Indigenous Development of Electronic Systems For Improving Paper Productivity

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ABSTRACT

Paper is one of the essential commodities in the modern world. Together with energy, paper consumption per capita is often considered as an index of standard and quality of living. In our country there are about 25 forest based large mills and about 200 small mills based on agrowaste and recycle material. Most of these factories either use outdated instrumentation or none at all for quality control during production. As such the quality of paper produced by these factories is not upto International standard. Cosequently the productivity decreases and the energy consumption increases.

Presently in India the value of import of paper and newsprint is steadily increasing. It is estimated that the actual demand is likely to increase annually to reach a target of approximately 20 lakh tons by 1990- To meet this growing demand, one way is to modernise the existing mills with a view to increasing their productivity through minimising rejects based on controlling the quality of paper produced. For this purpose it is necessary to employ the modern control instrumentation techniques in the pulping zone as well as on the paper making machine. In this respect, modern microprocessor based electronic systems would play a very vital role. Also it has been well recognised by many instrumentation and control engineers that an adequate process control system installed in the plant substantially minimises the overall energy usage while keeping the production at planned level. In India implementing these appropriate control system in existing mills, in a cost effective manner seems to be a challenge.

With this in view, we in CEERI Madras Centre. started the development of microprocessor based on-line quality control instrumentation for monitoring Low Pulp Consistency, Basis Weight, Calipre and Moisture in the pulp and paper industry. Necessary grant-in-aid was provided by the Department of Electronics, Government of India. The instruments developed are based on latest state-of-art techniques right from the sensor down to the system. The low pulp consistency monitor (LOCOMON) employs an Opto-Electronic technique that is unaffected by extraneous elements like pressure. flow. temperature, etc., and it can be connected to a by-pass line of main flow line of pulp. The sensors for Basis Weight, Moisture and Calipre are mounted on a 'O' frame with scanning facility to scan the web of paper during production. These sensors also use state-of-art techniques viz., Nucleonic technique fot Basis Weight, Capacitance method for moisture and reluctance technique for calipre measurements. A dual microprocessor based dedicated data system 'SCANPAC' processes the raw data and computes the parameter information such as cross profile, trend profile production summary, etc which are displayed on an integral VDU (CRT).

The instruments have individually undergone field trials in a paper factory near Madras and performed satisfcactorily. It is for the first time that such appropriate instrumentation systems have been developed in our country particularly for small paper mills which use a variety of raw materials like bagasse, country wood, straw, waste paper etc., and as such not economical to use the imported monitoring and controlling equipments The Centre is presently concentrating on R&D projects pertaining to Digester Control, Bleach Plant, Stoch Preparation, modification to Paper Quality Control System, etc. A Centre of Excellence to cater to the R&D needs for modernising this industry through the use of Microprocessor Based Instrumentation Systems has recently been initiated.

The paper provides the details on the work explained above, the results of field itrials and our future programme.

1. Introduction

The importance of paper and paper products to a modern economy is self evident. Paper usage is an indicator of a nation's development. Its per capita consumption is often considered as an index of standard and quality of living. In this country there are about 25 forest based large mills and 200 small mills based on recycle material and agrowaste. Most of the large mills have a certain degree of obsolete instrumentation and process control required for their operation and there is no small mill in this country having any kind of process control instrumentation. The instruments used by them are mostly mechanical, hydraulic and pneumatic in nature. In most of our plants, visual methods and off-line quality parameter measurements are still employed in certain stages of operation. The major difficulties encountered in the use of electronic control instrumentation in the paper

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industry as felt by the manufacturers are, (a) Non-availability of reliable instruments and spares locally and (b) Maintenance problems.

2. Need for Quality Control

Quality of paper produced depends largely on three parameters viz. Basis weight, moisture and Calipre. The present accepted practice in most of the Indian industries is to frequently tear a piece of paper from the On-line roll, measure the Basis weight and occasionally its Moisture content. This technique of determining the moisture content takes roughly an hour. The operator thereafter assumes that the data thus collected occasionally remain the same across and along the machine direction till the next sample data are collected This is not true and these Off-line methods can not be relied upon to assess the quality of the paper produced in real time. This calls for a dedicated data system for monitoring these important quality parameters in real time.

To achieve this, one way is to space series of transducers across the web and make them monitor these parameters. Considering the cost of transducers, this will not be an effective solution. The next alternate is to use a set of transducers which can monitor Basis weight, Moisture and Calipre and move these transducers across the web and take the sample values periodically for monitoring. This is the procedure currently followed in all the paper industries abroad. This needs a real time scanning system with a ppropriate transducers located on it (O-frame) and a dedicated data system (SCANPAC).

