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DEVELOPING A NEW GENERATION OF TSHD DRAGHEADS

Rene Exalto [1], Ruud Ouwerkerk [2], Caspar Kramers [3] and Paul Vercruijsse [4]

ABSTRACT

For the major part of the twentieth century the drag-heads applied on TSHD's were based on the erosion concept. In the mid seventies split hull hopper dredges were introduced, followed a few years later by the drag-arm mounted pump. Split hulls could discharge sticky materials and drag-arm mounted pumps could lift higher densities from larger depths. As the Californian and IHC Mud drag-heads continued to be the excavation tools, in spite of countless experiments with other concepts, it was obvious that in the excavation process gains could be made.

The introduction of the Jumbo dredges in the mid nineties initiated also concentrated but broad research on drag heads, targeting a more active contribution to the excavating process. Propulsion power and deposit resistance were evaluated in detail. After experiments and feed-back, IHC itself introduced its Excavating drag-head about a decade ago. Such Excavating drag-heads are in the meantime being applied throughout the world, including in the USA.
Research continues, among others with flow analysis, means of excavation, jetting concepts and process control.

An excavation problem, encountered by a new hopper dredge in the Yangste estuary in China, initiated the development of a dedicated drag-head for that specific deposit. That drag-head, named the Wild Dragon, is fitted with a visor with chisels, with jetting through the teeth. The drag-head's position is electronically controlled and the visor's position hydraulically enforced. That drag-head proved in 2004 to be able to effectively and efficiently excavate that deposit of very fine materials (< 90 mμ), previously experienced not possible. This paper also shares more recent experiences with later deliveries of the WILD DRAGON.

In the meantime continuing R&D activities on this product facilitated to apply a number of these innovations for drag-heads for other, more "common" applications. Feed-back shows that these developments prove to be another step ahead in the ability of the hopper dredge to actively excavate a broader range of deposits.

A more recent "back-to basics" research effort, separate from the further development of the WILD DRAGON concept, is creating a computer model of the complete excavation process, among others applying artificial intelligence and using Computational Fluid Dynamics. That R&D effort is still in progress and no definite conclusions and recommendations can be published. Indications are that significant deviations from earlier applied principles can be expected. Preliminary results are pointing towards a more complete system approach to optimize production, rather than dealing with the drag-head as a stand-alone product.

This paper summarizes the results of the research and development of the drag-head within IHC of the ongoing further development of the Excavation Drag-head and the WILD DRAGON, culminating in the design of the excavating drag-heads presently being applied as state-of-the-art. A short indication of the separate research effort with the modeling of the excavation process is included.

Keywords: draghead, visor, cutting, jetting, fine sand, WILD DRAGON

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INTRODUCTION

The Trailing Suction Hopper Dredge is about 150 years old. Steam power facilitated the introduction of centrifugal pumps. In the mid 1800's the US Army Corps converted three steam ships into hopper dredges. In 1870 Mr. Smit, the founder of one of the six shipyards that formed IHC, built in Holland a hopper dredge with a centrifugal pump.
History documents that the US Army, Corps of Engineers was in the major part of the first half of the 20th century a leader in hopper dredge development and research. The first US hopper dredges, attempted to scoop up the deposit, a means of mechanical excavation, using the pump to lift the material to the surface. Among those drag-heads remains the Frühling head likely the most well known drag-head concept from those days.

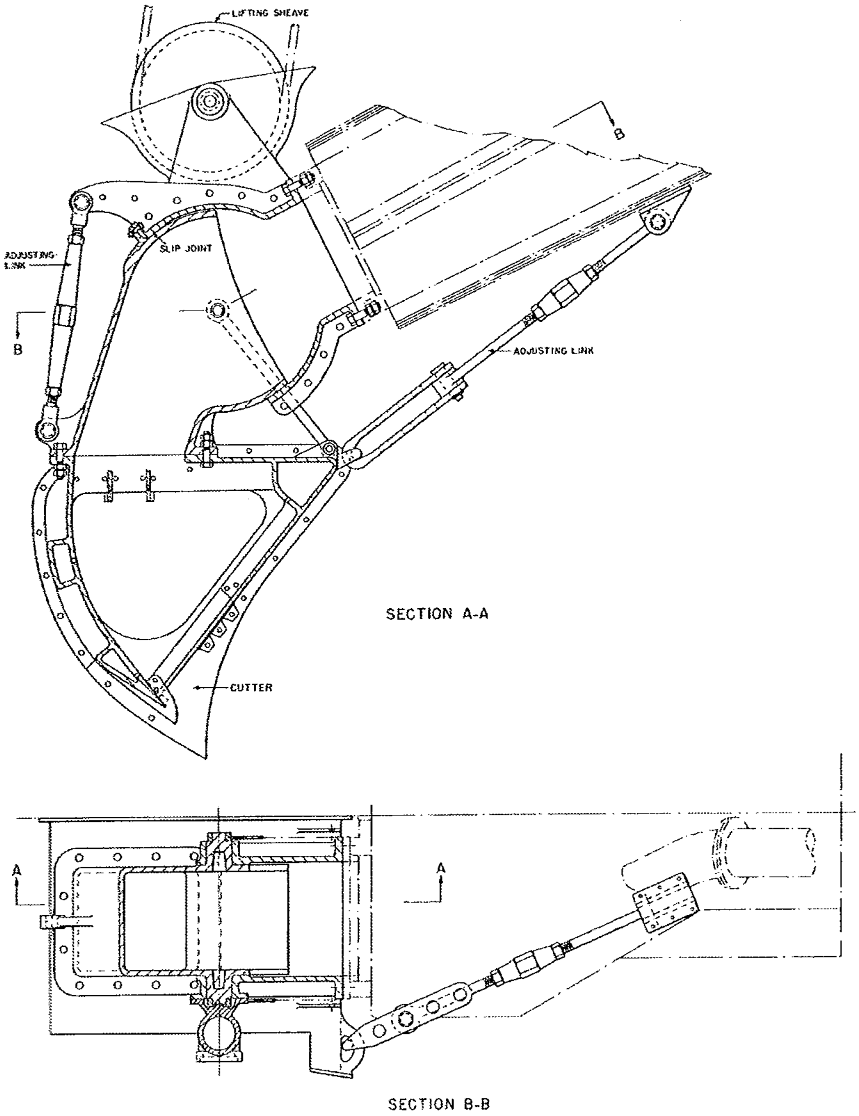

Figure 158. Dredge NEW ORLEANS—Fruehling drag.

Figure 1. The Frühling Drag-head as applied on the hopper New Orleans (1912) – (Sheffauer 1954)

At the end of the 19th century the developing application of steam power, widening its use for propulsion, was at that time a limiting factor for that mechanical excavation process. Mechanical scooping creates a considerable drag-head resistance. When propulsion facilities improved, the concept of the German Frühling continued to return. Scheffauer reports in 1954 that since 1902 some 70 (seventy) Trailing Suction Hopper Dredges were equipped with a drag-head derived from the Frühling concept. Typically, dredges that applied this type of drag-head were often fitted with a stern drag-arm. A position mainly selected for the trailing force experienced and propulsion required. The illustration shows that the large trailing forces resulted in relative narrow heads compared to today's standards.

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STATUS TILL THE END OF THE 20TH CENTURY

The principle of a drag-head being towed over the bottom evolved rather quickly over from the mechanical scooping of the deposit from the bottom, which the early drag-heads attempted. This suction and erosion principle governed the hopper dredge's excavation method for many decades. Till a decade ago the erosion type drag heads most commonly applied were the Californian drag-heads of the thirties and the IHC patented "Mud" head of the seventies.

Both drag-heads work basically according to the suction and erosion principle: the vacuum of the centrifugal pump creates a high flow at a narrow contact surface between bottom and drag-head visor, sucking the water with water with high velocity, carrying sand. Those drag-heads consist of two parts: a fixed part that bolts to the drag arm and the visor(s) mounted with a hinge construction in the fixed parts. Depending on the dredging depth, the angle of the lower tube of the drag arm can vary. The visor can rotate for a number of degrees around the hinge to remain in contact with the bottom and different means to force remaining in touch with the bottom with mechanical means have been tested and applied. (pin-bar, springs, pneumatics, hydraulics).

The Californian drag-head, developed by the US Army, Corps of Engineers is considered suitable for digging in more compacted sediments. The Californian drag-head fitted during its life with a number of developments – jetting in the heel, teeth and a variety of wear blocks, while visor holding devices have been applied between fixed part and visor. In today's variations of the Californian drag-head, the Corps' design of 80 years ago can still be recognized.

