Automated Water Treatment Systems for the Phosphate Industry

Steven E. Nygren - Market Development Manager
K.Jay Pillai - Product Manager
Samuel H. Sutherland - Senior Account Manager
Nalco Chemical Company

Nalco Opticus® and Autofloc® process control systems have been in operation in five continents at hundreds of mineral processing plants for the past decade. Industries include coal, bauxite, copper, silver, gold, lead, kaolin, construction aggregate and others . Each system has been customized for the specific on-site water treatment needs and requirements for the specific operation. The goals of each Nalco system across industries remain similar: optimize the unit operation, increase productivity, minimize overall production costs, produce a favorable return on investment, and contribute to company profitability. These Process control systems have played a major part in distinguishing Nalco as the world leader in Water Treatment technology.

The latest extension of Nalco technology has been into the water treatment operations of the Phosphate industry. The system being treated is a complex operation consisting of eight thickeners, plus a variety of associated collection and overflow tanks. An Opticus computer based process control system has been operating nearly all aspects of the circuit for over a year. This includes not only chemical addition to the vessels but feed and underflow pumps as well. The current operating system is Nalco's Opticus 7.0 for Windows 95.

The Opticus computers are located on the company LAN (local area network) in three locations. These include the plant control room, the engineering office, and the foreman's office. In addition, Nalco personnel can, via dial-up connection, provide support, upgrades, and troubleshooting. Complete functionality (password PIN protected) is available from any location. All field I/O are connected via a Primary computer. A future upgrade is planned that will allow full redundancy for I/O via a Standby computer.

The heart of any automated process control system is the logic that drives it. Several control options such as feed forward, feed back and a combination are possible; each offering a particular set of advantages and disadvantages.

