technology is a vital means of implementing productivity management with respect to expediting the program, fewer people involved and reduced costs, once the basic system has been established and is functioning smoothly.

As much of all summarized information as possible should be available not only to managers and supervisors, but also to foremen and all production and service personnel. By this means, chances of improvement will be better and everybody may become a more effective team player through being better informed.

Production planning has a key role in productivity management, which is primarily the production manager's responsibility. Planning may require the use of a coordinator under the production manager. This is a very important function and, if properly executed, will pay dividends. The position requires liaison with the order and sales departments and the production manager's personnel. A complete knowledge of all operations is necessary. There also must be sufficient liaison with the commodity buyer and the purchasing manager.

The matters of safety and compliance with pertinent regulatory agencies are very necessary parts of productivity management. In a small plant, the plant engineer and production manager may have responsibility for them. In a medium or large plant, they may call for a staff engineer. Safety must be emphasized throughout the organization in all process manuals, worker training and monitoring. Management has the responsibility to provide a safe working environment as well as worker training. Aside from the humanitarian aspects, injured workers may mean lost time with attendant inefficiencies and added costs. There must be compliance with all regulations on locker rooms, toilet facilities, liquid and solid waste disposal, and air and noise pollution.

There should be specific job descriptions for everybody in the factory. These should be in language understood by all, and available to the specific workers. This information is essential for effective productivity management. It should be kept updated and can be referred to at the time of salary or wage adjustments.

In summary, productivity management is motivating people in a created desirable environment to do more complete and efficient jobs, all for increased profits. It can have a vital role in plants to the extent that there is management receptive to its implementation. Significant dividends are a better work place, more efficient operation and greater assurance of quality products at lower costs.

Productivity Management in Vegetable Oil Refineries[1]

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If managed properly, computer-based process control has significant potential for productivity improvement in vegetable oil refineries. It has been technically feasible to utilize computer process control since the early 1970s. Because of apprehension of computer system reliability, the estimated cost of retrofitting and the high risk involved with a new technology, no one made a major commitment until 1981. With experience and confidence gained from successful applications in wet corn milling, the A.E. Staley Manufacturing Co. made a full commitment to computer-based process control in the design and construction of its Des Moines soybean oil refinery. Subsequently, others in the industry have made applications beyond the scope of programmable logic controllers.

The intent of this paper is to examine the computer-based process control experience logged to date in vegetable oil processing, to point out both benefits and shortcomings, to outline the strategy utilized to achieve successful application and finally to offer some experienced counsel to those contemplating a commitment to computer control. The perspective offered is that of a former plant manager responsible and accountable for the hard-measure results of a computer-process-controlled operation.

[1]Presented at the AOCS meeting in Philadelphia, PA, May 1985.

BENEFITS

There are many potential benefits of computer-based process control. While the magnitude of possible improvement will vary by plant, the specific advantages of computer control are the following:

Endpoint control. This is enhanced for batch processing operations such as hydrogenation. With precise programmed reaction conditions (temperature, pressure, catalyst addition and hydrogen gas input) for hydrogenation, the physical characteristics for each basestock produced are more uniform. The results of improved basestock uniformity are more predictable product blending/mixing results, fewer correction requirements for blends or mixes and a possible reduction in basestock inventory. With conventional control, a larger basestock inventory often is maintained in an effort to dampen the variation between batches of the same basestock.

Material usage. More precise, responsive control results in minimum use of materials such as caustic soda, sulfuric acid, bleaching earth, filter aid, catalyst, hydrogen gas, nitrogen gas and other processing reagents and aids. The hydrogen gas plant operating rate can be programmed according to hydrogen demand, and hydrogen venting can be consistently avoided.

Operating mistakes. Once the process control

system is reliably programmed, mistakes are limited essentially to equipment failures. Consequently a significant reduction in mispumpings and spills is achieved. This can substantially reduce the expense associated with oil mispumpings and spills such as additional inventory, reprocessing, degrading, loss, handling and cleanup.

