set of certified components does not automatically mean the total dive system will be certified. This is a major reason why a vessel may not meet its scheduled delivery date.

"These are highly complex systems," says Mat Lock, Dräger's Global Head of Business Development for Engineered Solutions. "Wherever there are interface points, requiring shared data, there is potential for conflict.

"The certification and approval process is also not to be underestimated. It can take between six months to a year to obtain the Diving System Safety Certificate and to complete manned trials, so a vessel could remain at a quayside awaiting system certification for extended periods."


Self-propelled hyperbaric lifeboat

Henk agrees: “Approval can be a time-consuming factor in DSVs, and parties can start pointing at each other. In the meantime, the customer has to charter interim vessels to meet contractual obligations, thereby incurring further additional costs.”

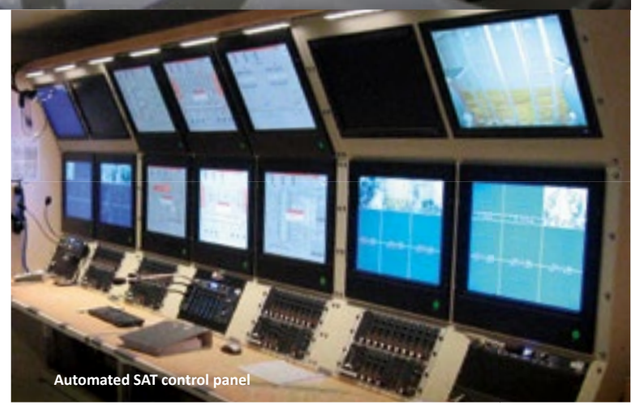
The IHC-Dräger alliance is prepared to take responsibility for the Diving System Safety Certificate, which leaves the owner with just the execution of the manned trial prior to its first contract. This represents true turnkey single-contract responsibility.

A single source

Seeing an opportunity to provide a solution to these obstacles and remove the risk element, IHC and Dräger decided to join forces to offer the market a single source for fully integrated DSVs.

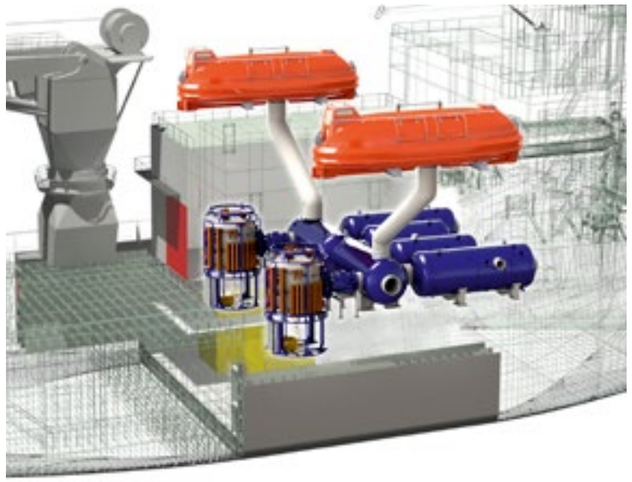
Under a single contract with the customer, the IHC-Dräger alliance takes total responsibility for the execution of these complex projects, including full integration and certification, and the performance of the equipment. It maintains a high level of interaction with the customer, who subsequently benefits from having one point of contact.

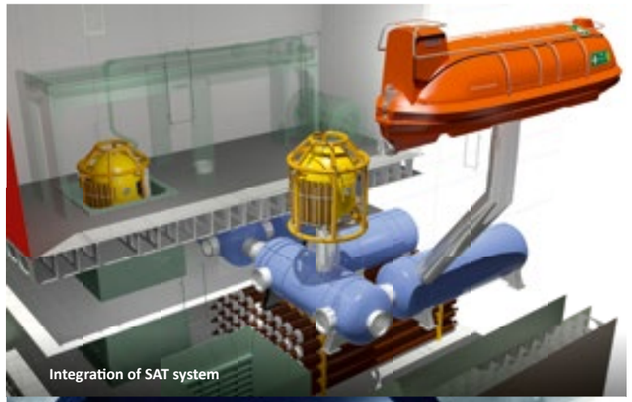
“We have successfully combined mission equipment and vessel design into one package, and we can present this to the market as produced in-house,” says Cor van der Harst, IHC Product Director

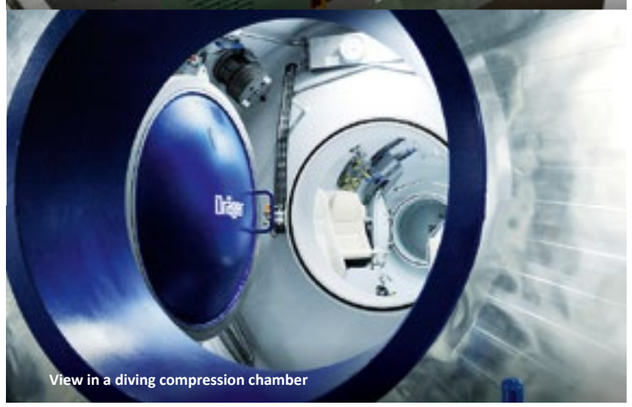

Automated SAT control panel

Diving Support Vessels. “On top of this, IHC’s native DIVA Vessel Automation is being extended to mission equipment by DIVA-Dive.”

The IHC-Dräger alliance currently consists of a dedicated core team of 24 (12 employees from each company), which represents a significant commitment to the new alliance. Half of the team is located in Germany at Dräger’s facilities in Lübeck, the other half are spread across two IHC locations in The Netherlands: Kinderdijk and Raamsdonksveer.


An 18-man integrated saturation diving system


Integration of SAT system



View in a diving compression chamber

A shared ethos

The process of aligning the two companies to ensure they could operate as a single entity was helped by the fact that IHC and Dräger already shared a similar ethos and culture. “Both are European companies with international audiences, dedicated to meeting customer requirements and driven to provide high-quality solutions that are delivered on time,” says Mat.

Nonetheless, it took time to prepare for the alliance’s introduction to the market, with discussions on project execution and life-cycle management ideas lasting almost a year. “There was no urgency with this from either side, because it was important to set the foundation,” says Johan de Bie, Managing Director IHC Hytech. “It took time and imagination to find the right commercial constellation.”

Since the announcement in May, the IHC-Dräger team has been working together to establish responsibilities in marketing, design, engineering, production, realisation and life-cycle management to highlight who does what and at what stage. This helps to avoid misunderstandings and also provides greater transparency for the customer.

“It involves makers’ lists, types of equipment used, methodology, contract forms, and so on,” says Cor. “Everything is interconnected and agreed as a basis and starting point before the first meeting with a customer.”

Once an order is confirmed, there is also greater transparency concerning the approval stage. “We have the discussion about product and installation approval with the customer upfront, in order to make this as smooth as possible,” says Johan.

Initial focus

Initially the IHC-Dräger alliance will focus on supplying vessels with automated 18-person twin bell saturation diving systems. This accounts for one third of the market (there are approximately 75 DSVs operational in the world). Twelve-person single bell units account for another third.

Hinting at the alliance’s aim to widen its scope in the future, Henk says: “During our market research, we realised that the 18-person twin bell systems were the workhorses of the industry, so we decided that we should offer this type of solution to our customers initially. It is also a system that we can configure upwards and downwards.” Mat adds: “It’s an approach of scalability.”

The key international players in the industry, who have already established working relationships with IHC and Dräger, have responded positively to news of the alliance. It offers an alternative to the regular main contractor-subcontractor type of arrangement or the OFE/pre-procured novation type arrangements often seen in the DSV market.

“I think the alliance is unique, particularly in terms of the joint level of responsibility that both companies are willing to take,” says Henk. “It’s not only about the product, but the total proposition. We are addressing issues that our customers have encountered in the past, but have not been fully understood until now.”

