

# Indigenous capability for electronic process control in pulp and paper industry

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'Paper making is more of an art than technology, is a common phrase being used in the paper maker's circle. In the earlier days of paper making, instrumentation played only a minor role all over the world. But today, there is a startling contrast of installations in a modern industry. This development is not only to make better quality paper but to provide the required quality with the least personal skill. What was before an 'art' has now become a logical and scientific processing.

Process control instrumentation has generated its own importance in Pulp and Paper Industry for not only as a legend of sophistication, but for a well defined improvement of the product and cost reduction by achieving close tolerances in quality and reducing the down time and losses.

Above certain levels of plant capacity, complexity and machine speeds, controls are only possible by fast acting electronic processors and intricate control loops, man-machine communications are quite futile for the safety and operations of such systems.

Today with our indigenous capability for the manufacturing of process control equipment along with years of experience in process knowledge and systems designing, we have now attained expertise in the application of microprocessor technology to overcome what, at one time, was thought impossible.

## CHANGING OVER TO ELECTRONIC CONTROLS

It has almost been convention, to have pneumatic instruments in any plant. Pneumatic instruments since ages have contributed to the controls of any industry and even today they are performing well at many places.

After the independence in the fifty's medium scale industries in Pulp & Paper Technology upto 60 TPD were existing with a sketchy instrumentation of those times. Large mills came up in the sixties with capacities of 100 TPD and above

which were then provided by a pneumatic control systems confined to a limited skeleton network. It was only recently that second-hand paper mills were allowed to be imported to boost up the industry within the capacity of 30 TPD which have suffered the lowest level of instrumentation due to economy of scale. The emerging trend of the eighties is better economy of scale of the paper mills on one hand and lower cost of instrumentation in the same. This trend is expected to boost the incorporation of more and more sophisticated instrumentation technology in the paper industry.

With the increasing complexity in the control functions and unbelievable developments in the field of electronic in the recent years, electronic control systems have not only proved their superiority for comprehensive control capabilities, faster responses, proven reliability, fast and easier maintenance but also costless and are simpler to produce. Moreover, they are the only solutions of certain measuring and control functions in the field of analytical measurement, computational controls and other microprocessor based automation systems and data acquisition.

Recent developments in the Electronic Process Management and Control instrumentation has made convenient long distance transmission techniques for control signal and data logging, centralized control centres, on-line digital process control computers and continuous or intermittent on-line measurements of the process variables.

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To compare the features vs. product technology Table I lists some interesting features.

**TABLE-I FEATURES VS PRODUCT TECHNOLOGY**

Features	Mechanical Instrumentation	Pneumatic Instrumentation	Electronic Instrumentation	Microprocessor based Instrumentation
Accuracy	O	O	N	S
Flexibility	O	O	N	S
Ease in understanding	S	S	O	N
Computational Ability	O	O	O	S
Upward Design Ability	O	O	N	S
Maintainability	N	N	O	S
Wear & Tear	S	S	O	O
Surveillance Monitoring	O	O	N	S
Communications Architecture	O	O	O	S

O-WEAK    N-NEUTRAL    S-STRONG

#### INSTRUMENTATION OF EXISTING MILLS

Majority of the pulp and paper industries in India are either old or new with old machines. In the past few years, these industries have mushroomed up in different capacities and sizes. Majority of them are between 10 to 60 TPD. It has rather been an unfortunate part on these machines not to have even a moderate scale of instrumentation, as in their times, instrumentation as such was not much developed.

Instrumentation and systems requirements varies from mill to mill due to the type of process, raw material, product and type of equipment. This requires individual plant study for most effective instrumentation and application engineering in view of the restriction for change in design and equipment layout, particularly if it has to deal with an existing operation. Moreover at times, when the improvisation of instrumentation to an existing operating industry is to be undertaken, is becoming equally important to look into the wide process parameters to be controlled in this industry. Application and selection of appropriate basic instrument type and to decide the order of instrumentation priority in various areas of the industry, indicating optimum investment vis-a-vis return on

investment by way of quality improvement of the product and reduction in manufacturing cost, is also critical.

By adopting the latest techniques in Electronic Process and Power Controls, the industry can substantially benefit by producing the required quality of paper with highest efficiency alongwith critical control on the losses of raw material.

#### INDIGENOUS CAPABILITIES

Today, we have the indigenous capability for the design and manufacturing of electronic process control instrumentation. We have already indigenously and are producing systems of sophisticated techniques and hybrid technology. These systems ensure improved operational safety with high degree of reliability.

