Automation of Palm Oil Mills

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ABSTRACT

Automation is the function of monitoring and regulating process operations non-manually or remotely to check or maintain the required processing conditions and product quality, the use of instrumental techniques of analysis in the laboratory and the use of computers for data processing and other miscellaneous applications. Applications where automation is justifiable and the impact of changing trends in automation technology, especially the recent influx of microprocessor-based systems, are discussed briefly. Applications in the palm oil mill where automation is fairly well-developed and is being developed, as well as ideas for future applications are reviewed. An example of a practical approach to automation in palm oil mills is given using automatic control of crude oil dilution.

INTRODUCTION

Automation is justifiable to improve process efficiency, i.e. increase yield and/or reduce production cost; to improve product quality, and to meet safety requirements. The degree of automation required for a particular plant is governed by factors such as the throughput of the process, the complexity of the process, whether process conditions are critical and plant utilization requirements. The reasons for the first three factors are obvious; the fourth factor is relevant because it may be costly to find suitable staff to operate a plant which has to be run under adverse environmental conditions, or during weekends and public holidays, or overnight.

Automation may be based on an application of principles of hydraulics, pneumatics, electrics or electronics or a combination of any of them. Today, the trend is towards memory programmable microprocessor-based systems (1). Such systems offer a number of advantages when compared with others, the most obvious being their ability to be programmed to do a variety of tasks. The task performed by a given microprocessor can be modified as and when required simply by altering the appropriate instructions. Other advantages are their relatively low cost when used extensively, ability to store large quantities of data and to process this data at very high speeds, and ease of expansion. Some disadvantages of microprocessor-based systems are that they are technically complicated, specialists are required for design, programming and maintenance, and small systems can be expensive.

REVIEW OF AUTOMATION IN PALM OIL MILLS

In general the extent of automation in palm oil mills remains very limited (2). The relatively poor level of automation is due not to hardware limitations or to a sheer reluctance by the industry to adopt automation, but rather to software limitations (limited experience to enable the selection of appropriate systems). However, changing trends in automation technology, especially in the field of microprocessor applications, along with changing management attitudes, can be expected to accelerate the pace of automation. It is perhaps necessary to emphasize the latter factor because today's mill managers are much more receptive to technological changes.

Applications in the palm oil mill where automation is fairly well-developed will be discussed separately from applications which are in the process of development and ideas for possible development in the near future. It is difficult in a paper of this nature to be very exhaustive, to provide justification for the automation systems reviewed or to suggest a standard plan for automation of all palm oil mills. The automation needs of each mill must be assessed separately.

Sequence Control

Some palm oil mill operations consist of simple sequence steps which have to be repeated frequently. Sequence control relieves operators of these tedious tasks and makes them available for other productive activity. Also, fully automatic sequence control gives greater flexibility in the control of the processing cycle as it is easy to change the operation cycle to meet changing process requirements with little need to further train operators on how to implement the change. Fully automatic sequence control of batch or intermittent-type operations also enables the coordination of these functions into the control requirements of continuous type processes.

Present Applications. Automatic sequence control of individual sterilizers (Fig. 1) currently is receiving a lot of attention. Systems in use are comprised of both analog and digital versions. Such systems essentially perform the following functions:

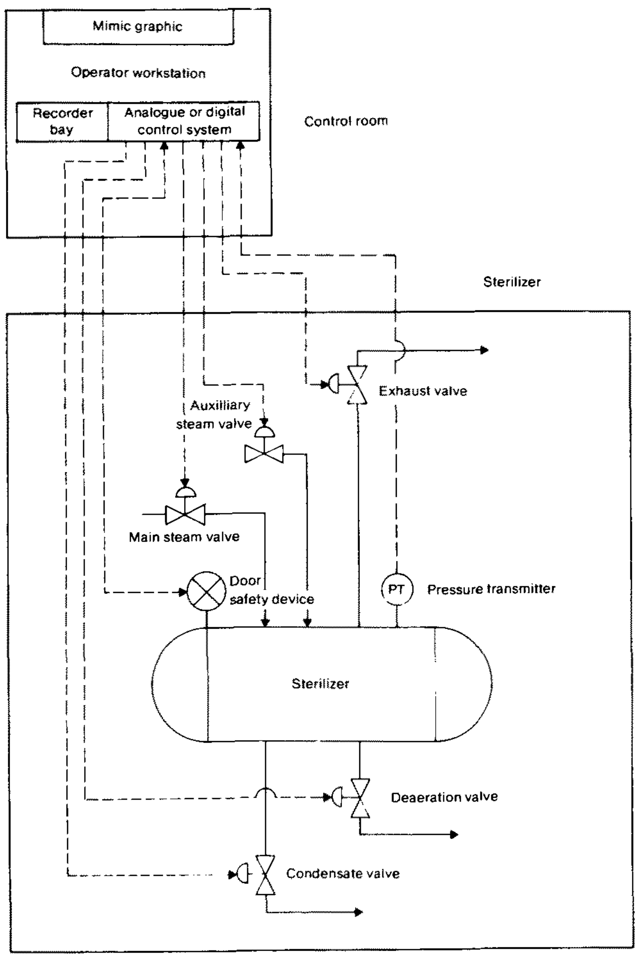

FIG. 1. Automatic sequence control of sterilizer.

• Automatic opening and closing of the following valves in any sequence required:
—main steam and auxiliary steam valves.
—exhaust valve.
—deaeration valve.
—condensate removal valve.

• Automatic control of sterilizer pressures according to any pressure-time program desired. Figure 2 shows a typical pressure-time curve for triple peak sterilization cycle.

In one analog system, the desired pressure-time program is scribed as a "curve" onto a Mylar sheet with a special pen. The system is able to trace this "curve" and send out a pneumatic signal as the set-point of sterilizer pressure to a controller. The pressure transmitter also sends a signal to the controller. The controller compares the measurement signal with the set-point signal and corrects for any deviation by modulating the main steam control valve. The sequencing of the opening and closing of the other valves is achieved by the use of contract strips on the Mylar sheet.

Another commonly used system is a hybrid between analog and digital systems. This sytem uses a microprocessor-based quartz-controlled timer to program the length of each sequence step, while the position of the valves at each step is determined in analog fashion by using a function drum.

In fully digital systems, the sequence of valve movements and the pressure-time curve required are determined by programming. The problem of programming may be reduced to the much simpler task of configuring by the use of function blocks for handling standard operations involved in digital control. The advantages of the digital system over the analog system are greater flexibility and lower overall cost when used for a large number of sterilizers. Systems in use consist of relatively cheap programmable controllers and expensive computers used to perform shared digital control of a number of sterilizers and other operations in the mill. As can be expected, the cheaper systems have limited capability and flexibility compared to the more expensive systems.

The "self-cleaning" type of oil purifier uses a sliding bowl bottom to open and close slots in the bowl wall through which solids are discharged. Automation has been achieved by incorporating an electronic system to set the time interval between discharges and to control the sequence of valve movements necessary to stop the feed to the purifier, allow wash water to enter the bowl and slide the bowl bottom down to allow discharge of solids. After a timed interval, the sequence of valve movements necessary to return the purifier to normal operation is activated.

Automation of periodic discharge of settled solids from clarification tanks and desanders also have been arranged using systems operation on the same principle.

Possible Future Applications. A formidable challenge in the automation of palm oil mills is the automatic sequencing of multiple sterilizers. At least one mill is known currently to be conducting studies in this area. Microprocessor intelligence could contribute to an improved and more consistent sterilization process by removing the human element involved in the sequencing. Sterilization with improperly sequenced cycles causes the demand for process steam to fluctuate greatly. Through automatic sequence control it may be possible to reduce the extent of this fluctuation, thus also contributing to improved boiler performance.

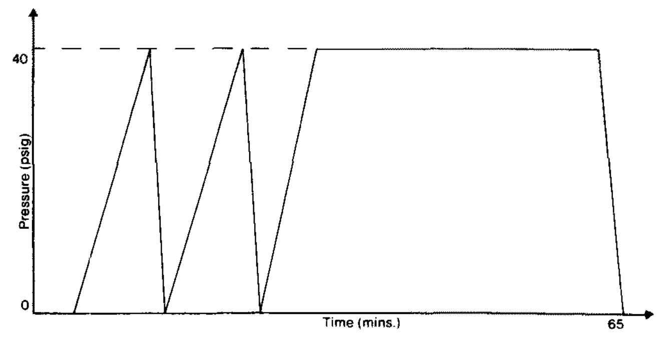

FIG. 2. Typical pressure—time curve for triple peak sterilization cycle.

Continuous Process Control

By using closed loop control systems, the need for human intervention at any stage, once the controller has been set to a particular value, can be minimized. The controller itself attempts to maintain the process to the set value by taking action according to functions built into the controller. It is possible to implement different forms of control such as simple on-off control, ratio control, proportional control, integral control or three term PID (proportional, integral and derivative) control. The availability of microprocessors has enabled implementation of sophisticated control whereby it is possible to compensate for dead time or implement a combination of feedback and feedforward control system categories. Hierarchical computer-based production/process control systems also have become practical.