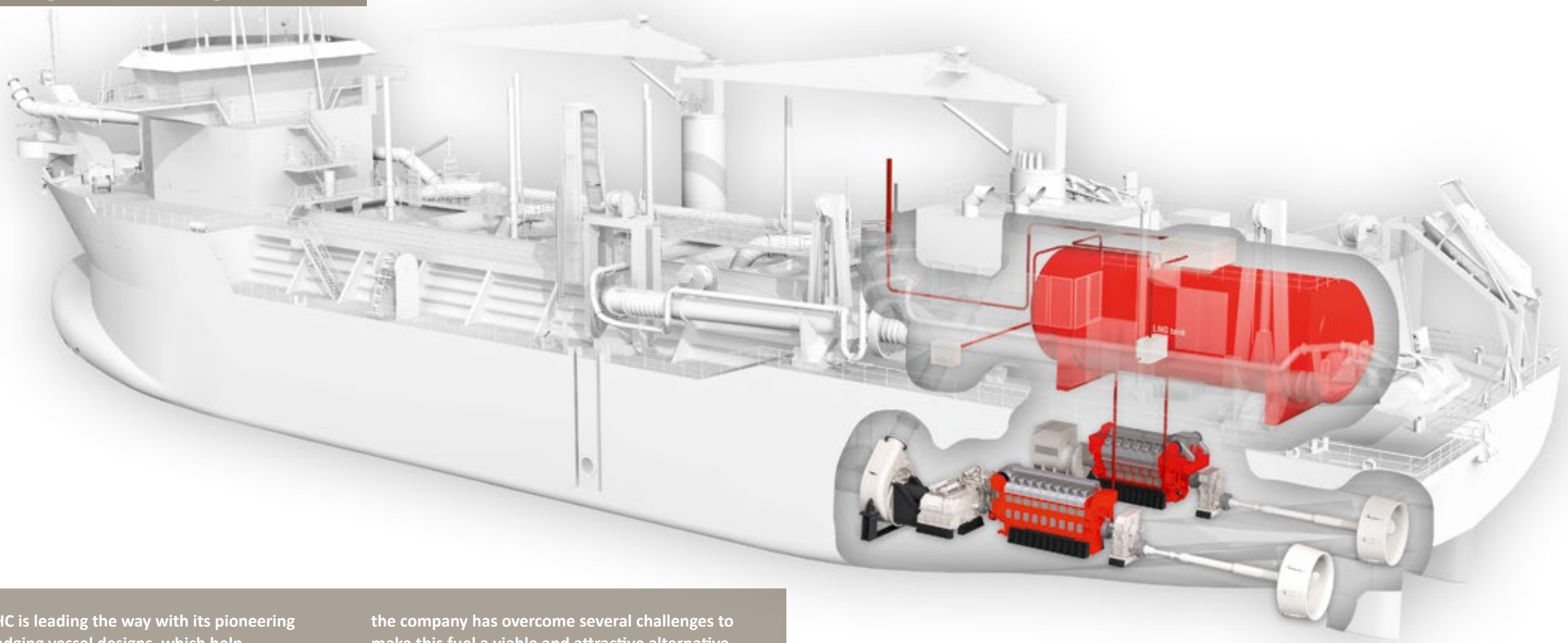
The best solution

IHC and Dräger have combined forces to offer a unique proposition to the integrated DSV market. Both companies have faith in each other’s capabilities and have made a significant investment to ensure the success of the venture. Both IHC and Dräger are fully committed to what they consider to be the best possible solution in the market today, both contractually as well as technically.

Working together on the vessel design and relative aspects of interconnection and interfacing brings an improved understanding of the total diving philosophy. This has already started to make an impact on how diving systems are designed, enhancing quality and reliability. The IHC-Dräger alliance can only be a positive and promising development for owners and operators in today’s competitive and challenging offshore industry.

The LNG system with vaporiser, LNG tank and LNG engine highlighted

Liquified natural gas: fuel for the future



Royal IHC is leading the way with its pioneering LNG dredging vessel designs, which help to reduce emissions and operational costs considerably. Supported by its R&D department, the company has overcome several challenges to make this fuel a viable and attractive alternative for customers.

Royal IHC was awarded the contract for the design, construction and delivery of the world's first liquefied natural gas (LNG) low-emission dredging vessels earlier this year. Ordered by DEME, the 7,950m^3 SCHELDT RIVER and 3,500m^3 MINERVA trailing suction hopper dredgers will be powered by dual-fuel LNG/diesel engines. Scheduled for operation by the end of 2016, they will operate in Sulphur Emission Control Areas (SECA) in Europe, namely the North and Baltic Seas.

This order represents a significant milestone in the development of LNG dredging vessels and the culmination of several years' work, which began in IHC's R&D department in 2010. Development engineer Leonard den Boer explains: "At that time, the first LNG ships in The Netherlands were inland barges, not seagoing vessels. There wasn't much belief in LNG and it was difficult to convince people that it might be a fuel for the future."

Industry research reflects a shift towards LNG-fuelled vessels in recent years, however. In 2010, there were just over 20 LNG-fuelled seagoing vessels in operation worldwide (not including LNG carriers). By 2015, this had more than doubled and, in addition, more than 30 were either ordered or under construction.

The benefits of LNG

So what's changed over the past five years? As reported in the Spring 2015 issue of *IHC Insight (A design approach to reducing fuel consumption, p14-17)*, emission regulations and legislation are becoming increasingly stringent. On a global scale, the IMO is preparing the Energy Efficiency Design Index (EEDI) for dredging vessels, defining steps in the reduction of CO_2 emissions. Since January 2015, there has been a limitation on SO_x emissions from exhaust gases for vessels working in SECA in Europe and the USA. From January 2016, there will be further restrictions on NO_x in the USA, and this is also expected for the North and Baltic Seas, in a number of years. In The Netherlands, the Ministry for Infrastructure and Environment [*Rijkswaterstaat*] is encouraging CO_2 reduction in dredging projects with the CO_2 performance ladder [*prestatieladder*].

To tackle these environmental developments, LNG brings substantial benefits. Compared with diesel, it produces 25% less CO_2 emissions, and much lower levels of particulate matter NO_x and no SO_x. Therefore it complies with all existing exhaust gas emission regulations without the need for exhaust gas after-treatment.

"Dredging companies such as DEME publish their commitments to reducing emissions in their annual reports. The biggest contributor to their carbon footprint is the fuel consumption of their dredgers," says Leonard. "They are also willing to invest in LNG vessels to achieve a future proof solution for the emission problem enhance their chances of winning dredging jobs in ports and harbours, such as Rotterdam, which are also committed to cutting CO_2 and NO_x emissions."

Another important advantage of LNG is cost. This is particularly relevant for SECAs, where it is no longer possible for vessels to sail on heavy fuel oil due to sulphur levels. "Companies can either use exhaust gas after-treatment, which requires further investment, or switch to marine diesel oil (MDO), which practically doesn't contain sulphur," says Leonard.

Alternatively, they can sail on LNG, which is estimated to be 30% cheaper than MDO, resulting in a 5-10% saving on cost per cubic metre. "Although the installation of LNG is a substantial investment, fuel price represents a major part of operational costs," he adds. According to IHC estimates, companies can expect a return on their investment within a few years.

The two LNG dredgers ordered by DEME

Impression of an IHC Beagle 8 with LNG installation

Leading the field

IHC and DEME are now leading the way in the development of LNG-fuelled vessels, which is still an ongoing process. Several challenges have already been overcome, however. Designer Pim Keijzer, who worked with Leonard on the two DEME dredgers, adds: "The tender for DEME helped us to push forward on this development; to achieve a lot in a short space of time and to be creative. We faced competition from other shipyards and had to submit a strong design at the best price."

One of the issues in IHC's initial vessel designs was the positioning of the LNG tank. LNG fuel is stored onboard at minus 163°C before it is vaporised by heat transferred from the engines as they are cooled. The evaporated gas is then conveyed to the engines.

According to previous IMO regulations and the International Code of Safety for Ships using Gases or other Low-flashpoint Fuels (IGF Code), the tank couldn't be placed too close to the hull. "We discussed this with classification society Bureau Veritas in Rotterdam, with regards to regulations they were developing," says Leonard. "Last December, they changed the IGF Code, which meant we were able to place the tank closer to the hull over a limited length, so it was easier to install it in the vessel."

Pim adds: "The tank is the biggest challenge because of its volume and dimensions – it requires twice as much space as a diesel tank. When you have decided on the position for that, then the design is 80% complete. You have to find the most economical solution and integrate the LNG tank and installation without influencing the rest of the ship."

Safety is a priority

The difficulty is not so much due to the installation, however, but due to the additional safety provisions that are required when using a liquid gas at such a low temperature. For example, during bunkering, if the liquid is spilt on deck, the hull may crack. Similarly when it is evaporated, double-walled piping is required in case of leakages.

"Safety is a big issue and receives tremendous attention and care. Wherever there is a chance of gas escaping, we must provide all the necessary precautions such as appropriate ventilation and electrical equipment required to create a secure working environment for the crew," says Pim. "These additional factors are also a reason why an LNG installation is a costly investment."

