Computer Process Control in Modern Pulp and Paper Industry

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1 INTRODUCTION

The computer revolution has made a great impact on the industrial development. The scale of improvement and development in computer technology has placed it within the reach of even small industries, business houses and offices. Computers cover a broad span of applications and the computer process control (CPC) is one of the major application in the process industries. Today computers can monitor and control most major and many minor control takes in the modern pulp and paper industry. For example :

- Computers can be used to monitor liquor composition and flow rate into the digester. It can measure the liquid temperature, residence time and heat input and then it can compute cooking-zone temperature adjustments to prevent over-cooking and under-cooking and therefore boosting up the digester yields substantially.

- The most widespread use of computers is to control the paper machine. It can calculate the set-points for stock flows, machine speeds and water flows to the headbox and finally adjusts the stock flow based on measurements and feedbacks from the dry end in order to control basis weight. It inereases the production, reduce the above broke and minimizes the grade-change time.

An exponential growth in the use of computers has revolutionized process control in the pulp and paper industry. Why the swift modernization in process control is undergoing ? One could say that reliable computer hardware is available do to the job. It is compatible with a wide range of mill uses and environments. The advent of minicomputers has brought about rapid advances in computer process control practically in all sectors of pulp and paper industry : the pulp mill, the bleach plant, the paper machine etc. Better control means more money. Financially, minicomputer have made CPC a realistic and almost necessary investment in the mills Better product uniformity fewer rejects, less downtime, efficient use of energy and materials require the process computer installations in the mills. The minicomputer can not be ignored because of their increasing capability and decreasing cost per word of core memory. The online instrumentation monitors greater proportion of product than laboratory testing and produces more representative production data while decreasing the human error component. The CPC system can operate in real time, using continuously generated data to optimize production variables. The time lag involved in laboratory analysis is practically eliminated

2 CONTROL LOOP AND SENSORS

A typical automatic control loop consists of three basic components : sensor (with transmitter), controller and control element (Fig 1). The sensor is at the heart of any control loop. Automation is not possibls without a reliable measurement of controlled variable. In general, few variables can be measured directly with use of active or passive transducers others are based on measurement of related properties. For example, the moisture content of paper can only be measured directly by laboratory methods, but the moisture content can be inferred from measurement of such related properties as resistance, absorption of microwave energy, absorption of infra-red energy. The pulp and paper industry uses many of the common process variable sensing/monitoring and control techniques. However, the industry has many variables which are unique to itself. These include chip moisture control, effective/active alkali

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TABLE—1

Sensing Principle of Important Variables in the Modern Pulp and Paper Industry

	Variable	Principle of Measurement	Remarks
1.	Chip Moisture	Radio frequency sensing fields	The capacitance and resistance of chip samples are determined by bridge using radio frequency sensing field. A thermistor determines chip temperature and a load cell measures the weight of each constant volume sample. The output is a temperature and density-corrected moisture content.
2.	Effective Alkali	Conductivity titrations via Computer interfacing.	The conductivity titration provides an alkali concentration of black and white liquors. Via computer interfacing, each sampling, titration (with H_2SO_4) and flushing cycle is performed automatically.
3.	Residual Lignin	Calorimetric method.	A known amount of fibre is reacted with dilute HNO_3 under controlled time/temperature conditions A calorimeter measures the color intensity of the reaction liquor, which is directly proportional to lignin content of fibre sample before reaction. The residual lignin is directly related to Kappa number.
4.	Consistency	Fluid shear and fluid viscosity Polarized light beam.	The cellulose fibres, because of their optical activity, will partially depolarize a polarized light beam. The ratio of measuring current to reference current gives a linear relationship with the dry fibre content of the pulp stream.
5.	Pulp Freeness	Level measurement of the drainage volume from the stock line.	The sensor extracts a pulp sample from the stock line, measures drainage through the collected fibre mat, and finally flushes away the sample. Pulp freeness is determined by level measurement of the drainage volume.
6.	Sheet Moisture	Infrared transmissions Microwave technique, optical technology	———
7.	Basis weight	Radioactive technique.	A radioactive (Krypton 85, Strontium 90) beta source alongwith either a scintillation or ionization chamber detector to measure the strength of the source after passing through the sheet is used.
8.	Caliper	Magnetic reluctance.	The positioning head of the sensor contains a floating magnetic plate which gently touches the underside of the sheet and maintains a contact between the top of the sheet and the measuring head. A pulse frequency, related the pole-to-plate separation due to sheet, is generated and is transmitted to the computer interface. The sensor slides gently across the moving sheet and continuously measures the caliper.
9.	Color	Optical technology.	Measurements are accomplished when a light beam passes through the paper web is detected by a silicon diode detector. As the paper moves through the light beam, it produces a high frequency alternating waveform at the detector.