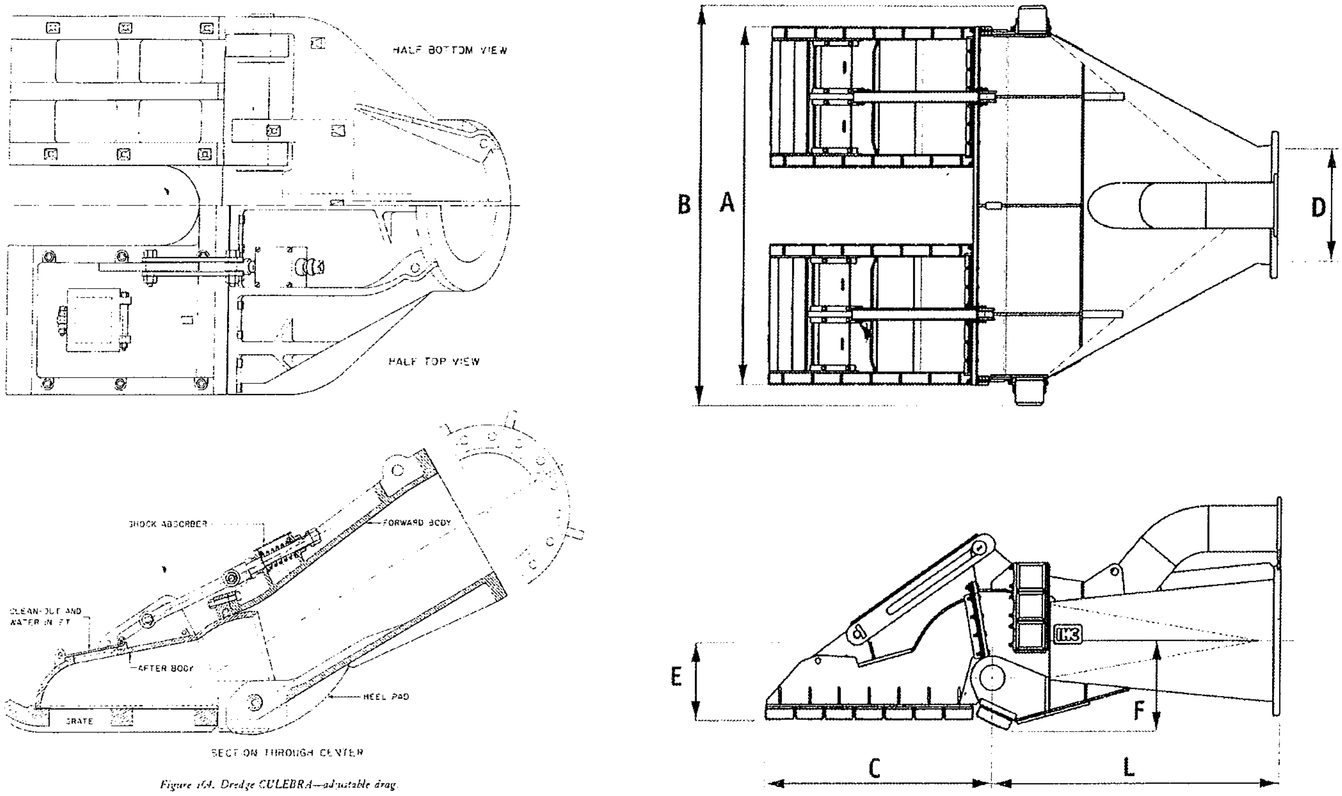

Figure 164. Dredge CULEBRA—adjustable drag.

Figure 2. The development of the Californian Drag-head.
Left: The model as tested by the US Army Corps of Engineers on the Hopper Dredge "Culebra" in 1927. This model would later be labeled as the Californian Drag-head (Sheffauer 1954).
Right: Today's version of the Californian Drag-head as carried by IHC in stead of cast and a guide bar in stead of a spring.

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The IHC head was developed for softer, silty deposits, The Californian drag-head is characterized by two shoes on the visor, with wear blocks with narrow openings on the bottom surface, exciting the erosion flow. The IHC head as the opposite is characterized by one large visor, with wear shoes at the aft end, to carry the head.

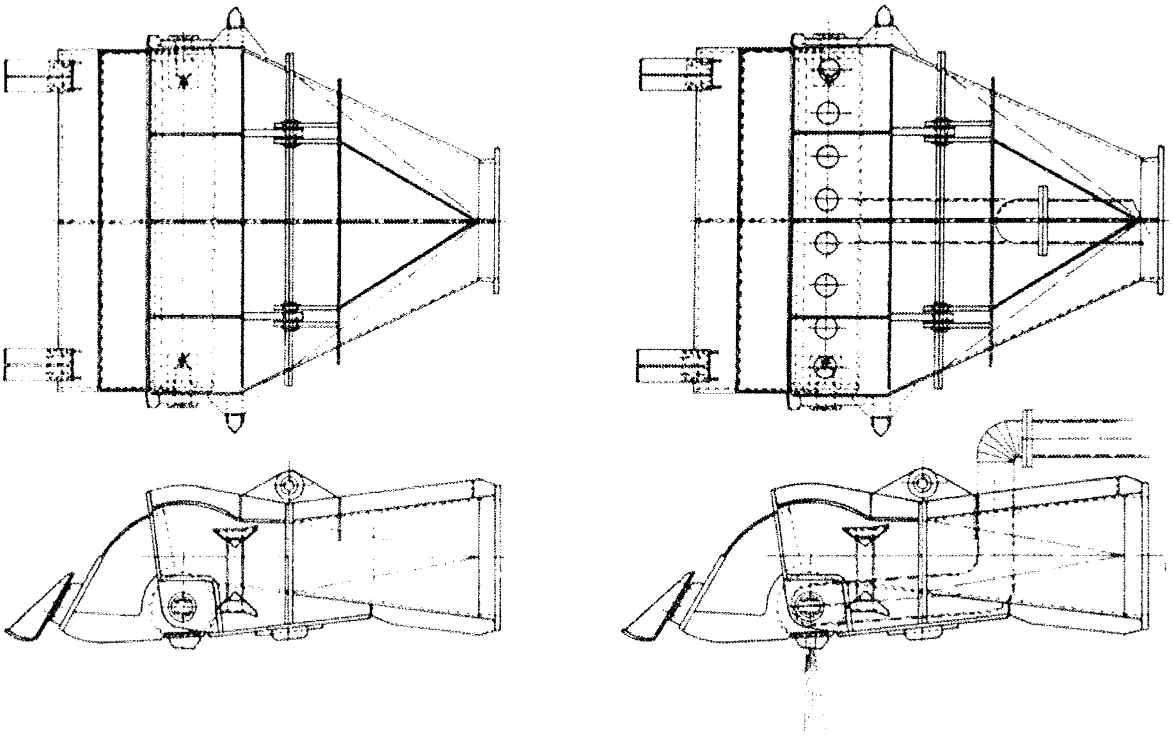

Figure 3. The patented IHC "Mud" draghead with one visor and visor heel pads.
Left: Classic execution
Right: With jetting

Attempts To Improve The Production

Teeth

The erosion concept proved to be limited in more compact deposits. Different teeth concepts heads have applied during the 20th century on different drag-heads and experimented with at different locations in the world. Chisels and teeth sold by earth moving companies were applied, but also plain bars as well as rotating knives, all intending to loosen more compact deposits.

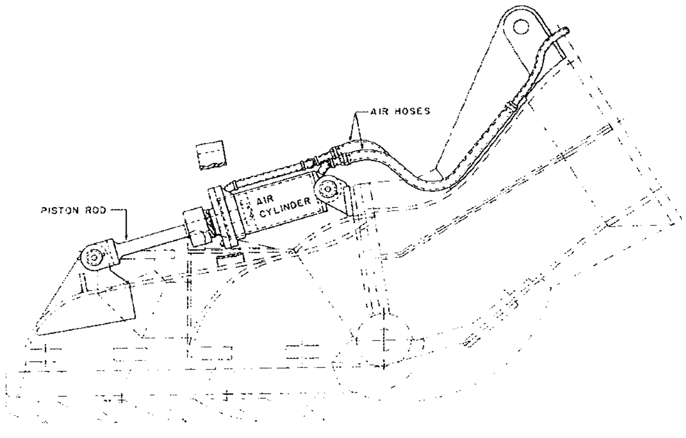

Figure 167. Power-loaded California type drag.

Figure 4. The US Army Corps applied already in 1950 cast teeth and pneumatic pressure on the visor (Sheffauer 1954)

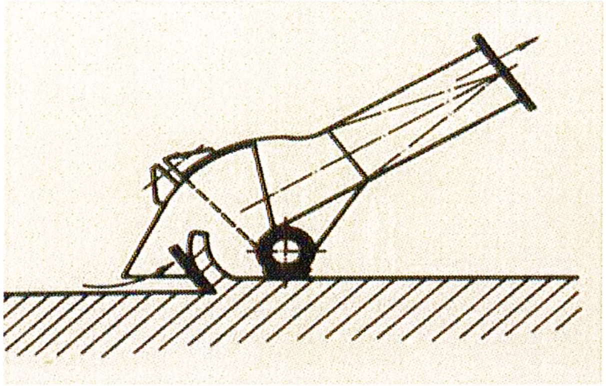

Figure 5. The IHC drag-head, although intended for silts, could be fitted with a cutting tool nickname to be a "cheese cutter", to harvest clayey silt layers

Jetting

Jetting in drag-heads is being applied for many decades. The most observed application is jetting via a number of nozzles mounted in the heel of the fixed part. The definition of the target of jetting varied within the applied concept widely, from: "adding water to fluidize and break the cohesion" to a actually "cutting the material loose before it is exposed to the suction force through the visor". The amount of nozzles, the flow used and the pressure applied, (up to hundreds of bars/psi's) varied greatly. Pressures of 8-10 bar (120-150 psi) and a modest flow made that a luxury addition, resulting in some increase in production in compact sand.

