An Integrated Approach to the Control of Paper Machine-Wet End

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Introduction

In the present day Paper Industry, there is ever growing demand for increased production, greater product uniformity and improved earnings. There is greater realization now than ever that in order to achieve the above objectives, more and better process control need to be utilized. It is also being felt that in many areas of paper making, there are several inter-dependent variables or parameters. It is just not sufficient to control such parameters individually. But those should also be controlled in relation to each other. In other words, for such areas, integrated control systems need to be used. One area, which affords the opportunities for the introduction of Integrated Control System, is the Wet End of the Paper Machine.

It is well known that many of the final sheet characteristics depend upon the performance of the Wet End. For example, the sheet strength and formation are affectcd by Efflux Ratio which is defined as the ratio of jet velocity to wire speed. Similarly paper substance or basis weight depends upon the fibre fiow to the machine which in turn depends upon the thick stock fiow and the consistency. Unfortunately, the majority of variables at the wet end inter-act with each other. Interaction of head box level and total slice pressure is a well-known example. Unless all the variables are controlled not only separately but in relation to each other, variations of product quality can result. With this realization, *an Integrated Wet End Control System will be introduced in Tribeni's proposed new machine*. The system is outlined in this paper.

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Description of the System

2.0 The essentials of the Control System are shown in Figure 1. For clarity, equipment and/or controls not relevant to the present discussion have been omitted.

The system can be divided into three main parts.

(a) Conventional Process Control Instruments.

(b) An On-line combined Substance and moisture gauge.

(c) An Analogue Process Control Computer.

Conventional Process Control Instruments :

These are the various sensors, controllers and final control elements and are conventional in types. These instruments provide the various inputs to the computer as well as accept-outputs from the computer. These instruments have been so arranged that during the servicing of the computer, production does not suffer greatly. As is evident from Fig. 1, Electro-Magnetic Flowmeters, Slice position transmitter, Control Valves etc. come under this category. As far as possible, Electronic instruments will be used.

On-line combined Substance & Moisture Gauge

It will be a full web width traversing type gauge. Substance of the paper is measured by absorption (or Transmission) of Beta-rays, Beta rays source being Krypton-85. Moisture is measured by Dielectrio or Capacitance method. Either single spot (Machine direction) or Cross Machine direction profile measurement can be made. The latter measurement can be either on demand or automatic at preselected intervals. As the equipment incorporates a Bone-Dry Weight Calculator, besides Total Weight Deviations and Percentage Moisture, Bone Dry Weight Deviations will be indicated.

A feature of interest is the provision of a Wet End Console besides the usual O-frame (Carrying the measuring heads) and Dry End Measuring Console. The dominent purpose of providing the Wet End Console is to make available to machine operator a facility for speedier and more accurate slice screws adjustments for minimizing the cross machine direction substance variations. The console will be located near the Machine Head-Box and will house the following facilities.

(i) **A X-Y Recorder :** The purpose of this recorder is to obtain an on-line Cross Machine direction Substance profile similar to one obtainable from an 'OFF' machine or Laboratory Substance profiler but with many additional advantages. The machine operator can demand a profile at any time he likes. He can either have a single profile or several profiles super-imposed over each other. He can, thus, know quickly the effects of any slice screw adjustments made by him.

In X-Y Recorder, pen moves across the chart width (i.e. along X-axis) in step with the Gauge measuring heads and the recorder scale is graduated in positions of slice screws. The substance deviation or % moisture signal from the gauge moves the recorder Chart forth and back, along the Y-axis. Thus a deviation vs slice screws position grapth is plotted by the recorder.

(ii) **Machine Direction Recorder :**

It will be a 2 Pen, 2 Zone recorder for simultaneous record of any two output signals of the Gauge, when in single spot measuring mode.

