# Application of Computer Based Control System In Paper Machine to Improve Quality and Productivity

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ABSTRACT

This paper briefly covers the applications of computer based control system with specific reference to Paper Machine. A brief description of various equipment, property measurements and control system as installed in M/s. TAMIL NADU NEWSPRINT AND PAPERS LIMITED, bagasse based 300 tonnes per day Newsprint and Writing & Printing Paper producing unit, is presented. Experiences and observations in operations and maintenance of the system during the past three years are enumerated. The paper also suggests some improvements and upgradation of the system for improved utilisation of various inputs with maximisation of quality and productivity.

## INTRODUCTION

COMPUTERS and MICROPROCESSORS are rocking the entire world in literally every field, with their numerous applications. It is but natural that their application in measurement and conrol has become inevitable, especially with the advent of reliable hardware, unlimited capacity and flexibility. The effective use of computer based on line measurement and control in paper making has first been done in India by TAMIL NADU NEWSPRINT AND PAPERS LIMITED, PUGALUR where a computer based system supplied by ACCURAY CORPORATION of USA has been installed to control the main parameters of the final product.

## INDUSTRY'S NEEDS

When an industry invests a huge sum on a process control equipment, the following expectations and demands should be met :—

01 Maximum availability of the system and controls for the process.

02 Accuracy and reliability of the system.

03 Effective return on investment by optimising process inputs and production.

04 Should be user friendly and resistive to mal-operation.

05 Should be maintainable by customer maintenance personnel.

06 Mean time between failures (MTBF) and mean time to repair (MTTR) should be to the minimum.

07 Should have easy ways to check the sensor measurement stability.

08 Flexibility for modification due to change in process needs.

## COMPUTER HARDWARES :

The heart of the 1180 Micro system is a minicomputer and two micro computers to interface with the operator, sensors and the process measurements and actuators. Other separate boards are hooked with the system for different functions like memory, sensors and process interface and for communication. The mini and micro computers incorporate self diagnostic features for easy troubleshooting. The minicomputer has capability to automatically restart in the event of power outage without operator intervention and also hold back the earlier production data on the diskette.

The System utilises two diskette drives which have system program diskettes which get loaded into the RAM memory of the computer during start up. There is a dot matrix printer which gives

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management information reports like reel report, grade report, shift and day report and other sensor check sample reports. The Operator console is an interface for the operator and the computer system. The Operator station has push buttons for different operations and a colour video display which shows reports like alarm message, process summary, production summary, profile, trend, status report etc. Using energy module program material consumption, percentage of flow and energy consumption are calculated with the process input measurements and displayed on video display instantaneously and also can be printed out at required intervals.

## FRAME SCANNER

A frame with a moving carriage carrying the sensors for basis weight, moisture and caliper is located in between calender stack and reel. One micro computer is dedicated for the scanner and sensor signal processing. Frame interface modules mounted in the frame itself take care of final operations of the frame and sensor and also collect the sensor signals and transmits to the micro-computer for further processing. The carriage also has sensors to detect sheet edges, and scan limits are automatically adjusted. A sheet break detector installed ahead of the frame moves the carriage off sheet in case of sheet break. The carriage with all the sensors move in cross machine direction at the rate of 60 seconds per scan and collects 60 data boxes of measurements for profile display on the video. Automatic compensation has been provided for the sensors for dirt accumulation, source decay, air temperature variation and the profile measurements are also compensated for frame misalignment, if any.