During the last few decades, experiments with jetting have been abundant. Targeting to cut material loose, pressures of several hundred bar (several thousands of psi's) were and are applied. Higher cost for pressure development and severe erosion effects in nozzles makes that type of high pressure jetting a less common application.

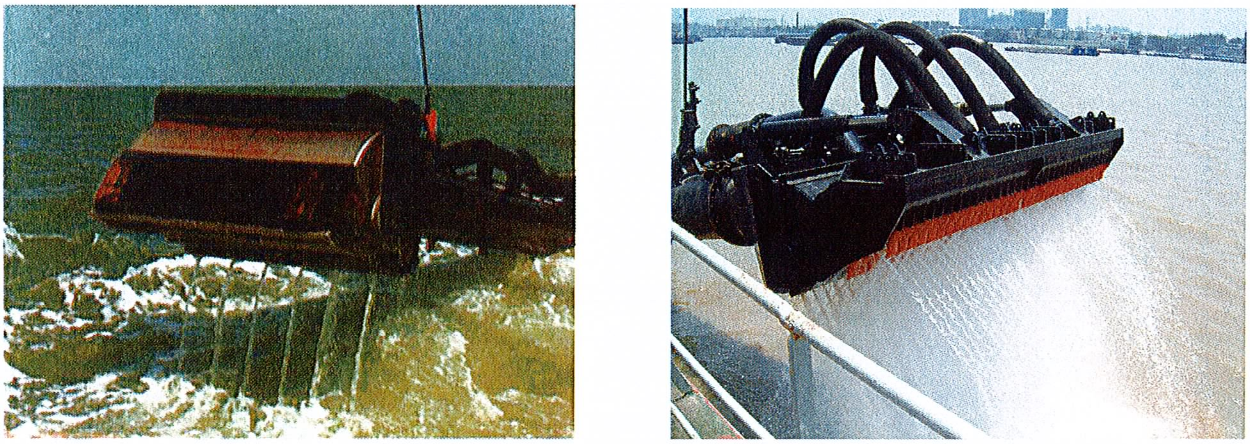

Figure 6. Jetting as applied on dragheads.
Left: Jetting from the heel of an IHC Mudhead (1980)
Right: Jetting in the Wild Dragon through heel and teeth bars (2004)

The production impacts show to be varying highly and jetting remains a subject of continued research.

Controlled Visor Forces And Visor Angles

Although angles of attack of the visor were in different ways attempted to be forced, these drag-heads remained to basically fall back on the erosion principle. A number of varieties of forcing the visor down of specifically variations of the Californian drag-head variants were developed and applied, however the erosion concept remained the governing principle. Pin-bars, springs, pneumatic cylinders all sought to hold the visors face flat on the surface.

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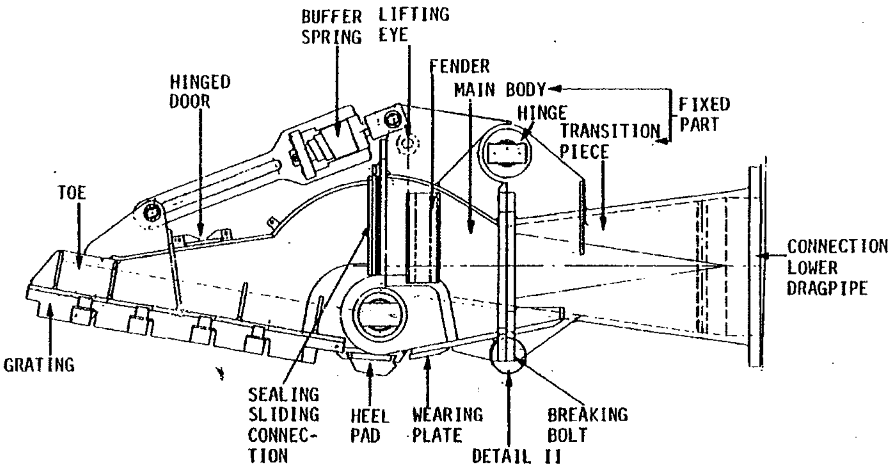

Figure 7. The IHC Californian drag-head fitted with spring to force visor down

Other Developments

The swell compensator/shock absorber in the hoisting wire of the drag-head winch facilitated the drag head to follow a bottom profile varying in vertical height. Although rarely applied, the contact bottom pressure can be varied, depending on deposit characteristic.

Variations of the erosion drag-head dedicated to specific purposes, were also developed worldwide. IHC developed so its Venturi drag-head and its Silt drag-head. In 1972 IHC installed in cooperation with Dredging International an experimental drag-head on the hopper dredge MAAS: a submerged dredge-pump mounted on top of the drag-head, targeting an even larger vacuum to increase production. A vacuum can however be so high that the drag-head sucks itself into the bottom. A high vacuum proved not to be a substitute for an excavation force.

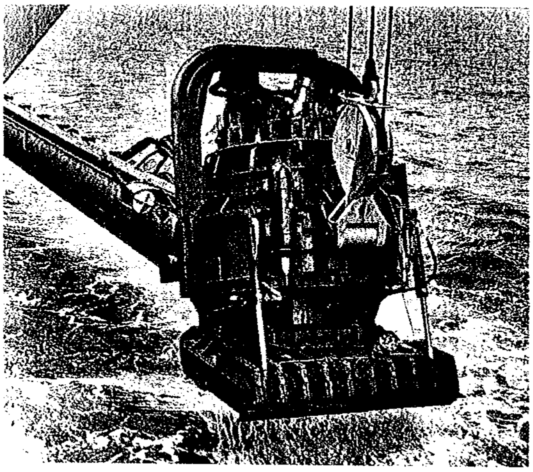

Figure 8. The dredge-pump of the hopper dredge MAAS integrated into the drag-head

At the end of the 20th century also electronic control started to be applied, such as the gap control on the trailing edge of the visor of the IHC drag-head. A decade ago the introduction in dredging operations of DP/DT, (Dynamic Positioning/Dynamic Tracking) together with the presentation of dredge track started to make it possible to keep the drag-head in reasonably accurate controlled path.

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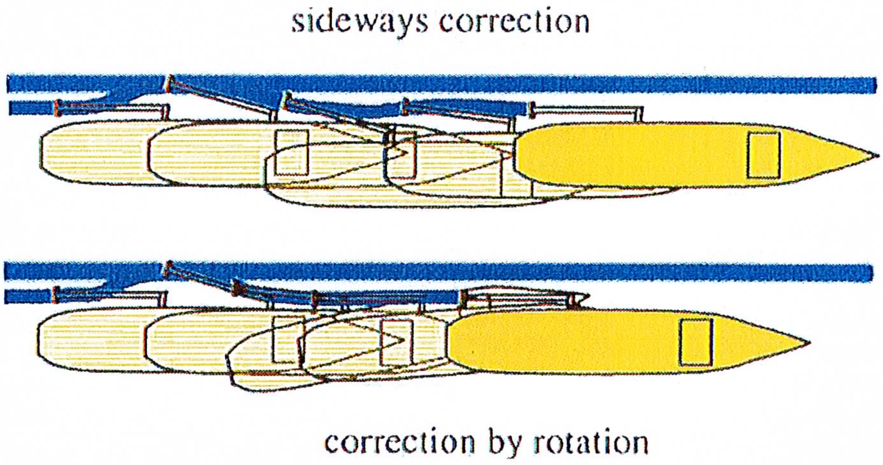

Figure 9. The (DP)/DT system's ability to correct the dredge's course, to keep the drag-heads in the track.

EXPANDING THE TASK OF THE TRAILING SUCTION HOPPER DREDGE

The hopper dredge was traditionally applied in areas of high traffic, where anchor suspensions entailed a risk and in areas where sea conditions limited the application of stationary cutter suction dredges

In the mid seventies, the first the split hull hopper dredge was introduced. While a split hull is compared to a similar mono hull roughly 30% heavier, advantages were seen due to the fact that split hulls have the ability to discharge more effectively more compact and sticky material. At the same time the drag-arm mounted dredge pump was introduced and it became an established tool.

The Active Drag-head

Applications like the split-hull hopper dredge and the drag-arm mounted submersible pump allowed more compact, heavier material to be lifted and discharged, but the excavation process continued to apply the erosion principle. IHC performed at that time extensive research on an active drag head. A hydraulically operated knife roller was mounted in the visor.