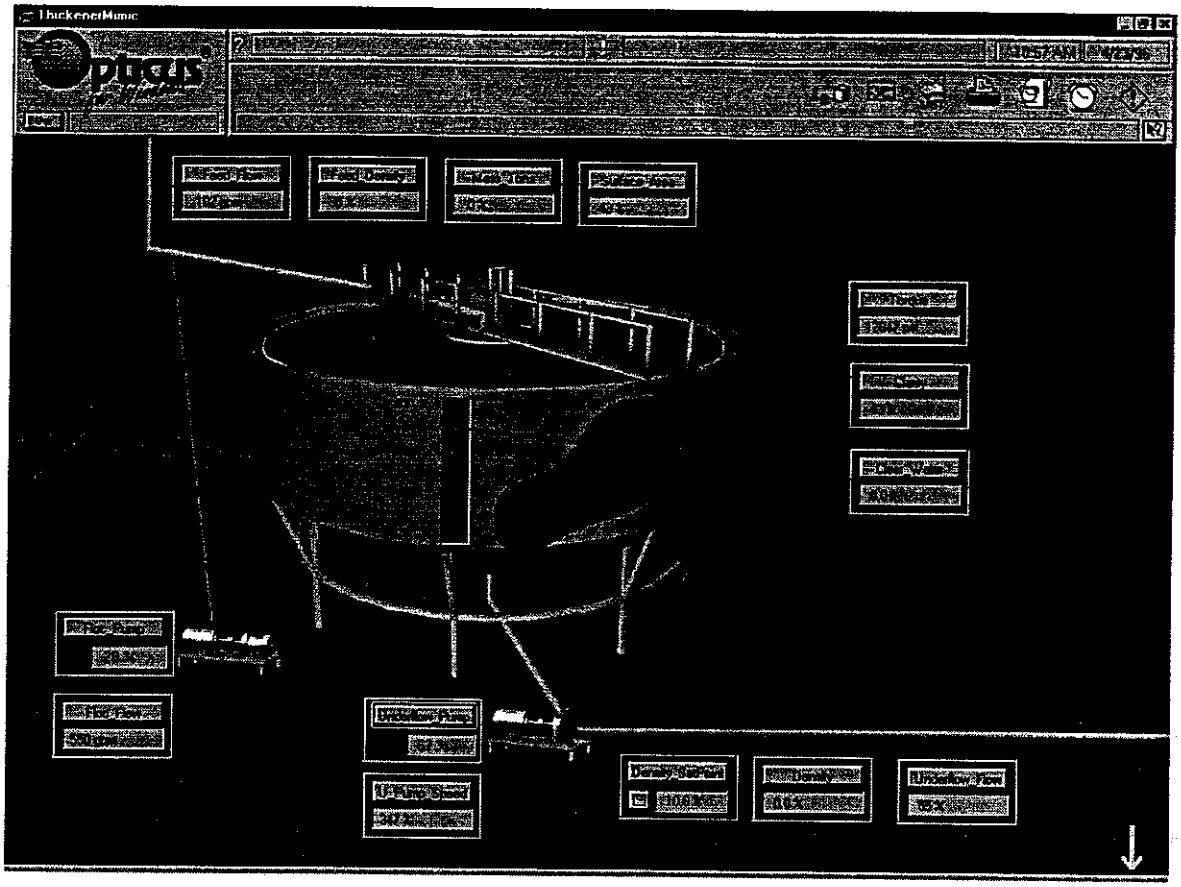


Figure 1: sample screen showing the Operators' view of one thickener.

Control Logic

Thickener control is accomplished using a combination of Nalco proprietary sensors and mathematical algorithms. Many control systems rely exclusively on feed back control. In a feed back system the process must undergo an upset before a measurement and adjustment can be made. In thickener control, for example, flocculant control based solely on bed level actually requires the bed level to be upset before a change is made to chemical dosage. The results of the change must then wait a lag time (defined by the process) before an accurate measurement can again be made.

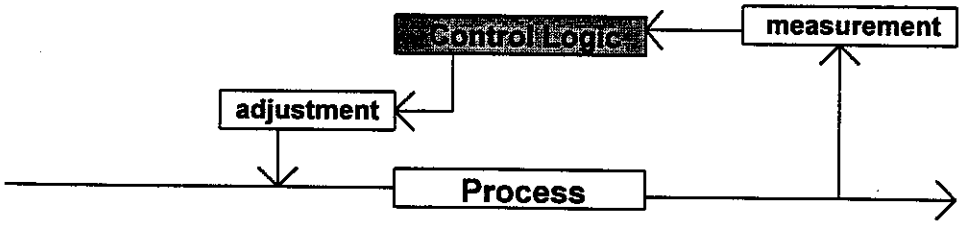


Figure 2: feed back control

However, due to fluctuating conditions in many systems, it is important to implement feed forward control for flocculant addition. Feed forward control measures critical values before they enter the process. Doing so allows a predictive adjustment to be made.

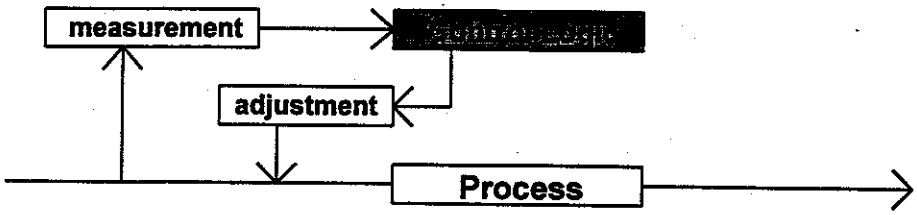


Figure 3: feed forward control

While feed forward control is fast, it is imprecise because it does not correspond to the end effect. On the other hand, feed back control is more precise but slow and does not adopt to a rapidly changing input condition. Thus, in most control systems is it advantageous to take advantage of both feed forward and feed back logic. This control strategy allows prediction and prevention of upset as well as monitoring process results and fine tuning. Nalco's Opticus system takes this strategy one step further by implementing "expert" control. In expert control the feed back element is actually used to automatically fine tune the feed forward element.

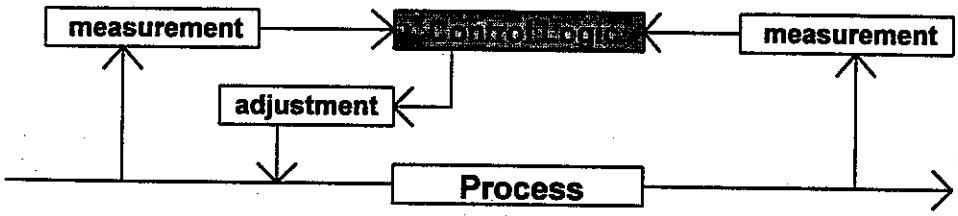


Figure 4: feed forward / feed back expert control

Feed forward control of a thickener is accomplished by measuring the Total Surface Area of the slurry before treatment (using a Nalco patent pending sensor) . This measurement combines the effects of particle size distribution and percent solids. Nalco research has shown a direct (non-linear) correlation between increased surface area and flocculant demand.