Present Applications. Automatic control of oil loss and nut breakage in press fiber is achieved by adjusting the screw press cone position or the feedscrew speed in order to maintain constant pressure on the press cake at the outlet of the screw press. One method by which this may be done is by applying a constant pressure on the piston connected to the opposite end of the cone. Any increase or decrease in pressure at the cone is automatically compensated by a lateral movement of the cone such that the forces exerted by the hydraulic fluid on the piston and the press cake on the cone are exactly equal. Another method is to detect the change in pressure by the change in torque in the main screw. This is sensed either by a kilowatt sensor or a less expensive current sensor.

The control of temperature of hot air used for drying in nut and kernel silos and the maintaining of acceptable temperatures in liquid process vessels and oil storage tanks are achieved by the use of popular thermostatic controllers to regulate steam flowrate (Fig. 3).

Constant pressure is maintained in the back pressure vessel during periods of heavy steam demand by the sterilization process by regulating the flowrate of high pressure make-up steam after throttling (Fig. 4).

Digester level is maintained approximately full by the use of on-off control of the thresher feeder. This can be achieved by using a rotating blade whose movement is impeded when the digester is full (Fig. 5). Another technique commonly employed is to sense the current in the drive motor of the conveyor for recycled fruit.

Intermittent boiler blowdown is used to control the level of total dissolved solids (TDS) in boiler water. The level of dissolved solids is related directly to the scale-forming tendency of the water and must be kept below a specified maximum. Conductivity measurements are used to ascertain the level of TDS. Sampling is done at predetermined intervals by opening the blowdown valve to allow accurate measurement by the sensor. When the measured level is above a present value, the blowdown valve is left open until the conductivity measurements drop to the present value; otherwise, the valve is closed at the end of the programmed sample duration time (Fig. 6).

Float operated level switches which provide on-off control of pumps are used commonly in crude oil buffer

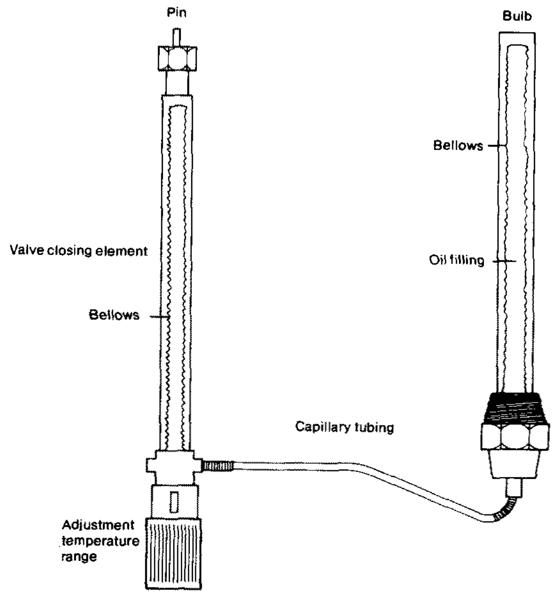

FIG. 3. Thermostatic controller.

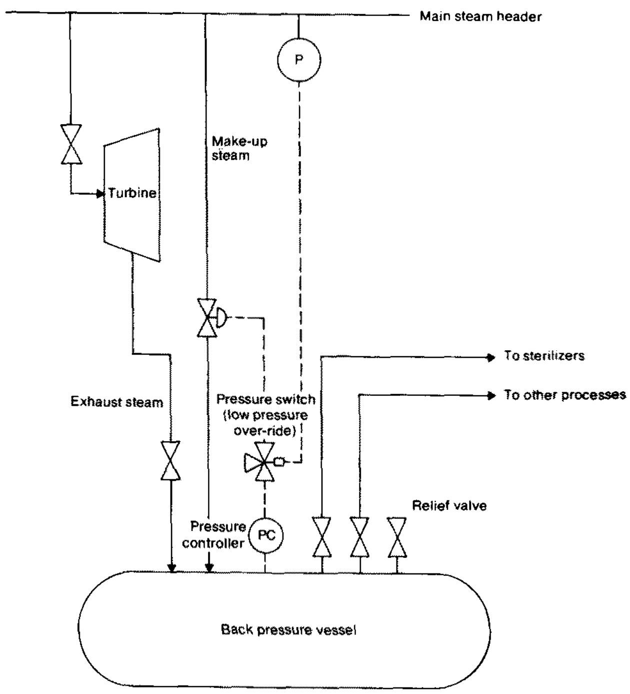

FIG. 4. Control system for back pressure.

tanks and vacuum dryers.