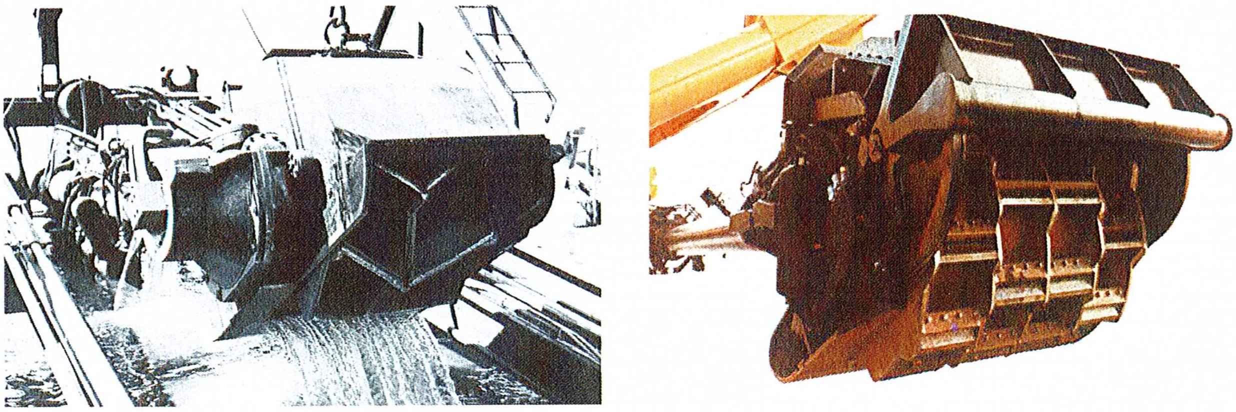

Figure 10. Active drag-head, with a hydraulically driven cutter roller in the visor.
Left: Test model with fish-grate knives on test unit "Multimol" (1976)
Right: The prototype as installed on the TSHD: Johanna Jacoba" (1978)

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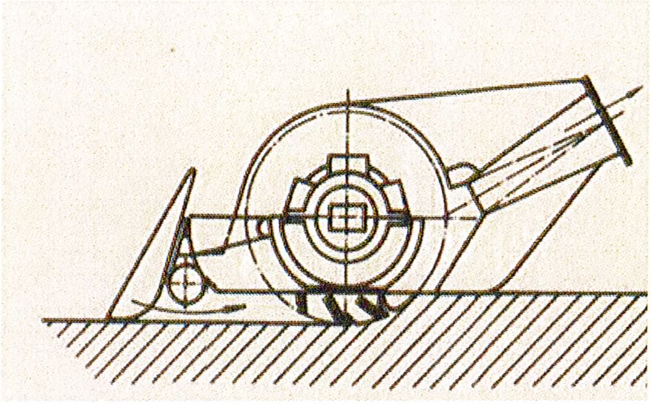

Figure 11. The principle of the Active drag-head of figure 10.

After having a model prototype tested successfully with an R&D cutter dredge, the first full scale prototype was fitted on the TSHD "Johanna Jacoba" This new hopper was fitted with a heavier drag-head davit, winch and swell compensator, as the drag-head weight as well as excavation forces were foreseen to exceed those normally applied for a Californian or IHC Mud-head. The drag-head was first successfully tested in a clayey deposit in the entrance of the Jade River near Wilhelmshafen, Germany and further tested in the more compact deposits in the North Sea.

That drag-head did indeed excavate those materials. However the idea that the cutting process could cut the stiffer materials and the inboard pump's suction would suck out those materials, did not materialize. Applying either straight fish grate knifes did not result in significant difference, if stiffer materials were encountered. Also, the drag-head lifted itself and surfaced with a clogged knife roll when the material was highly compact. Further, when attempting to create parallel tracks, the drag-head often found its way back to the lowest part, most often being the earlier dug parallel trench. That phenomenon was not experienced during testing, as that was done on a cutter suction dredge. (In those days drag-arm position was measured only in the vertical plane via a less accurate pneumatic depth measuring gauge. Only the angle of the drag head hoisting wire gave an indication of the approximate position of the drag-head relation to the vessel.)

This drag-head initiated a truly active cutting process. The first production model as delivered did however not produce immediately what it targeted: cut more compact, sticky deposits. IHC proceeded to develop a modified execution, facilitating the cutting and transport process via another better concept. While this truly active excavation concept was considered to be ahead of its time, this variation of the concept was at that time not pursued any further, due to various reasons, including the abandoning of the split-hull concept.

The Jumbo Dredge

The demand that larger reclamation jobs be executed against lower prices per dredged unit than at that time were quoted, such as made for instance for the new Hong Kong Airport Chep Lak Kok, pushed dredge contractors towards increasing the dredging and carrying capacities of their fleet units. In their wake the dredge builders were challenged to build larger Trailing Suction Hopper Dredgers. In 1994 the Pearl River was introduced to the market as the first Jumbo dredge and since than an impressive number of dredges with a hopper larger than 10,000 cubic meters have been delivered, far more than doubling the world's hopper dredge carrying capacity.

The pressure to operate such large investments efficiently, caused a pressure to study every detail of the dredge operation, and the excavation process became once again a center of attention. Dredge owners developed and experimented with different drag-heads. Visor operation, width, water supply and weights were among the elements evaluated.

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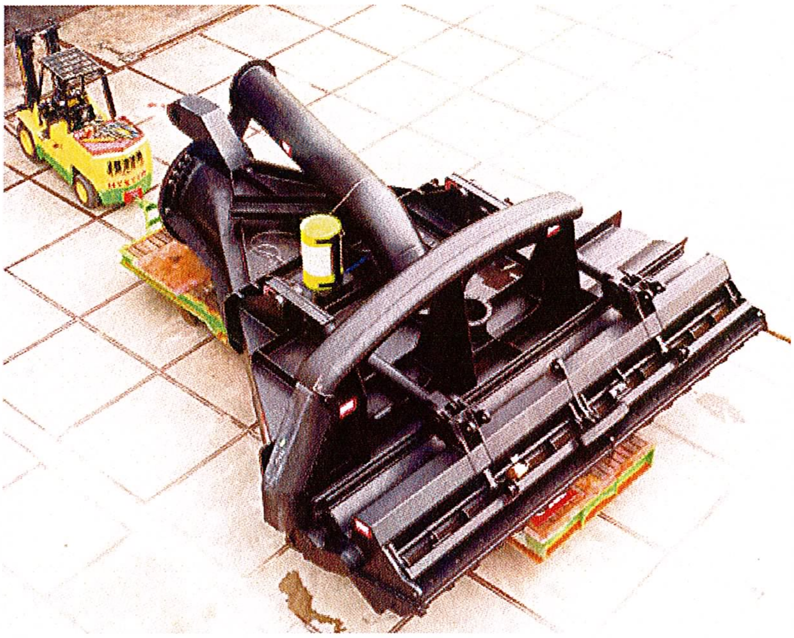

Figure 12. Drag-head of Volvox Terra Nova, for one drag-arm ID 1200 mm (47") with a 6000 kW submerged pump

IHC developed at that time the Excavating Drag-head. The excavating was effected by trailing the drag-head over the bottom, but no longer let the visor be horizontal with the bottom surface. A controllable (hydraulic) or pre-set (Pin bar) angle of the visor, further equipped a row of chisel teeth targeted a forceful excavation, showing a variation of the earlier Frühling scooping concept.

Jetting still remained concentrated in the heel of the fixed part, intended to diminish the cohesive resistance of the layer to be removed.

The IHC Excavation Drag-head At The Turn Of The Century

Experiences with other drag-heads with teeth in compact deposits had shown a drag-head behavior, ready "to ride up", when resistance grew higher, diminishing by itself the dredging depth till the equilibrium was found between pull with weight of the drag-head and the resistance.

A wider, less deep cut proved to be a more economical approach and the drag head designs became wider than the Californian and IHC Mud-head, which typically had a width of 2x I.D. of the drag arm.

As the drag head was designed to dig itself in deeper into the deposit layer, a fear of choking arose. Water supply valves were therefore added to the top of the visor. In the first of the prototype executions, the water valves were executed as a trailing edge and would be controlled hydraulically. These drag-heads did improve the production and IHC could adjust its production calculation prediction for hopper dredges.