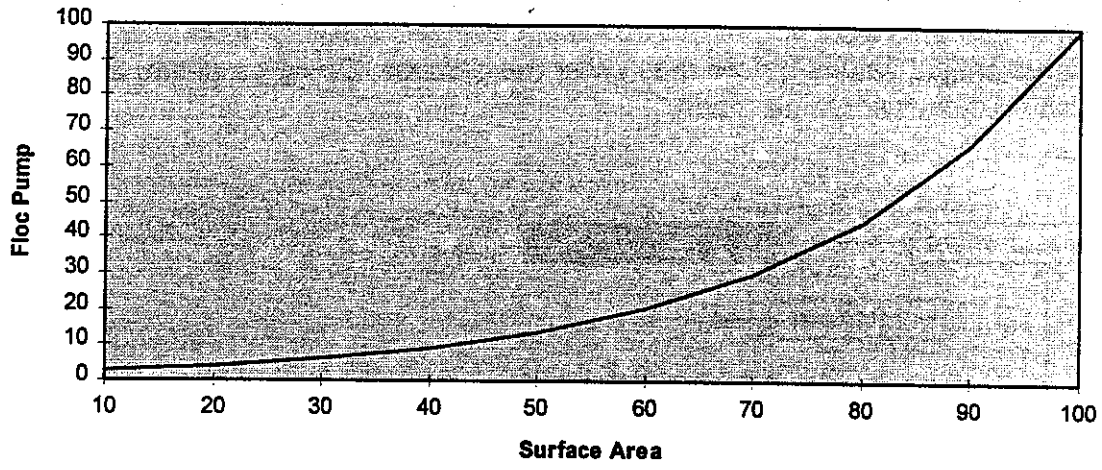


Figure 5: total surface area vs. floc demand

After site specific tests are complete, information can be entered into the Nalco proprietary control system and feed forward control can be performed.

Feed back control is accomplished by measuring mud depth, effluent clarity, and rake torque. If any of these parameters vary from specification then the control system makes a correction to the flocculant pumps and then makes a correction to the feed forward component. This is in effect a self tuning system. For example, if specifications for mud depth are 7-8 ft and the mud level falls below 7 two actions will occur. The flocculant pump will be adjusted and the feed forward calibration will be corrected.