A few larger paper mills recently set up in our country, use imported instrumentation for this purpose. Unfortunately, such instrumentation may not be suitable for the small paper mills existing in our country, since they are outdated and rather slow in production operation. But they now require the support of modern electronic systems to improve the quality of their product, conserve energy and increase productivity.

3. Scope for Electronic Systems Usage :

The instrumentation needed for the pulp and paper industry may be divided into two parts viz., wet and dry end instrumentation. Let us first consider the wet end instrumentation for a typical industry. The stock is pumped from machine chest at about 3% consistency to the stock regulating box. A continuous record of available stock is a necessary operating information. This is provided by a level recorder. To ensure stock of uniform consistency, a recording consistency controller automaticaly adjusts the flow of water for dilution at the suction of the stock pump which serves as a mixer. The stock then passes into a refiner where the degree of refining is controlled. The rate of stock delivery may be controlled using the basis weight parameter. The head of the stock in the head box determines the velocity of stock flow into the wire. It is essential for a good sheet formation, this velocity be the same as the wire speed. For this, the head box level/pressrre needs a close control. The rate at which water drains from the stock through the paper forming wire has great effect on the uniformity of sheet formation. After the initial drain by gravity, appropriate amount of vacuum is applied to the wire to ensure a uniform rate of water removal. An automatic vacuum recorder control is used for this purpose. The paper then enters the press section with about 50% water and leaves with 25 to 30 per cent. Most of the remaining water is driven from paper in the dryer section. The moisture measurement at various points along the machine is important.

The dry end section instrumentation mainly ensures a proper moisture control by measuring moisture content on the paper reeling out. At this end, a tachometer calibrated instrument is fitted to provide data on the production rate in meters/minute. The sheet tension as well as its calipre also could be monitored here, to ensure uniform build up of the roll.

There are certain special types of instruments needed for the measurement/control of the following parameters in the paper industry.

*Low and high level consistency	*Moisture of paper reel
*Basis Weight	*Calipre
*Flow of stock (low volume)	*Ash content
*Brightness and colour	*Residual chlorine

Recently it has been proved abroad that control of paper machines with computers would be possible not only on new and large machines but also on small and old machines, considering the increasing cost of raw materials and energy, and the improvements, reduction in cost due to the control systems technology.

The pay-out on account of use of such computer control technique would be high returns for a given investment. Long term performances and the resulting returns on investment will normally be the prime consideration in procuring a control system. It has been found that a control system that provides accurate measurement and sophisticated control as well as high reliability and easy maintenance can pay for itself in less than one year. While developed countries, have high capacity high speed paper making machines, it may be reasonable to assume that a developing country like ours would find medium size machines optimal for our requirement. We have more than 200 mills in our country producing anywhere from 10 tones per day and above, forming a considerable part of present production capacity. These will become obsolete production wise in due course, if they are not modernised with use of advanced computer based electronic control instrumentation technology.

4. Modernisation Through Microprocessor Based Systems

Microprocessor based direct digital control instrumentation wouid not only enable manufacturing quality paper but also helps the management to economise production and avoid wastage of raw materials and energy. The possible benefits in this case are shown in Fig. 1. Let us consider firstly, the basis weight parameter. Basis weight can be measured at the reel (Dry end) of a paper machine very accurately through nucleonic technique. The measured value is frequently compared with the target basis weight and the error is taken through feed back to control stock flow as shown in Fig. 2. Measurement and feed back control of basis weight typically reduces reel average deviation from the target value by 70% as shown in Fig. 3. This reduction in variations by itself constitutes an improvement in the quality of the product. The potenatial savings in the area of raw materials and energy are through the reduced use of fibre and improved energy efficiency. The basis weight can now be fixed to a lower average value through feed back control, keeping the specification (with respect to basis weight) above the minimum value as shown in Fig. 4. This shift in the basis weight average means less fiber usage during production. Maintaining lower basis weight average means reduction in energy usage. As an example, if a 5% reduction in the average basis weight is possible, it would result in approximately '5% reduction in drying demand which would also mean increasing machine speed by 5% wihch would make the drying demand the same as before the basis weight shift is introduced. The result is same tonnage through put, same energy usage, and 5% more area production. Quality improvements come from reduced product variations resulting from accurate measurement and control. Quality improvements are the results of direct measurement and control of basis weight, moisture, consistency etc. Gross direction basis weight measurement and the consequent cross machine profile display can be used to determine the best slice alignment.

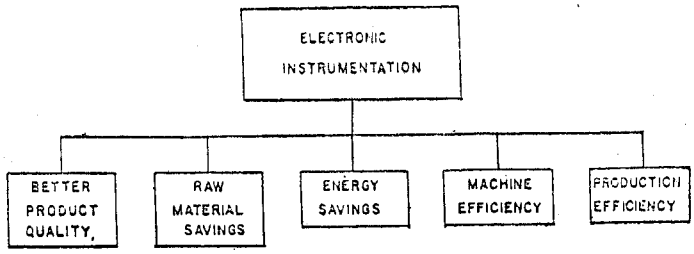


FIG 1. BENEFIT STRUCTURE.