Despite these issues, it is considered a safe concept. With all the additional measures in place, it is possible to place the tank just below deck, near the crew quarters. At some point during the engineering phase, IHC arranges an official meeting with its engineering department, the classification society, engine supplier, LNG tank supplier, flag state and customer, so that everyone can check the installation before it is built and ensure risks are minimal. "We'll perform a failure analysis to identify potential hazards and assess what could go wrong in order to build the safest possible installation," says Pim.

Challenges of using dual-fuel engines

The LNG tank also has an impact on the autonomy of the vessel. "These tanks are quite expensive initially and customers prefer to make a low investment, so they tend to purchase just one small tank. However, if customers want to sail on LNG for two weeks, that would require a large tank – it depends on the requirements of the company," says Leonard. "They might choose one week autonomy on LNG and another week on MDO."

DEME's Head of the New Building and Conversion Department Jan Gabriel has also commented on using dual-fuel engines: "Normally, our dredgers will sail under full power for two to three weeks on diesel fuel. You can't apply that to LNG, you'll get a week to 10 days, otherwise the investment in tank size and cost would simply not be feasible."

The advantage of a dual-fuel engine is that the vessel can run predominantly on LNG (99% LNG and 1% MDO for ignition). When the LNG tank is empty, or if the vessel is in an area where LNG is not available, it can sail further on MDO.

Availability is still an issue, although the infrastructure for LNG and bunkering is starting to establish itself, particularly in northwestern Europe and the USA. “Five years ago, the industry wasn’t ready,” says Pim, “and even now it still needs more time to develop this.”

Rotterdam’s LNG terminal receives fuel that is produced and liquefied in Qatar, for example, then transported by a dedicated carrier. More LNG terminals have been built in recent years and the large amount of natural gas reserves around the world will last for many years.

Bunker ships are considered the most viable option for fuelling LNG vessels, as opposed to trucks and containers. For example, the SCHELDT RIVER is installed with a 630m^3 LNG tank, which would require 15 trucks to load. “A specialised LNG bunker vessel has recently been ordered by Shell to supply LNG-fuelled vessels in northwest Europe. The new vessel will be based at the Port of Rotterdam, and will load from the new LNG break bulk infrastructure. Scheduled for delivery in 2016, it can carry 6,500m^3 of LNG – a sizeable amount for fuelling these dredgers,” says Leonard.
It is also reported that NYK has ordered a bunker ship with a capacity of 5,000m^3, which will be based at the Port of Zeebrugge as from the end of 2016. Both are encouraging signs of development for the future of LNG dredging vessels.

Solutions for engine capability

One final consideration for the use of a dual-fuel (LNG/diesel) engine is load step capability. This refers to its ability to jump to 80% power from 20% in a short time, when a dredge pump is activated for example. A diesel engine takes the load step without a problem, but the dynamic engine response of dual-fuel engines is not at the same level.

“Engine manufacturers such as Wärtsilä, MAN and ABC have made progress in this respect and we visited these companies to test the engines and apply load steps in order to assess their capabilities. You have to find the limit,” says Leonard.

Direct-driven systems are also a new application for the dual-fuel engines. “The manufacturers are more experienced in electric-driven systems, however, and now we have partly direct-drive systems for LNG systems,” he explains.

IHC also considered temporary energy storage solutions, such as installing a flywheel or super capacitor, and visited ships that already have these features for other applications. But for the two DEME vessels, it will not be necessary.

“For the larger of the two vessels, we have connected two engines at the request of DEME,” says Pim. “It drives with two engines and one dredge pump. One engine drives the dredge pump directly through a gearbox and the other drives the dredge pump electrically. Having two engines helps to take the load steps off the dredge pump. Controlling this correctly is also a challenge, but IHC will use its skills and know-how to succeed.”

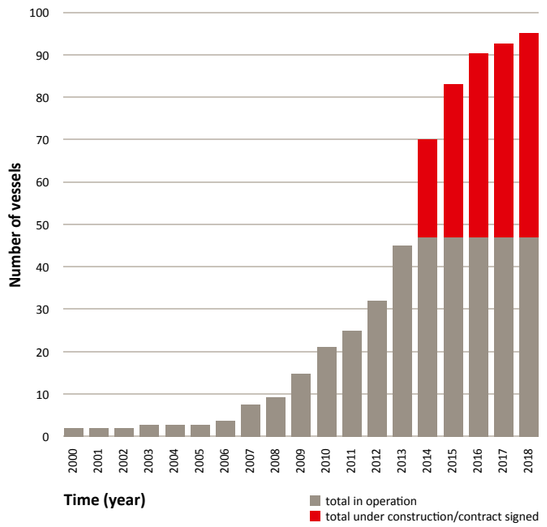
Growing potential

According to IHC, the level of interest in LNG dredging vessels is growing since DEME placed its order for the SCHELDT RIVER and MINERVA. Operators want to know more about the possibilities for LNG in their vessel designs.

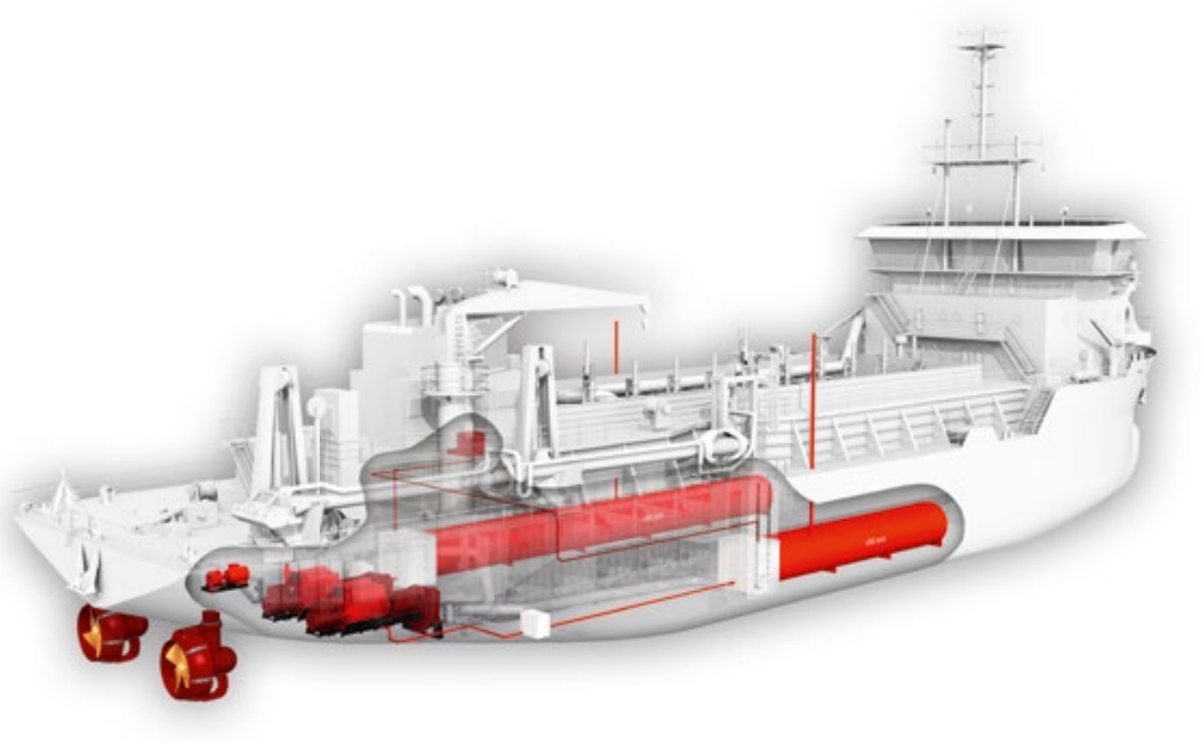
“The market knows that we now have the relevant experience on this subject,” says Leonard. “DEME has started a trend for other players in the industry to follow.”

IHC is also at the forefront of this trend, thanks to the advances it has made in LNG vessels coupled with its extensive dredging experience. Its standard Beagle 4 and 8 models, and the built-to-stock Easydredge, can accommodate the LNG installation, or it can supply custom-built vessels if required. The company will also continue to research and develop its vessel designs, and create training courses for crew members, as a sign of its belief in LNG as a solution for the future.