The reliability of a system depends not only on the system technology but more on the careful choice of components, circuit design, assembly techniques and stringent quality control. Today our country has quite a good number of industries producing high quality professional grade electronic components from passive, to active devices with international standards exporting to U.S.A., U.K., Germany, Holland, Hong Kong, and many other countries of Europe and Middle East.

Our self-reliance in electronic process and power controls is rooted in a firm faith in indigenous capability and has brought significant breakthroughs in technological innovations. Moreover, the importance given to thermal power plants and process industries in Sixth and subsequent Five Year Plans has led to an increase in demand for control instrumentation.

To go a little further in the indigenous services available in the country today in the process control instrumentation, we can broadly classify them as under :

1. Plant/Project Study and Analysis.
2. Systems Engineering

Control systems	Detailed Engg. & Drawings	Annunciation System
Scanners	Sequential events controls and data acquisition system	Data logging
Interface	Analog Controls	Digital systems and computers

3. Manufacturing and equipment supplies.
4. Erection and commissioning.
5. Application— oriented R & D related to microprocessor based systems.

Now with a boost from Electronic R & D Centre (ER&DC), an autonomous Government sponsored R & D Centre in electronic comprising of technology assimilation and upgradation, its adaptation and innovation, with test and development centre alongwith other facilities, has encouraged the growth of small and large industries in this direction.

Our Public Sector Industries have also come out with flying colours in the field of electronic process control instrumentation to cater to the needs of thermal power projects and other process industries in India. In collaboration with renowned and professional manufacturers of the world in this field, these mammoth organizations have addressed itself to technology assimilation of the know-how received from their collaborators and further to understand the idea i.e. know-why to the know-how to effect maximum indigenisation. This has paved the way for technology upgradation of the know-how received and in result also attained new products range as a result of complementary technology.

Some of the systems worked out and are being worked indigenously are as below :

- a) Modular microcomputer based systems.
- b) Alarm Annunciation systems and Programmable control system (for open-loop control).
- c) Desk top microcomputers.
- d) Data Acquisition system.
- e) Micro-mini-computers.
- f) Data capture system.
- g) Advanced programmable logic control systems.
- h) Temperature scanners.
- i) Sequential event recorders.
- j) Surveillance monitor etc.

#### **PROCESS VARIABLES IN PULP AND PAPER INDUSTRIES**

To maintain a fairly good state of balance between pulp and paper making process, it is very essential to establish balanced conditions between the two. This can be efficiently managed by providing a proper means to determine the state of conditions between the pulp and paper making, in accordance with predetermined established values. Also to maintain a process variable constant, on-line continuous or intermittent measuring

and controlling instruments (as applicable) are essential to give controlled variable conditions as required.

The important process variables which need to be measured, controlled or recorded in pulp and paper industry are :

- a) Flow
- b) Level
- c) Pressure
- d) Temperature
- e) Analytical
- f) Consistency
- g) Speed
- h) Moisture
- i) Basis weight
- j) Tension
- k) Draw

#### **FLOW MEASUREMENT**

Flow measurement has been one of the very important process parameters in pulp and paper industry. It is the most frequently encountered parameter in this industry. To suit various applications, different type of flow measuring instruments have been developed based on entirely different concepts and principles.

Table 2 gives a brief comparison of some of the flow measuring system used in pulp and paper industry.

#### **LEVEL MEASUREMENTS:**

Liquid and solids levels is another very important variable in the pulp and paper industry for proper process operations. This is perhaps the major part of this industry's instrumentation.

From heights of the bleaching tower to precise level control of closed head box, the extent of the level controls are phenomenal. There is a wide range of instrument types of suit for the right application.

Instruments for the measurement of levels are not only intended to display levels but have functions to indicate and other connected functions such as jet velocity, pressures formation factor etc. in the wet end of paper machine.

Some of the typical level measuring instrument needs in pulp and paper industry for liquids and solids are listed below:

