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Computer Control in the Extraction and Edible Oil Industries

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ABSTRACT

The cost of computers is coming down, and the availability of programming languages and application packages for process control is increasing. These facts indicate that computers should find more application to extraction and edible oil plants. Some of the potential applications for these industries, with examples, are discussed.

Process control computers have not found wide application in the vegetable oilseed extraction or edible oil processing industries. Two reasons for this might be: (a) plant capital costs for typical-size plants in the industry are an order of magnitude less than costs for typical plants in the petroleum, petrochemical, or chemical process industries where such computers have found wide application. As a result, the cost of computer control in the vegetable oil industry may represent a higher fraction of the total plant cost than it does in the larger industries; (b) application of computers to plants requires more sophisticated engineering support for both application and maintenance than is available at many plants.

Computer technology (hardware and software) is advancing rapidly, and the capital cost for computers is coming down whereas the capital cost for the process equipment in the plant continues to rise with inflation. Thus, the economic barrier to computer application is becoming less significant. The remaining barrier is largely one of communication between the process engineer and the computer and its hardware and software manufacturers. This paper will develop some background information on computers, from the process engineer's viewpoint, and show some examples of computer applications in the extraction, vegetable oil processing and allied industries.

Most of the discussion in this paper will be directed toward the computer size defined for the past few years as a "mini." Computer sizes may be broadly defined as the micros, the minis and the large main frame machines.

The mini-size computer has been available much longer than the more recent microcomputer and has been applied to most process control functions. It is characterized by processing speeds and memory capacity intermediate between the micros and the large machines, and has sufficient capacity to handle almost any individual plant to which it might be applied.

HARDWARE

Process control computer hardware has developed during the past decade at a much faster rate than has process control software. Computer speed is doubling every one and one-half years, while costs are coming down at a similarly rapid rate. Hardware is currently available in sufficient processing speed and memory capacity to do anything we might imagine in the process. One problem in using this new capability is understanding and defining the process so that the computer program can anticipate all of the variations which may happen in the process and direct the appropriate action.

Process control computer systems have many similarities to data processing computers, but there are some significant differences about which the process engineer should be knowledgeable. Figure 1 shows a very simplified block diagram of a process control computer system. The center portion of this figure shows the hardware which we would generally call a computer. From a hardware standpoint this unit can be electronically very similar to a computer used for data processing. On the right side of the figure are keyboards, cathode ray tubes (CRT or television screens), and printers, which are again very similar to the types of units found in data processing systems.

The unique difference between the hardware in process control systems as compared to data processing systems is the input and output hardware shown on the left side of the figure. The data processing computer system ultimately receives its inputs and outputs only from human beings via its keyboards and printers. The process control computer must receive process inputs and transmit outputs directly without human intervention.

The basic function of the input equipment is to tell the computer what the process is doing in terms that the computer understands. This basically means that the input equipment must present to the computer the state of the process variable in the form of a binary digital signal.

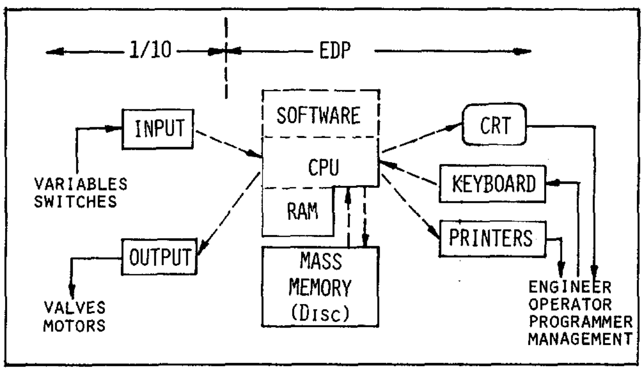

FIG. 1. Process control computer.

Similarly, the output section of the computer installation must take the computer's binary digital signal (coded in the language with which the computer works) and convert it into the type of signal which the process valve or motor can use. All of this must be done in "real time" since the process will not wait as can the human operator.

Another important function of the input/output equipment is to screen the computer from the harsh process world of high voltages and electronic static.

The process input/output hardware for a process computer control configuration is a major part of the total system hardware and represents a significant part of the cost. This area represents the principal differentiation between data processing computers and process control computers. This hardware area is where the manufacturer of the process control computer must contribute his unique expertise. Many of the typical process control computer suppliers will purchase the central computer unit (commonly called the main frame) from a manufacturer who makes such equipment for data processing. He will then develop his own input/output hardware and suitable cabinetry.

