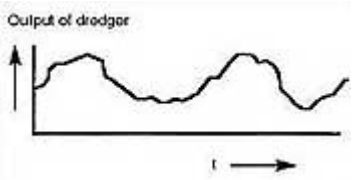
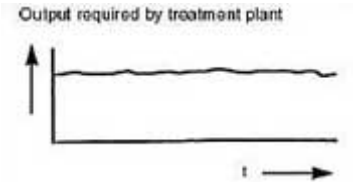
Advanced measurement, automation and control systems for mining dredgers

Introduction

The growing number of projects which IHC Holland has carried out in the mining sector have shown that far-reaching automation of mineral dredging systems is not only very useful and viable in economic terms, but indeed a must from the operational point of view. The explanation for this lies in the characteristic features of the dredge-mining process, which are:



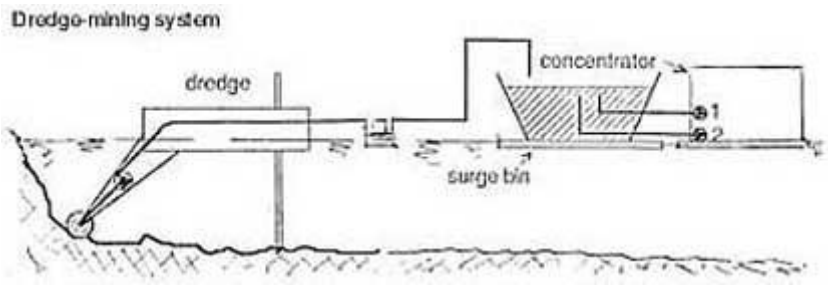
- a constant rate of production, defined by the customer and governed by the concentration plant;
- the process is continuous in terms of time and location;
- the material to be dredged is quite homogeneous and its properties are well known;
- the layout of the mechanical system remains unchanged for a considerable period.



A constant rate of production is deemed to be a rate which is maintained while dredging within relatively close limits. Fluctuations in the flow of dredged material are evened out by the use of a surge bin, but where the dredging process is manually controlled it is very difficult to keep production within set limits for any length of time.

Integrated, automated monitoring and control system

Full automation of the dredging process involves the integration of all data processing, control, alarm and presentation functions into a single, flexible Supervisory System. This has great advantages over earlier local automation systems, each of which had its own sensors, cabling, processor and controls.



If full advantage is to be obtained from an automated dredge-mining system, the mechanical and automation systems must be integrally designed. This will doubtless be the most effective in terms of cost as well. For example, the surge bin capacity and the surge bin level tolerance band will be greatly influenced by the distance between the bin, where the level setpoint is to be maintained, and the dredger, from which the process is controlled.

Mining dredger control system

Most dredge-mining operations nowadays are carried out with wheel-type dredgers, The soil is fed to a surge bin, and from there to a concentrator in which the valuable minerals are separated from the slurry.

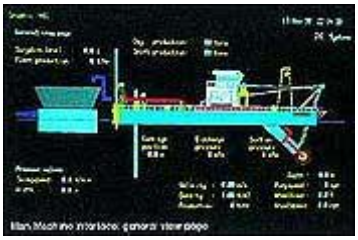
The main operational objective is to keep the flow of material to the concentrator as constant as possible. To this end, the surge bin level must be kept within close limits in order to maintain an uninterrupted supply to the feed pumps of the concentrator. This is achieved by means of the Concentrator Controller. Dredge-mining is a more complex process than conventional dredging. This is reflected in the presence of this controller and in the fact that the dredgemaster’s chief concern is to keep the surge bin level within certain limits, rather than to maintain maximum production.