#### **Level Measuring Instruments:**

1. Differential pressure transmitters (closed tank) for liquids.
2. Liquid level transmitters (Open Tank)—for liquids.

**TABLE-2 FLOW MEASUREMENT SYSTEMS**

Features	FLOW RATE MEASURING SYSTEMS (TOTAL QUANTITY MEASURING SYSTEM)			(PRIMARY ELEMENT) (SECONDARY ELEMENT)	
	Magnetic Flow Meter	Differential Pressure Transmitters	Target Flow Meters	Turbine Flow Meters	Rota-Meters
Nature of Fluid	Virtually any electrically conductive liquid or slurry (Pulp & Stock)	Liquid vapour mixed steam (Depends on Primary element).	Liquid, vapour, gases, light slurries & high viscosity liquids.	Lubricating & non-lubricating, free from suspended material & sediments.	Gaseous liquid free from suspended sediments.
Ease of changing capacity	Better	Best	Not recommended for low Flow rates	Better	Adequate
Principal of operation	Faraday's law of electricity	Bernoulli's Theorem	Velocity, force metering	Velocity, force metering	Area metering
Pressure loss	None	Good	Good	Adequate	Good
Moving Parts Chemically compatibility	None Strong	None Adequate (depending on primary element)	Moderate Poor	Turbine Rotor Poor	Yes Good
Effect of Density/ Viscosity Variation	None	Adequate	Adequate	Adequate	Tolerable
Effect of Temperature and pressure	None	None	Limited	Limited	Limited
Accuracy	Good	Best	Adequate	Best Precision digital totalizing.	Good
Repeatability/ long term stability.	Best	Good	Adequate	Good	Good
Flow Direction	Bi-directional	Uni-directional	Uni-directional	Uni-directional	Uni-directional
Ease of Maintenance (Cleanability)	Best	Adequate	Better	Good	Better

Detection of flow within a specified limit is also very important parameter to maintain a healthy operating conditions of various important plant equipment, such as gland cooling water supply Pumps and refiners etc. Detection of flow of solids in hoppers and chutes for various electrical interlocks and annunciation application is also important. For such requirements, there are 'Flow Monitors' and 'Flow Guards' for liquids and solids based on various systems such as target switch, microwaves equipment etc.

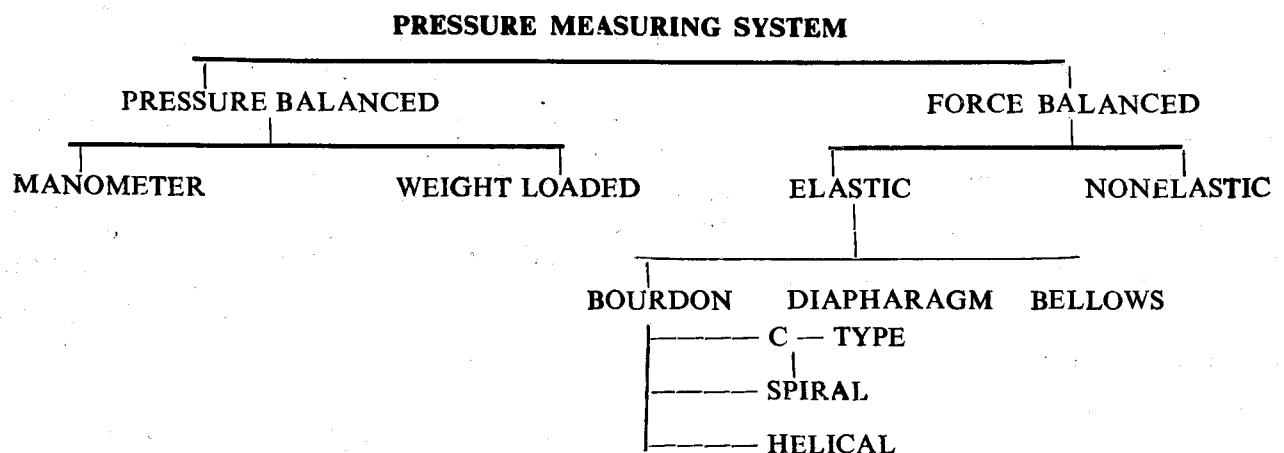
3. Float and Cable Instruments—for liquids.
4. Float Transmitters—for liquids & Solids.
5. Nuclear Radioactive Instruments—for liquids & Solids.
6. Ultra Sonic Instruments—for liquids & Solids (non-contact type)
7. Capacitance Level Transmitters—for liquids & Solids.
8. Tuning Fork Transmitters—for Solids.
9. Paddle Wheel Transmitters—for Solids.
10. Electromechanical Level Indicators—for liquids & Solids.
11. Piezo Resistive Level Indicators—for liquids, Slurries, Sludges, Pastes etc.

## PRESSURE MEASUREMENTS

The measurement of pressure can be considered as the very basic process variable measurement as the same is utilised for measurement of flow (dp cell) level (liquid pressure) and other indirect measuring technique of other process variables.

Pressure measurement can be found in practically every area of pulp and paper manufacturing, from wood preparation of paper making.

