

Ship Building i n d u s t r y

Control Gurus

EFFICIENT DREDGING

Efficiency Ideal

DESIGNS FOR A LIFETIME

Saltwater Standoff

TECHNOLOGY ON TRIAL

Control Gurus

The Art of Efficient Dredging

For ShipBuilding Industry, the team at IHC Systems stepped back from the daily hustle to reflect on the role of instrumentation, sensor technology and control integration in dredging. They put pen to paper on a journey from the 'primordial' instrumentation used in reconstructing post-war Europe to modern artificial intelligence. It leads to total vessel integration.



This feature highlights the role of instrumentation, sensor technology and control integration in the art of Efficient Dredging. This art is defined as removing and/or depositing dredged material at the right, specified location and to the right depth or profile, within tolerances as specified by customers and rules prescribed by authorities.

Efficient Dredging results in the best ratio between material moved, costs and environmental load. Moving either less or more material is inefficient and can have a negative impact on the dredge operation in terms of costs and emissions, plus unwanted hydro-mechanical and/or environmental side effects.

Armoured Operation

In Efficient Dredging, the contractor 'armours' every factor in the entire operation – from planning, logistics and the availability of bulldozers, vehicles, pipelines, etc, to floating equipment and well-educated crew. Only in this way, the vessel-operators can conduct the job against the lowest possible spill levels, costs, fuel consumption, emissions, use of other resources and environmental impacts. In other words,

Efficient Dredging equals sustainable dredging. The focus of this feature is on active floating equipment, such as cutter suction dredgers (CSD), trailing suction hopper dredgers (TSHD) and excavator dredgers. Here, the 'armouring' includes integrating, adjusting, controlling and tuning a multitude of different equipment and physical parameters to the prevailing circumstances, which can vary even during a single dredging shift. Tuning parameters postulates knowing physical units. From that, the role of instrumentation and sensor technology is clear: instrumentation translates physical units into readable and understandable indications.

Hydraulic Transition

Until the sixties, instrumentation on hydraulic dredgers – that is, dredgers which transport mixture by pumping – was limited to a vacuum indicator for the dredge pump or an ampere meter for its motor, signifying the load and the proneness to cavitation of the pump. The very experienced operators of those days had grown up with the transition from the dredge bowl and the bucket chain dredger to hydraulic dredgers. For these people, the vacuum/ampere indication,

added to the colour of the mixture, sufficed to keep the dredger running. The governor of the diesel engine represented the only automatic gear. As Europe rebuilt itself from two world wars, the transition to hydraulic dredgers brought an almost unbelievable increase in dredging capabilities. In this situation, quick results were more important than output efficiency. Gradually, however, economic considerations and stricter rules urged contractors to squeeze more out of dredgers, requiring more attention to decisive process parameters. Discharge pressure meters emerged, as well as mixture density, velocity and basic tonnes of dry solids (TDS) measurements. The first attempts to remotely indicate the suction depth and the load rate of the vessels resulted in pneumatic operated pieces of fine-mechanic instrumentation.

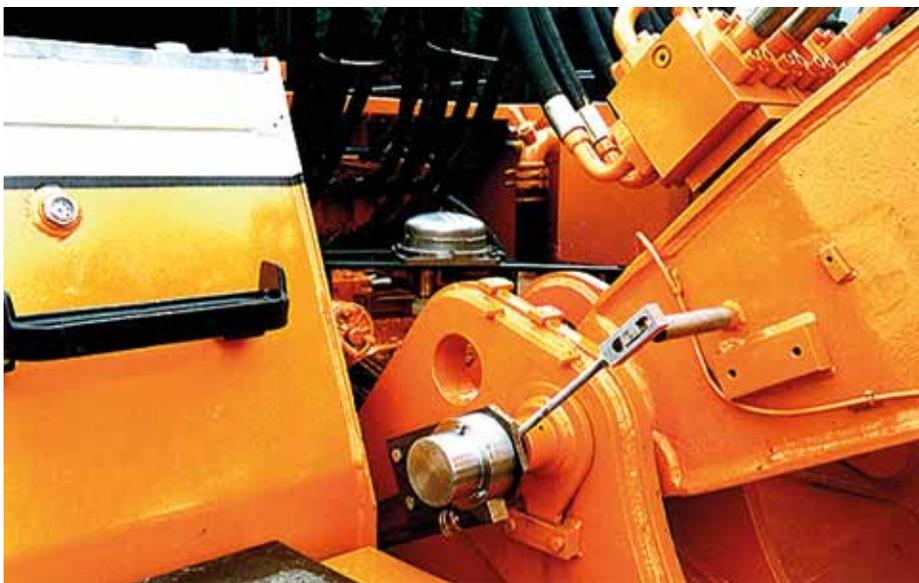
Built to Purpose

This pioneering instrumentation had no counterpart in the regular instrumentation industry, led by large companies such as Foxboro, Fischer & Porter, Honeywell and similar. Attempts to adapt such regular instrumentation generally failed. Consequently, Dutch suppliers like Observator and the predecessor of IHC Systems decided to

Efficient Dredging involves the 'armouring' of every factor in the entire operation, including the floating equipment.