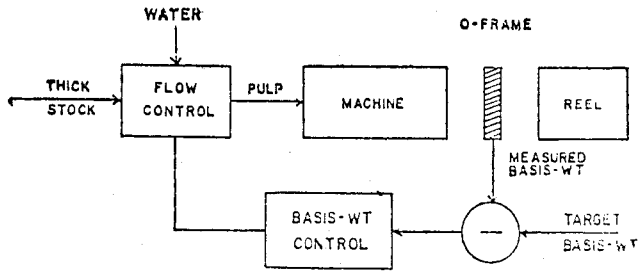


FIG 2 BASIS WEIGHT CONTROL.

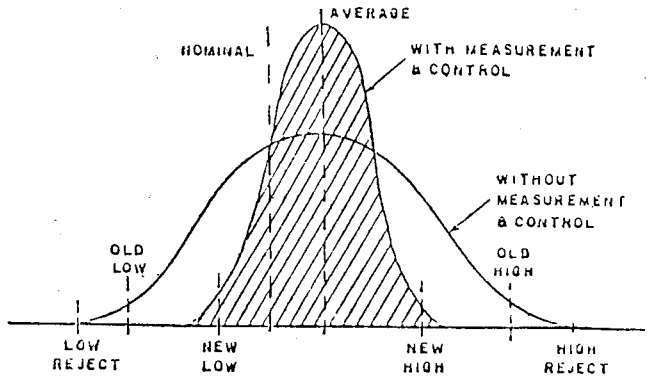


FIG. 3. REDUCTION IN REEL AVERAGE VARIATIONS

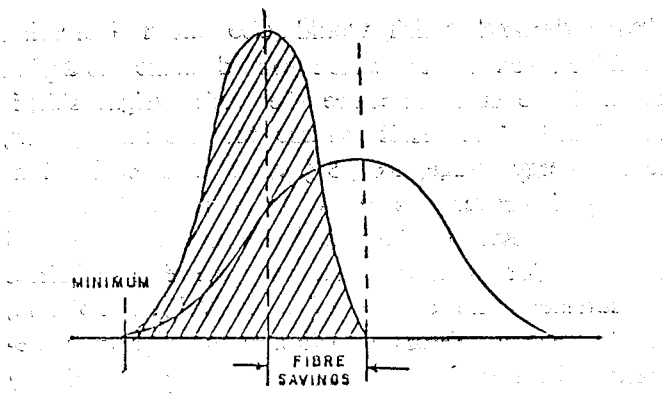


FIG . 4 . MATERIALS SAVINGS

Moisture uniformity is probably the most powerful variable in paper manufacturing because of its far reaching effects on product characteristics and subsequent processing. Reduced moisture variations may result in less energy usage per ton of paper produced. Lower variations in moisture means the average moisture can be run at a higher level without exceeding the maximum value. Moisture shifts of 1 to 2.5% have been documented resulting in energy efficiency improve ments upto 10%. By monitoring the moisture profile at the reel (Dry end), it is possible to reduce the moisture variations and shift the average moisture to a point that the peak moisture is just under the higher tolerable limit as shown in Fig. 5. An increase in End Moisture' permits an equivalent reduction in fibre content while maintaining the required basis weight. The result of increasing the 'End Moisture' permits an increas in machine speed without increasing the dry steam quantity. It has been observed that a 1% increase in 'End Moisture' permits a 3 to 15% increase in speed depending upon the particular paper machine,

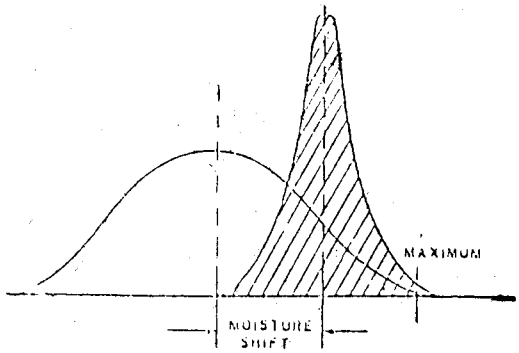
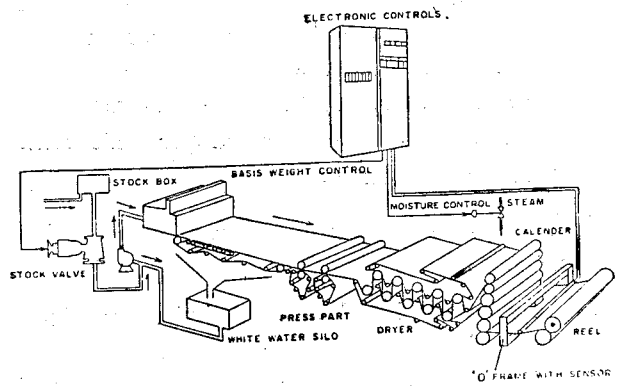


FIG 5 CONTROL OF MOISTURE VARIATION

and the paper produced. The increase of speed permits an increase in production.