Pressure measurement systems are also divided into two basic parts i.e. primary element which is in direct or indirect contact with the pressure medium and secondary element translating the interaction into appropriate pressure values for transmission into electrical or other signals.



The measuring element material are mostly brass, bronze, beryllium copper, stainless steel, Ni-span and Cu-Ni-Mn Alloy Suitable for different applications and pressure span. Often these measuring elements are interphased with scales to prevent process fluids with high temperature, corrosiveness, sludgy, semisolid, viscous, fibrous and solidifying in nature.

The pressure transducers inter-acting with elements are often of strain gauge, capacitance and magnetic types.

## TEMPERATURE MEASUREMENTS

Temperature has an important role to play in the entire process of pulp and paper making. A proper control on this process variable ensures

efficient, economical and safe operations. The primary sensing elements are of various types in thermocouple, RTDs along with other semiconductor sensors too. These give a convenient long distance temperature transmitting capability with fast response.

Today, high level of temperature measuring and controlling technology has been attained with economy. Temperature profile display in the form of bar graphs and digital display with multiplexing capacitors on dryers rolls and digesters is of immense importance and help.

Non-contacts infra red measuring techniques instruments are now also being developed.

## **ANALYTICAL MEASUREMENTS**

Analytical measurement and control have gained the most by the growth of electronics and its application in this field. The purpose of analytical measurements is to provide data in the composition of a process stream to maintain the predetermined requirements. Originally, analytical measurements were conducted qualitatively and quantitatively in labs. These measurements are of chemical or physical in nature, and are diversified into many types of electrochemical and chemical analytical systems.

In paper industry, the most common are electro-chemical types, such as conducting, hydrogen-ion concentration (pH), iron-selective potential, oxidation-reduction potential (ORP), amperometry and capacitance. Turbidity, colour and humidity are also a part of physical analysis.

## **CONSISTENCY MEASUREMENT**

When we think of instrumentation in pulp and paper mill, consistency measurement is the first thought which comes to our minds. Besides being one of the most important measurement, it is one of the most critical constant measuring in-stream pressurised transmitters are getting more and more popular. They are based on apparent viscosity measurements and shear force principle. Many other principles and methods are being adopted and worked out for such elusive measurements. Optical based devices work better for low consistency measurements (0.1 to 1 per cent). Due to the restricted requirement of this measuring instrument in pulp and paper industry only very few manufacturers have gone in for its manufacturing.

## **MOISTURE MEASUREMENT**

Moisture measurement and control has its own part to play in the pulp and paper industry. Though this process variable is generally amongst the neglected ones it has more importance to the paper web than fibrous raw materials. Uncontrolled moisture can display a number of physical and mechanical peculiarities in the characteristics of paper, particularly in the specialized writing printing types.

Continuous moisture measurements are indirect and deduced, and are effected by other process variables such as basis weight, temperature, composition and pH. Some of the methods adopted for this measurement are based on capacities and microwave absorption. At times the values are computed through a microprocessor based system.

## **BASIS WEIGHT MEASUREMENT**

Paper is usually manufactured and sold within specified basis weight requirements. Therefore it is frequently required to have an automatic control over this variable, specially when we deal in speciality paper and boards.

Radioisotope instrumentation is adopted for the on-machine continuous measurements. The isotopes used for different type and grammage of paper and strontium 90, Radium 226, Cesium 137, Thallium 204, Krypton 85 and Promethium 147. Alpha rays are used for low grammage. The detection methods are of two types—Transmission and reflection or back scatter type.

These instruments can be manufactured ingeniously on demand.

## **SPEED, TENSION & DRAW MEASUREMENTS**

The most critical requirement of speed, tension, and draw control and indication is at the paper machine and finishing section. Today our country has produced and is quite confident of producing any type of sophisticated paper machine variable speed line shaft or section drives. These are Thyristor convertor drives for D.C. motors, or V/F control drive for A.C. motors. On a sectional drive machine, it is possible to have all possible controls on draw settings, such as straight draw or progressive draw operations with its indication, tension control on reeler and calender, or load (convent), sharing between much roll and forward drive roll drives, dynamic or regenerative braking, slack take-up etc.

With these systems, we have a close control over the machine speed performance as well, they are designed to take care of the machine protections and smooth loading over the power supply system.