Since a lot of work on automatic control of boilers is at the development stage, it will be more appropriate to discuss this in the following section.

Possible Future Applications. Another formidable challenge in the automation of palm oil mills is the automatic control of boilers. This may be necessary for better fuel utilization, for meeting legislative requirements on boiler stack emissions, to ensure the availability of steam at all times especially during periods of heavy steam demand, to lower maintenance costs and increase the useful life of boilers through better operating practices, or for safety. Since these objectives also can be achieved, or at least

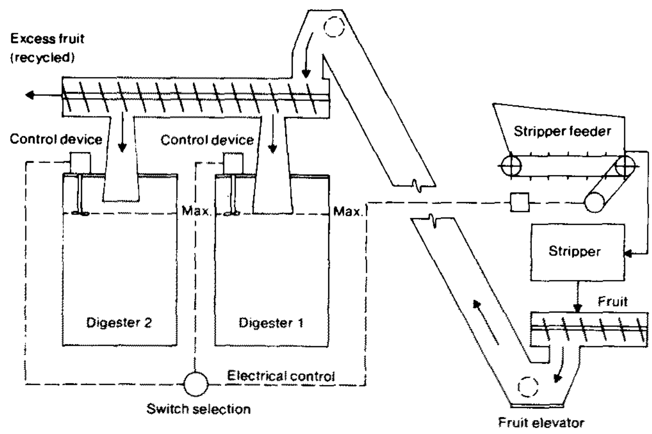

FIG. 5. Digester level control system.

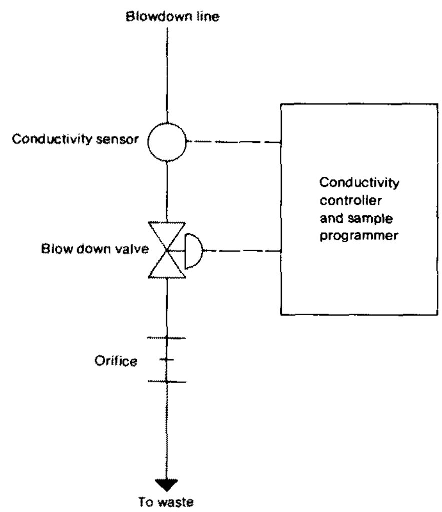

FIG. 6. Automatic control of boiler blowdown.

partially, through other methods such as installing air pollution equipment and improving steam management by using steam accumulators, the system actually implemented will be a compromise between automation and other techniques.

Two primary ingredients are used in the production of steam: heat and water. Combustion control systems are designed to provide a continuous heat balance between fuel in and steam flow out. Drum level control systems are designed to provide a continuous mass balance, since for every pound of steam generated and removed from the boiler, a pound of water must be added to replace it. Fig. 7 shows the process parameters which have to be given consideration when contemplating control of boilers.

Steam flow, feedwater flow and drum level are important parameters to consider when studying drum level control. Many mills use float operated level switches to provide on-off control of feedwater pumps. Better control can be achieved when level sensing devices such as floats are used together with modulating valves to regulate continuously the amount of feedwater entering the boiler drum. For even closer control, some mills have implemented three-element level control systems (Fig. 8) where all of the three paramaters mentioned above are given consideration.

For implementation of combustion control some of the parameters are difficult to monitor, especially fuel flow. Direct positioning combustion control systems where the