System build-up
The Concentrator Controller provides the Dredger Control System with information concerning the required rate of production and the surge bin level. The Dredger Control System combines a number of interacting control functions, i.e:

- Swing Speed Control, which ensures that the swinging action is such that the preset production values are met. Various operating modes can be selected by the operator, e.g. digging, dredging free-flowing sand, and cleaning up.
- Swing Width Control, by which the dredger is kept within the predetermined channel, and effective dredging of the relevant area ensured.
- Slice Thickness Control, with which the speed of the bucket wheel is matched to variations in the swing speed, and a uniform thickness of cut maintained.
- Hydraulic Transport Control, the role of which is to calculate and set the optimum velocity of the dredged mixture in the delivery pipeline. Minimum flowrate, desired rate of production and optimum power consumption are among the parameters which are taken into account.
- Vacuum Relief Valve Control. This is basically a safety device to prevent blockage of the suction inlet, but it is also used to dilute the mixture if the density should rise above the critical value.
- Spud Carrier Stop Control. This is used in conjunction with control of the production and the limits on the wheel loading.
- Ladder Depth Control. This forms part of the pattern of control to ensure adherence to the dredging plan. An integrated system will also embody a number of general control functions, such as a sequential starting and stopping control for motors and drive systems, and logic control of the hydraulic system, including the necessary operating interlocks, alarms and controls.

Many controllers are automated in such a manner that operator action is limited to a high level, single push-button start-up control. Controls are optimized in terms of duty. For example, greasing control is only timed or selected when the equipment is in operation. If redundant equipment has been installed, the system will automatically switchover to the stand-by system from time to time in order to even out the number of operational hours.

Dredger position and mining area presentation system
This is a separate monitoring system which provides a real-time presentation of the position of the dredger within the mining area. It assists the operator to position his cuts and adjust the dredging depth in accordance with a pre-planned schedule, and thus to dredge the area accurately.



The soil data obtained during the pre-dredging survey can be fed into the system and can provide feed-forward dredging control and calculation of the quantity and composition of the dredged material. Data obtained from the concentrator and from the post-dredging survey can be fed into the system in order to evaluate the dredger's performance.

Dredger control system hardware and 'man machine interface'
A standard automation computer, additionally equipped with an intelligent graphical facility, which is connected to a color video display unit (CRT) and an industrial-grade, 'coffee-proof' keyboard, forms the heart of the automation system. The graphical facility, the display and the keyboard together form the so-called Man-Machine Interface. A range of control video pages can be selected via the keyboard. Selection keys are provided for the supervision of the various tasks, or control of any physical part of the dredger. Special keyboards are available with selection keys contained within a mimic diagram of the dredger.

When a page is selected, a schematic presentation of the function to be observed appears on the screen, together with the necessary value, trend indications, warnings, etc. The dredging, electrical and other installations are controlled by means of page-dependent function keys.

A Programmable Logic Controller (PLC), which is connected to the automation computer, executes the actual measuring, interlocking and control functions. All sensors, pushbuttons and other controls on the console are connected to this PLC, as are the survey computer and the control devices for hydraulic motors, diesel engines, etc.

Other features of the dredge-mining system

Reporting
During dredging, representative data for each swing are recorded. These can be used to evaluate the performance of the dredger later on. Shift report functions automatically generate production figures and duty and maintenance indications.

Trending
By means of so-called trending diagrams, the magnitudes of selected dredging parameters in the immediately preceding period can be displayed on the VDU screen, providing the operator with information on trends developing within the main dredging process. The operator needs this information in order to change the settings of the automation system so as to optimize the dredging process.

Historical functions
Selected dredging parameters can be stored for long periods, enabling the dredging process and the performance of the mechanical system to be reviewed over a considerable length of time.

Diagnostics
For each operational mode, a previously determined pattern of active status values of transducers, relays, solenoids, proximity switches and other devices has to be complied with. If a failure occurs, the system will display a warning, or sound an alarm, informing the operator whether end how he must take action. Remotely controlled system maintenance

Maintenance of the system can be carried out remotely, even from a long distance, with the aid of a telephone modem. This means that if a modification to the fault-finding procedure should become necessary, this can be made and tested in the factory or office, and implemented in the dredger's control system by telephone.

Conclusion
The application of modern automation systems has radically altered the way in which men and machines operate. Proceeding from the premise that each should do what he, or it, does best, and with an optimum result in economic terms as the objective, repetitive control actions have been assigned to the machine, while man's role has become one of supervision. Although this implies greater recognition of the human intelligence, the operator of an automated system is required to possess a greater knowledge of dredging, mining and control than his predecessor. Optimum use of modern equipment coincides with a situation in which a balance is struck between the technological capacity of machines and man's understanding. Where this is achieved, the result is a significant increase in efficiency and performance.

(Source: *Ports & Dredging* nr. 136 from 1991)