levels, residual lignin, stock consistency and freeness, basis weight, caliper, sheet moisture content, colour, brightness, opacity etc. The most important aspect in any control strategy is to choose a proper sensor to sense the variable. There has been significant development in sensor/transducer technology with advent of computer/microprocessor based process control. The sensors applicable to specific pulp and paper industry variables are listed in table-1. As can be seen, most of the sensor development is based on basic principles of physical sciences and these have been integrated into electronic circuitary.

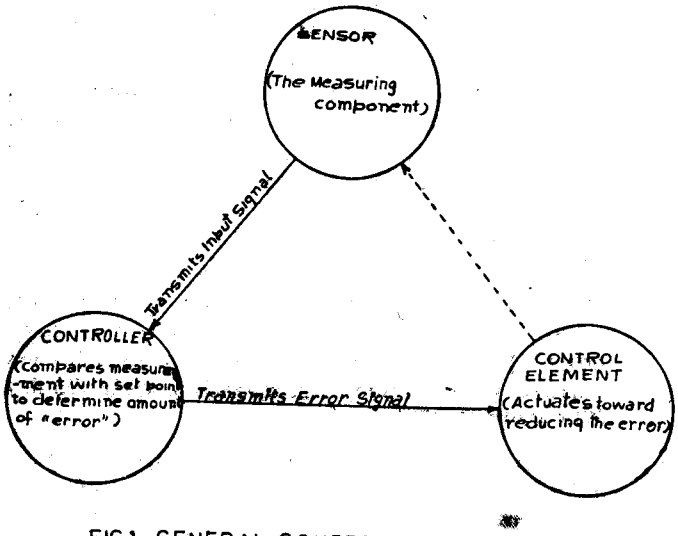

FIG.1. GENERAL CONTROL LOOP

These sensors measure the process variables and transmit an appropriate signal to the controller. The controller compares the incoming signal to the set point and transmits an error signal to the control element. The control element is then actuated in the direction of correcting the error. A typical consistency control loop is shown in fig. 2. showing these principles.

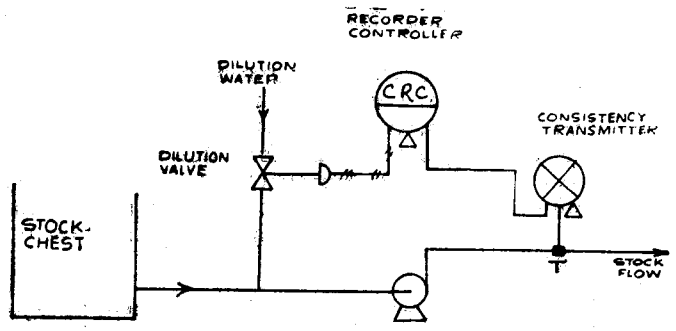

FIG.2- CONSISTENCY CONTROL LOOP

3. PAPER MILL PROCESS CONTROL

The CPC strategy is applicable to various sections of the pulp and paper mill. These are discussed under the following sections.

—Pulp mill and bleach plant control

—Paper machine control

The recovery plant consisting of multiple effect evaporators, recovery furnace, boilers and causticizing are similar to many chemical plants and their process control strategy is not discussed here.