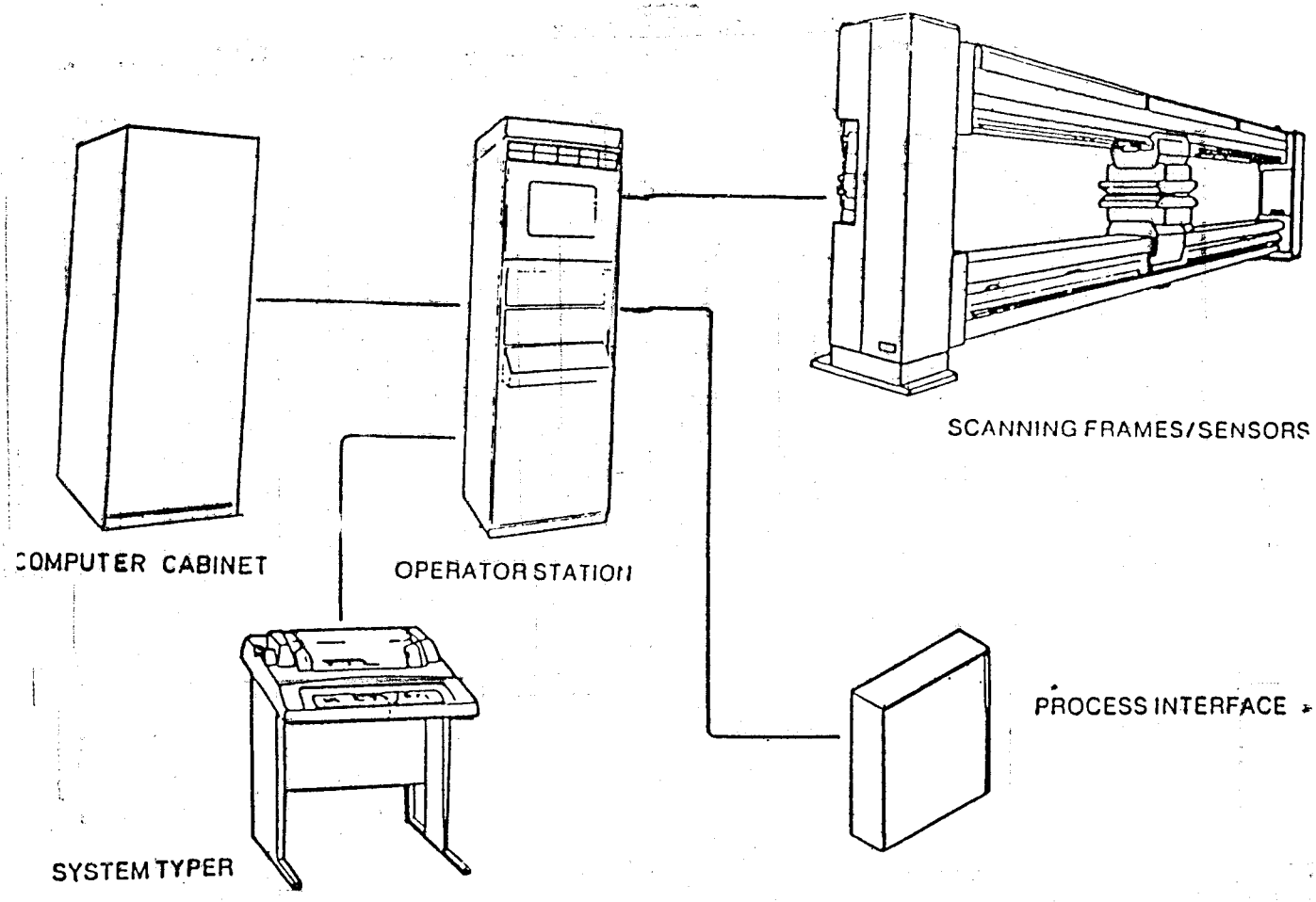



Figure 1 — System Overview

## SENSORS

The basis weight measurement has a beta radiation source and detector, the amount of radiation which penetrates through the sheet depends on the weight per unit area of paper sheet.

To sense the moisture content, an infrared source of two different wave lengths of different characteristics are passed through the paper and the difference in absorption of the material is a measure content in the paper.