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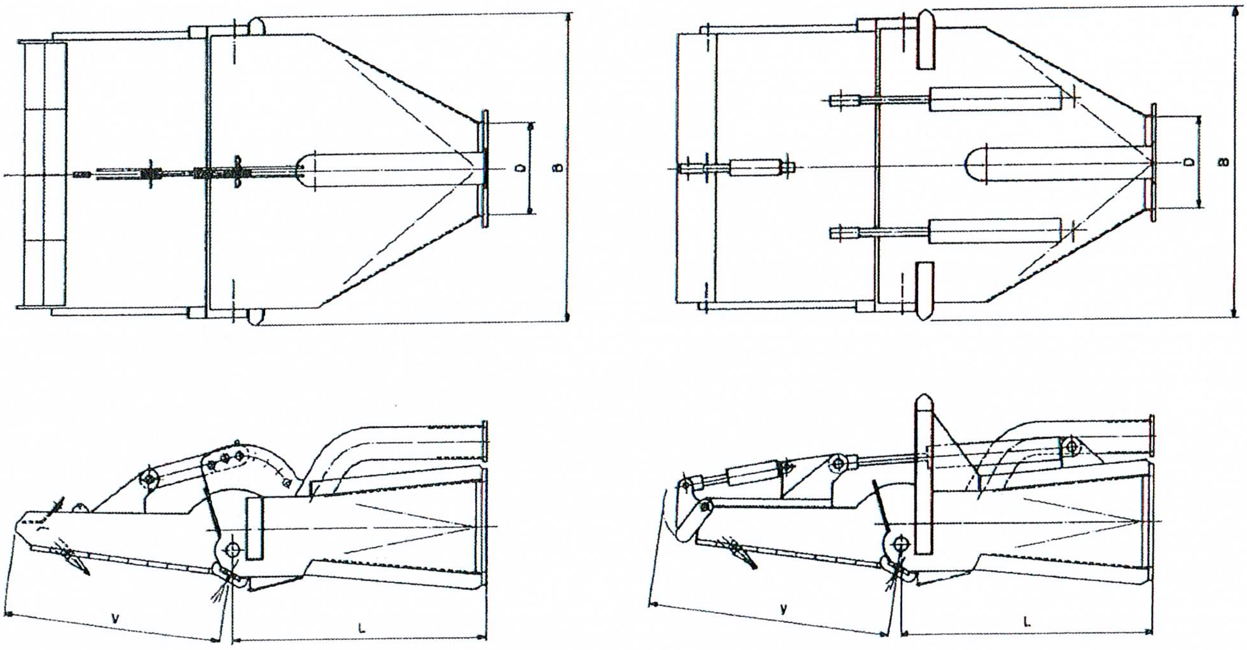

Figure 13. The IHC Excavation Drag-head at the turn of the century.
Left: The passive type with pinned visor.
Right: The active type with hydraulically operated visor and water supply trailing edge valve.

With the increase of the Jumbo hopper dredges, in quantity and in size, the experimenting with the drag-heads increased. Practical experience provided the feed-back that production increased both due to jetting variations as well as choosing positive visor angles and application of tooth rows.

The increases in production were significant, however the variations of the different parameters drag-head width, visor angles and varying control, water supply jetting pressure, volume, place of jet injection etc. led to different interpretations. Research continued and still continues.

THE WILD DRAGON

A built-to-purpose variation of the excavating drag-head, the WILD DRAGON, has drawn a lot of attention. The development of this semi active drag-head has been described and documented well (references 10 and 11)

The newly delivered 12,888 m3 Trailing Suction Hopper Dredge Xin Hai Long (2002) was deployed on a bank in the Yangtze estuary in China, on a tough bank, that stationary dredges could not handle due to its location in the traffic lane and governing wave conditions.

The new Xin Hai Long showed on that specific bank only a poor production with its IHC excavation drag-heads.

This "failure" let IHC investigate the deposit. Laboratory tests were performed on the material. The deposit was a fine The deposit was a fine material with a d50 of 60 to 100 mμ material. It was analyzed that the deposit was so fine that the classic trailing speed, cutting the deposit was higher than the speed of the water penetrating he pores of the fine deposit. Its cohesion was not timely broken: and actually a cavitation-effect in the cutting process can be observed.

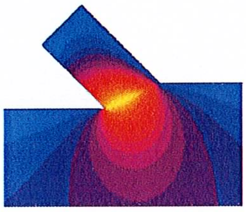

Figure 14. The core of the resistance.

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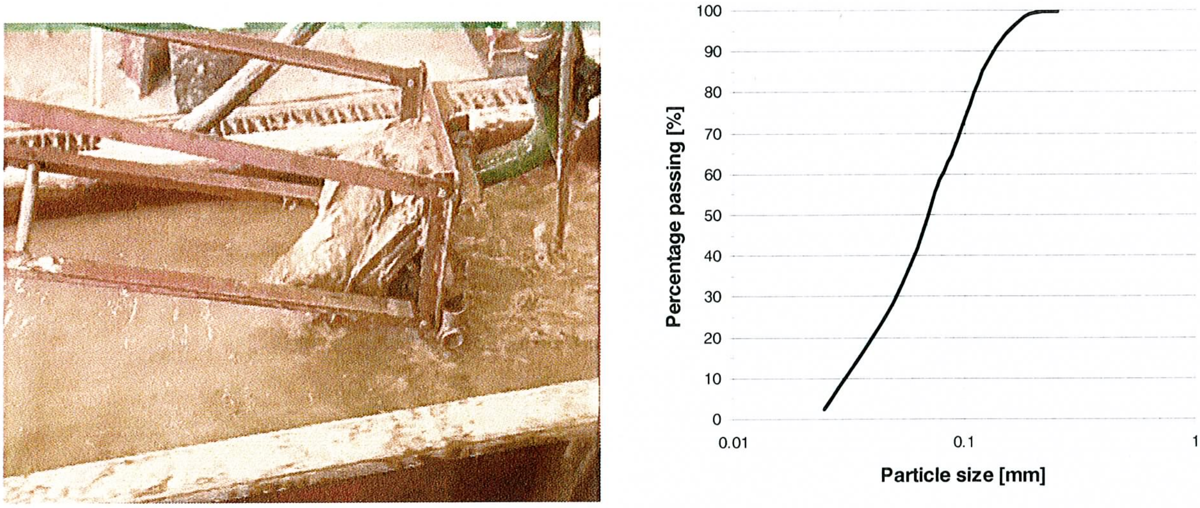

Figure 15. The very fine sand from the bank in the Yangtse.
Left: Testing the material characteristics during a test cut.
Right: The sieve curve documents the very fine characteristics.

Experiments targeted to excite the water saturation process, at the place where it was most important: where the cut chip tears loose of the material. Experiments were also were made to insert water into the cut of the teeth. That proved to provide excellent results. The theoretic modeling was tested in a laboratory towing tank. The concept translated resulting in a new drag-head., where jet water is injected through the teeth into the cut surface. The modeling and testing showed that in this case it was not the high pressure that cut, but rather the volume, the flow of water that saturated the deposit broke the cohesion. By assisting the natural soil processes, the resistance is reduced, facilitating the cutting of larger volumes.

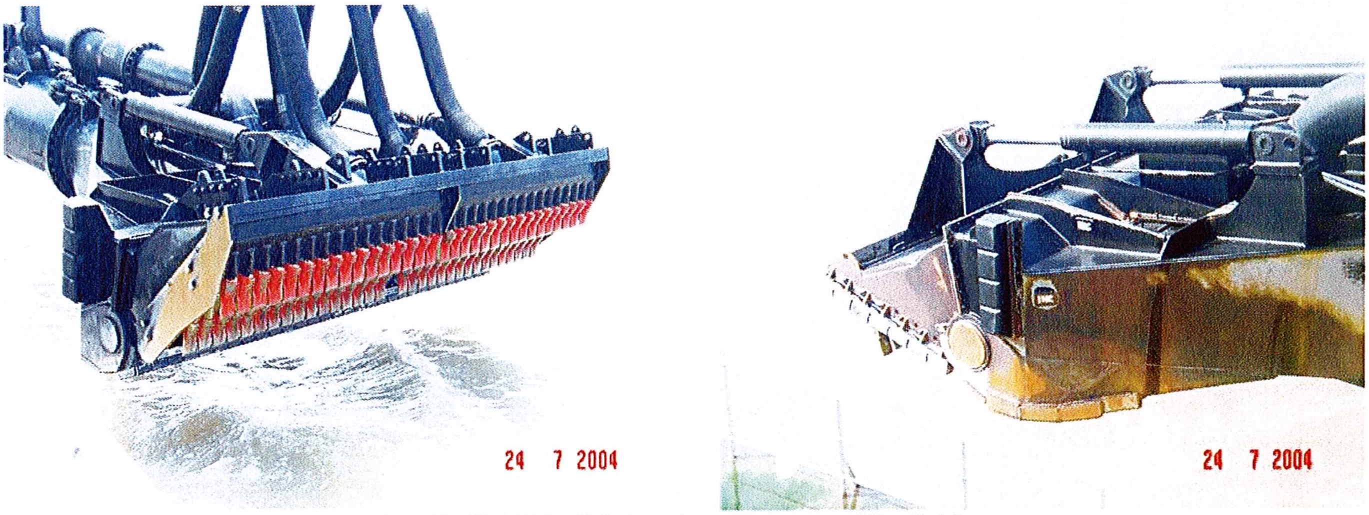

Figure 16. The WILD DRAGON, as installed on the Xin Hai Long
Left: View on visor with two rows of teeth.
Right: View on visor operation (observe wear pattern)

The propulsion power of the Xin Hai Long, equipped with nozzles and CPP, was more than sufficient, even in the governing currents. Its drag-arm was designed for the excavating drag-head forces and hydraulic power could be brought down along the drag-arm, to be connected to the visor operation. The Wild Dragon, developed with its two

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rows of teeth in the visor and jetting through the teeth, was optimized for the specific material with a d50 of 90-100 mμ. For that deposit this innovative dredging tool proved to be excellent and outperforming the excavation drag-head.