3.1 PULP MILL AND BLEACH PLANT CONTROL :

The transducers based computers can be used to help management to improve the regulation of steady state production runs and scheduling of batch digester operations. The advantages are higher yields, greater throughput, reduced digester chemical and evaporator operating costs. Computers in the pulping process monitor the chip and liquor input, temperatures, pressures, residence times, analyzes chemical compositions and measure the pulp discharge. The mathematical model of the digester system can also be set up in the computer which enables the system to consider wood species, chip moisture and density as process disturbances. This mathematical model can also control the chemical composition of white liquor and its flow rate into the digester, the ratios of white to black liquor, residence times and heat inputs.

The computers also help management in controlling the bleach plant process variables more effectively in order to produce more uniform pulp at reduced chemical costs by regulating individual process stages and scheduling grade or production rate changes. The production rate change is important to bleach plant regulation since variation in incoming brown stock flow or any consistency may seriously affect the regulation of other downstream process stages.

3.2 PAPER MACHINE CONTROL :

The most wide spread use of computer is to control the paper machine. A number of proven computer techniques are used to control basis weight and moisture content. The efficiency of the paper machine can be improved significantly in terms of higher yields, lower costs, better quality, and reduced grade-change time. The computer techniques utilize both feed back and

feed forward control. The sheet is scanned as it comes off the dry end of the machine, computing the basis weight and moisture content. The steam flow valve in the dryer section is manipulated to control moisture and the stock valve to control the basis weight.

4. THE HIERARCHICAL SYSTEM

Under the hierarchical system, the data are captured by the host computer from the dedicated process computers (Fig. 3). These data are used not only to optimize the process itself, but also to serve much broader operating and management information requirements. The small dedicated process computers perform the routine tasks of unit process control, communicate with each other and with host computer in the mill. All the information regarding desired section of the mill can be made available instantly from the host computer for operations control and management planning. The host computer can also store optimization programs and can transmit new operating instructions to the process computers in the mill area according to the requirements of the changing situation. These process computers are capable of maintaining direct contact with on going mill process for the purpose of monitoring and control while at the same time collecting and reporting vital operational data. For example, the IBM system —7 can be used in all three major sections of the mill– the digester house, the bleach plant, paper machine and recovery plant. This system feeds the necessary data to the host computer; calculates the process set points, issues operator guide information, alerts operators to threatened process upsets.

Adopting hierarchical approach in the modern pulp and paper mill, the following are some of the important operating and management informations which can be