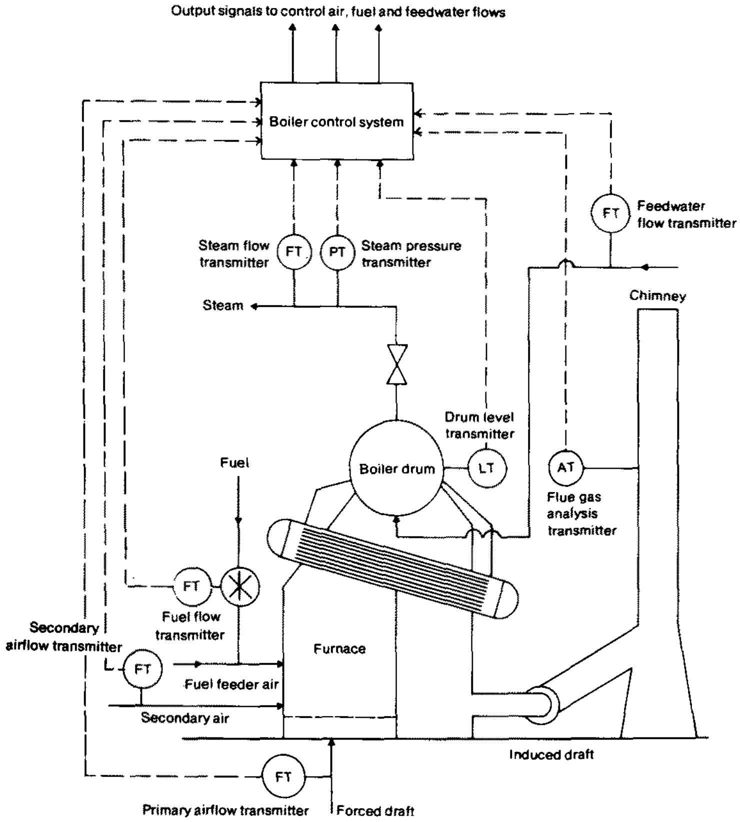

FIG. 7. Control of boiler.

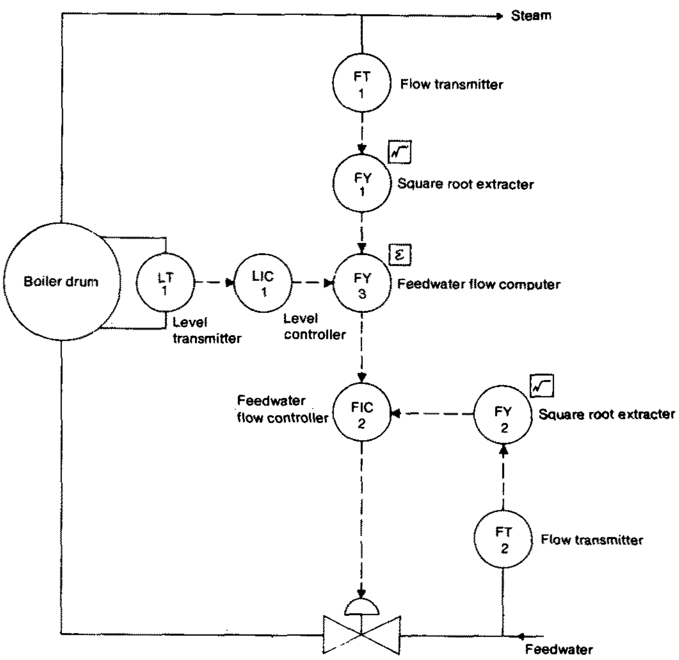

FIG. 8. Three-element boiler drum level control system.

master pressure controller directly controls fuel flow, without any flow measurement, currently are being evaluated in some mills. Even though combustion control schemes have been implemented widely with other solid fuel burners, no extensive study has yet been made with palm oil mill boilers. This is due partly to the fact that there is sufficient waste material available as fuel to produce all the steam required for process heating and generating the electrical power needed for oil and kernel extraction.

Another possible area for the introduction of automation is control of crude oil dilution by use of flowrate measurements and continuous ratio control. This is discussed in greater detail later on.

Process Data Management

The concept of process data management is given in Figure 9. The benefits to be derived from automation are improved equipment and process monitoring, more advanced data processing than is possible manually, labor saving and improved reliability of figures. Proper instrumentation is an important aspect of process data management. Instruments for measuring parameters such as temperatures and pressures are readily available but the metering of other parameters in palm oil mills such as levels and flowrates has still to be studied properly. Methods exist for continuous on-line monitoring of some parameters such as free fatty acids, but no such techniques exist for the majority of analyses carried out in a typical palm oil mill laboratory. Automation in the laboratory will require the use of rapid instrumental techniques to replace laborious chemical analytical techniques wherever possible.

Present Applications. Commonly used instruments in palm oil mills consist of:

- Pressure and temperature indicators and recorders to monitor various processes.
- Belt weighers to quantify the total input of raw material and for estimating extraction rates.
- Nut weighers to quantify nut production for estimating kernel extraction rate.
- Basculators, Doppler flowmeters and magnetic flow-

meters to measure sludge output to quantify absolute oil losses.

• Orifice plate steam flowmeters to measure steam generated by boilers and steam to sterilizers.

Microwave oven drying and the Fosslet method for volatile matter and oil analysis are used commonly in many palm oil mill laboratories.