Microcomputer based nucleonic control system for basis weight and moisture measurement installed in paper machine between the calender and the reel as shown in Fig. 6. enables production control as in Fig.7. The average shift illustrated is a reduction in the margin of safety employed by the Operators, which is designed into the specifications. The average shift represents an economic benefit. Fig. 8. gives a glimpse of productivity increase due to the improvements in various factors through control.

FIG 6 SCHEMATIC DIAGRAM OF PAPER MACHINE WITH 'O' FRAME INSTRUMENT



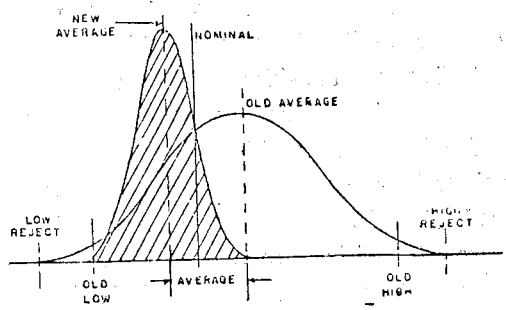


FIG 7 PRODUCTION CONTROL

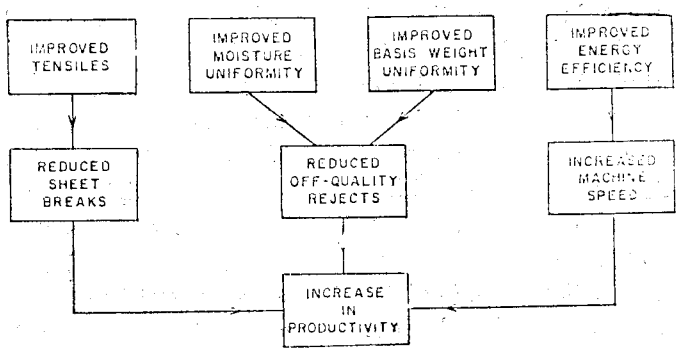


FIG 8 PRODUCTIVITY INCREASE

Following an old adage that paper is made on the beater and not on the machine, it is essential to initiate action first on raw materials control, processing of raw materials at the bleaching, refining, and at the stock preparation zone and then come to the paper machine. Once, it is prossible to provide a homogeneous flow of pulp from the pulp mill, the quality of paper will automatically improve and subsequent paper machine instrumentation would help to stabilise production and improve productivity by cutting down time, the wastage and things like that. It is felt that instrumentation at the pulping zone of the industry will probably have the fastest pay back period and the largest market particularly, for our Indian pulp mills handling non-conventional raw materials which are agricultural in character like bagasse, rice and wheat stock, and waste paper. So, it is essential to develop micro processor based control instrumentation that would help utilising optimally non-conventional materials in the existing digesters, bleach plant, etc. Digester control essentially improves the pulp yield, reduces steam consumption per ton of pulp and the uniformity of the steam demand on the boiler house. Some of the R & D programmes which have been considered with a view to modernising the industry, are discussed in the following pages.

5. Indigenous Development of Electronic Systems at CEERI Madras

Taking all the above factors into consideration, CFERI Madras Centre have developed the entire instrumentation including sensors for On–line measurement of Basisweight, Moisture, Calipre and Tonnage. The 'O' frame developed primarily holds all the necessary sensors and their front end electronics and enables collecting the data On–line across and along the machine direction. In literature there are several approaches available, but we have selected the most proven principles and techniques adopted by the leading manufactures abroad. We have also taken into consideration their merits and the availability of different components in our country for the purpose. In the following sections are explained in brief the principle of measurement of the three parameters and the functioning of the 'O' frame that facilities scanning and SCANPAC.