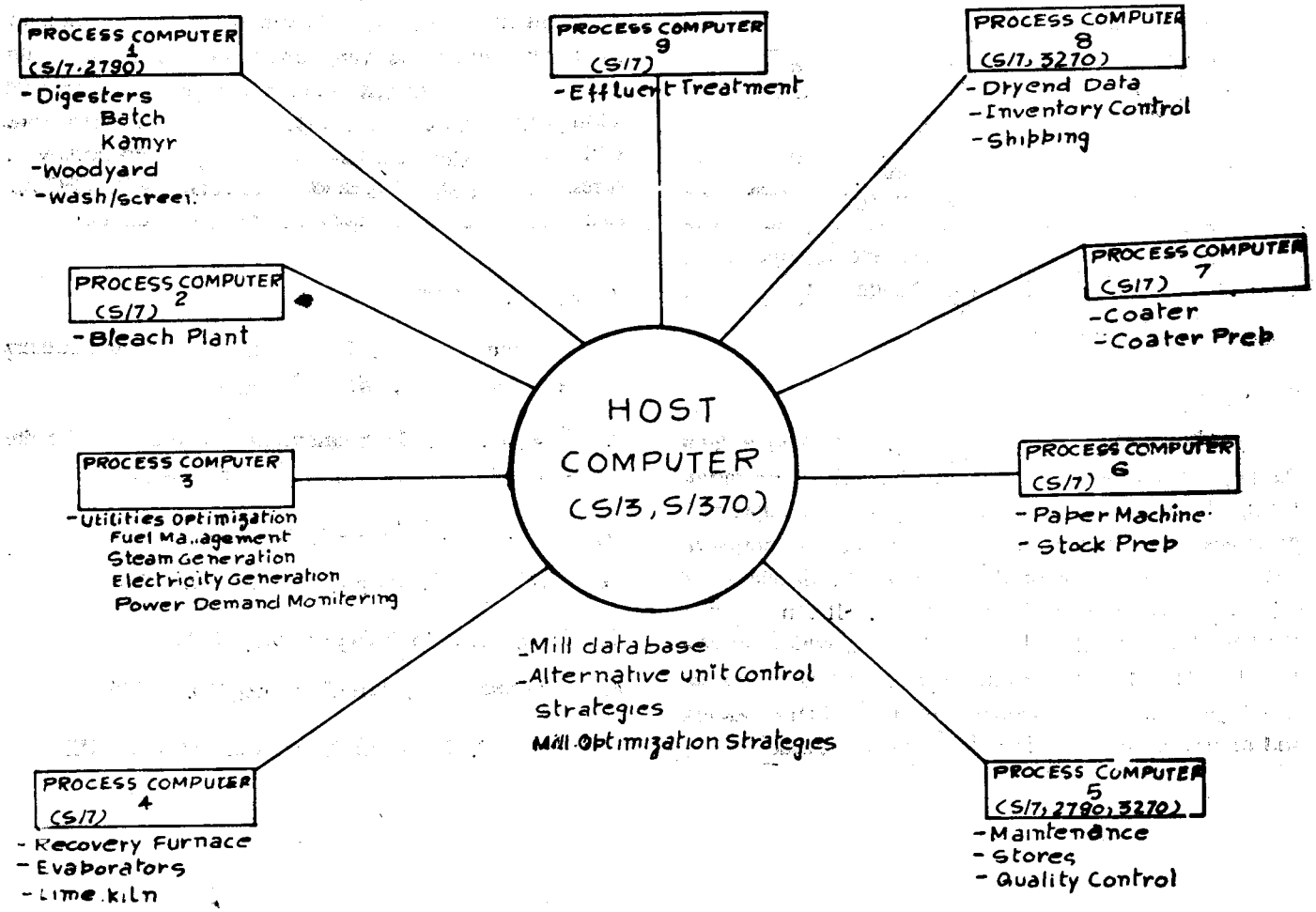

FIG. 3 HIERARCHICAL SYSTEM OF PULP AND PAPER MILL CONTROL

made available from the host computer and/or from the process computers.

— The process computer communicates its real–time data directly to the host computer. The host computer, in turn, generates fully–processed current information about the total mill operation in summary form. There is virtually-continuos monitoring of mill production rates and yields, pulp and chemical compositions and consumptions, flow speeds, grade changes, downtimes etc. All the data are correlated by time segment and end-product quality. Performance at each stage of production is compared with standards. The deviations are flagged to management attention, and mill status information is quickly available by means of terminal inquiries.

— The data caputured by process computers and relayed to host computer are immediately available to billing departments. Using this information, they can check roll footage accuracy, production managers can make daily entries, and profit centre managers can make performance evaluations.

— The host computer can prepare a morning report based on data collected from various process computers and pinpoints production, machine downtimes, shrinkage between reels and wrapped rolls, overruns and precise usage of such costly materials as titanium dioxide.

5. Conclusion :

These examples are representative which high light the key role of the computers in controlling and monitoring functions in the modern pulp and paper mill processes and operations. The heirarchial computer system offers great potential in terms of mill operating efficiency, economy and profitability. It can serve as the basis for a total mill control system which accurately depicts and helps to manage the critical interrelationships and interdependence of individual processes and processing stages. The hierarchial approach is the primary thrust of the present and future in paper mill computer utilization.

The Indian pulp and paper industry both in large integrated sector and small sector is at cross roads with practically no profit margins. The rising energy costs; reduced raw material availability and poor quality of product have adversely affected the performance of mills. The survival depends essentially on mill modernization which to a large extent depends on process control to reduce operational costs and increase productivity. It is the time that mill manager and entrepreneurs concentrate on investments which pulls the industry out of the crisis. The fast development of of electronic industry, particularly microprocessor based process controls alongwith fairly reliable cheap computers, opens up a new and challeging alternatives. The pri ces of the computer controls are competitive and the investments are justifiable with low payback periods. The limited experience of some of the larger mills on computer controls is very promising. It is right time to look at the skilled manpower needs required for taking care of CPC. It is hoped that the current decade will see a major change in industry operations with stress towards high degree of automation with CPC for cost effectiveness and improved product quality.

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