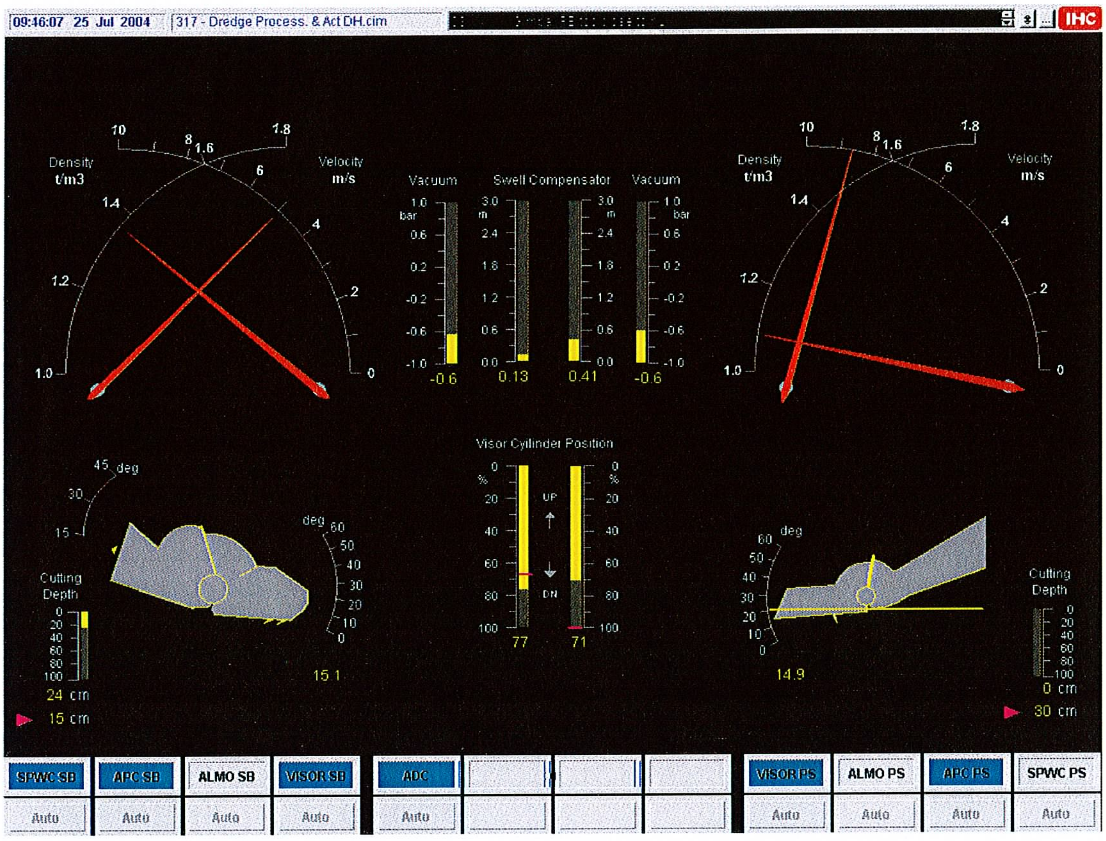

Figure 17. The Port dragarm with a WILD DRAGON indicates a density dredged of 1.38, the starboard one, equipped with an excavating drag-head, shows a density of 1.08

More Experiments With The WILD DRAGON

The success stories of the WILD DRAGON made that tool a desired product. IHC continues to point out that that drag-head was a custom designed solution for a compact deposit of very fine sand. However, of course the question was raised if that jetting concept with adding water through the teeth to the “hot spot” of the cutting process, would also improve production in other types of material.

IHC tests every hopper dredge extensively in the North Sea. Dredge trials have been performed for many decades in one and the same area, a sandy area south of Hook of Holland with “Goeree sand”, a 300 mμ sand area, rather smooth without a lot of pollution. That area allows proper reference testing and a data base with the test results of tens of hopper dredges over many decades is available. The results of these drag-head tests could for instance be compared to the results of the extensive comparative tests with a Californian drag-head, IHC Mud-head and a Venturi drag-head, performed in 1980 when a new-built hopper dredge was used as a “dredging laboratory” for a week and 30 parameters pertaining to drag-head performance were electronically recorded and collected in a data-logger .

Figure 18. TSHD ABUL, fitted with two WILD DRAGONS (Californian drag-heads on deck) being tested near Goeree in the North Sea, near The Netherlands coast.

In 2007, the new 6000 m3 hopper dredge "Abul" for Pakistan was tested in the same Goeree sand with its WILD DRAGON drag-heads. The concept proved also in this 300 mμ sand to outperform the excavation drag-heads. Densities of 1.6 were achieved, not pursuing the upper limits.

During the Abul's first year of operation in Pakistan, IHC was in the position to test these WILD DRAGON drag-heads once again, but this time under practical operational conditions; first in an area of Port Quasim, in a deposit characterized by a d50 of 100 mμ with 30% of the material being silt (<63mu). Measurements of the hopper-load recorded a settled sand bed of 1.5 m deep, while the hopper was fully loaded, i.e. this fine material with a density of 1.65 settled slowly. Investigation of samples showed further a significant amount of particles of this sand to have a typical plate shape (phyllo-silicates). The material has a low porosity; the plate shape of the material left small spaces. This deposit proved to be also a very compact deposit of very fine material. Also here it had already been confirmed by earlier dredging attempts: also this deposit had proven to be removed by conventional methods only with great difficulties. The Wild Dragon proved to be well suited to excavate this deposit. Testing the drag-head without jetting through the teeth reduced the production to virtually nil.

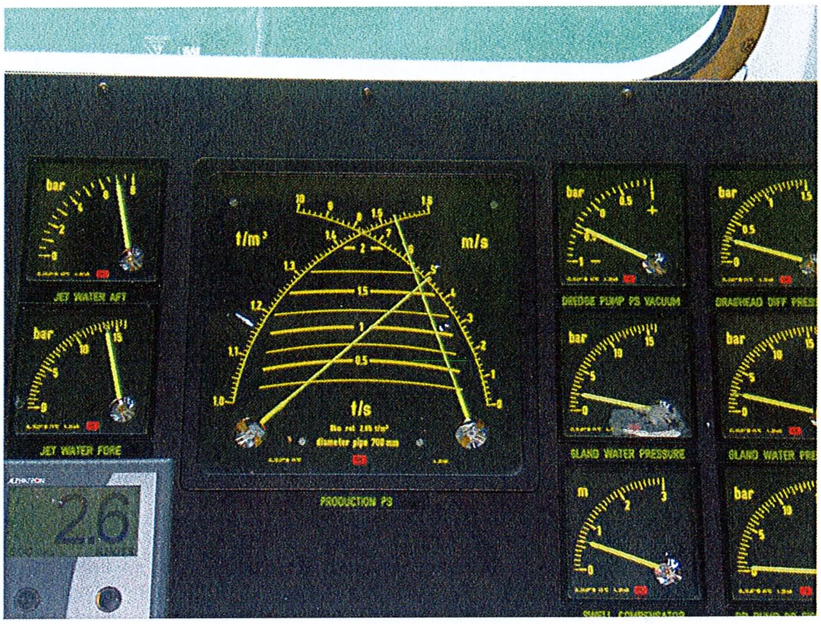

Figure 19. The cross needle indicator showing 1.55 at the ABUL, not being the upper-limit.

The hopper loading time of the ABUL in Karachi deposit in its home territory could however not be compared to the tests in the Goeree sand: many pollutants (tires, fishing nets, bags) interfered with a smooth excavation process. The California drag-heads were an equal tool in that coarser deposit, mainly due to the many pollutants to be removed.

Figure 20. The Abul WILD DRAGON drag-head having caught burlap bags. In the meantime, WILD DRAGONS have been delivered elsewhere and applied in production jobs.

Figure 21. The WILD DRAGON is also applied within the USA, "showing its teeth".

Operational Differences

Finding the optimum angles of visor and drag-arm for a specific site have to be found done by experimenting and once the optimum set-points are believed to be found, the control has to be reasonably stable.