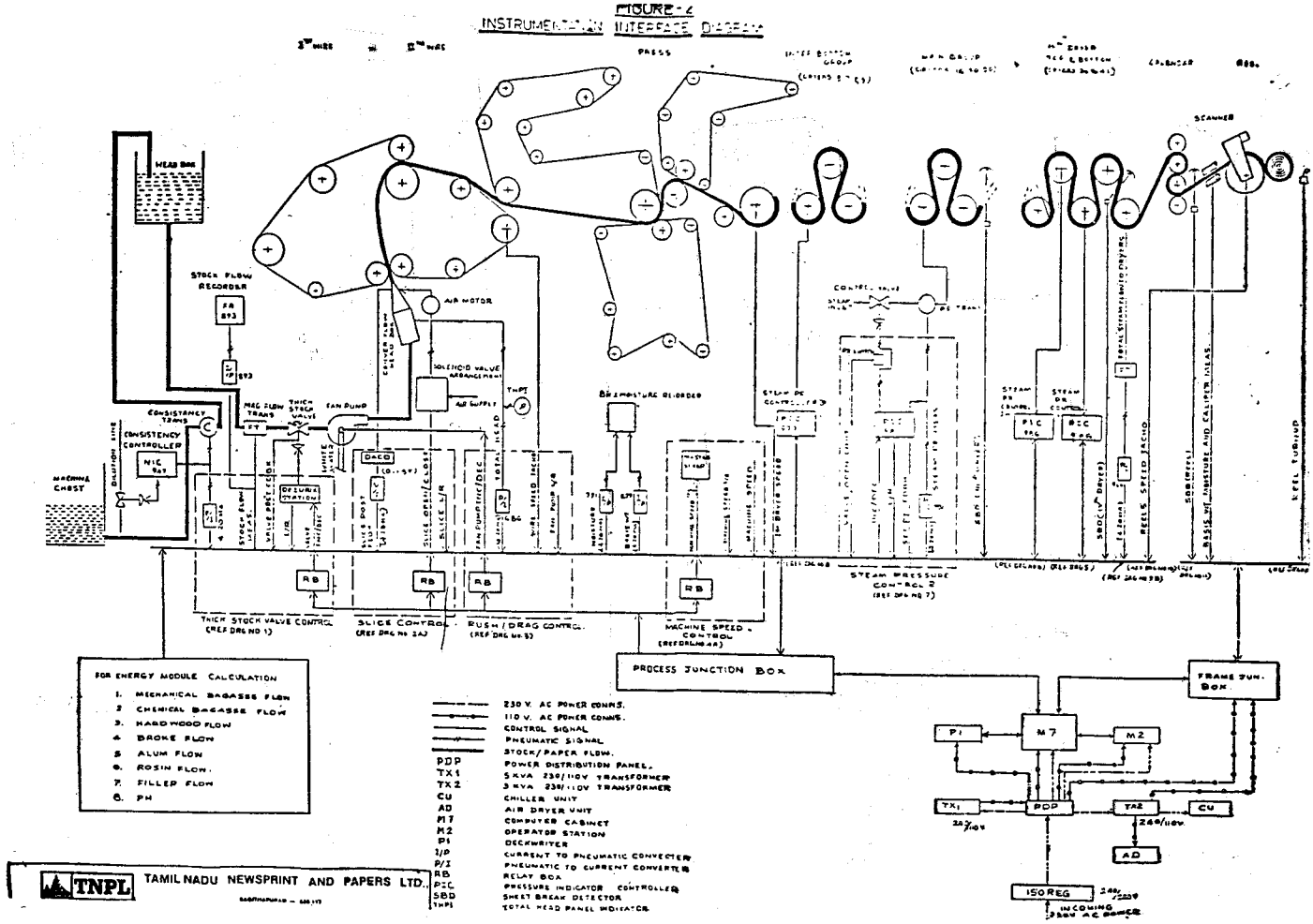
The caliper measurement is done by a non-contact type sensor which has a target which floats with constant air bearing. The target moves up in the presence of paper by maintaining the same air bearing. A proximity sensor measures the position of the target which is converted to a meaningful information of thickness of the paper.