## **CONTROL SYSTEM**

To control any system manually or automatically, we first need to measure the variable to be controlled. The measurement of most of these variables in the pulp and paper industry has been dealt earlier in this paper. Now after these variables are sensed through its sensing elements, the measurements are transduced into electrical signals (4-20 mA or 0.20 mA or 0-5V D.C) in its respective transmitter and displayed on an indicating scale with analog or digital display locally or at a remote place with recorders wherever required. These signals provide the operator with the informations to make the necessary controlling adjustments manually to function as an open loop system.

For an automatic control operation, these signals are feed to a controller which performs adjustments automatically in accordance to the required set points established by the operator or a microprocessor. This regulates the manipulated variable through a final control element to complete a closed loop operation.

Such closed loop controls can perform their functions independently or in mixed operations governed by a programmed logic.

As a result of increasing trend towards process control instrumentation, concept of centralization of controllers, recorders, processors has been conceived for ease of operations. With this, a demand of auxiliary means of long distance signal transmission system has increased. This has led in more of electronic transmission system with electrical signals to reduce the bulky and costly pneumatic tubing network.

Further with the introduction of microprocessor and digital controls, analog signals with less immunity to noise are now being replaced by digital signals with logic levels indicating either a "yes" or "no".

A key point in such a system is that the processor is driftless and as such eliminates the need for annual calibration checks, etc. Calibration adjustments and set points adjustments are done in digital formulas, rather than knob twisting or beam bending.

## APPLICATIONS

The knowledge of instruments alone is quite incomplete without the knowledge of their applications. Applications come from the soundness of process know-how of that industry. In other words, fabrication of instrumentation scheme is a combined effort of sound and experienced process people with that of instrumentation experts. To cover the entire scope of electronic process control in pulp and paper industry is beyond the scope of this paper, but some typical examples of pulp and paper mills using conventional process will be covered under this article in an orderly fashion.

## A PULP MILL INSTRUMENTATION

### A-1 Handling and Processing of Cellulosic material :

The measurement to be carried out in the raw material during handling, storage and processing are very important for inventory control point of view as well as for proper control of variables during pulping. This would cover broadly the following :

- a) Moisture measurement of incoming raw material.

- b) Continuous weighing and integrating the quality being processed in the digesters.
- c) Solid level indication and control for interlocking of the feed and digester conveyers of raw materials silos.
- d) Energy conservation techniques to take care of varying load on chippers and cutter motors by using thyristor starter with energy saving unit.

**A 2 Digester Room : (Batch Digester) :** An uniformly cooked pulp is the ultimate aim of the digester control. The control of the following process variable is desired :

- a) Recording and control of inlet stream flow in the digester with integral pressure temperature relationship control through pressure indicator controller.
- b) flow control loop of black liquor circulating pump for maintaining uniform temperature of the cook.
- c) Automatic control on metering of white liquor and black liquor feed to the digester for maintaining a predetermined bath ratio and percent chemicals through pre-set parameters.
- d) Automatic timer cum-annunciator for cooking cycle.

### A-3 Pulping Process (C.P., M.P., C.M.P., T.M.P., C.T.M.P.)

The chemical pulping has been covered under A-2 and mechanical pulping, chemo-mechanical pulping, thermo-mechanical pulping, and chemo-thermo mechanical pulping are all combinations of chemical and mechanical pulping. The scope of controls mainly revolves around the following :-

- a) Level control in fibrous raw materials bins is similar to one described under A-1.
- b) To have a control on retention time in live bottom bin, the extraction screw speed can be controlled vis-avis pre-determined parameters.
- c) In case of TMP the fibrous material is to be metered as a pre-determined rate before being fed to the pre-heater to a rotary valve to maintain a constant level of chips in the pre-heater to control the retention time.

- d) To control the feed rate of chips into the refiner in the case of mechanical pulping and chemi-mechanical pulping the screw feeder speed is controlled through a variable speed motor. As a safeguard to the damage of plates, the load of screw feed can be monitored to unload the refiners in case the infeed of chips have stopped due to any reasons.
- e) For Thermo-mechanical pulping or chemi-thermo mechanical pulping we have to maintain an interlock circuit between the auxiliary electrical equipments to ensure a sequential start-up of the process.

The critical instrumentation scheme which is important for this process to be controlled has a constant level, a gamma-gauge control on the pre-heater which forms a continuous digester and maintains the control over retention time. This control of level is attained by controlling the feed rate of the metering bins.

The rotary valve is protected with the interlock scheme and runs at a uniform speed unaffected by level control function. The most critical control of the thermo-mechanical pulping is the control of temperature which is indirectly controlled by steam pressure as this has a quicker response on this variables

#### **A-4 PULP WASHING :**

The control elements in this section usually consists of consistency regulator controller, level controller, flow controller, temperature and vacuum controller. These variables are controlled by simple loop techniques.