Diagnosis and troubleshooting. The capability of trending, logging and alarming offered in computer process control is invaluable for process diagnostics and troubleshooting. Problems can be quickly identified and resolved.

Yield and quality performance. Tighter and more consistent process control (a reduction in both under- and over-processing) provides the opportunity for improved yield and product quality performance.

Energy reduction. Numerous applications are available for energy reduction, including combustion efficiency and load management. Load management involves monitoring, trending, alarming, and scheduling and controlling energy loads (steam, electricity, etc.) to minimize use and avoid excessively high peak demands.

Process safety. Better process safety can be provided in terms of alarms, interlocking, failsafe modes and emergency shutdowns.

Inventory control. Continuous tank level reporting and inventory calculation provide an effective data base for both operation and management functions.

Inventory reduction. With close-coupled processes and controlled processing rates to keep the total system in balance, in-process oil inventory can be significantly reduced.

Tank car and tank truck utilization. A common problem with manual control of tank car and tank truck loading is underfilling, as operators tend to be conservative to avoid spillage. Computer control combined with on-scale loading allows either precise weight or maximum filling.

Process capacity. With computer-linked and -paced operations, design capacity can consistently be achieved.

Performance and accounting reports and operating logs. The computer control system is capable of providing any type of performance and accounting report and operating log within the scope of the information sources connected and the programming provided. Formats for other reports and logs can be programmed and the data entered via the computer terminals by the operating personnel as needed.

Product blending accuracy and economics. Development and application of computer programs for blend/mix calculation and implementation provides both a higher degree of accuracy and the opportunity to use the most economically advantageous formulation within specification limits.

Staffing. Up to a 67% reduction in staff can be attained for the processing operations (operating, maintenance, clerical, supervisory and management personnel combined) compared to a manually operated plant.

Reliability. With both proper hardware selection and an effective (high performance) operating team, greater than 99.0% reliability can be achieved consistently with the computer process control system.

Information access. The computer control system provides a variety of information access capabilities. Within the capacity of a particular system, archival storage of information normally accessible to the computer can be provided. Nonprogram operating instructions (start-up and shut-down procedures, for example) can be stored in the computer for recall and display by the operating people. Information from peripheral operation like quality control and maintenance can be entered via remote terminals for direct process control file update or instructional access by operating personnel. The process control computer can be networked for information access by others at either the plant site or remote locations.

The potential benefits are both impressive and achievable. Most plants could justify the cost of retrofitting for computer process control. However, before you stop reading and rush off to get started, the total picture needs to be examined—the shortcomings and how to computerize successfully.

SHORTCOMINGS

Scheduled plant start-ups and shut-downs. Computer process control would be even more attractive if these did not have to be contended with. To the uninitiated, computer control operation implies pressing a terminal start-up key, operating key or shut-down key to cover all possible needs. Unfortunately, it is not quite that simple. While technically feasible, it is not economically justifiable to size the computer hardware and develop the computer software to cover plant start-ups and shut-downs. Thus, manual procedure is required for most process start-ups and shut-downs. Following such manual procedures does not necessarily imply manual local control of devices. Devices normally controlled by computer programs can be accessed via the computer, but the operator is required to initiate the commands.

Unscheduled shut-downs and subsequent start-ups. While scheduled start-ups and shut-downs are obvious needs, the unscheduled shut-downs and subsequent start-ups potentially are more disruptive. Electrical power outages are the best example of an unscheduled shut-down. A skilled operating team can recover from an electrical power outage in minutes—probably faster than with manual control. If the operating team is not sufficiently skilled in both the control and process system dimensions of the operation, recovery from a momentary outage could take hours.

Initial start-up operation with computer process control. Not to be confused with ongoing plant start-ups (scheduled or unscheduled), the initial plant or process start-up operation with computer process control is much more difficult than with conventional control. Regardless of how thoroughly everything has been approached—hardware, software and process control devices—defects will be found and correction required before operation can occur. Nothing operates with computer process control unless every element is working properly. Initially this reality is frightening. It is a period of great demand on both the start-up team and the total organization which requires a high degree of commitment, discipline, patience and perseverance.