In the sixties, the mixture density and velocity meter meant an unbeatable breakthrough to modern instrumentation.



The reliable 'mechanical interfacing' of dredge sensors remains a challenge.

build instrumentation for the purpose – and succeeded. Looking back, this instrumentation can seem rather crude. After 40 years one of the authors vividly recalls walking a 60m long deep-dredger ladder, while carrying a submersible vacuum transmitter weighing over 30 kg. Regarding accuracy, crudeness is a fair description, too: accuracies of ± 5 -25 percent were no exception. However, this 'coarse' instrumentation had one

large benefit over any industrial counterpart: It kept working in the very unforgiving circumstances on floating dredgers. These can include clogging by sand, violent vibrations, dust, mechanical-load variations, extreme temperatures, abuse as mounting platform and more. Mostly, the instrumentation also stayed watertight! The first mixture density and velocity meters, or rather 'estimators', operated with adapted industrial pneumatic transmitters with capillary membranes. They had a high failure rate. When the radioactive mixture density meter and inductive velocity meter emerged, they brought a breakthrough. The technology still cannot be beat, despite attempts to do so, for example through IHC Systems' ongoing research on potential replacements.

Technology Grows Together

In the sixties and seventies, sensor technology focused on durability at acceptable accuracies. For the emerging modest inboard control circuits such as pump speed controllers and vacuum relief valves, this dedicated instrumentation was vital. Relying on industrial sensors could disturb routines and result in clogged pipelines, water hammer, bursting pipes, and even injuries. The accuracies and prices of this 'primordial' instrumentation were a good reason for leading West-European contractors and manufacturers

like IHC Systems and Observer's daughter Meconaut – which finally merged in the nineties – to look back to the regular industry again for economical, useful compromises between robustness and accuracy. This appeared to be a successful move, resulting in the current state of affairs, in which most instrumentation is composed from a fortunate mix of industrial sensors, dedicated mechanical additions, adapted specifications and specific features. Nowadays sensor technology seems to have reached a balance. Standardisation and accuracies of ±1.0 percent (or better) are similar to those of onshore instrumentation, including programming possibilities and smart remote-adjustment facilities. A limited number of sensors have attained a commodity character and can be purchased from any supplier of quality instrumentation.

The newest challenge is to adapt instrumentation to the deep-sea dredging and mining applications that will start operating within the coming years. The lesson from accidents in deep sea oil exploration is that equipment better be thoroughly tested before being lowered thousands of meters below sea level. IHC Systems therefore makes use of a certified pressure vessel in which the equipment can be fully operated under pressures equivalent to 3,000 m of water depth.

Focus Shift

Beginning in the nineties, other developments became important for Efficient Dredging. Computer capacity multiplied tremendously. Subsequently, PLC, PC and SCADA systems on board dredgers were extended and supported by increasingly sophisticated communication networks, WiFi and satellite communication. Touchscreen control of dredgers is normal practice for vessels built these days. Using commonly available 'high street' hardware and software platforms, companies developed more reliable control, automation and presentation systems. These appear to have an impact on

Efficient Dredging that exceeds the impact of instrumentation as such. Consequently, investments in this field surpass those in the field of instrumentation by far.

Therefore, as insight grows, both manufacturers and users see that making large investments in dedicated sensors for every imaginable application on board dredgers is not useful. Instead, they look for a viable compromise between quality, reliability and performance. And in case of doubt, today's affordable sensors and processing capacity make essential measurements possible as redundant systems. This is not to say that instrumentation knowledge and sensor technology will disappear from the investment schedules of the dredge building industry. Sensors are too important for supplying reliable process parameters to the above mentioned systems. In particular the 'mechanical interface' or 'process connection' of sensors for dredge equipment remain a pure challenge because of the tough circumstances. Condition-based maintenance systems and new control technologies (see below) require the measurement of uncommon parameters, reflecting terms in sophisticated equations. For some other parameters, there are simply no replacements available – as demonstrated by the enduring principal position of the radiation principle for density measurements.