Central control rooms and control panels for housing controllers, indicators, recorders, alarms and switches and mimic graphic displays are employed in some mills. Such systems will improve equipment and process monitoring under normal and abnormal conditions. They also will facilitate start-up and shut-down operations.

Automation of sample collection for laboratory analysis is possible through the use of programmable controllers for timing the movement of mechanical samplers. The movement of these sampling devices controls openings through which samples are discharged by gravity.

Possible Future Applications. Microcomputers based on manual data entry may be used for processing laboratory information. One possible system is given in Figure 10. Also, microcomputers or data loggers may be used for collecting and manipulating on-line process information such as temperatures, pressures and flowrates. Advanced users may rely on cathode ray tube (CRT) based displays to condense information available from large panel boards. By using microprocessor intelligence, such systems are able to condense the information the operator needs to control the plant efficiently and safely. Apart from displaying control loop information in conventional controller format, such systems can provide live process graphics, historical trending and alarm summaries. Such systems also permit updating of operator information to account for changes in plant design.

Use of Computers for Business Data Processing and Other Applications

This category covers applications of computers for management and manipulation of data for accounting and administrative purposes as well as other applications such as budgeting and word processing. Two types of data processing systems can be implemented—batch processing and on-line processing. In batch processing, a group of transactions is collected manually and input into the computer at a prescribed time. In on-line processing, transactions are entered into the computer as they occur. This can be done manually or by direct interfacing with the equipment.

The use of computers in such applications is becoming more economical because of rising labor costs and the availability of small, low-cost computer systems specifically designed and programmed for handling common applications. Also important is the greater flexibility in reporting and the higher efficiency achieved through computerizing.

Present Applications. Computer systems based on manual data entry are used for keeping track of fresh fruit bunch (FFB) purchases. Such systems are especially useful for

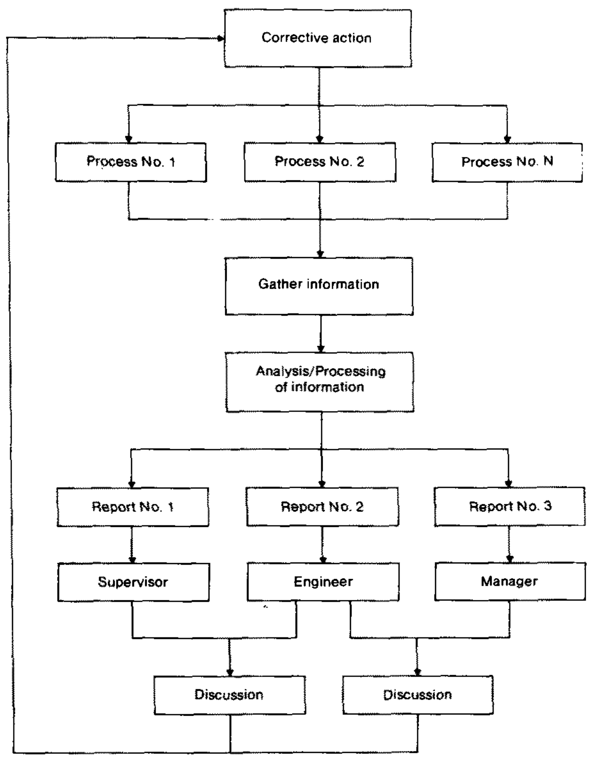

FIG. 9. Concept of process data management.

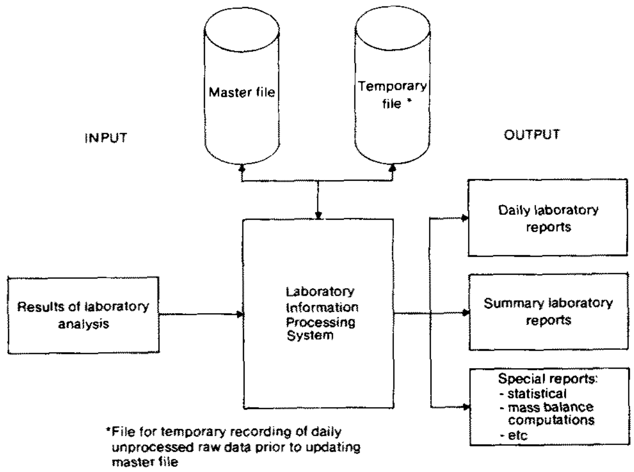

FIG. 10. An illustrative example of a suitable laboratory information processing system for implementing in palm oil mills.