5.1 Basisweight Measurement :

On–line basisweight of paper can be measured with the use of nuclear radiation as shown tn Fig. 9. The attenuation can then be expressed by the following BEER'S law.

$$I/I_o = \text{Exp}\,(-\mu et)$$

Where, I is the transmitted radiation intensity

I_o is the incident radiation intensity
μ is the mass attenuation co-efficient
e is the density of the paper
t is the thickness

Solving this equation, ϱ t is obtained. The measured variable e t may be further broken down as follows :

Basisweight (ϱt) = Fibre basisweight + Ash basisweseght + Moisture basisweight

However, the basisweight sensor enables monitoring the total weight per unit area of paper ie, (ϱt). It has been found that the highest measurement accuracy for paper is possible with beta radiation. It is now a normal practice to use conical measuring beams with Kr. 85. Since Kr.85 is not available in our country, we have standardised on Promethium 147 Thallium 204 as our beta radiation sources. Promethium 147 is suitable in the lower ranges of the basisweight scale and Thallium 204 at the higher ranges. While substantial work has been done using Geiger-Mueller tubes and solid state detectors, the ionisation chamber emerged as the optimal detector since it could be highly stabilised and made rugged. However, present day industrial grade photomultiplier tubes also work as efficient detectors in Industrial environment. The basisweight instrumentation developed at CEERI Madras Centre is explained in brief now, with reference to Fig. 10.

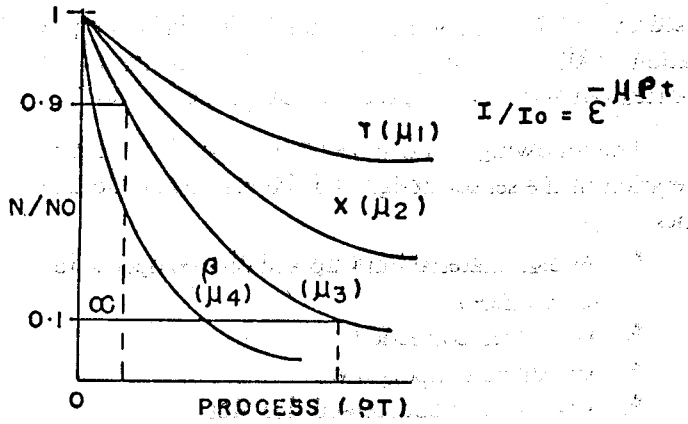


FIG.9 RESOLUTION

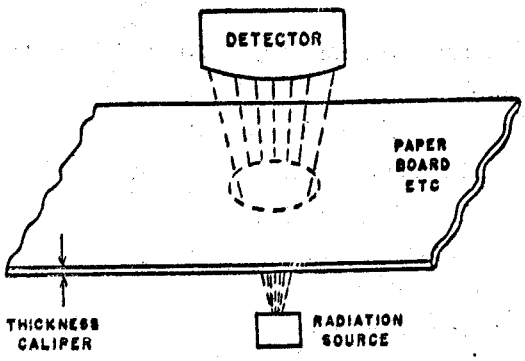


FIG.10a BASIS WEIGHT MEASUREMENT TECHNIQUE

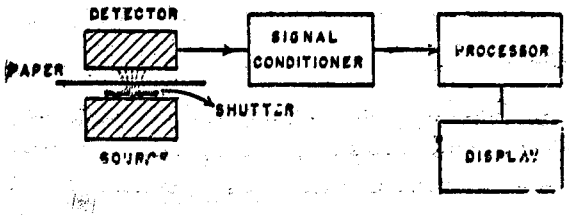


FIG.10b BASIS WEIGHT INSTRUMENT DEVELOPED BY CPRI

A stable industrial grade photomultiplies tube acts as the detector of beta radiation. It is provided with a stabilsed power supply for operation. With proper control, shutter could be opened and the beta radiation allowed to reach the detecting face of photomultiplier. Initially, the number of counts No is registered for a duration of 5 Sec. without paper. Then, with paper in between, the counts N for the same duration are noted. Basis-weight is now computed from these two values. However, for providing necessary constants in the calculation, calibration will be done. The value No is again noted, say, after every 30 minutes and used during the next 30 minutes for basisweig ht computation. All processing and computational work is carried out with a microprocessor based electronics.

The following points have been taken into consideration in the sensor design and the associated electronics.

* Foreign material built up and dirt compensation Source decay
* Air profile correction
* Air colum temperature
* Alignment of source and detector
* Safety with the use of scaled source with proper shutter operation.

5.2 Moisture Measurement :

The process of paper making is basically to convert wet pulp containing fibres and additions into a sheet to have a certain basisweight, and to contain a certain amount of moisture. Measuring this quantity of moisture in real time enables controlling the drying process and indirectly helps saving energy due to optimising the use of steam.