Number of seagoing LNG-powered vessels

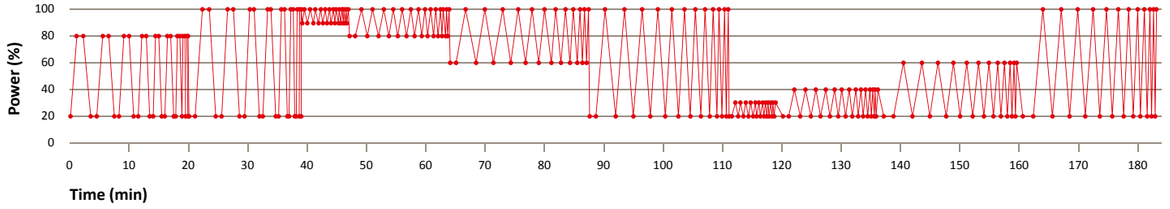


Source: DNV, 2014, LNG for shipping – current status

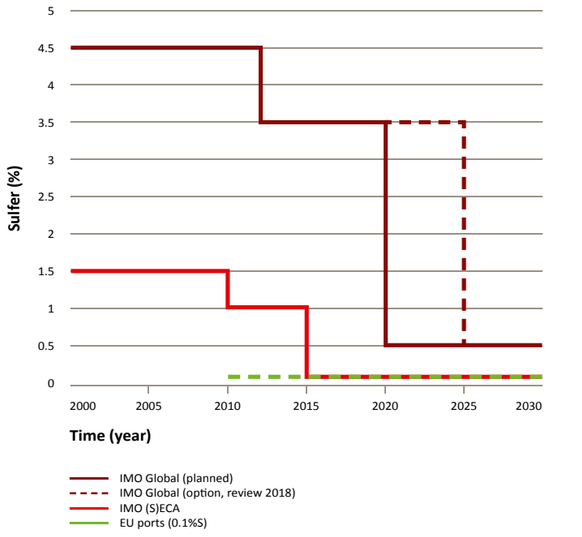


Study of an IHC Beagle 4, powered by LNG

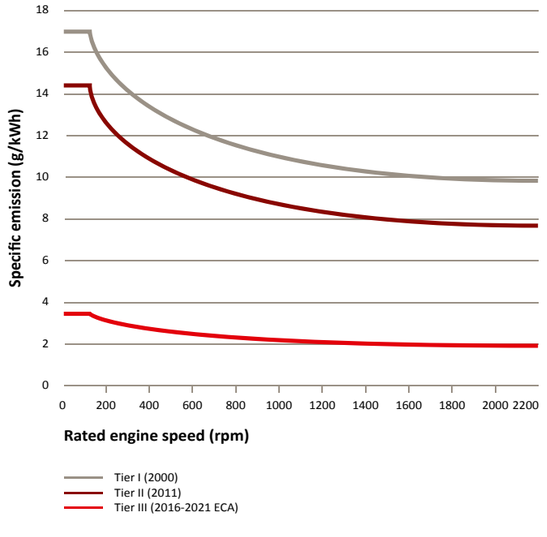
Load step test for dual fuel engine



Sulphur limits



IMO NO_x emission limits



Around the world with IHC Services

In order to support customers and optimise their operations, IHC Services carries out a wide range of activities in locations worldwide. Take a journey to China – via the UAE, Saudi Arabia and Thailand – to discover more about its innovative solutions, and learn why so many leading dredging, mining and offshore operators rely on its invaluable expertise.

IHC Services offers 24/7 worldwide customer support to operators in the offshore, dredging and mining markets. With service centres located strategically around the globe, including China, Singapore, UAE and South America, Royal IHC can respond quickly to customer requirements wherever they may be.

Services fall into three categories: operate, maintain and upgrade. Operate includes training and consultancy, 24/7 Service and rental services. Maintain comprises parts and logistics, repair and condition-based service. Upgrade covers feasibility studies, life-cycle engineering and renovation.

“Our goal is to solve problems,” says IHC Services Executive Director Wouter Kruijt. “To offer customers operational support in all they do – help with answers to questions, spare parts and training – we need to make sure they can operate as well as possible.

“We are a full service provider that can supply every single item our customers require as well as deliver a complete integrated system – from steel structures, electrical installations and power systems to mission equipment. We also have a presence in almost every location where our customers are, so we can provide a direct service.”

To illustrate the extent of this reach, as well as the varied and innovative work of IHC Services, this article shines a spotlight on some recent modification, repair and renovation projects in locations around the world, including Dubai, Dammam, Bangkok and Tianjin.

In collaboration with customers

IHC Services in Kinderdijk carried out an emergency repair on the QUEEN OF THE NETHERLANDS for Royal Boskalis Westminster NV (Boskalis) in March and April this year. Built in 1998 at Verolme shipyard, the trailing suction hopper dredger was equipped with an IHC dredge installation.

Dave Bartels, Superintendent Technical Services/Project Manager, explains: “The QUEEN OF THE NETHERLANDS had problems with her port side and starboard hull guides and sliding pieces. Without intervention, the installation would have gone out of service within the foreseeable future. The damage was limited to the sliding tracks and pads on the sliding piece, with minor wear to the sliding pieces.”

As an original equipment manufacturer (OEM), IHC had specific knowledge of the vessel’s engineering configuration. Experienced specialists were able to interpret the problem before offering assistance and collaborating with the team from Boskalis to develop a solution. An on-site specialist, an account manager and two engineers worked on the project, which had a lead time of approximately three months, including three and a half weeks in Dubai.

IHC replaced sections of the hull guides and the sliding pads, and carried out a touch-up repair to the apron, part of the trunnion gantry. The challenge was to be able to renew the sliding pads of the sliding pieces. The complete suction pipes were repositioned on the saddles to access the lower sliding pads, and in the aprons an access was cut away to replace the upper sliding pads.

The replaced sliding pads have an aluminium/bronze layer welded on top of a mild steel base, which were engineered and provided by Boskalis. Only the top hull guides were damaged severely, the guides below the flection were worn but still smooth, so these were only cleaned and polished.

"During the work, the trunnion gantries were inspected and it was discovered that the port gantry was slightly out of alignment. So we adjusted the gantry catch by adding a filling plate in forward catch," says Dave. "The starboard gantry needed longitudinal alignment, and so a plate to guide the apron in the correct position was added."

While the vessel was in dry dock, the suction inlet was checked and was also found to require attention. The worn hull rings were replaced, as were both port and starboard liners. On the final day in dry dock, the sliding pieces and the movement down to the suction inlet were tested and no issues were noted.

"The main objective was to repair the tracks and sliding pieces to last until the vessel's next scheduled repair. The long-term modification can be engineered and prepared – having said that, it looks like this repair will easily last longer," adds Dave. "This project highlights the collaboration between IHC and Boskalis – both parties put in their best effort to pursue a joint objective, with positive results."

A quick response to minimise downtime

IHC Middle East & India is based in Dubai and Mumbai. The IHC Services team is able to provide a quick response to all customers in the region, aiming to be on site within a day.

A recent job involved the overhaul of the cutter drive of a Beaver 65, which was working on a port construction project in Dammam, Saudi Arabia. This was an emergency repair because the damaged drive had a direct influence on the efficiency of the vessel and had to be repaired as soon as possible to minimise downtime. Its owner requested assistance from IHC because of its in-house knowledge and expertise, and to ensure the downtime was kept to a minimum.

Technical Manager Catalin Gherghe says: "The customer is quite new to dredging and a relatively new customer of ours – this is its first IHC vessel. So it was an advantage that we could react so quickly, even in a different country. Within a day of notification, our specialist was on board."

IHC was required to initially provide technical advice and then supervise the overhaul, which took place at a non-IHC workshop that had limited tool availability. The work required the removal of the complete lower part of the ladder, the cutter motor and shaft, and the replacement of bearings. All parts were then mounted back on to the lower part so it could be fitted back on the dredger.