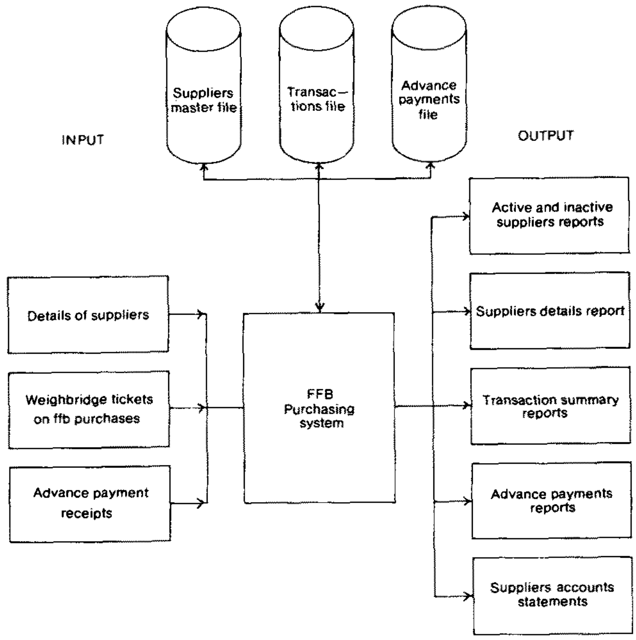

FIG. 11. An illustrative example of a suitable FFB purchasing system.

mills which purchase a high percentage of the FFB processed (Fig. 11). Computerized inventory control systems based on manual data entry are used for keeping track of mill spare parts. These may be used closely with accounts payable systems.

Computerized payroll processing systems based on manual data entry are used by some mills. A special feature is the ability to integrate with other systems to generate special reports which indicate the distribution of labor and material expenses to the various stations or individual equipment in the mill.

Computerized weighbridge systems are widely used for keeping track of all primary stock movements (FFB, oil, kernel and bunch ash). The primary objective for installing such systems is improved security. The report generating capability varies from reports indicating daily movements to monthly summaries and reports indicating the extent of fulfillment of contracts.

General ledger systems are available for generating the reports needed for accounting purposes.

Possible Future Applications. Popular computer software such as electronic spread sheet programs can be used for budgeting and in other computation requirements and word processing programs used for correspondence. Computers also can be used to assist in maintenance management. A system which is able to keep technical and history records of plant equipment, enable scheduling of planned maintenance, issue job orders, keep track of work in progress and provide information such as costs, downtime, relative frequencies of planned versus breakdown maintenance, analyses by type of work, costs, etc., should be very useful to palm oil mills.

ILLUSTRATION OF A PRACTICAL APPROACH TO AUTOMATION

To illustrate a practical approach to automation in an oil mill, the automatic control of crude oil dilution is selected as an example. Studies by Lim and Whiting (3) have indicated that for an optimum settling rate, dilution must be maintained in the range between 25% and 35% of water (Fig. 12). Above and below this range, the settling rate is poor. Manual control of crude oil dilution has been very unsatisfactory due to high variability in crude oil flowrate.

The flowrate and composition of undiluted crude oil is uncontrollable and is determined by the pressing process. Precise control of the composition of diluted crude oil is not possible without composition analyzers. Using the ratio control scheme shown in Figure 13, the composition of the diluted crude oil should be controllable within a fairly close range. The flowrate measurement of dilution water (W) comes into the summing junction of the ratio controller. The set point of the controller is generated by taking the flowrate measurement of diluted crude oil (DCO) and multiplying by the desired ratio (K). At all times W must be equal to K×DCO, so that if W > K× DCO the controller decreases W and vice-versa. In the ratio control scheme given, control is achieved by manipulating a valve which controls W while the flowrate of undiluted crude oil is left uncontrolled.

For the above control scheme to work, it is necessary to be able to measure the flowrates of dilution water and diluted crude oil. Dilution water flowrate is easily measurable as water is a Newtonian fluid. The major obstacle is the selection of a flowmeter that can measure DCO flowrate. DCO is a non-Newtonian, thixotropic fluid which cannot be measured by ordinary differential pressure flowmeters.