Once the initial problems are solved and the operating team develops skills to immediately recognize, diagnose and resolve the ongoing problems which will occur, operation by computer process control is more reliable and beneficial than by conventional control.

Skill requirements. While fewer total people are required with computer control, the skill requirements are significantly greater than those required by conventional operation. To achieve the benefits outlined, every member of the operating team must be capable of understanding, operating, troubleshooting and maintaining all but the most complex aspects of both the computer control system and the process control devices. If not, the installation of computer control will result in either increased staffing or failure to achieve the potential benefits. This statement might raise the assumption that if the benefits are as outlined, then adding a few more highly trained specialists to operate the computer system probably is justified. The fallacy with that assumption is that it takes more than a few specialists to successfully operate with computer control. Experience has demonstrated that people assigned exclusively to operate computer systems involving CRTs and keyboards incur rapid emotional burnout and become ineffective after a few weeks. Thus job rotation is an essential requirement, for that reason and others. To perform at peak level, the personnel operating in the field need knowledge of the control system, and those operating in the control room need intimate knowledge of the control devices, equipment and processes in the field. The same is true with respect to maintenance functions. People performing maintenance need to understand both the control and processing systems thoroughly in order to work efficiently and assure compatibility with ongoing operations. To consistently get the job done with computer control, close-knit teams of multiskilled technicians are required who develop and maintain peak performance by a variety of job assignments and a high level of participation in the management process.

Process control computer-generated report accuracy. Lack of consistent flow meter accuracy and tank level gauge reliability remain the weak links in the accuracy of process control computer-generated reports.

Computer process control feasibility. For some unit operations, the cost of computer process control is not justifiable. In deciding on the scope of computer control, cost-benefit analysis is needed for each unit operation.

By now, some of your bliss over the list of benefits may have disappeared. Furthermore, you may have concluded that an impossible task has been presented. That is not the case—the steps for successful implementation are presented next.

HARDWARE SELECTION

There are two general cases to consider for hardware selection: a new plant installation and an existing plant retrofit. For new plants, there are two main approaches to computer control systems—two-track and one-track. With the two-track approach, both a distributed computer process control system and a conventional control system are provided. The manual control system is a backup for the computer control system. Initially, before a high level of confidence in computer control was developed, the two-track approach commonly was used. While the two-track approach provides a familiar backup system, there are two disadvantages. First, additional cost is incurred. Second, because the computer requires a higher level of skill and discipline to operate, there is a tendency to use the conventional backup system as the primary one and lose the benefits of computer control. The one-track approach provides only a distributed computer control system with some level of redundancy. Experience has demonstrated the superiority of a properly executed one-track approach.

Determining the control system architecture and equipment for a new plant installation involves defining the operating objectives carefully. As previously stated, a cost-benefit analysis should be made for every unit operation to determine the feasibility of process control. Next, the equipment or hardware must be selected to match the control system objectives. In sizing the computer hardware, there is a tendency to select too small of a system initially, which can prove to be costly. Prudence notwithstanding, it is recommended to err on the side of over-capacity in selecting hardware. Because of rapid development and changes in the computer hardware business, be sure to obtain appropriate vendor assurance of long-term support for spare parts and service to avoid premature obsolescence.

There also are two approaches for retrofitting an existing plant. First is an evolutionary approach which involves providing computer control for one process at a time. The second involves determining the total plant requirements, progressing with the installation and making a process-by-process changeover to the computer-based control system. In terms of hardware cost, the total initial system approach is less expensive; however, the total cost including outside resource requirements, adaptation needs and disruption to operations could be more expensive than the evolutionary approach.

The information given for new plant installation applies to retrofitting an existing plant; however, some additional points should be made. In the evolutionary approach, it is essential to define the ultimate system architecture and equipment first to be sure that the evolutionary building blocks are compatible with the long-term objective of a distributed system and a central control room. There are many choices of vendors and equipment which would satisfy the control needs of individual processes. To attain the final objective, the individual process control systems must be compatible for linkage to a communication highway. Regardless of the choice, there will be some hardware throw-away or redundancy, which is not necessarily a negative, in following the evolutionary approach.