Two specialists from IHC Middle East Service Centre were supported remotely by IHC colleagues based in Kinderdijk, The Netherlands. The required spare parts, including the bearing, were

Fitting the back lower ladder part

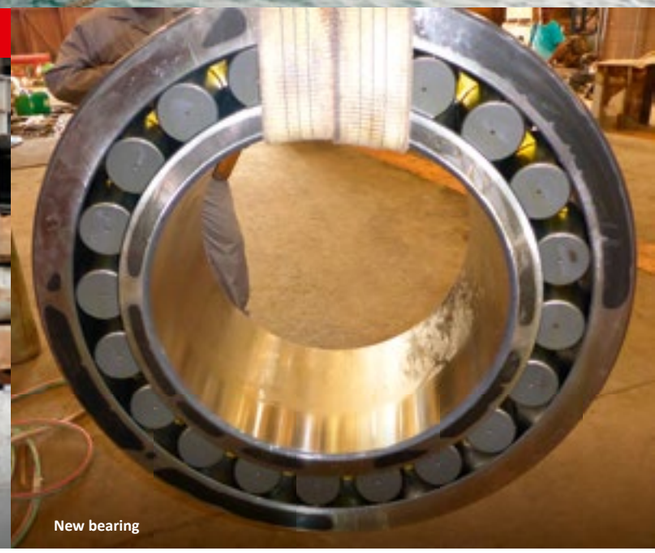
THE NETHERLANDS

Installation of upper sliding pads

Repaired hull guides

DUBAI

Lower part in workshop, motor removed



New bearing

sent from the office in Dubai. The overhaul was completed in eight days. "On the eighth day, the motor performed its test run and dredging commenced on the following day," says Catalin.

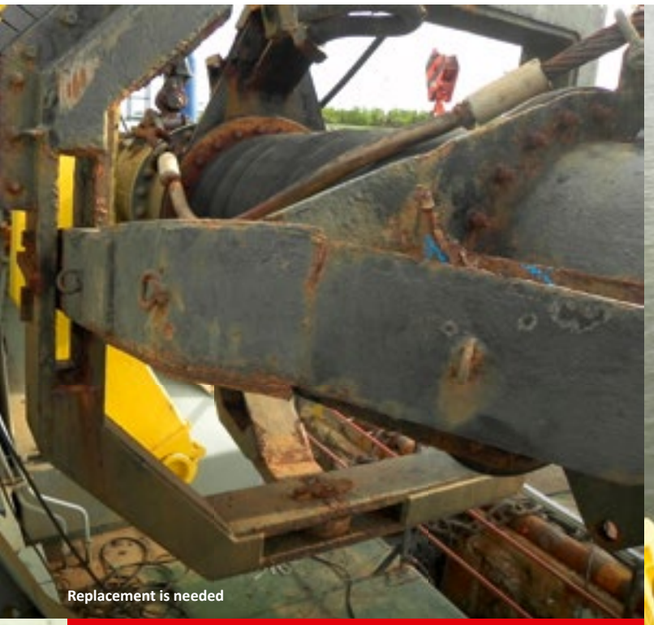
As well as highlighting IHC's capability to act fast and travel to a customer's site, wherever it may be, this job demonstrates the high level of cooperation between various departments within IHC to provide the best solution for the customer. It also demonstrates IHC Services' ability to perform large-scale, high-risk projects with shipyards and workshops around the Middle East.

OEM expertise

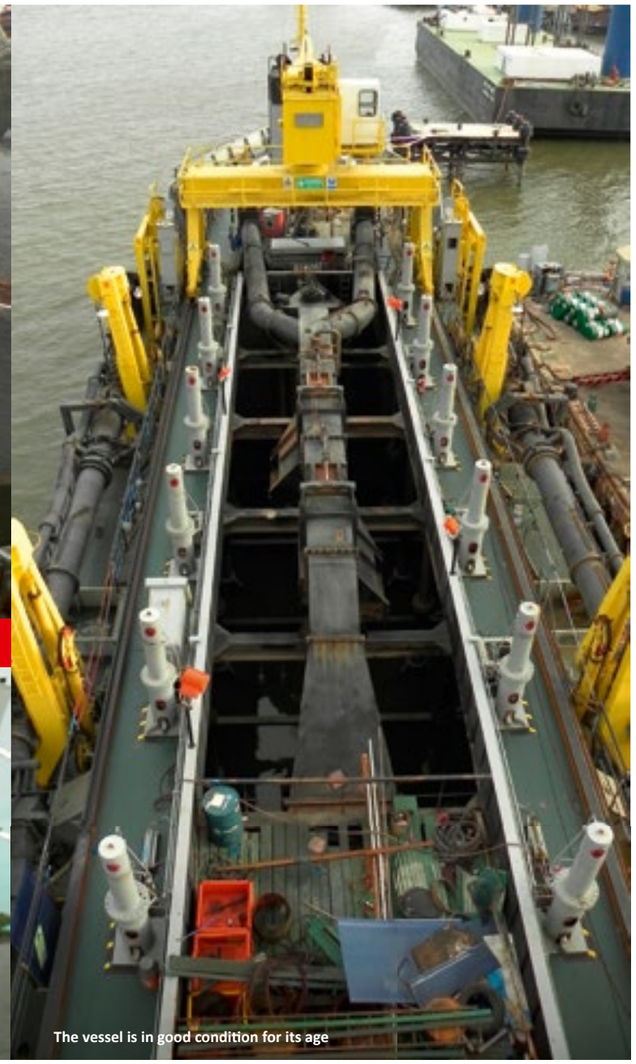
From its location in Singapore, IHC Asia Pacific Pte Ltd serves the region of Southeast Asia. One of its longstanding customers in that region is the Port Authority of Thailand (PAT), a state-owned corporation responsible for the regulation and governance of the country's ports, based in Bangkok.

Royal IHC has worked with PAT since 1955. It has a fleet of hopper dredgers with IHC equipment installed, including two vessels that IHC built in cooperation with Italthai Marine Ltd shipyard in Bangkok.

One of these vessels, SANDON 8, which was built in 1990, required a replacement suction tube and draghead. The vessel performs maintenance dredging in Bangkok Port, and the starboard pipe was worn and severely corroded. PAT contacted IHC as the OEM and designer of the vessel and equipment to carry out the work. Project Engineer V Jayakumar says: "We supplied the upper and



Replacement is needed



The vessel is in good condition for its age

SINGAPORE

Communication can be a challenge

lower suction tube, sliding piece with suction bend and dragheads. All these parts were sourced in The Netherlands and delivered within six months."

With Service Engineer Tin Maung, Jayakumar supervised the removal of the vessel's old parts and ensured that the installation of the new components was completed to IHC standards. The job was carried out in a Bangkok shipyard in 20 days.

"The main challenge was the tight schedule," says Jayakumar, "but the coordination between the shipyard, the customer and IHC was very good. PAT performed the sea trials and we received positive feedback regarding the performance of the equipment."

Increasing production, reducing labour costs

IHC Dredging Technology (Tianjin) Co., Ltd has responsibility for IHC customers in China. One of its longstanding customers, with a considerable fleet of IHC vessels, is CHEC Dredging Co., Ltd. (CHECD), a subsidiary of China Communications Construction Company Ltd (CCCC). In September 2013 it signed a contract with IHC for the renovation of the pump room in its dredger, HANG JUN 4007.

Built in 1979 in Japan, the vessel was no longer performing satisfactorily and it was becoming increasingly tough for CHECD to compete. "Before renovation, the dredger's production levels were quite low as a result of the pump's decreased efficiency, and so could not meet the requirements of the customer and its dredging projects," says Project Manager Liu Peng.

An improvement to its operation was required from IHC. Together with Dredging Advisory Services (the in-house consultancy of IHC based in Kinderdijk), the company began discussions with the customer on possible solutions and which kind of pump would complement the vessel's existing technical installation.

Once the pump type had been confirmed (an IHC high efficiency dredge pump), its pump room was modified according to the design of IHC's Life-Cycle Engineering department to ensure compatibility. Following delivery in August 2014, the pump was installed by service engineers from IHC China, who worked alongside the customer's engineers. The renovation was completed in January 2015. The trial run of the pump and fresh water test were performed smoothly.

MTI Holland BV Measuring & Diagnostics then monitored the pump, as well as the pump of the sister vessel, which had been converted by a local supplier. "The pump efficiency measurement was much higher for the IHC pump on the HANG JUN 4007 than the renovated pump on its sister vessel," says Liu. "The high-efficiency working range of IHC's pump is also much wider than the other pump. We proved to the customer that by using the IHC pump for dredging, total production increases by at least 30%."

As well as increasing production, the renovation will save the crew time and labour costs on repair and maintenance. They also receive full support on spare parts, such as impellers and Liquidyne, and advice on technical issues from the office in Tianjin. Following the success of this project, IHC secured the contract for another two CHECD dredgers. Furthermore, IHC also won renovation orders for the XIN HAI LONG hopper dredger – to increase suction depth and upgrade the SCADA system.

General Manager Ton de Gruijter says: "In China, the decision to grant an order is based on the business relationship much more than in western Europe, where the decision depends more on price. Economics are important here, but relationships are crucial, which is why we have a local office with local employees, who speak the language of the customer and understand the local culture."