The water in paper basically stays in the pores of the fibres. Several physical properties of water can form the basis of moisture measurement. In the infrared region of the spectrum, water molecules absorb photon energy of certain wave length (1 91 μm). Although infrared absorption technique is considered presently to be the best for moisture measurement, to start with, we have developed a capacitance based sensor for the purpose of scanning. In the scheme developed by us, we measure by a novel technique, the capacitance. The dielectric constant of dry material (paper) is between 2 to 5 and the value for water is 80. Thus, the presence of a small amount of moisture causes increase in the dielectric constant and hence a change in capacitance value. Parallel rods as shown in Fig. 11 constitute the capacitance sensor. The web of paper rides over this sensor. This technique works efficiently even with low frequencies and high moisture content values. Microprocessor based electronics is used to measure the capacitance and this enables computing the moisture content in paper in real time. An infrared based sensor is also under development and it will be field tested shortly.

5.3 Calipre Measurement :

In the industry non-contact calipre (thickness) measurement is becoming popular. However, one side contacting configuration still exists. This configuration has the advantage over the two-side contacting configuration due to fewer sheet breaks and freedom from sheet compressibility effects. The basic measurement configuration is shown in Fig. 12. With reference to this figure, paper moves in front of the nozzle without touching it. Due to thickness variations in paper, the back pressure will vary. The gap width is also so selected that, this comes exactly at the centre of the linear range. This allows detecting the increase or decrease in the thickness of paper, with a proportional change in pressure. Now the nozzle is supplied with

a constant pressure air and the back pressure is monitored using a monolithic pressure transducer.

5.4 O—Frame :

The sketch of 'O' frame is shown in Fig. 13. This frame holds all the three sensors and the front end electronics for pre-processing the signals. It also has a motor to scan the sensor assembly across the web of paper continuously. The motor electronics provide signals pertaining to direction of scan, the scan speed etc. The limits of the scan is programmable through the SCANPAC keyboard. Necessary hardware, safety arrngemenrs. in vital places, are provided to take care of any failure of electronic components. The frame console also holds in parallel some of the important keys of SCANPAC, such that the operator can control the operation of 'O' -frame and SCANPAC either from SCANPAC or from the 'O'-frame. The frame also has lamps to indicate the direction of the sensor movement, shutter status (open or close), power status etc. to observe even from a distance Another important feature is that the scan head is taken to HOME (a place where the sensor assembly stays, off paper, when not in scan) in case of paper cut, standardisation of source, etc,

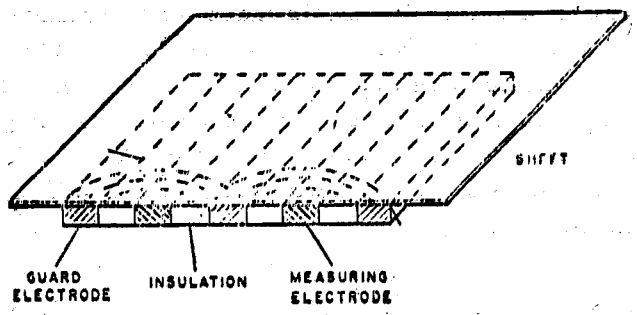
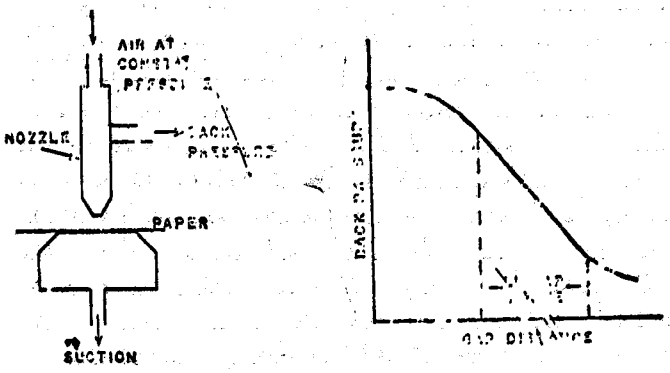


FIG. 11



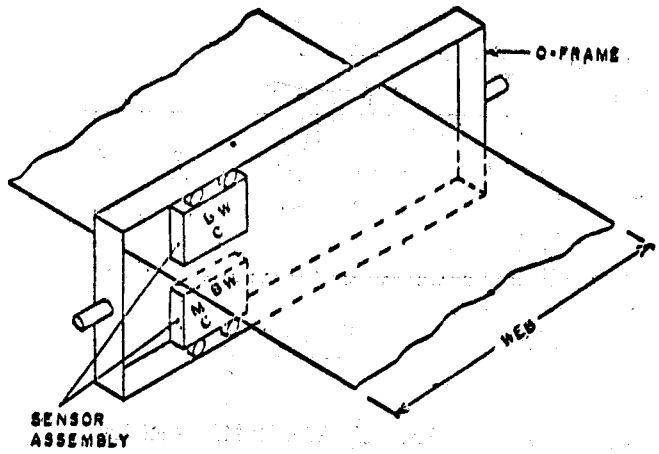


FIG. 13

5.5 Scanpac :

The SCANPAC enables mointoring parameters such as Basisweight, Moisture, Calipre and Tonnage. This is a dual microprocesser based system and it collects signals from the sensor assembly available in the 'O' frame, controls movement of scan head, interacts with the operator through the keyboard, analyses the data collected along and across the paper web and display them in a most appropriate form on a CRT display. The system SCANPAC for the purpose of analysis, can be divided into two parts as 1) Measuring system and 2) I/O system.