## CONTROL SYSTEM

Paper Machine control systems are unique, complicated and it is difficult to accomplish without using advance electronic controls. Figure—2 shows the flow diagram of the paper machine alongwith different analogue and digital inputs, outputs connected to the computer. The analogue signals are current signal of 4–20 MA and digital signals are potential free contacts. There are two methods of actuating the final elements: they are pulse train and pulse duration depending on the type of actuators. The control systems employed in TNPL are explained below :

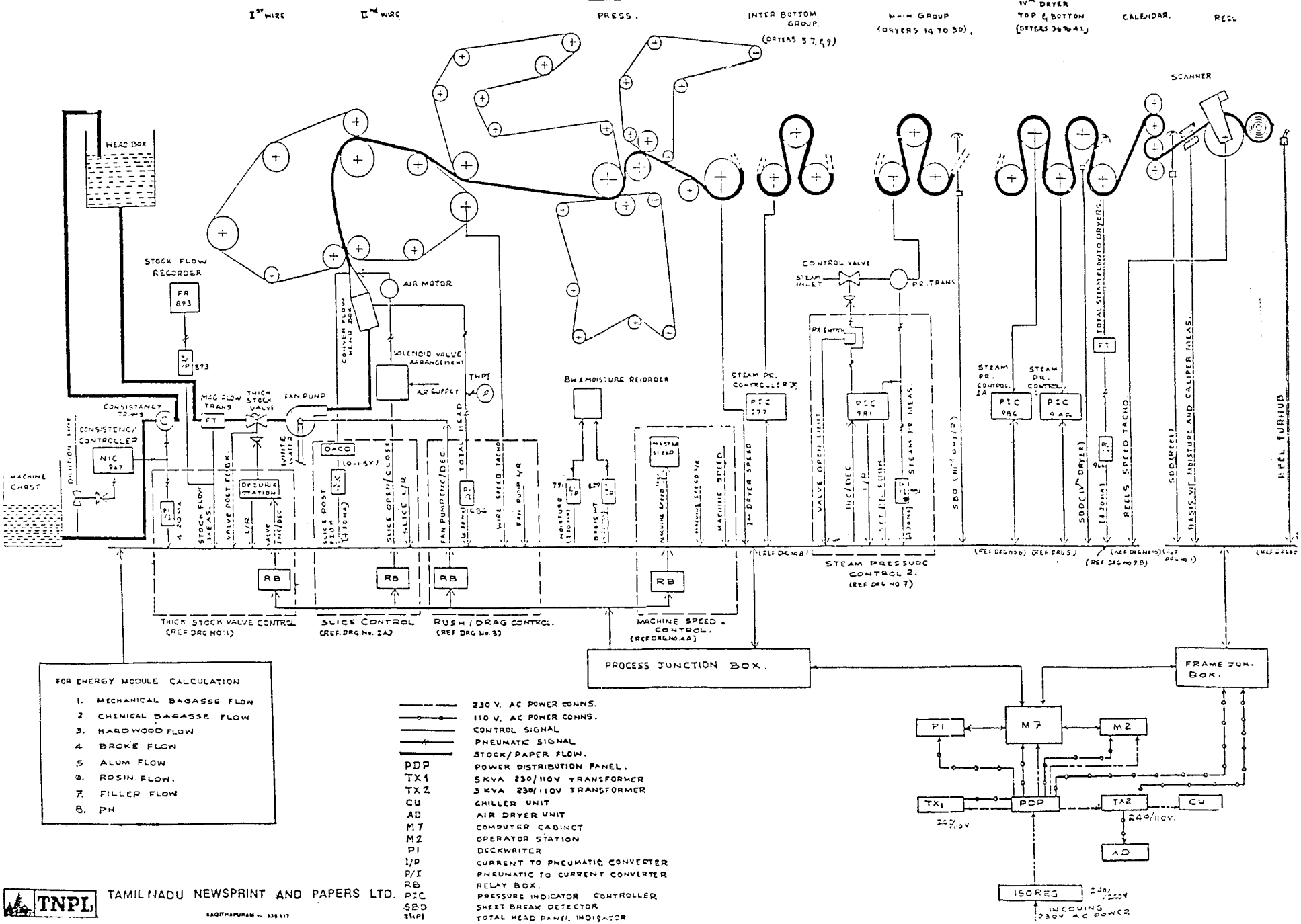
FIGURE - 2

INSTRUMENTATION INTERFACE DIAGRAM



# FIGURE-2

## INSTRUMENTATION INTERFACE DIAGRAM.




TNPL TAMIL NADU NEWSPRINT AND PAPERS LTD.