Intelligence & Simulation

New possibilities emerged with the application of artificial intelligence (AI) and model-based estimation and control of parameters (MBC)^[1]. These allow the approach of 'immeasurable' values and control routines online. They also enable the verification of sensor signal correctness and, in specific cases, temporary replacement of a failing signal by 'dead reckoning', just as car navigation systems do during tunnel passages. In addition, control systems can be tuned with parameters that once were not available at all. Examples are the forces on the suction pipe of a

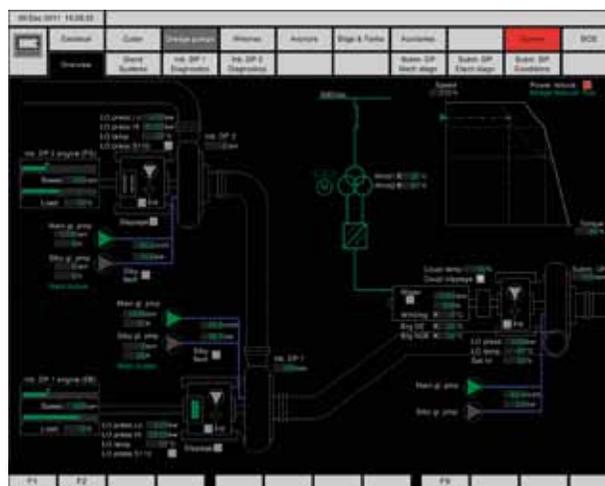


The tachometer signals of the winch motors can be utilised for every required purpose throughout the entire vessel.



IHC Drives & Automation manages the technology to integrate the dredge control system and vessel management system.

TSHD, which usually wreck Dynamic Positioning/ Dynamic Tracking (DP/DT) algorithms. These had to be measured by highly vulnerable measurements in the suction pipe hinge joints, until IHC Systems found a patented AI approach, which functions even better. Another example is the AI-based control of long multi-pump (>10km)



On the bridge, the evident consistency between IHC Systems' dredge control system (left) ... and IHC D&A's vessel management system SCADA screens prevents any operator misunderstanding.





Fully operational six weeks before transfer to the owner, thanks to total vessel control integration: Shanti Sagar XVI

dredging circuits. By estimating the average grain size, the operator can control pumps much closer to critical values, achieving efficiency improvements of about 25 percent^[2]. Dedicated, real-time simulators make it possible to develop and thoroughly-test 'in practice' these self-learning (adaptive) systems. IHC Systems built its TSHD, CSD and Excavator simulators from scratch in the first decade of this century. Primarily intended to test intricate control circuits, these simulators have reached a high degree of precision. Leading dredging contractors worldwide increasingly adopt simulators for their training programmes^[3,4,5]. The latest example is a simulator for training DEMA operators – already accustomed to the CSD simulator – on several generations of the dredge control systems (DCS) on board DEMA's TSHD fleet. Meanwhile, the use of simulators for testing capabilities continues unabated.

Total Vessel Control

Sensors, integrated PLC/SCADA/AI/MBC control and monitoring systems along with simulator utilisation are key to Efficient Dredging. However, in order to take effect, every control command signal, irrespective of its intelligence, must be followed up by inboard actuators and powering systems – such as diesel engines and/or electric or hydraulic motors for dredge pumps, cutters, winches, spuds, spud carriers, propeller installations, excavator booms, sticks and buckets. In addition, these must be supported by a wealth of auxiliary systems and components such as compressors, pumps, valves, cylinders, filter systems, etc. These require extensive electric power generation and distribution systems.

Besides, this equipment should operate reliably and should not cause downtime. Efficient Dredging would imply that this principal and auxiliary equipment is optimally tuned to translate automation signals into the most efficient physical movements and actions of pumps, cutter heads, winches, propellers and so on. Because these large energy consumers usually operate on high energy levels, for example 3,000 kW at 690 VAC, they are controlled by variable frequency drives, which are able to convert signals into controllable high energy currents and voltages.

For the purpose of efficiently managing the whole system 'dredger' with her subsystems, IHC Drives & Automation supplies proven sub-control systems, named platform automation, power management, propulsion management and alarm monitoring and control systems. The ideal case for Efficient Dredging materialises when these are integrated into a vessel management system (VMS), which flawlessly communicates and interacts with the DCS – and is operated similarly. Its benefit is, among others, that sensor signals are available in every subsystem and can be freely used, even for different purposes. For example: the tachometer signal of a specific winch is used in the variable frequency drives for speed-control feedback, whereas it is also available to DCS for estimating the swing anchor positions.

New Era

In 2012 this total integration occurred for the first time in history when IHC Beaver Dredgers, IHC Systems and IHC Drives & Automation joined forces. They equipped the non-propelled, 13,000kW IHC Beaver 9029 CSD, the Shanti

Sagar XVI, with a joint VMS/DCS on the backbone of similar hardware, communication networks, software routines and SCADA build-up, among others. This system then consistently managed every onboard function – except for propulsion of course. The first tangible result was a considerably reduced commissioning period – which also saves the time of the shipyard, being the 'third partner'. This led to the favourable situation where the vessel was fully operational six weeks before transfer to the user. Today the vessel dredges at her home base, Mundra Port in India^[6]. She will turn out to be the first example of an innovative approach in Efficient Dredging.

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All illustrations courtesy of IHC Merwede

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