Optimal tools at sea

IHC Services values its relationships with customers, who in turn rely on its expertise and ability to respond quickly. Operators in the offshore, dredging and mining industries are becoming increasingly international in their outlook and consider their vessels as assets. The services provided by IHC take care of these assets, enabling customers to focus on delivering their core business to their own clients.

"We try to step into the shoes of our customers and see things from their point of view," concludes Wouter. "Our innovative strategies and technological solutions can help develop their operation, bringing in greater revenue for them. Our aim is to provide optimal tools at sea."

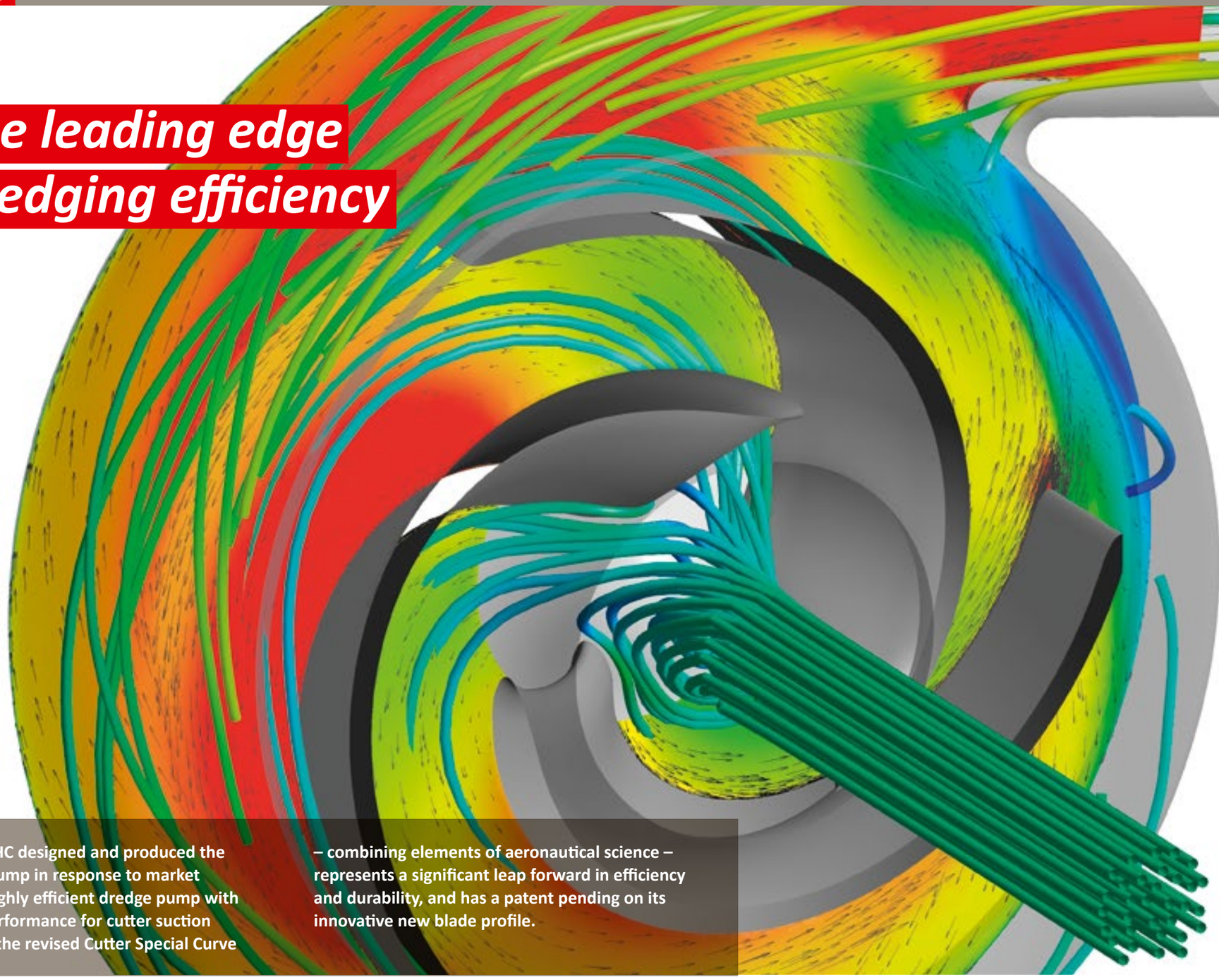
CHINA

The dredger HANG JUN 4007

Installing the IHC pump equipment on board

Pump efficiency measurement by an IHC MTI engineer

At the leading edge of dredging efficiency



In 2004, Royal IHC designed and produced the Cutter Special pump in response to market demand for a highly efficient dredge pump with good suction performance for cutter suction dredgers. Now, the revised Cutter Special Curve – combining elements of aeronautical science – represents a significant leap forward in efficiency and durability, and has a patent pending on its innovative new blade profile.

The performance of any dredging vessel is heavily reliant on the efficiency of its pump. This is especially true for medium and large cutter suction dredger (CSD) vessels, which frequently operate across a wide variety of challenging environments working with material ranging from clay and sand to gravel and hard rocks.

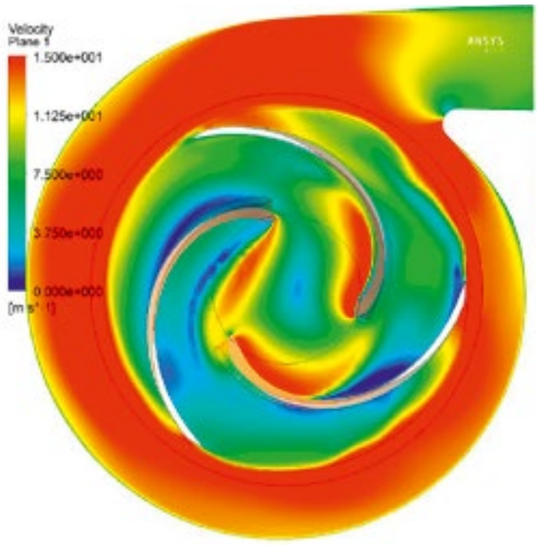
Key to the efficiency of a dredging vessel is the spherical passage of the dredge pump. This is defined as the space through which the material (of spherical shape) is able to pass in relation to the suction diameter of the pump. A larger spherical passage can prove incredibly beneficial, especially when a blockage in the pump can lead to expensive downtime.
The unique selling point of the original Cutter Special (CS) was its larger spherical passage – 50%, meaning rocks half the size of the inlet opening will pass through the pump without causing an obstruction.

"The CS pump proved to be very successful, with a wide range of vessels benefiting from its productive design and innovative capabilities," says Hasan Bugdayci, Royal IHC's Product Manager for Dredge Pumps. "But three years ago, in response to customer feedback, coupled with technological advancements we have made in-house, we decided that the system could be improved even further."

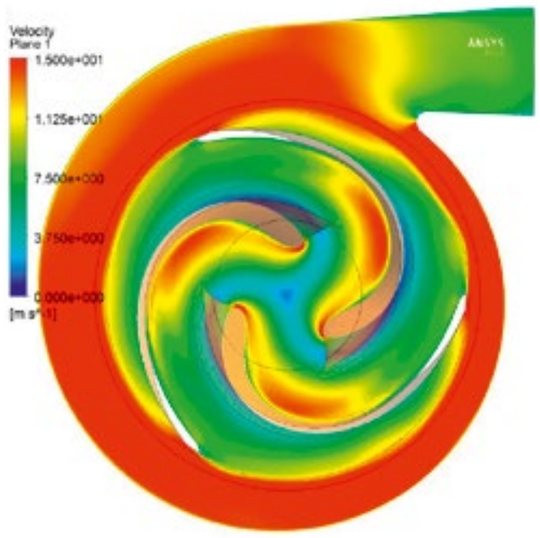
Hasan's team initially carried out measurements in both the field and the lab to determine exactly where improvements could be made. Following this research, IHC began designing a new version of the Cutter Special with two overall aims – to increase the pump's efficiency and to improve its wear resistance.

Design criteria

A number of performance criteria were identified for the new and improved Cutter Special pump – now named the Cutter Special Curve (CS Curve). Specifically, the goal was to revise some of the pump's characteristics without having an adverse impact on others. "We wanted to improve the efficiency and wear characteristics without losing pressure and without reducing the size of the spherical passage," says Hasan. "It was ultimately decided that only the blades and the volute would be modified, with the front and rear shrouds remaining the same as the CS."