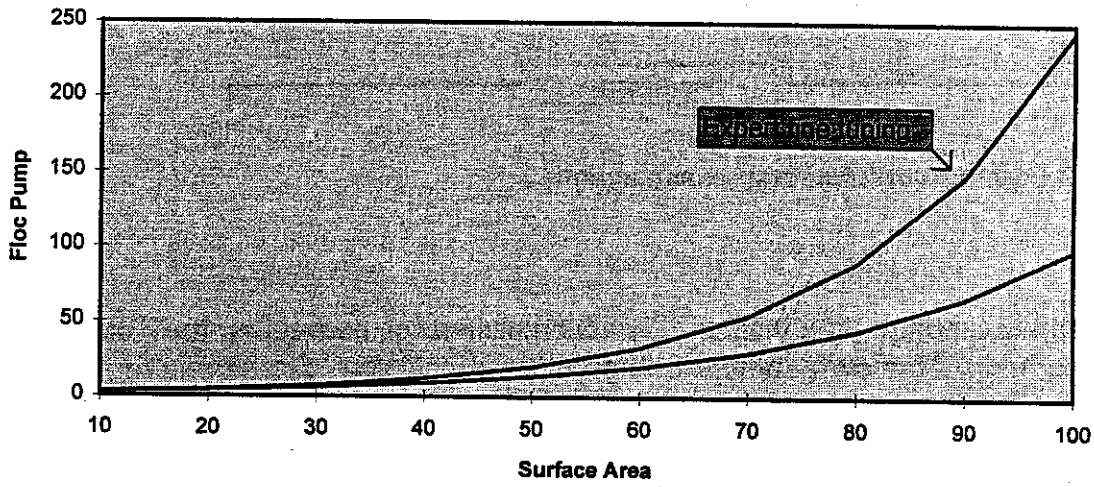
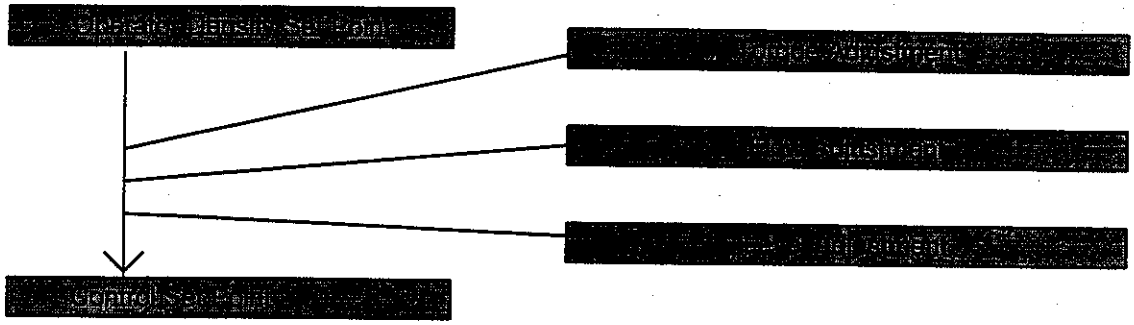


Figure 6: real time tuning of floc equation

Underflow control is performed using a series of complex cascading feed back PID loops. Primary control is accomplished by adjusting pump speed to match an operator entered density set point. The control system also monitors other systems parameters such as tank level, flow rate and rake torque. If any of these parameters are out of specification, the control system will modify the operator entered set point (now temporarily unattainable) to meet specifications.



Management Information

The Opticus system also provides a complete package of trend and SPC (Statistical Process Control) tools for supervisors and management. If allows for both short and long term tracking of critical plant performance parameters.