The purchase cost for computer hardware, particularly the data processing portions of the installation, has been decreasing rapidly; and this trend can be expected to continue. Thus, the hardware will become increasingly affordable, and the challenge to the process engineer is how to use it.

SOFTWARE

Another significant difference between process control computing and data processing is shown on the figure under the heading SOFTWARE. Software means the programs which the computer runs. There are 2 broad divisions, the operating system software which the computer manufacturer supplies to you and the applications software which you, as the user, must usually generate. Generally speaking, the more software you buy with the computer, the simpler and less complicated will be your job in getting the computer on line.

Software which is supplied by the computer control manufacturer for the user can be broadly divided into 2 classes: (a) machine or assembly language; (b) high-level languages.

Machine and assembly language programs might be described as being close to the computer's own internal language. Applications programs written in these languages are very long and detailed, and the programmer must have a good knowledge of the internal workings of the computer to accomplish the task. The complexity of the task and the background required practically excludes the process engineer from writing the program. Assembly language programs must be written by trained programmers who may have little inclination or time to understand the process. Communications between the process engineer and the programmer are a difficult, nonstandardized and time-consuming function.

Assembly language programs, on the other hand, offer maximal flexibility and the maximal use of the speed of the computer. However, with hardware costs coming down and computer capacity increasing, these advantages of assembly language programming become less important.

High-level computer languages are languages which use 1 or 2 English words to tell a computer to do something that in assembly language, might require 10 or 20 different and less intelligible instructions. The objective of a high-level process language is to make the computer understand the kind of words and instructions which can be generated by a process engineer.

EDP LANGUAGES	PROCESS CONTROL LANGUAGES	PC APPLICATION PACKAGES
ALGOL (1960)	PROC.BASIC	ACCOL
APL (1962)	FPL	CODIL
BASIC (1965)	PC^2	ICAP
COLBOL (1959)	POL*3	FCP
FORTRAN (1954)	SPL-4	PROVOX
LISP (1956)		
PASCAL (1971)		
PL/1 (1964)		

FIG. 2. High-level computer languages.

High-level languages for computers in the data processing field data back to the late 1950s. High-level languages for process control began to be marketed about 10 years later, but the real proliferation for process control languages has come in only the last 5 to 8 years. Figure 2 shows a sampling of some of the most popular high-level languages used in both fields. Actually, there are something like 150 high-level languages in use in the United States today. This large number illustrates one of the limitations of high-level languages: these languages are specialized in application, and, any given language, no matter how general, has a specific area of application for which it is best suited. Thus, FORTRAN is a language particularly well adapted for scientific calculations, whereas COBOL is particularly adapted to business applications. Either can do problems outside of its specific area, but its use in other areas is more cumbersome and less efficient.

The high-level process languages are divided into 2 main groups: (a) general Process Control Languages; (b) Process Control Application Packages.

General Process Control Languages are often versions of high-level business or scientific languages which have been modified to permit handling many process inputs and outputs in real time. FORTRAN or BASIC are the usual parent languages. These types of high-level process languages have wide applicability and can be learned by process engineers with some programming experience.

The highest level of process control languages are more properly called Process Control Application Packages. These application packages are usually written in one of the high-level general process control languages, but this language need not be used by the programmer. Instead, the programmer-engineer does the programming in a format very closely approaching the way he is used to thinking about his process. Thus, the format may be patterned after process sequencing (e.g., batching) or continuous control loops. The programming is often done in an interactive mode with the computer asking questions to lead the programmer through the proper steps.

Application packages often are designed for very specific functions, such as energy conservation, boiler control, or batch processing. They are certainly easiest to use where applicable, and there are some application packages available with wide applicability.

An effective applications package will be designed to provide extensive error-checking and-handling procedures, power failure detection and orderly shutdown, and many other procedures for good process control.

The primary benefit of the high-level languages for process control is that the process engineer can learn the language and can effectively write his own programs in more understandable form, to which he or another process engineer can subsequently refer when process changes must be implemented. Another advantage of many high-level languages is that program changes can be implemented on-line (while the computer is still controlling the process) rather than having to suspend the process control while the new program changes are put into the computer.