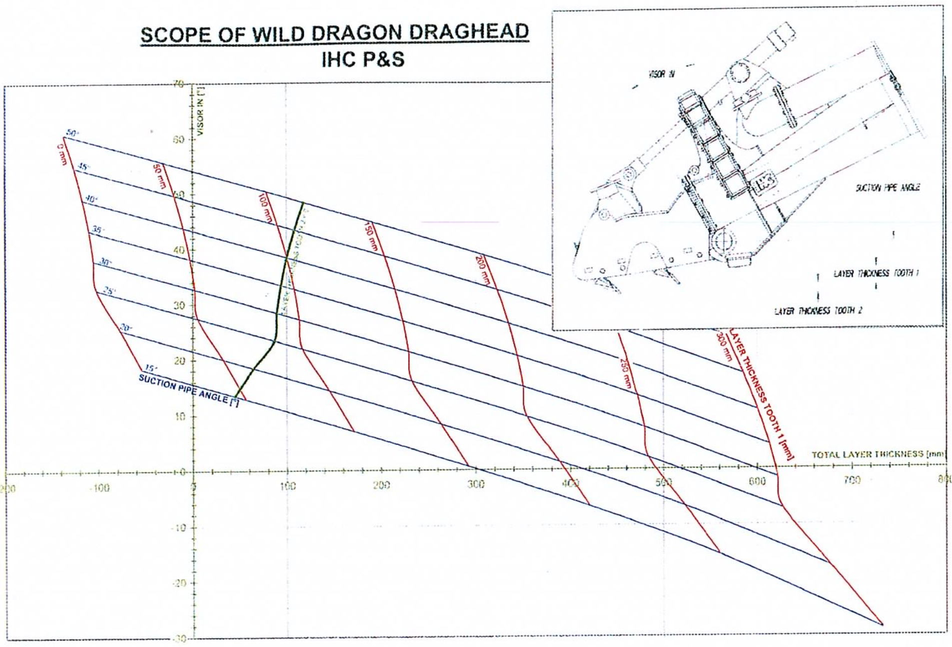

Figure 22. The operational instructions for the WILD DRAGON are more detailed than for the Excavation Drag-head.

Operationally that has shown to be a problem, as dredge masters intend to interfere too quickly with the operation. Their reaction time of say 30 seconds is remarkably faster than the settling time of the drag-heads and dredge process measurements of a few minutes. In that respect it should be noted that with the present instrumentation corrective actions are difficult to be made. Production indicators are most often installed in the pump room, and with 5 meter per second pump velocity, the action in the drag head may be observed 15-20 seconds after the fact. IHC installs pressure differential measurements systems on the drag-head.

Still, the complexity of the process requires that we include the warning that an optimum operation of a WILD DRAGON drag-head requires the drag-head to be operated electronically, with the angle of the lower drag-arm pipe to be controlled as well as the visor's position hydraulically corrected, based on the electronic data processing.

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Retrofitting New Drag-heads on existing hopper dredges.

For decades, variations of the erosion type drag-heads were the tools applied and drag-arm handling installations and propulsions were designed for that purpose. During the last decade production records have documented that excavating drag-heads outperform the erosion type drag-heads significantly. Owners and operators of existing vessels are interested in retrofitting their existing older dredges with these tools. Variations of the excavating drag-heads have been retrofitted on existing vessels. However there are limitations. The propulsion of the hopper dredge has to be sufficient to deal with the hull's resistance, the resistance of the drag-arm towed through the water and the resistance of the excavation process. In the USA the resistance of the turtle deflector has to be added in certain dredge operations.

The older dredges were not designed for that: till the mid seventies most hopper dredges were designed taking into consideration two knots current and two knots trailing speed, in the US some with four plus two. (The Corps of Engineers was even more conservative: four plus four knots) In free sailing conditions lower speeds than today were accepted.

Today's state-of-the-art dredges are designed with hull shapes with bows and stern with relatively much less resistance, higher free sailing speeds and Controllable Pitch Propellers (CPP's) and propeller nozzles that provide much higher trailing forces at lower trailing speeds.

The available power decided decades ago and the power requirement of today's drag-heads left and leaves sometimes limited room to introduce extra trailing forces. Customized executions can be and are designed for those specific dredges. The preferred width often cannot be accommodated by deck-davit arrangements of those older dredges, but also the available propulsion power may not allow the deployment of drag-heads with the full recommended width.

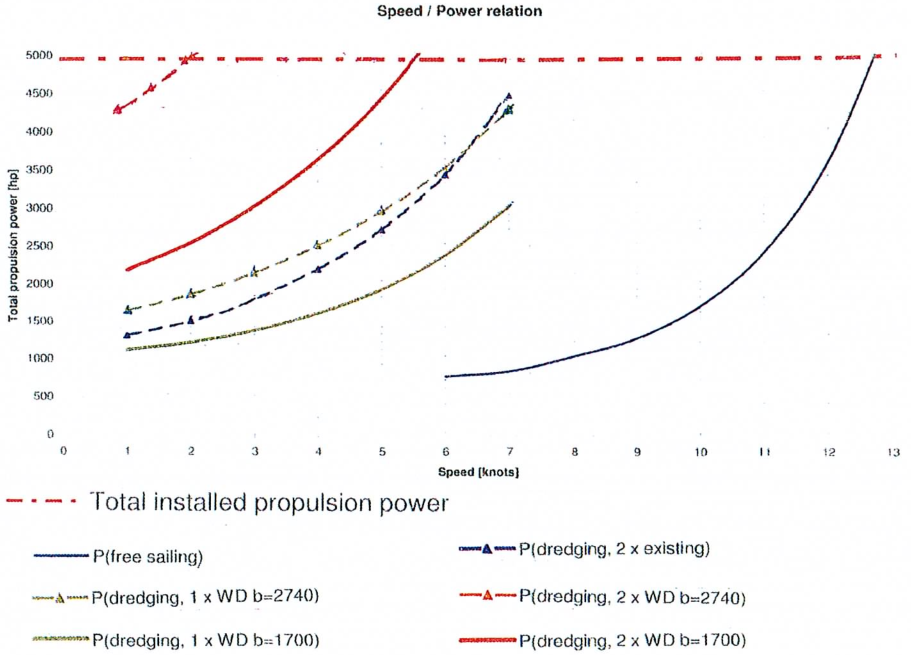

Figure 23. Typical: A 3000 cubic meter hopper dredge, with 5000 hp propulsion fitted with 700 mm drag-arms. This dredge can drag two classic Californian drag-heads, but for two WILD DRAGONS of 2740 mm. wide, it lacks the propulsion power at low speed: if these drag heads are selected to be applied, the width of the drag-heads will need to be reduced, or the selection made to deploy only one drag-head applied.

Further, not all dredges sailing today are equipped with advanced electronic measurements and control or hydraulic power that can be deployed on the drag-arm. Lifting capacity of drag-arm davits winches and swell compensators lay-out can limit the amount of modifications that can be added. A variation of the WILD DRAGON drag-head has been designed that can be retrofitted on existing Trailing Suction Hopper Dredges.

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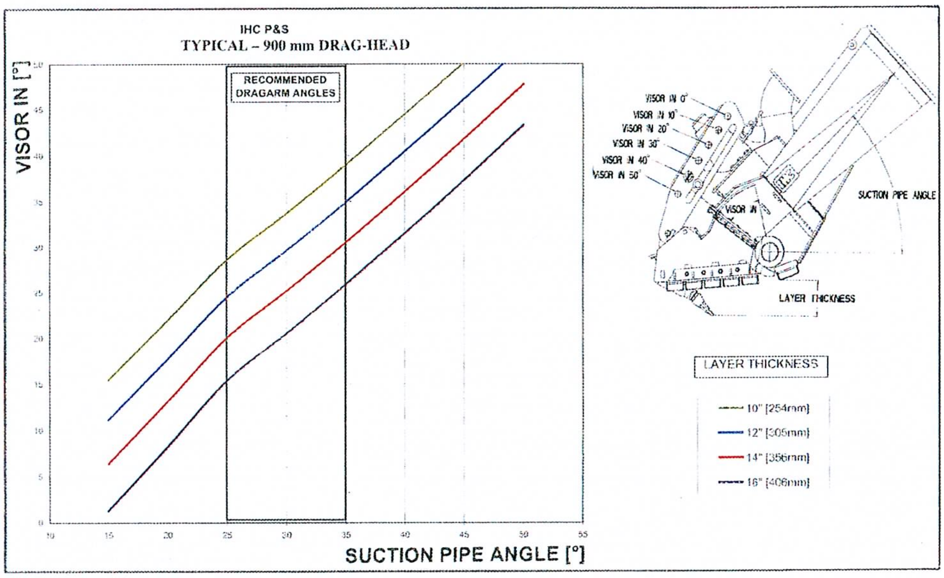

Figure 24. Optimum angles of visor of the Excavating drag-head and its drag-arm have to be found by experimenting and once found, the control has to be reasonably stable. Operationally that has shown to be a problem and there for IHC provides basic instructions for its drag-head settings.