The suitability of an ultrasonic Doppler flowmeter for measuring crude oil was assessed by using a quantitative mass balance approach (4). Figure 14 shows a flow sche-

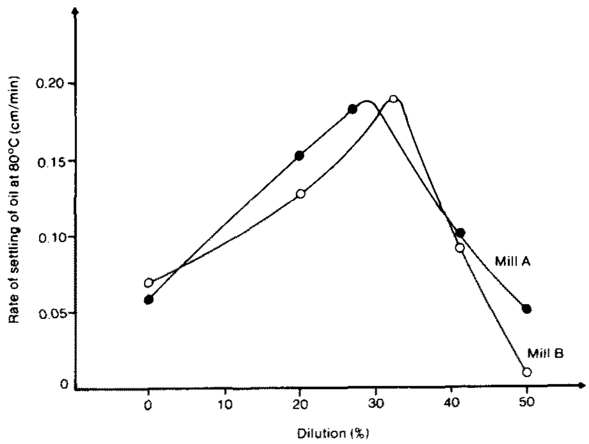

FIG. 12. Graph showing rate of settling versus percentage of dilution with water.

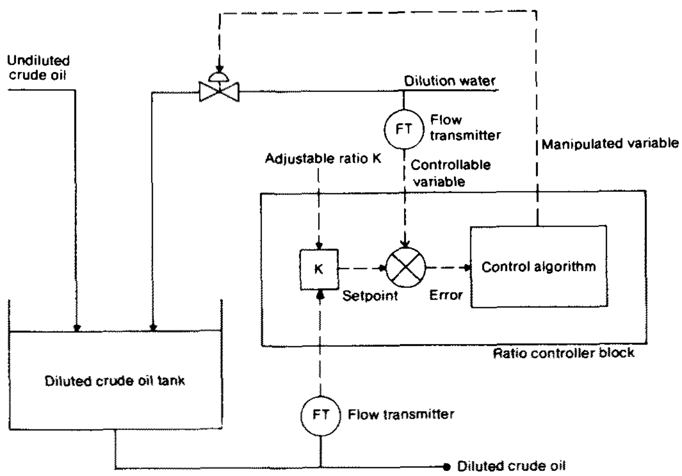

FIG. 13. Ratio control system for crude oil dilution.

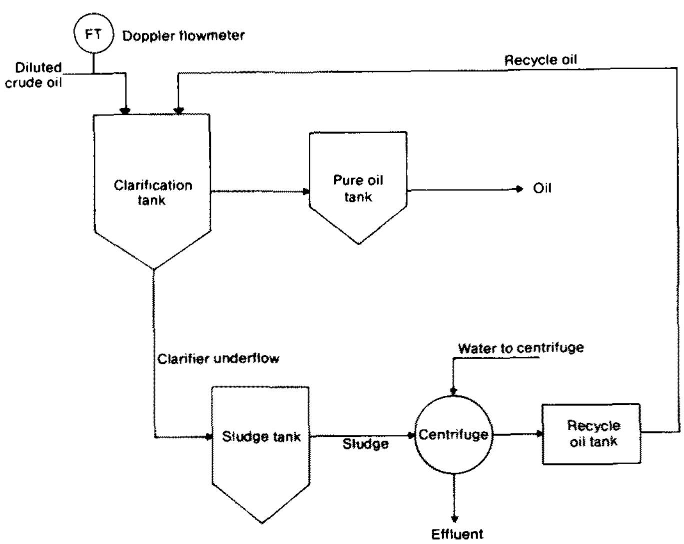

FIG. 14. Flow diagram of clarification station.

matic of the clarification station. Calculations of DCO flowrates were based on the following mass balance equation:

$$DCO = O + E + A/R_{cs} - W_c$$

where production oil, O, was measured by an oval flowmeter; centrifuge waste, E, was measured by rotary basculators; water added to centrifuges, W_c, was measured by a water flowmeter, and accumulation or reduction in the clarification tank, sludge tank, recovery oil tank and pure oil tank were obtained by tank dippings.

Hourly recording of calculated values of DCO and measured values of DCO by the Doppler flowmeter were carried out for 7 days. The total quantity of DCO by mass balance calculations was 747.87 tons, while that measured by the Doppler flowmeter was 719.50 tons. The Doppler flowmeter was, therefore, found to be a suitable measuring device for DCO flowrate giving an acceptable overall percentage error of 3.80% (Table I).

TABLE I

Mass Balance Measurement Versus Doppler Flowmeter Measurement of Diluted Crude Oil

Date	Mass balance measurement (tons)	Doppler flowmeter measurement (tons)	% Error
2/4/84	88.71	89.33	+ 0.70
3/4/84	124.44	125.34	+ 0.72
4/4/84	88.72	84.14	- 5.16
5/4/84	119.13	109.36	- 8.20
7/4/84	177.50	167.74	- 5.50
9/4/84	77.01	73.65	- 4.36
10/4/84	72.36	69.94	- 3.76
Total	747.87	719.50	
Mean			- 3.80

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