The benefits of high-level languages, however, do not come without penalties. One of these penalties is that the effective capacity of the computer is reduced because the computer must spend a significant portion of its computing time interpreting (or translating) the high-level language into the internal machine language. This process of translation is called either interpreting or compiling, depending on whether the computer makes the translation each time it must execute a particular high-language program statement or whether it "compiles" the program into its machine language when the program is first presented to it.

The time burden on the computer may become apparent to the process engineer in terms of the time interval between the times that the computer looks at a particular process temperature or outputs a new valve position. The purist in control theory might, e.g., feel that 0.1 sec might be the maximal time interval which could be allowed between servicing a particular process control loop; many computers, however, partly because of the burden imposed by high-level language processing, may actually require 0.5 sec to respond to many process inputs.

COMPUTER APPLICATIONS

With this background, "What can the computer do for my process?" can now be discussed. The simple answer to this question is that the computer can do almost anything you want if you can find a way for the process to let it know what is happening and if you can write a program which will tell the computer what to do with this information. Practically, justification for the additional capital expense of the computer must be rationalized.

Some justifications which are present in varying degrees for any process control application are listed in Figure 3. How these justifications may apply more specifically to extraction or edible oil plants is discussed in the following text.

The first point listed is process reproducibility. The computer will run the process the same way each time a particular process step is executed or a particular situation comes up. Operators each have their own idiosyncrasies in how they do things. Sometimes an operator may be able to out-perform the computer in a particular process situation because he is more sensitive to the process. On balance, however, the reproducibility introduced by the computer control will result in better process optimization and improved product quality. The challenge here is for the process engineer to understand the process well enough to program into the computer all of the things which must be evaluated and the proper response to be taken for all eventualities.

REPRODUCIBILITY	-	SAME WAY EVERY BATCH (FORMULA, PROCESS CONDITIONS)
CONTINUOUS MONITORING	-	FASTER THAN OPERATOR DOESN'T GET TIRED
DATA LOGGING	-	MORE DATA MORE FLEXIBILITY
SOPHISTICATED	-	FOR HARD TO CONTROL PROCESSES
EASY TO CHANGE	-	BY CHANGING PROGRAM INSTEAD OF REWRITING
SAFETY	-	CAN HELP IN MANY WAYS

FIG. 3. Computer advantages.

Two specific examples where process reproducibility is a major factor are the hydrogenation operation in edible oil manufacture and the start-up and shutdown operations in extraction plants. Hydrogenation is usually a batch operation, and there are many valves to be operated and process control variables to be watched for each step of the process. The computer can carry out these manipulations in a timely fashion with the same routine from batch to batch.

Start-ups and shutdowns in the extraction plant require a number of sequential operations, and safety is an important factor. When the process engineer begins to write the program for these operations, he will begin to appreciate how many variables there are, how many things might go wrong, and the complexity of the decisions which must be made. It is difficult to train a human operator to respond identically, each time, to any of these situations. The problem is compounded when you try to train 4 operators to do it the same way.

"Continuous monitoring" listed in Figure 3 describes the capability of the computer to look at process variables in an almost continuous fashion and not tire from doing such repetitive work. As an example, it can continuously monitor the motor loads throughout the plant and do something about an overload situation before the motor kicks out and the whole process is down.

Another justification point is "logging." Without the computer, 3 sources of historical data are typically available to the superintendent when he is trying to analyze what went wrong: written operator log sheets, the charts from analog data recorders and the operator's memory. The computer can do a much more sophisticated job of data gathering and logging and present this data in a much more easily assimilated form.

Further justification for computer control is the ease with which the control strategy or the process itself can be changed when needed. If all of the inputs from the process are available to the computer, changing the sequence of batch operations, the types of data to be taken, or the response of the computer to process upsets can be readily altered to meet the new needs of the process or of management.

Another benefit to be gained from computer control in certain specific process areas is the ability to implement more sohpisticated control strategies than is possible with conventional individual analog controllers. An example might be the control of meal moisture in the extraction plant where the process lag times are long enough so that conventional control strategies usually are not effective. Advanced control strategies incorporating long lag times or sophisticated feed forward algorithms (such as the Smith predictor -Ref. 8) can be readily programmed into the computer.

The last justification suggested for the computer involves improved plant safety. This would seem to apply particularly to extraction plants where the fire and explosion hazard of hexane is always present. The process reproducibility and continuous monitoring and alarming made possible by the computer should make a significant contribution to the safety of the plant.