(iii) **Remote Controls/Indications:**

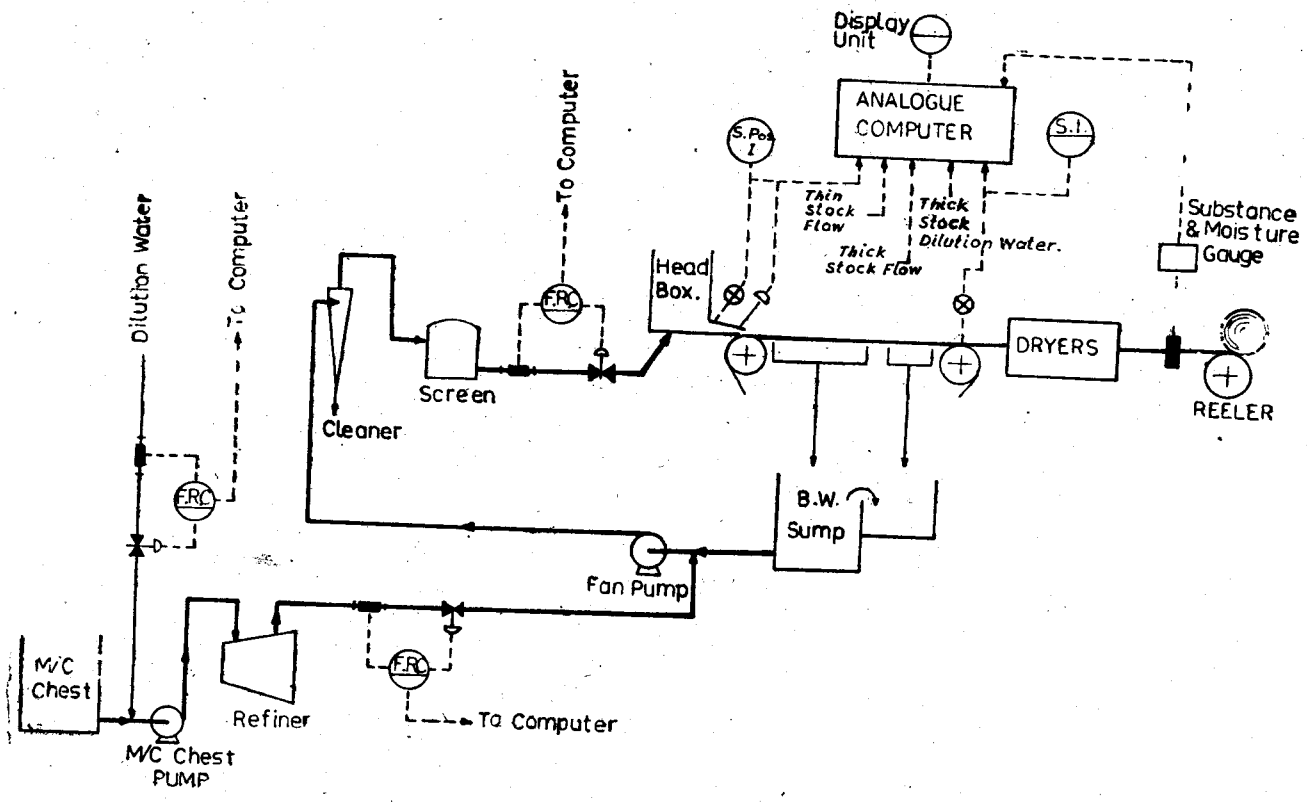
(a) Remote indication of Set Weight.

(b) Remote indication of measuring head position.

(c) Push button controls for :

1) Auto/Manual Profile.

2) Selecticn of parameter to be recorded.



WET END CONTROL SYSTEM
Figure-1

3) Measuring head movements.

2.3 On-line Analogue Computer.

2.3 1. **General :** This Computer can be termed as the heart of the whole system and will provide the desired integrated control. It will be an Electronic Analogue Computer designed to solve the various control equations. A change in any one parameter will automatically re-align those related.

Control Strategy

The first step in evolving the Control Strategy is to define independent and dependent variables. In the system depicted by Fig. 1, the following can be considered as the independent variables or variables whose values are dictated by a particular grade making.

(i) Wire speed.

(ii) Efflux Ratio.

(iii) Head Box Consistency.

(iv) Substance.

These varibles will be controlled at the desired levels in the following manner.

(i) Wire speed : Controlled manually by machine operator as dictated by optimum production.

(ii) Efflux Ratio : Controlled by computed thin stock flow control.

(iii) Head box consistency : Controlled by slice position control.

(iv) Substance : Controlled by control of computed thick stock consistency.

Two of the above control modes are elaborated below :

(i) Efflux Ratio Control

$$E=\frac{V}{S}$$

(1) Where

E=Efflux Ratio

V=Jet Velocity at Vena Contracta.

S=Wire speed.

Also Q=Av. V

(2) Where

Q=Thin stock flow

Av=Area of jet cross section at Vena Contracta

and Av=Ca.As

(3) Where

Ca=Coefficient of contraction.

As=Area at the slice.

Combining equations (1), (2) & (3), we have

$Q=C_a . A_s . E . S.$ (4)

Thus control of Efflux ratio is achieved by calculating the required thin stock flow by multiplying measured wire speed by the manually set desired value of Efflux ratio, the measured slice area and the value of the coefficient of discharge.

It is true that it is difficult to determine a precise value for Ca. However this should pose no problem as repeatable control is the aim and not the accurate readout of Efflux Ratio in absolute terms.

(2) Substance Control

A combination of Feed Forward & Feed-back control is used In Substance control. Desired thick stock consistency and machine speed are feed-forwarded on to the set point of thick stock flow. The thick stock consistency is computed and up-dated by feedback from the dry and substance gauge. In order to take care of distance-velocity lag of the paper machine, the up-dating of the computed consistency is a discontinuous process. The computer samples the output from the substance gauge at pre-set intervals which can be adjusted to suit the distance/velocity lag of the machine.

Description

The computer will accept input signals from various sensors, will perform the necessary computations and provide outputs to enable the necessary variables to be controlled. A digital display meter will be provided for displayed information on the following :

(i) Computed slice velocity.

(ii) Head box consistency.

(iii) Thick stock consistency.

(iv) Machine speed.

(v) Set in value—Efflux Ratio

(vi) Set in value—Head Box Consistency.

(vii) Set in Value—Bone dry weight.

(viii) Set in value–Thick stock Consistency.

(ix) Set in value—Consistency Water flow.

(x) Set in value—Back Water consistency.

The computer will have a built-in internal reference for checking computing accuracy.

3. Conclusions

It is expected that the introduction of the above integrated control system will lead towards the fulfilment of the triple objective of increased production, greater product uniformity and improved earnings. Also a better understanding of paper making process will be possible which will enable to introduce still better controls in the future.

4. Acknowledgement

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