Digital weight and moisture controls are used to control long term machine directional variations of basis weight and moisture by controlling thick stock control valve and main group steam pressure valve respectively.

Sheet break steam reduction control reduces the steam pressure to avoid overheating of dryers during sheet breaks and normalise when sheet is passed again without the intervention of the operation personnel.

Dry stock control prevents, upsets in basis weight and moisture due to consistency variation before the formation of sheet by correcting the thick stock flow.

Head box control provides control of rush/drag ratio by processing the jet velocity of the pulp from the head box and the wire speed and then controlling fan pump speed to increase the head.

Co-ordinated speed change ensures smooth transition of speed by changing inputs like steam pressure, stock flow, head box pressure and machine speed in feed forward manner until it reaches the desired speed at the mean time n a ntaining the quality.

Speed optimisation control is an intelligent control which takes care of process and machine limitations and optimise and also maximum production.

Automatic grade change control facilitates smooth and fast transition of machine production from one product grade to the next. This control makes incremental changes in dryer steam pressure, stock flow, rush drag and machine speed until the quality of the new grade is met.

The above mentioned control systems are being incorporated with the following advance control strategies. A special program decoupled digital and moisture control is used to eliminate cross coupling of basis weight and moisture for change in thickstock flow and steam pressure, since both the parameters, variations affect each other Under scan independent control program the sheet is divided up into six zones and control actions are being taken at the end as many as six intermediate zones rather than at sheet edge only. Another very useful program predictive model reference constructs a computer model of the paper making process, including transportation lag, the machines response to each ar d every individual control actuator and the dynamics of control interactions. This model predicts the machine response and prevents successive over control actions. Yet, another useful program eliminates uncontrolled process wandering within a dead-band through use of adaptive gain control which takes control action at redued gain until the error is zero. The state of art of the control systems, its facilities and flexibility are appreciated once the control functions are understood.

## THE OBSERVATION AND UTILISATION OF THE SYSTEM

The details of the existing system in operation at TNPL are described in the previous pages. The main aim of the paper is to deal with the best utilisation of available informatiou of the computer system to improve the quality, runnability and productivity. There are three distinct areas which affect the quality of the paper. The first is the kind of furnish, quality and machine configuration. The second is that group of variables which are strictly mechanical such as the machine sections balance, the wire levelness and rigidity and adequate maintenance. The third category contains the group of variables which is under the jurisdiction of the operator and whose optimisation largely depends on the quality of the paper. The main quality variables like basis weight and moisture machine directional controls and part of the operation and controls have been taken care of by the computer system. Now, we will see more about importance of the quality of the paper and making best use of the information available from the computer and correct other machine controls to improve quality, runnability and productivity.

### (i) Basis Weight

The importance of the basis weight and its uniformity of paper quality are the most important criteria which influence nearly all quality aspects. The non-uniformity in basis weight and moisture create the difference in strength property of sheet, uneven buildup in the reel and also create dimensional instability. The machine direction basis weight variations are effectively corrected by computer control.

It is observed that change in slice opening and change in machine speed cause adverse cross machine directional variation which is indicated as profile on the computer video display. The profile indications are displayed with the position of the slice screws. The abnormal changes in basis weight in the cross machine

direction can be corrected by adjusting the appropriate slice screws. The uniform basis weight also induce more smoothness at the calender stack. Due to expected increase in uniformity of quality and strength, both in wet and dry states a reduction in virgin wood pulp would be possible. In case of sheet order the allowance in that grade can be taken as advantage and the average basis weight can be maintained 2.5% less than the product target, this means saving of raw material and energy. Figure—3 shows basis weight variation with control and one without and the shift in average value.