Justification of the computer, of course, must finally be approached with more specifics than the simple generalities just recited, and these justifications must be reduced to dollars and cents savings to rationalize the added capital cost of the computer. It should be noted that the application of computers to new plant construction will always be considerably easier and cheaper than retrofitting into an existing process. With the state of computer technology at the level it is today, computers deserve serious consideration for data acquisition and control in any new installation.

Three obstacles to the more widespread application of computers into the industries we are discussing should be mentioned. The first of these is the problem of interfacing between the process engineer and the computer or the computer programmer, both at the time of the initial specification and installation of the computer and also later, when the changes in the process are desired. The newer, high-level programming languages and application packages have made this hurdle easier to overcome.

Another handicap which is present to a significant degree in the industries under discussion is the lack of field sensor or measurement equipment for the vital parts of the process which we need to control. The only reliable, on-the-line measurement devices which are available, beyond the usual temperature and pressure transmitters, are probably the meal moisture monitor, the very accurate metering of the oil loss monitoring systems, and turbidity meters for filtration measurements. On-line instruments which are not currently available, but which would significantly help with the control of the processes, include sensors for measuring the residual fat in extracted meal, hexane hold-up in the extractor, fiber and protein content of meal, refractive index of hydrogenated oils, fatty acids in oils, and even on-line sensing of SFI or some other consistency property.

A last hurdle which deserves mentioning is that computer technology is expanding so rapidly that several new models and new languages seem to be developed every year. There is a tendency for the process engineer who considers using a computer to want the most up-to-date system available. The consequence is that each time he approaches a computer project he is faced with the necessity to evaluate several completely new systems in a field which is rather foreign to his training and usual technology. On the other hand, there are obvious benefits to an organization in having standardization of computers throughout the company's plants in order that more technical and operating people can become involved and talk the same language. With computer technology as it stands today, a computer which was designed 5 years ago might be a better choice if it is one that is familiar to the technical and operating people because of prior use.

EXAMPLES OF COMPUTER APPLICATIONS

Four applications of computers in the vegetable oil or closely related industries will be described. One computer is used to control a feed mill batching system and to manage and report the numerous inventory controls which are a necessary part of such an operation. The principal goal of computer control in such an operation is closer control over final product quality. This is achieved by more accurate and more reproducible weighing and the consistency of operation through the plant. It is documented by numerous inventory balances.

A second application uses a computer in an export grain elevator. The primary process control function of this computer is the control of 6 hopper scales and the associated conveying euqipment involved in receiving and loading out grain. Associated with this process control function is a very large data acquisition and reporting program reaching all the way from inbound train car numbers and weights through bin inventories for something over 100 bins to the printing and accounting functions involved with preparing shipping invoices. The mass of accounting-type data handling involved in such an installation will be a revelation to the process engineer. It is a good example of a computer which was justified and started out as a process control computer and has been expanded, because the capabilities were there, to serve many other functions.

Both of these installations were programmed using essentially assembly-type computer language. These languages are quite complex and do not fit the requirement of a high-level programming type language for use by process engineers.

A third application consists of 2 computers, side by side, in an edible oil refinery. These computers are in the microcomputer-size range, rather than the mini-size range which is the primary focus of this paper. They are programmed in one of the high-level process control application languages. One computer in this system is involved strictly with hydrogenation control for 4 converters and the associated catalyst filter and basestock tank management. The second computer handles basestock blending and finished-product

The fourth application is a mini-size computer controlling an extraction plant. This computer is programmed in a very high-level process control application language. The computer was initially applied to only one phase of the extraction process, which was being modernized by the installation of new equipment, with the idea that additional process steps would be hooked to the computer on a stepwise basis. This program is still going on. Some of the control functions which have been or are in the process of implementation include start-up and shutdown sequencing, meal grinding control for power demand considerations, and hexane flow balances throughout the extraction system.

The initial programs and program additions for the edible oil and the extraction computer systems are being written and implemented by process engineers, using the high-level languages available with the computers. This type of process engineer is still somewhat of a specialized individual; but more and more process engineers are getting this type of background through training courses at the venders, involvement with hobby computers and experience with actual plant applications.

Almost universally, the operators respond well to computer installations. They adapt well to viewing process information on the CRT screen and to inputting process requirements via keyboards.

REFERENCES

The literature cited in the attached list of references comprises a few general publications which can be read by the process engineer who is new to the field and contains a majority of the computer control publications which pertain specifically to the extraction and edible oil industries. Reference 7 is a fairly comprehensive treatment of process control computer technology.

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