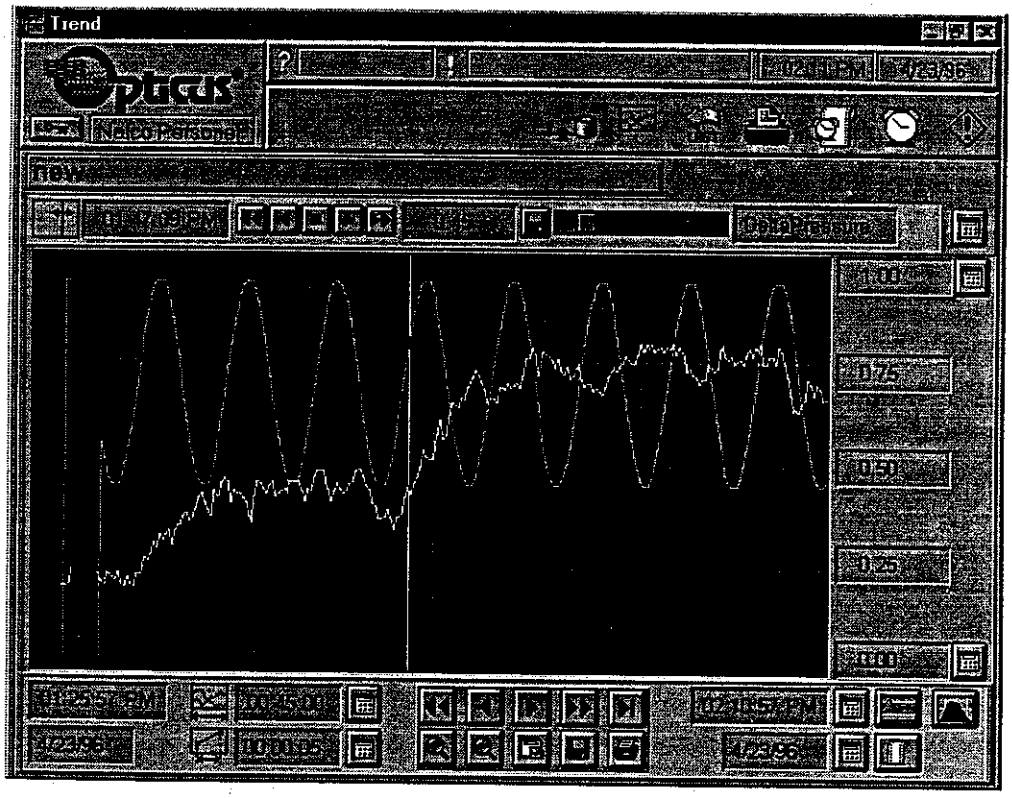


Figure 7: trend chart

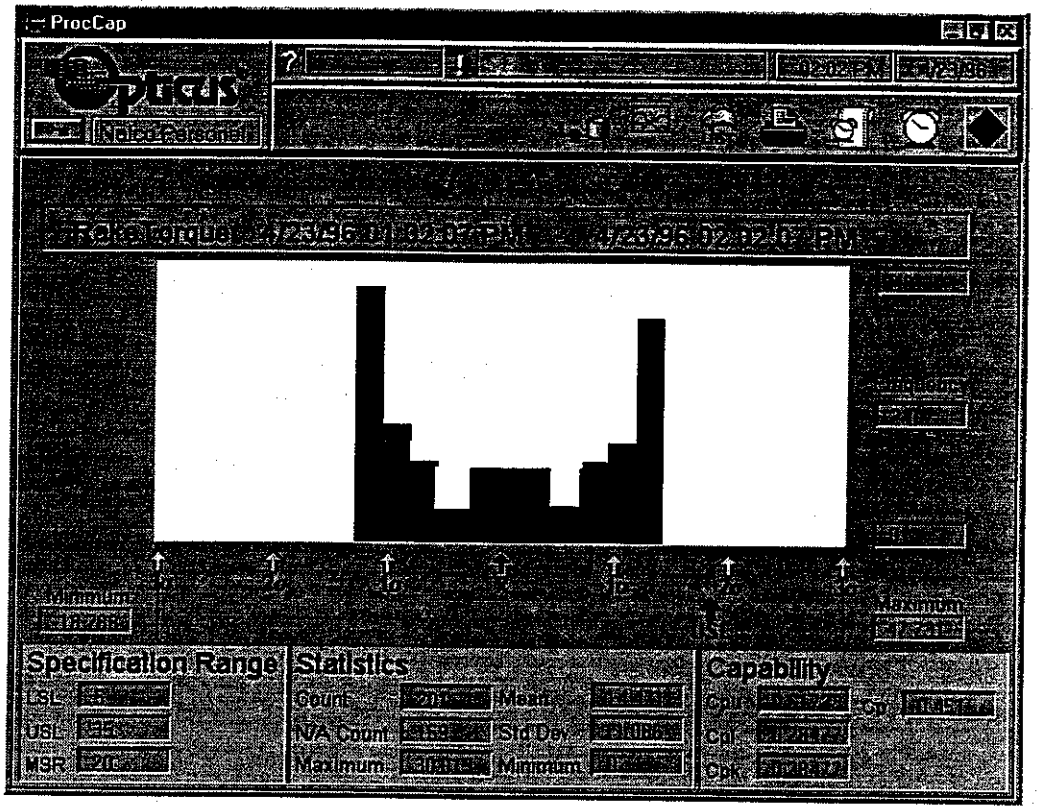


Figure 8: management SPC chart

Summary

Nalco computer based Opticus systems and controller based Autofloc systems have been proven as effective to controlling the units operations of many industries including phosphate. This system in place in a phosphate operation has realized the following benefits:

- lower reagent usage
- improved water recovery and management
- lower operator time requirements
- consistent underflow product
- lower treatment costs

The Future

The quality of phosphate ore reserves have been steadily declining over the years and is expected to get worse. Coupled with this, rising costs, scarce water resources, and increased competition will drive the trend to reduce costs and improve profitability. Systems such as these eliminate guesswork associated with the day to day operations and result in optimum process conditions. They also free up operator time enabling them to perform other day to day tasks.