SOFTWARE

While every aspect of the computer control system is significant to the final outcome, mastery of software is a more critical element for the end user. Hardware design is the domain of the vendor, with the end user's role being to make the right choice. In the area of

software, both the vendor and the end user have major roles. Typically, the vendor is responsible for the computer operating system software (instructions for the internal functioning of the computer for utilizing application software), and the end user is responsible for application software development (instructions for plant process operation). While most vendors are anxious to provide service for application software development, such service is a potential trap of major magnitude for the end user. In the operating phase, the plant operating team has to be completely knowledgeable of the application software to make corrections, revisions and additions. Thus, the better choice is for each plant operating team to play a major role in application software development, for its members have the process knowledge that is an essential part of programming. Regardless of who does the initial programming or makes subsequent changes, it is an absolute requirement to maintain support documentation to enable a qualified person to comprehend and work with any software at any time. Breaches of this practice have serious consequences, including the inability to utilize computer control for the operation or process with the defective program and the expense of rewriting the program.

Software security is another vital responsibility of the plant operating team. It is essential that current backup copies of the operating system and application software be maintained. The copies in use on removable disks can be damaged, and immediate replacements would be required.

PLANT OPERATING TEAM

The most critical but often least considered aspect in achieving a successful computer control system is the plant operating team. The control system and the total plant are only as effective as the people who operate them. As stated earlier, to attain all the benefits of computer control, the operating team must know the system and be able to operate it, troubleshoot problems, fix what is wrong including hardware, software and field control devices, and improve on the system. Now the issue is how to develop such a team. The method that has been utilized successfully consists of three components.

First, it is important to develop the right motivational climate. True motivation comes only from within the individual. Unfortunately, too many supervisors and managers still hold to the idea of motivation by fear and intimidation. That approach yields at best mediocre performance and requires continuous close supervision. Internal motivation of each individual is a powerful force if properly released and channeled. For most workers, self-motivation can be stimulated and channeled to yield outstanding results in job performance if management provides the following:

A "big picture" perspective. People like to understand how their particular responsibilities relate to the total objectives of the organization. If such understanding exists, people will work to assure that their individual and their work team performances are supportive of the organization's goals.

Operating/unifying principles. The most effective organizations have carefully defined and consistently followed operating principles they consider essential to long-term success. If clearly defined, understood, accepted and followed, these principles serve as a strong unifying force. They give people a sense of confidence, trust and pride in being members of the organization. Ideally, the principles are reflected in the productive and quality output of both the individuals and the organization.

Performance results. To be motivated, people need to know "the score" (hard-measure performance results)—how the company, the plant, their work team and they as individuals are doing. Can you imagine the player apathy that would develop in a sports contest if the score were not posted continuously and individual players were not coached to improve their performances? The same holds true in a business—"people can't play to win if they don't know the score."

Challenging and meaningful work. While not sufficiently acclaimed, challenging and meaningful work is one of life's great treasures. With appropriate consideration, all jobs can be designed to be meaningful, to provide challenge and to offer a variety of experiences. Ineffectively designed jobs stifle motivation. In essence, monotonous jobs deprive people of their dignity and creativity.

First-class membership. People respond in kind to the way they are treated. If they are treated like first-class members (associates or partners) in operating the business, they will develop emotional ownership of the business and act accordingly.

Responsibility. Every member should be responsible for the organization's total mission. Identification with the total mission invites and fosters maximum cooperation and effort instead of "it's not my job" attitudes or "tunnel vision" mentality. Every employee should be assigned "ownership" responsibilities in the business and be held accountable for the results. Everyone also should be assigned backup responsibility for someone else's specific responsibility. With this approach, the total mission and all sub-parts are covered—covered with a depth of talent and commitment.

Rewards. Reward people for the right contributions, and the mission will be accomplished with excellence. Reward employees for the skills they bring to and use on the job, and they will develop and use their skills accordingly. Also reward workers for hard-measure performance results (customer service, product quality, operating costs and production volume). Do not reward anyone for "a shine on the seat of the pants."