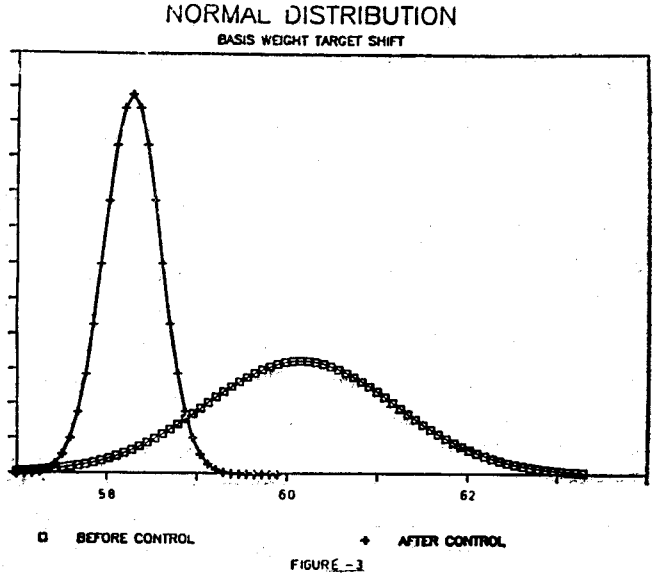



FIGURE -3

**(ii) Moisture**

When uniform moisture profile and reduction in long term variations are achieved, it is possible to increase the moisture to the maximum acceptable value, figure—4 shows shift in the moisture target. The increase in moisture earns saving of fiber and also reduction of steam consumption in dryers.

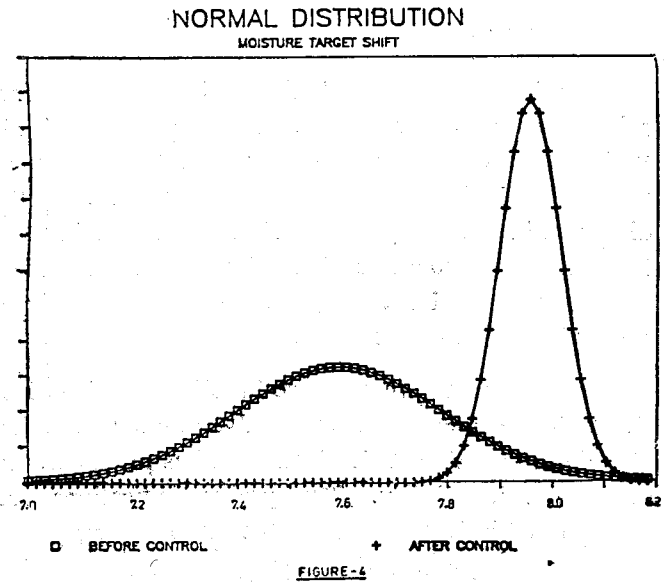



FIGURE-4

**a) Problems in printing press due to moisture variation.**

The high level of moisture induces a sheet quality that is both compressible and resilient which are essential characteristics for good printing impression. The uniformity of the moisture level overcomes tension variation during running at the printing press and helps in minimising sheet breaks. Also as the moisture content of the sheet falls off below a certain level, the strength is reduced. The high moisture level is not only important from the stand point of printing operation and strength requirement, but also to conditions with the surrounding relative humidity in the press room.

**b) Moisture profile variation due to press section controls.**

There are number of machine controls and other systems which can cause moisture profile variation. If the press controlled crown roll oil pressure is high or lower than the required it causes moisture profile variations as shown in figures 5 and 6. The oil pressure settings may need to be changed for different grades, furnish, rush/drag ratio and machine speed. Moisture variation of $\pm 4$ to $\pm 5\%$ from the average value is noticed during start up and grade change. Unless it is corrected it can cause frequent sheet breaks apart from affecting the quality and uneven reel buildup. These profile variations can be manually adjusted by suitably setting the controlled crown roll oil pressure.

Figure 5: Low oil pressure at controlled crown roll

Figure 6: High oil pressure at controlled crown roll

Another control which can affect the profile variation is the controlled crown roll loading bellows. If the pressure to the loading bellows are not appropriately fixed it may cause profile variations as shown in figures—7,8,9 and 10. It should be adjusted suitably to get a uniform moisture profile.