#### **A-5 PULP SCREENING :**

The major objective of this instrumentation in screening operation are, to control :

- a) The consistency of unscreened stock to the screen.
- b) the flow of unscreened stock to the screen.
- c) the flow of dilution water to the screen.
- d) the level of rejects to storage tank.

#### **A-6 PULP BLEACHING :**

In addition to the usual control mentioned under pulp washing the important instrumentation in the bleaching is the measurement of oxidation reduction potential (ORP). This measurement can be made at a proper location in the chlorination tower and is related to the residual chlorine.

### **A-7 CHEMICAL RECOVERY :**

The important control elements in this section are enumerated below :

- a) Level control in different evaporators.
- b) Continuous baume density recorder on the feed liquor.
- c) Flow recorder controller for regulating the water rate to the barometric condenser in accordance with the set point.

### **B) PAPER MILL INSTRUMENTATION**

The instrumentation in paper mill has been a subject of interest from quitesome time and has been most critical in this industry. Therefore, a great deal of work has been done in this field and still lot of developments are being made.

#### **B-1 Stock Preparation :**

This section of pulp and paper industry requires proportioning of different furnishes, dosing of various additives and loading material, control refining and consistency control of high and low consistencies and control of pH. All these variables can be looped for sequential operation to maintain a continuous refining and other stock preparation activities to run in a logical order.

#### **B-2 Paper Machine (Fourdrinier)**

Instrumentation and control techniques has been used to a greater extent in this section of industry. This consists of

- a) Head box level control
- b) Vacuum profile control of flat boxes
- c) Indication of Jet-velocity and wire-speed ratio.
- d) Electronic Eye-monitoring of the web in different sections of wet and dry ends.
- e) Dandy-roll controls with differential speed measurements.
- f) Dryer temperature profile indication and control.
- g) Basis weight and moisture control.
- h) Paper machine speed control
- i) Tension and draw control

#### **B-3 Finishing Section :**

This section has a major control on super calendar, sheet cutter and slitter rewinders. These controls are mostly on their drive systems, tension and marking.



### **C) UTILITIES :**

Instrumentation in utility section has been most neglected in the industry which can partly attribute to the non-availability of professional expertise, but increasing cost of utility.

#### **C-1 Boiler House :**

With the rising cost of fuel, optimum utilisation has become very important. In order to achieve this target utilisation of fuel should be maximum with minimum losses through flue gases and proper condensate returns. This is a vast area which instrumentation techniques can cover to control the minimum quantity of air by flue air gas analysis etc.

#### **C-2 Water treatment and effluent disposal**

Water quality is very important for processing of pulp and paper while effluent treatment is attracting concentration from ecological balance view point and quality maintainance of river waters.

Instrumentation can play a very important role by pH monitoring and controlling and suspended solid level measurement for optimum dosing of treating chemicals. Water toxicity in the effluent can also be monitored and proper control effective. BOD Analysis with Various other control confined their application in this field.

### **ROLE OF MICROPROCESSOR AND PROCESS COMPUTER IN PAPER INDUSTRY**

Stimulated by the development in the aerospace technology the micro processor has found a role in almost all aspects of today's activities. In the world of instrumentation the microprocessor is taking on more and more of activities previously reserved for larger electronic systems. With the advent of this small extremely powerful device there has been a revolutionary change in the concept of control technology all over the world.

Though the application of this has been right from a domestic washing machine to cameras but the same have much bigger functions depending on the selection and application.

With more and more applications of the systems day by day and improvement in the manufacturing technology on a large scale has brought down the price within the reach of even a common man.

On the other hand, this does not mean that we can force him systems based on this at places where it is really not utilised. For large pulp and paper industry where there are control loops above 30 to 40 numbers the controls based on this are not very viable. But in industries of higher capacities application of microprocessor has proved to be a blessing.

Various intricate controls in the continuous digesters for performing the control with computational requirements system based on microprocessor are of great use. All the activities co-relating the different function and controls of the entire paper and pulp industry distributed on a large area, the microprocessor can interface to give a balanced control activities throughout the plant with its extended abilities to also furnish management control and data acquisition facilities.

### **ACKNOWLEDGEMENTS**

The authors wish to thank Mr. S. K. Sharma, Mr. Surajit Ray, and Mr. S. T. Than of our company for their kind cooperation and suggestion in the preparation of this paper.

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