5 5 1 Measuring System :

This system supported by one Z-80 microprocessor chip enables collecting and processing of data corresponding to basisweight, Calipre. Moisture Temrerature of air column between the sensor assembly and RPM of the camp roller for tonnage calculation. The temperature of the air column is necessary to provide correction to basisweight monitored due to temperature variations of the air column. It also enables calculating the cross and trend profiles of the basisweight, calipre, moisture and the deviation of these data from the target values fed in by the operator through the kevboard available in I/0 system. The scan width of paper of 3 mts (maximum web size in our present design), is divided into lanes each of 25cm width. The speed of the sensor head is so adjusted as to cover each lane in 5 seconds. Deviations in the trend and cross profile values of these parameters calculated by the measuring system is transferred to a common memory shared by the measuring system and the I/0 system. For every basisweight value collected within one lane of

25cm in 5 seconds, about 350 values of calipre, moisture and temperature data are collected and the average of these are calculated and given as one cross profile value. A maximum of 12 such cross profile values are made available for every scan of paper of 3 mts web, and then the deviations from the target values for every value so collected are computed. At the end of every scan a new cross profile in terms of percentage of deviations from the target ualue is put on the CRT display. The average of these 12 cross profile (CD) values collected in each scan is taken as one trend value. 15 such trend values are accommodated on the CRT screen undertrend (MD) display.

Auto-calibration of the sensore takes place once in every 30 minutes with the sensor head brought to its HOME position. This is primarily necessary for the basisweight measurement to account for the source decay. Also during calibration, the measuring system essentially checks the drift in the sensor amplifier etc, in the absence of paper. The limits of these errors are taken into account while the measurement is done. If the level of this error signal is outside the permissible limits, which may happen due to some damage in the sensor or in its circuitry, it indicates the failure of the calipre transducer on the CRT. During calibration of the mosture measuring system, the capacitance of the transducer is essentially measured without paper. The value of the capacitor normnlly drifts because of the temperature and hence correction due to this temperatue is necessary. Since this drift lies between two limits, any capacitor data outside these limits is attributed to the damage either of the capacitor or in its associated circuitry. In such a case the moisture measurement gets suspended. All these software checks are introduced in the system to see that the system as a whole provides reliable information.

5.5.2 I/O System :

This system is supported by another Z—80 microprocessor through which the operator interacts with the measnrement, frame operation, basisweight source shutter control, programming the data, CRT display, print out of the required data, etc. A 12" monocrome CRT screen for displaying all the necessary information for the operator, a keyboard with 47 keys for operator interaction, a dotmatrix printer for CRT page dumpout, real time clock, separate displays to indicate the paper cut at three different places on paper machine, a hooter to give alarm during paper cuts etc, constitutes this system.

5.6 Achievements under CDES Programme :

The Departments of Electronics, by way of appreciating the progress and achievements of the centre, has recently set up a Centre of Excellence in the area of Electronics Systems Development primarily for modernising the Indian Pulp and Paper Industry. The research and developmental work that are being carried out under this Centre for Development of Electronic Systems (CDES) are highlighted below :

5.6.1 Digester control Instrumentation :

A computer based mathematical model for the batch digster was developed based on the data collected from a nearby paper mill. Also animation software for the operation of batch digester was completed. IR moisture meter being developed under another programme will be used on line for measuring moisture. The weight of dry bagasse being loaded into the batch digester will be computed using a weightometer and the information derived from the Moisture meter. A digital controller configuration is being worked out to achieve the end. A paper mill near Madras has been identified for our trials.

5 6 2 Brightness Monitor :

An optical technique was chosen for monitoring the brightness of pulp. This involves measurement of the intensity of reflected light (blue as per TAPPI standard) along the circumference of a 45 degrees viewing circle with a constant intensity light incident perpendicular on the object (pulp). Two designs of the sensor assembly were completed and fabricated. Necessary electronic system was also designed and fabricated. Integration is being done and testing will start soon. A facility for obtaining on line calibration has also been provided in the design.

5 6 3 IR Moisture Monitor :

A sensor assembly of the IR moisture meter was designed and fabricated. It essentially employs two wave lengths, viz : 1.8 and 1.91 umts of which thc latter is affected by water present in the paper. The electronic system and the software modules for carrying out computation were written and tested. The system is being developed with a view to monitor four moisture channels in real time. The sensor assembly essentially employs two filters mounted in a telecentric

section, a derated Tungsten filament lamp, and necessary optics. Laboratory tests are being done with a view to finalise the design and take up prototype fabrication of the complete system.