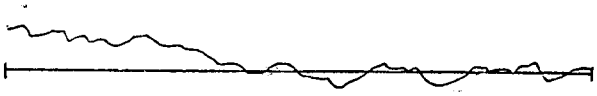


Figure 7: Pressure low at front CC Roll loading bellows

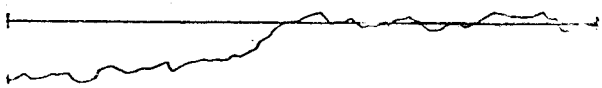


Figure 8: Pressure high n Roll loading bellows

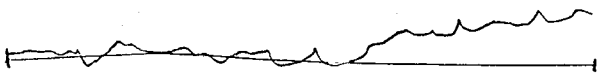


Figure 9: Pressure low at back CC Roll loading bellows

**(c) Moisture profile variation due to other machine conditions.**

Machine conditions like plugging of felts, choking of couch roll and pick up roll and condition in dryer section also can cause variation in moisture profile and it is possibe to indentify by experience. At these conditions further loading of press section may result pressing of felts. If the moisture profile variations are at the edges as shown in figure—11, it can be corrected by pocket ventilation system. If it is seen at some other points, then minor adjustments can be made with slice screws without affecting the basis weight profile at the same time bringing down the moisture profile variations.

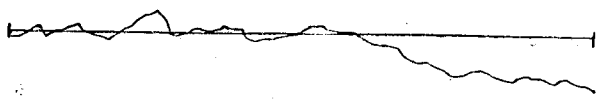


Figure 10: Pressure high at back CC Roll loading bellows

Figure 11: Due to felt plugging (or) due to Dryers

## COMPUTER SYSTEM ACE AS A TOOL

In some cases it is possible to locate machine control and other machine and process problems. The computer has access to monitor number of variables simultaneously at five seconds intervals and to get print outs. A typical case of false deduction is given below:

Once variation in deckle width was noticed and it was prominently visual at the edges of the reel and the variatons were cyclic. On examination the computer system indicated that moisture profile was changing when the basis weight profile was stable. It was suspected that only pressing of controlled crown roll can cause such a problem, and it was found that the third press controlled crown roll oil pressure was oscillating between 9 to 9.5 kg/cm$^2$. This problem was eliminated after tunning the third press controlled crown roll oil pressure controller. In this case the variation in moisture profile ushered us to identify the problem. The same problem may not be faced in other Mills but the computer can act as a tool to locate other machine problems also.

## IMPROVEMENTS

Based on our experience and needs it is telt that the following system improvements can be incorporated to increase the utilisation of the system.

The computer system should be available with facilities to store all the production data in the diskette to avoid voluminous storage of printed reports and retrieval of such reports. It also should be provided with facility to reprocess the data in required formats.

The system can be provided with facility for entry and display of laboratory test reports of the quality of paper furnishes for easy monitoring and controling the quality of paper and also improving the runnability of the machine by optimising the inputs.

It is preferable to have a trend page for process variables on the video display and a printer/plotter.

## UPGRADATION

In Western countries automation is felt mainly to reduce manpower requirement. But, in country like India where there is ample manpower we can think mostly in terms of maximising the production and quality by computerisation. The measurement of main basic qualities like basis weight and moisture and closed loop control of the above get the high profitability. Apart from the above controls mentioned it is also felt that by automation, there are other areas in paper machine which will fetch us effective return on investment.

Ash measurement and control facilitates maximum use of filler which means saving of fiber. The amount of filler required for each grade and for different rate of production can be calculated and effectively controlled without variations.

Consistency of incoming pulp and proper blending pulps and additives have very important role on quality and runnability of the machine. Only alternative for the best control of the above is with computer based system.

The other important controls are freeness control with control refiner and head box consistency control.

For further improvement of quality and efficiency one has to opt for cross machine directional control of basis weight, moisture and caliper.

## CONCLUSION

The computer system has been in operation in TNPL for more than three years and it has been established that system and control availability is more than 99.5%. Mean time to repair is minimum with the help of alarm messages, error codes and advance interactive diagnostic diskettes. Though initially some apprehension was there about the usefulness of the system, after seeing the performance the operating personnel are engrossed with the system and it has become highly exigent. The importance of the quality of paper efficient utilisation of raw materials are also felt very much because of the stringent quality requirement of speed printing machine and high cost of raw materials, and this could be achieved only with advanced computer based measurements and controls.

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