The second component is to provide effective training. One of the dichotomies of American business is that most companies are willing to make substantial capital investment in equipment and facilities, but fall short in realizing investment potential because of unwillingness to spend adequately on the training and development of people. The origins of this incongruous situation are several. The major contributors are underestimating the requirement; lacking the skill to train; delegating the responsibility to a staff or resource group, which in turn receives little support from the line organization, and demonstrating insufficient tangible evidence of short-term return. Regardless of past practice or experience, introduction of computer process control necessitates a change in

attitude and commitment to personnel training and development. The training to effectively introduce computer process control consists of three general subject areas:

Technical skills. Training to develop technical skills includes chemistry of fats and oils, processes and unit operations, processing equipment, computer process control system (hardware, software and field control devices) and finished product specifications and applications. The training presentations include theory, practical operation, problem diagnosis/troubleshooting for both the processing operation and the computer control system, maintenance of process equipment, maintenance of the control system hardware and devices and computer programming. The training methodology consists of lectures, demonstrations, video cassette presentations, programmed instruction and actual work assignment.

Problem solving and people skills. Training objectives for this area are to provide each member of the organization with the necessary skills to confront and solve problems of any origin, to maximize individual effectiveness and to achieve a high level of synergism in teamwork activities. The training consists of an array of problem solving techniques, a series of concepts and models for gaining better self-understanding and improving interpersonal relations, group exercises for team development and techniques for achieving interteam cooperation. Practical skills in communication, goal setting, planning and evaluation are provided.

Administrative skills. In this area, the training focus is providing each member with the knowledge and ability to master the practical administrative details of each functional area of the business: production, maintenance, quality control, engineering, accounting, financial analysis, personnel, purchasing, sales, transportation, regulatory compliance, security and community relations.

The training program for each topic is well defined in all areas and is administered to assure effective presentation and comprehension. Comprehension or mastery is demonstrated by a variety of qualification requirements. Integrity of the training system is vital to assure properly qualified personnel for operating the plant and to provide equitable compensation. Skill development is directly linked to base pay.

The final step in developing a plant operating team is to select the right people. The selection process is crucial in developing an effective team to operate a computer controlled plant. Whether the selection is made from internal or external candidates, the process must be designed and executed carefully. The traditional one-on-one interview is insufficient, regardless of the interviewer's skill. A dynamic assessment process involving broad representation of the functional membership is essential in candidate selection.

Where union contracts with rigid seniority provisions are in place, it is necessary to either negotiate a waiver in preference of the assessment process or take a more disruptive approach of disqualifying those individuals who are incapable of meeting the performance requirements during the training stage. Regardless of the approach, tolerance of substandard performance by any member of the team places the total investment at risk and is unacceptable.

RESOURCES

In applying any new technology, most companies do not have abundant staff to independently implement computer-based process control. Consequently, external resources must be utilized to some degree. External resource utlization can range from a complete turnkey project (maximum) to one-person guidance (minimum). The choice should be made by careful analysis of needs and objectives. There are some general points to consider in deciding on external resource use. First, at this stage of development for computer process control, there are no "painless births." In other words, the end user or client ultimately must bear some of the cost to master the system and receive the payback. External resources can carry some of the burden, but not all. The end user must never abdicate control of the project to the external resource(s). The probable price paid for abdication of responsibility is a protracted and more expensive system start up. Next, as a general rule, maximum use of outside resources will reduce the project time, increase the project cost, and, depending on the thoroughness of preparation by the permanent team, increase the start up time. Minimum use of outside resources will significantly lengthen the project time, reduce the project cost and reduce the start up time. Finally, in selecting resources, be careful—be sure that they know what they are doing and that you know what you want to do.

Computer-based process control requires a substantial investment in computer hardware and software and the development of people to achieve significant long-term benefits. It does not lend itself to quick-fix strategies for performance improvement. External resources can be helpful in implementing computer control, but the end user should not expect a painless "birth."