Flow field analysis of CS pump. The spectrum represents the magnitude of the flow's velocity within the impeller



Flow visualisation inside CS Curve pump. The flow remains attached to the blade surfaces

Improving performance

The first step in the redesign process was to analyse the flow field in the original model in order to assess the pump's performance. Edwin Munts, Research Engineer at MTI Holland, uses computational fluid dynamics (CFD) in order to achieve this. CFD employs complex mathematical models and algorithms in order to simulate the fluid flow inside a pump.

"This technique provides key information, such as pressure and required power, from which we are able to calculate efficiency," explains Edwin. "Moreover, CFD provides a detailed flow field visualisation, which can be used to identify potential problem areas.

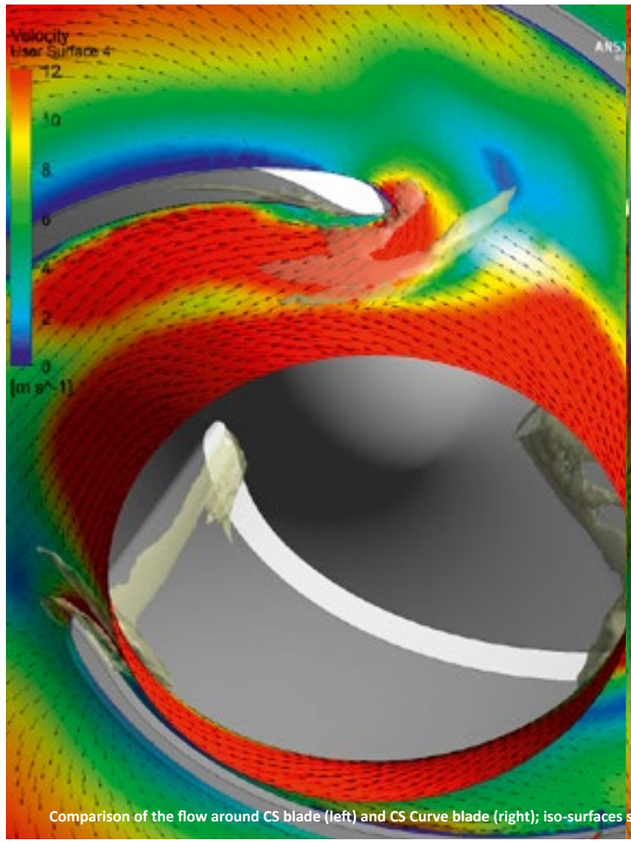
"This type of approach has its limitations, but over the years we have built up a significant amount of experience using the correct models. Our calculations are quite accurate, and very close to actual live measurement data."

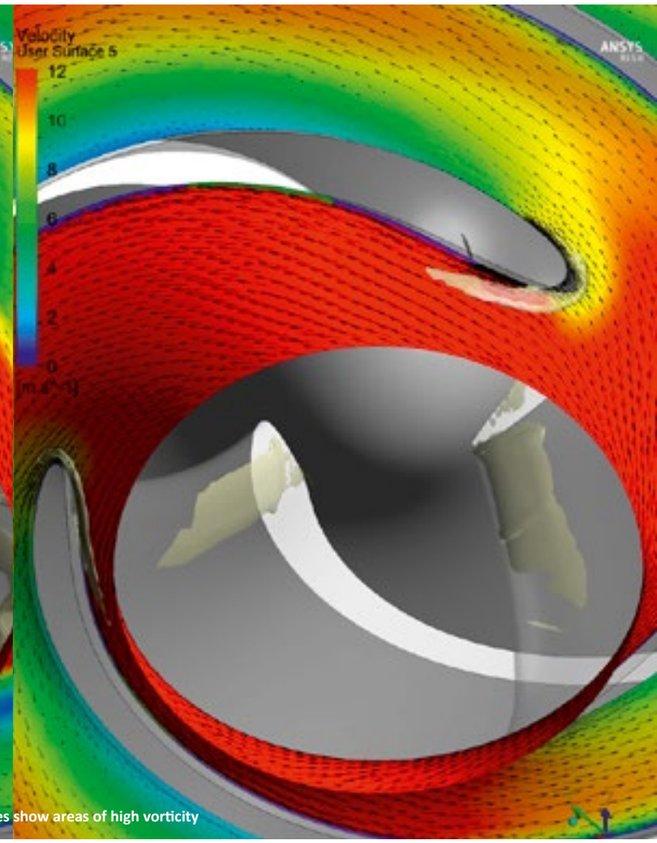
Ideally, the results of an analysis would demonstrate that the direction of the flow within the pump follows the contours of the blades. "But that's not what we see in the first Cutter Special pump," says Hasan. "In each channel the pattern is somewhat inconsistent, with varying velocities in chaotic directions."

When the inward flow is not properly aligned with the blade, it separates from its surface at the leading edge and a low velocity region, or 'separation bubble', is generated. This separation bubble acts as an obstacle, causing a chain reaction in the flow over the other blades.

"These separation bubbles consume energy from the flow within the pump," says Edwin. "As energy inside the pump is reduced, there is less energy to increase the pressure of the flow. We ultimately found that flow separation was responsible for the observed reduction in efficiency."

Having discovered how efficiency can be reduced through analysis of the flow field, the team knew how they could make improvements to the pump. "We had to design a new blade that wouldn't cause the flow to separate," says Hasan. "This required a modification to the blade profile to ensure it is optimally aligned with incoming flow across a number of different working conditions."





Comparison of the flow around CS blade (left) and CS Curve blade (right); iso-surfaces show areas of high vorticity

Aeronautical science

Historically, dredge pump blades have been designed to be uniformly thick across their entire length. The new IHC design changed this common component, presenting a blade that is much thicker at the leading edge and thinner towards the trailing end.

"The new design is very similar to a NASA space shuttle profile," says Hasan with a smile. "So there is actually some rocket science in the new pump!"

Wear at the leading edge of the CS blade is clearly visible after 15 million m^3

Wear at the leading edge of the CS Curve blade is minimal even after 13 million m^3

3D sand printed CS Curve impeller model, ready for casting


View of CS impeller suction opening


View of CS Curve impeller suction opening


Virtually no wear at the trailing edge of a CS Curve impeller after 13 million m³

The modification means that the flow now remains attached to the blade surface. This results in stronger symmetrical flow field between the different impeller blades and, because it is not disturbed from its intended path, it doesn't disturb the flow around the other blades either. The desired result had been achieved. "We assessed the new design using CFD, and calculated a 5.5% increase in efficiency compared to the previous pump," explains Hasan. "But when we came to measure it in the lab, we found it to be 1% more efficient than CFD calculations indicated! Therefore, the actual efficiency difference between the CS and the CS Curve is 6.5%."

Beneficial side effects

Along with increased efficiency, the team's goal for the CS Curve was to improve the pump's wear characteristics. Specifically, to reduce local wear occurrences on the blade-shroud connection and the volute cutwater.

As the newly designed blades are thicker at the leading edge, there's already an additional advantage in relation to this goal. "Wear inside the impeller is often most severe at the leading edge of the blade," says Edwin. "Now that this area is significantly thicker, it simply increases the components lifetime by providing more material – a very beneficial side effect!"

However, a number of other key design modifications were required in order to fully maximise the overall longevity of the new pump. One new feature is the addition of sweep to the blades. This is another innovation appropriated from the aeronautical world, in which the blades are inclined at an angle relative to the incoming flow – similar to a fighter jet's wings.

"In the CS Curve, the leading edge of each blade incorporates a sweep angle," says Hasan. "This decreases the impact velocity of the flow onto the blade, which in turn reduces wear and boosts performance. And by applying sweep, you're also elongating the blade, which again means there is generally more material to wear."

Reducing local wear

In addition, the connection between the blade and the front shield was modified to help solve the problem of local wear phenomena in this area. This wear is caused by so-called 'horseshoe' vortices that occur whenever a flow travelling along a solid surface meets an object in its path.

"The boundary layer of the incoming flow impacts on the leading edge of the blade," says Edwin. "This boundary layer has less energy the closer it is to the blade's surface, and so it is pushed back on itself to create a vortex. Velocities within such a vortex can be very high; eating away at a surface until a hole is formed."

Again, CFD simulations were performed to investigate these ideas before they were implemented. In this scenario, three-dimensional iso-surfaces are analogous of areas where vorticity pressure exceeds the acceptable threshold. Comparisons to the CS design indicated that vorticity strength has been significantly reduced.