Although the ability to adjust the visor position hydraulically is highly recommended by IHC, in a retrofit the incorporation of a WILD DRAGON with a visor only manually adjustable may be the only option, consequently taking a less optimal production for granted. A pressure different vacuum meter on the drag-head will provide instant indication of the process, however to properly react the drag-arm's configuration position will be required to be properly measured and the winch system needs to allow then to effectively correct

Major measurements, like the production per drag-arm, indicate the variations of the densities passing the drag-head only 15-20 seconds after that that instance of the excavation process occurred. That has shown to be a challenge for dredge masters: they like to intervene quickly. This process requires the visor to set itself and the process to balance out and time is needed for natural equilibrium to be found.

WHAT WILL BE THE NEXT DRAG-HEAD MODEL?

The success of the WILD DRAGON in different tests has caused an increased demand for that specific tool. As stated that drag-head functions indeed in an optimum way for that specific deposit of very compact fine sand of 90-100 mμ. It's success is partially indeed because of applying jetting through the teeth, but the whole concept has to be included in the success, including electronic control of drag-head as well as drag-arm and a hydraulic positioning of the visor.

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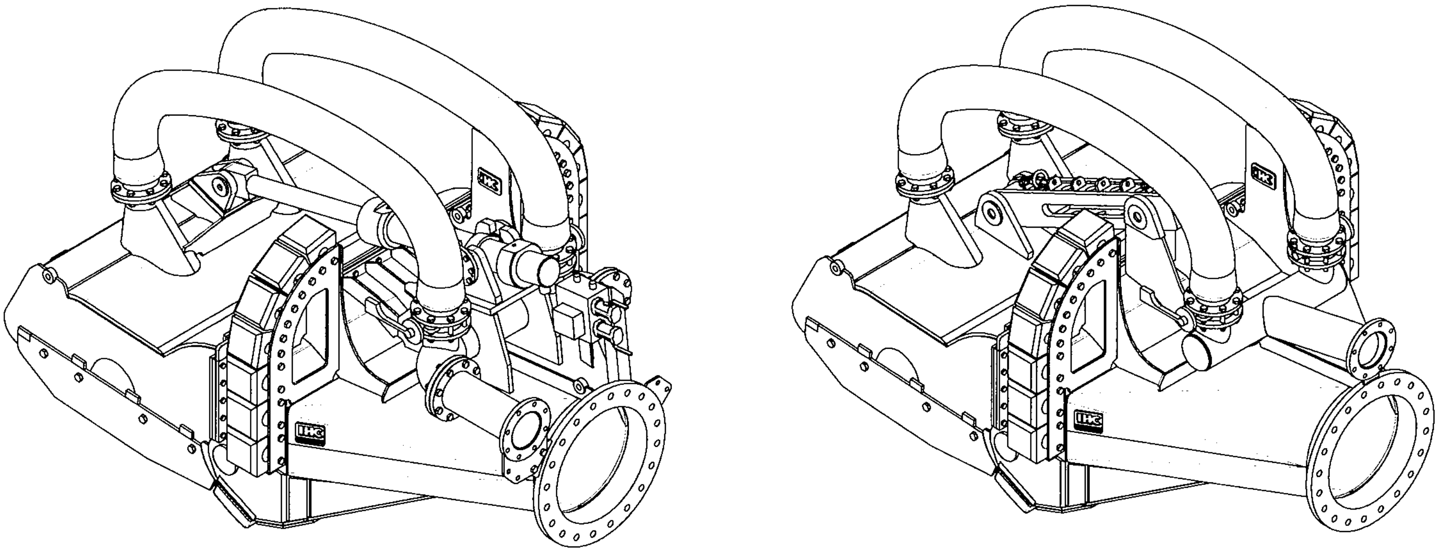

Figure 25. The WILD DRAGON as offered to the market.
Left: The original WILD DRAGON with hydraulically operated visor.
Right: The economy model with pinned visor and one row of teeth.

For retrofitting on existing dredges, a lighter version of the WILD DRAGON can be made available. While hydraulic operation of the visor and the electronic control of drag-arm and visor are considered an integral condition for the success of the optimum performance, many existing dredges cannot be fitted with fully equipped WILD DRAGONS. Propulsion power, the lifting capability of drag-head davit, drag-head winch and its wire rope, its swell compensator may not be able to fit the full width, while bringing hydraulic power down to the head. A pinned visor version with the width custom designed and one or two teeth beam(s) with jetting at a classic location can be offered.

The continuing R&D efforts are giving indications that while such a drag-head will provide another step forward , this is likely not going to give the decades of one governing design, like the Californian drag-head did in its time.

Modeling The Complete Excavation Process.

Up till now the development of the drag-heads evaluated the factors that are known to contribute to the excavation process -- either individually or in one or other way combined – including but not limited to the pump's vacuum, the visor's position, the application of cutting tools (teeth, knifes), inserting water for the purpose of liquefying, breaking the cohesion, cutting.

When analyzing the recordings of the instruments, it proves that the actual production is highly fluctuating. So much that sometimes the production could choke the pump. Now that process itself, from the compactness of the deposit, the impact of jetting – breaking the cohesion and resistance or cutting chunks has been modeled.

Electronic processing of those data and experimenting with controllable variables, including lower drag-arm angle, visor angles, water supply indicate that average performance can still be improved, but points in addition to drag-head development, also towards applying other dredge methods.

Measuring results also showed that the wear pattern leaves room for optimizing the flow inside the drag-head, for which Computational Fluid Dynamics (CFD) proves to be an excellent tool.

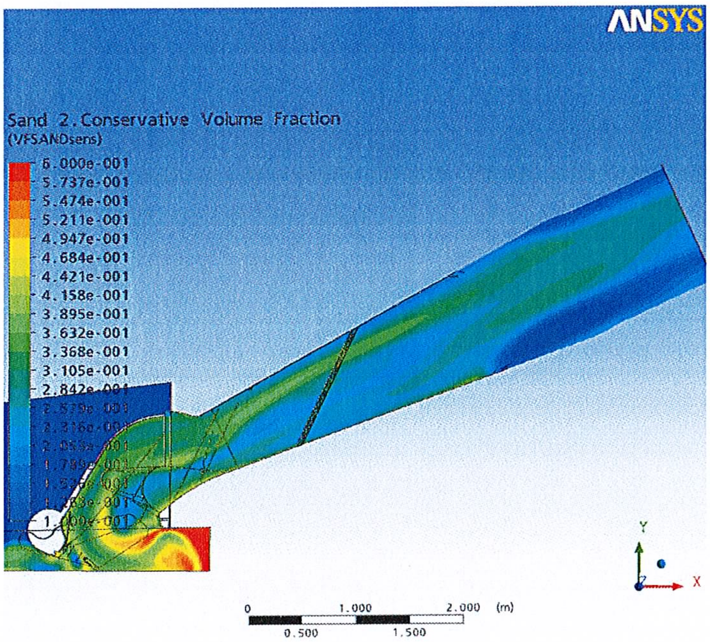

Figure 26. Example of a CFD analysis of the flow through a drag-head and the drag-arm.

Impacts of this model analysis on the design of the drag-head and lay-out adjustments can be expected.

Further evaluation and research of parameters influencing that process continues. Artificial intelligence is applied to model based control. Starting with the deposit and the effect of water brought into it during the cutting process at a specific velocity but also considering the excavating process the first step and dredge methods may also impact the performance. In the equipment the following dredge elements drag-arm angle and pump speed have to follow the excavating process rather than assuming to set parameters in which the drag-head has to perform.

The modeling, testing and evaluation are foreseen to result in the forthcoming years in adjusted shapes and further measurements and control parameters for the process. Measurements show that in spite of the jetting, the process remains highly variable.

CONCLUSION

The Wild Dragon can serve as an excellent example of a concentrated research effort, resulting in the creation of a tool that resolved the specific excavation problem addressed. That should be kept in mind: that drag-head was developed for a specific kind of deposit. The largest gain is to be obtained in clean deposits of very fine compact materials. Applications in other deposits have confirmed its strong advantages for such deposits. However in other deposits with deviating characteristics it showed that, while the concept is a promising one, its advantages against other tools may be limited. The large jetting volume is not necessarily required for deposits with coarser sieve curves. Further, the teeth bars in the visors of the drag-heads create a smaller suction opening and make the drag-heads more sensitive to larger obstacles, including pollutants.

The concise R&D effort for the problem that lead to the Wild Dragon solution, did invite another way of R&D effort for further development of excavation modeling. Based on a broad "back to the basics" research started, applying state-of- the art software modeling, CFD analysis and that R&D effort continues today. It appears that the conclusion will not result in another drag-head alone. The complete excavating system, dredge methods, drag-arm and drag-head control, swell compensator pressure variations and measurements with feed-back are subject of being included in the control of the excavation process. The new drag-head being the center of a controllable process is expected to contain the well known drag-head elements, including controllable visor, some jetting and teeth, but not be the center of the excavation process, but may be rather the tool that executes a process, directed by measurements and controlled by winches, swell compensator, propulsion power and speed.

The excavation process, including drag-heads (and cutters) will remain an R&D target for IHC for the years to come.

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