5.6.4 Field Trials :

The system as a whole, 'O' frame and SCANPAC was initially field tested at M/s. Pondicherry Paper Mills, for a limited period. Some changes in the ,O' fame structure and software were found necssary. These changes were then implemented. The system is presently undergoing trials at M/S. Dhanalakshmi Paper Mills near Madurai in Tamil Nadu. The results are encouraging.

The specifications of the system undergoing trsals are as follows :

Basisweight	.. 25 to 500 GSM
Moisture	.. 0 to 20%
Tonnage	.. 100 Tons
Accuracy	.. ± 2% FSD
Display	.. Video, 31 cms.
No. of pages	.. 16
Data entry man/machine communication	.. Keyboard
Scanning speed	.. 3 mtrs. per minute
Scan width	.. 3 mtrs. (Maximum)
Averaging width	.. 25 cms. (Lane width)
Paper break	.. 3 places, visual and audio alarm
Power supply	.. 230 Volts, 50 Hz.

5.7 Cost Benefit :

Based on the basis weight data collected during the field trials at M/S Pondicherry Papers Ltd., with the Nucleonic Basis Weight Monitoring System developed at CEERI Madras Centre, the cost benefit details have been worked out. The workout is only a sample calculation to show that a simple monitoring instrumentation like the one developed at CEERI, Madras Centre, could help the industry to avoid wastage during production. The quality control could then be achieved in an appropriate manner. For a mill situated at Pondicherry which normally has to produce around 50 tons of paper per day, around 8.85% of paper produced does not confirm to quality with regard to basis weight, since the basis weight changes beyond ±2% of the set value. Assuming the approximate cost per ton of paper as Rs. 10,000, the wastage per day, only on account of basis weight tolerance, works out to be (extending the sample calculations to hold good for the entire day) as Rs. 44,250. But in practice, this waste paper could be recycled back and made as paper again, for which steam has to be used again for drying purpose. At the rate of 4 tons of steam/ton of paper produced and the nominal cost/ton of steam as Rs. 150/– the extra cost incurred is Rs.2,655/– per day equivalent to Rs,79,650/– per month. This is on account of steam alone. Six monthly savings i.e. Rs. 4.78 lakhs, would roughly be the cost of the microcomputer based monitoring equipment. So, the cost of the equipment could be taken, in about six months and then the pay of starts

6. Future Programme of Work :

The following will be the R & D programmes envisaged.

* Chipper House/Digester Instrumentation :
Typical basic control functions that would be performed by the proposed microprocessor based control systems are :

- * Chip charging
- * Liquor charging
- * Steam control using H-factor correction
- * Kappa number control
- * Relief control
- * Blow control

* Stock and Bleach Plant Instrumentation :

The primary reasons requiring the usage of microprocessor based control instrumentation in this zone are :

- * Saving chemicals by ensuring that only sufficient amounts are used for each stage of bleaching.
- * Minimising degradation of pulp by decreased yield and strength due to action of the chemicals on cellulose.
- * Improve quality with computer control maintaining the output brightness of pulp at the required level under both steady-state and dynamic operating conditions.
- * Increase throughput
- * Minimise the total volume of effluent from the plant.

* On Machine Instrumentation :

Certain special types of instrumentation that are needed on the paper machine are given below in the next page. These instrumentation systems will also be designed and developed employing modern microprocessors.

- * Felt tension controllers
- * Felt edge aligners
- * Paper break annunciators
- * Wet end moisture monitors
- * Machine draft velocity monitors, etc.
- * Modifications to Dry End and Roll Handling Instrumentation :
- * Mositure Profile Controller :
- * Basis Weight Controller :
- * System for Head Box Slice Profile Control :
- * Real Time Tensile Strength Monitoring Instrumentation With Drive Control :
- * Millwide Control and System Instrumentation :
- * Process Modelling and Simulation :
- * Development of Stand-alone Systems for Laboratory Uses :

7. Conclusions :

In this paper an analysis of the situation existing in our pulp and paper industry in respect of control instrumentation usage has been made. Also, the need to modernise the industry with micorprocessor based control instrumentation that would increase the productivity and also help conserving energy, has been discussed. The importance of using electronic systems towards quality and process control in the pulp and paper industry has also been brought out. A glimpse of R&D work that has been completed and those that are envisaged in our Centre have been highligted. It is felt that creating a strong base now for the development of the electronic systems needed would not only help modernising the existing plants but also help newer plants to go for modern systems with a view to conserve energy and improve productivity through quality control.