Similar conditions along the shrouds of the cutwater in the CS pump also lead to the formation of harmful horseshoe vortices. "In order to avoid this, a modification was made that results in a curvature of the cutwater," says Edwin. "This helps to reduce frontal impact and increases the life span of the component."

Patent pending

The modified blade profile within the CS Curve has proved to be so innovative, a patent has been applied for. 'Impeller blade with asymmetric thickness' is currently pending.

"When we started this process, we had no idea that we would patent the idea," says Edwin. "We have produced a dredge pump that combines a big spherical passage with a high level of efficiency. It has the potential to make other pumps obsolete."


Wear at the trailing edge of a CS impeller blade after 15 million m³


Horseshoe wear on a CS impeller blade

Another important advantage of the new design is backwards compatibility. "As we only modified the blades and the volute, if a customer is already using a CS pump they can simply change the impeller and benefit from all the latest technology," adds Hasan. "The customer will not need to adjust any of their existing configurations in order to do this."

Although the Cutter Special pumps were primarily designed for CSDs operating in areas with a large presence of particles such as rocks and boulders, they have the potential to outperform in other fields including operations in sand and other mixtures.

Consequently, this pump may also prove beneficial to trailing suction hopper dredgers.

Pushing the industry forward

The new CS Curve was officially launched in September 2014, when a number of customers were invited to the IHC premises. A presentation on the revised design was given and visitors were allowed access to the laboratory for a demonstration of the new parts in a live environment.

"Following the launch, we have since delivered new impellers to be installed in CSDs operating in countries including Kuwait and Croatia," says Edwin. "It was important for us to visit these customers to find out first-hand how the new products are performing, and so far we have received excellent feedback."

IHC is able to use this feedback from the field in order to expand upon its knowledge base. The development of advanced in-house tools, such as new CFD models, enables pioneers such as Hasan and Edwin to respond to demands in an increasingly challenging market.

"We have a commitment to our customers to offer them the best possible technology available," says Hasan. "The CS Curve was produced through a combination of IHC's extensive experience in the field, and continuous research and development. It demonstrates our promise to keep pushing the industry forward."

Fifth pipelaying vessel for Sapura Navegação Marítima

Royal IHC has successfully named and launched the pipelaying vessel, SAPURA RUBI, in a ceremony at its shipyard in Krimpen aan den IJssel, The Netherlands. The naming of the fully integrated vessel was performed by Ms Glaucia Maciel, Human Resource Manager of Sapura Navegação Marítima SA.

The SAPURA RUBI is the fifth 550t pipelaying vessel that IHC is supplying to Sapura Navegação Marítima, a joint venture between SapuraKencana and Seadrill. All five vessels are being completely designed, engineered and built by IHC. Like her sister vessels, the SAPURA DIAMANTE, SAPURA TOPÁZIO, SAPURA ÔNIX and SAPURA JADE, the SAPURA RUBI is destined for Brazilian waters to develop deep-sea oilfields of up to 2,500m on behalf of Petrobras.

The vessel will be equipped with a pipelaying spread designed and built by IHC, and two below-deck storage carousels, with capacities for 2,500t and 1,500t of product respectively. A vertical (tiltable) lay system with a 550t top tension capacity will be permanently installed for the deployment of a range of flexible products, and the tower orientation allows for maximum deck space. A custom-designed IHC control system integrates each aspect of the pipelaying spread to ensure excellent levels of performance, safety and reliability.

Arjan Klijnsoon, IHC's Executive Director Marketing & Sales, says: "With these ships, Sapura Navegação Marítima has entrusted IHC with an impressive order. The entire project has been on – or ahead of – schedule, which proves us to be a reliable partner in complex activities.

"The operational vessels, the SAPURA DIAMANTE, SAPURA TOPÁZIO and SAPURA ÔNIX, are all performing very well. With the launch of the final vessel, we have almost reached the end of a fantastic project. I am confident that the outfitting and delivery will be completed on schedule."

To watch a video of the launch ceremony, please visit the Royal IHC YouTube channel.

TSHD MAHURY launched in Bulgaria

Royal IHC has successfully launched the MAHURY, a 1,840m^3 capacity twin-screw trailing suction hopper dredger (TSHD), at partner shipyard MTG Dolphin Shipyard in Varna, Bulgaria. The vessel is being built for Baggerbedrijf de Boer – Dutch Dredging. Its Managing Director, CJ van de Graaf Jr, attended the launch, which took place on 14 August.

The new TSHD is Dutch Dredging's fourth IHC-built vessel, after the ALBATROS, LESSE and AMAZONE. The MAHURY is an upgraded version of the ALBATROS, which was delivered in 2013, and was well received by the customer. Based in Sliedrecht, the company specialises in maintenance and capital dredging projects in Europe, South America, the Middle East and Africa.

The MAHURY includes two dredging marks in its design that allows the vessel to operate at different distances from the shore, while still adhering to regulations. The first dredging mark is for operating within 15 miles from shore, and the second within 8 miles from shore.

Dutch Dredging made the decision to invest in a new IHC-built vessel because of the company's positive experiences with the ALBATROS. IHC's high standard and on-time delivery performance were also important factors in the decision. This project further strengthens the good relationship that exists between the two companies and MTG Dolphin Shipyard.

"Dutch Dredging required an efficient, versatile dredger, with high levels of productivity and the MAHURY will serve as an excellent addition to its expanding fleet of IHC-built vessels," says André Kik, Account Director at IHC. "The relationship between our two companies is based on high levels of trust and cooperation, and we are proud to work alongside Dutch Dredging as one team."

The MAHURY is scheduled for completion on 31 December, ten weeks before the contracted date.

Success for IHC Services

IHC Services has secured an order for a substantial renovation project for a vessel owned by Huta Marine Works Ltd in Saudi Arabia. Work on the HUTA 14 self-propelled cutter suction dredger (SPCSD) will be carried out by IHC Middle East based in Dubai, and the Service Operations department in The Netherlands.

The renovation involves the replacement of three large diesel engines, and the electrical installation for the underwater pump drive. Royal IHC is responsible for the engineering of the rebuild, purchase and delivery of the hardware, supervision during the installation and commissioning of the dredger after conversion.

"The vessel, built in 1986, has a total of four engines but one had already been changed by a previous owner," says Robert Jonk, General Manager of IHC Middle East & India. "Two dredge pump engines are already out of order and require replacements, and the third engine is about to break down. The submerged dredge pump needs to be changed, and the current parts are now obsolete."

The renovation will bring immediate benefits to Huta Marine Works, which specialises in dredging, marine infrastructure and harbour construction. Based in Jeddah, the company has a fleet of 15 CSDs, of which 12 were delivered by IHC. The new engines and dredge pump drive on the HUTA 14 will result in reduced downtime and enhanced efficiency.

"IHC Services was awarded the contract mainly as a result of good communication with Huta Marine Works, and effective cooperation between various departments and units within IHC," says Robert. "We have supported this customer on a number of other repair projects, and regularly supply spare parts."

Now the contract is finalised, four members of staff in Dubai will be involved in the project and eight in Kinderdijk, The Netherlands. The hardware will be delivered to Jeddah in spring 2016, ready for installation.

IHC Services carries out approximately three renovation projects such as this per year. Following the success of this order, Robert and his team believe there will be greater potential for further renovation and upgrading of other CSDs owned by Huta Marine Works.

MAIN FEATURES

- **Coiled tubing: far-reaching possibilities**
- **Go with the flow: introducing the Plumigator I airless overflow**
- **A joint approach: IHC's alliance with Dräger**
- **Fuel for the future: LNG dredging vessels**
- **Around the world: a spotlight on IHC Services**
- **The leading edge: the new Cutter Special Curve pump**

ABOUT IHC

IHC is focussed on the continuous development of design and construction activities for the specialist maritime sector. It is the global market leader for efficient dredging and mining vessels and equipment – with vast experience accumulated over decades – and a reliable supplier of innovative ships and supplies for offshore construction.

IHC has in-house expertise for engineering and manufacturing integrated standard and custom-built vessels, advanced equipment and also providing life-cycle support. This integrated systematic approach has helped to develop optimum product performance and long-term business partnerships. The company's broad customer base includes dredging operators, oil and gas corporations, offshore contractors and government authorities.

Royal IHC

P.O. Box 204
3360 AE Sliedrecht
The Netherlands

T +31 184 41 15 55

www.ihcmerwede.com
communication@ihcmerwede.com