An Electronic Control System for a Paper Converter Machine

Prashad Gandikota[1] and Subramaniyan Renganathan[2]

Central Electronic Engineering Research Institute, Chennai
Bharath Institute of Higher Education & Research, Chennai

The electronic control system described here primarily gives instantaneous measurement of coat weight irrespective of base paper basis weight and controls the moisture content of the finished product in online and real-time. Coat moisture is controlled by controlling the air temperature of each dryer hood individually with an aim to minimize energy to produce acceptable quality in the final product. Two mechanical scanning frames, fitted with appropriate sensors, are installed at strategic locations on the coating machine to continuously monitor/control these important parameters. Further, the system has the required MIS to give process information details. The Electronic system will cater the needs of a wide range of coating products. The system has been field-tested in a full-fledged paper mill near Gujarat. This paper deals with system integration, its features and its performance results during the field trials.

INTRODUCTION

Modern electronic control systems are playing a very important role in terms of expansion, enhancement and optimization of any dynamic process. More so in the case of batch processes like Off-line coating machines that have serveral complex batch process operations. Integrated electronic control systems equipped with advanced controls address these complexities for a better control of the process in a modular manner. One such indigenous system has been successfully installed and commissioned in a paper mill near Gujarat to control an Off-line coating Machine.

The Off-line Paper converter machine of the paper mill adopted for field trials of our system has a single coating station. Here, the raw paper of a specific GSM passes through a coating station to coat the surface of the paper and a divergent air stream from air knife acts like a broom air knife, located immediately after the coat station sweeps excess coating solution on the paper. During this coating operation air pressure, relative position of the air knife to the web, viscosity and speed of the roll will have a bearing on the coat film thickness and lip opening is not used to adjust this parameter. The coated paper thereafter will pass through a series of five hot air impinging dryer hoods with blower fan of centrifugal type attached to it and having a common stream manifold with control valves. Rolls support uncoated side of the paper web, in order to keep the paper at a certain distance from the air dryers. From the pressure chamber the hot air is blown towards the coated side of the paper web. The dry air absorbs moisture from the web and returns into suction chamber. From suction chamber, part of the air is evacuated through the moisture air duct. The leaving moisture air is partially recirculated. Leaving air must be replaced with new makeuup air that is taken into the drying unit through chamber. The drying unit is designed for steam heating the mixture of make up air and recirculated air pass through the heating coil and finally the heated air is sucked into the circulated fan. The drying rate can be adjusted by changing the steam pressure and thereby air temperature. A typical process line diagram is given in Fig 1.

The mill has been working on the following operating conditions for the product they produce:

- The machine speed is fixed based on the product in manufacture.
- The steam pressure and steam temperature of the air dryer hoods are maintained constant and steam flow is varied to control the air temperature of each hood.
- The impingement distance between drying unit and the paper web is normally fixed and will be treated as a constant.
- The pressure to air knife is fixed for each product

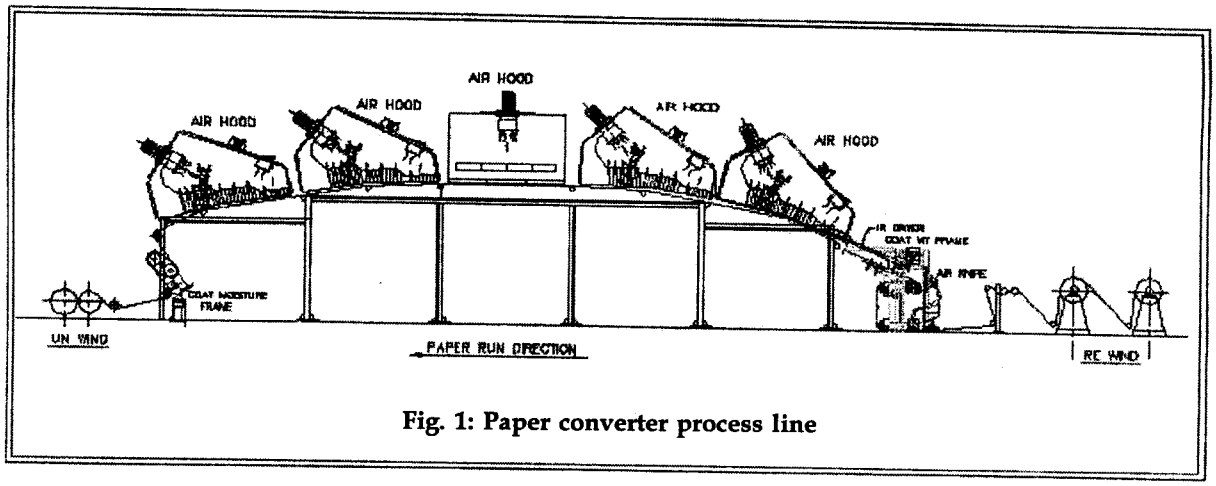

Fig. 1: Paper converter process line

in manufacture.

• The air jet velocity is constant for each hood having staggered nozzle arrangement.

The system is aimed at monitoring the coating process parameters coat weight and coat moisture of the paper. It is also proposed to implement coat moisture control of the coated paper by controlling the air temperatures of the five individual temperature hoods

RESULTS AND DISCUSSION

Coat Weight Measurement

Normally adopted method for coat weight measurement is that a sample of paper across the width of the paper is torn and taken to the laboratory for basis weight measurement. After coat is applied, the paper sample is collected from the paper running at high speed and is once again measured. The difference between these two is calculated as the coat weight measurement. If the Coat weight is to be measured online in this manner, two frames have to be installed, one frame at the unwind roll and another after the coating station, so that the paper weights before coat and after coat can be used to get the coat weight. This has also got the problem of lane values synchronization among the frame to get the true coat weight, which is rather difficult to implement if not impossible. Therefor, if sensor, which directly measures the dry coat weight irrespective of the base paperweight, is used, then it will be a more direct method and its control will be much simpler. One such IR based sensor is used in our system that measures the coat weight. The coat weight will depend on the blade angle, air pressure of the air knife and coat consistency. If air blade angle is fixed and coat consistency is maintained, the coat weight can be controlled by controlling the air knife. Though this has not been implemented practically in the mill, a provision has been made in the system to control this loop.

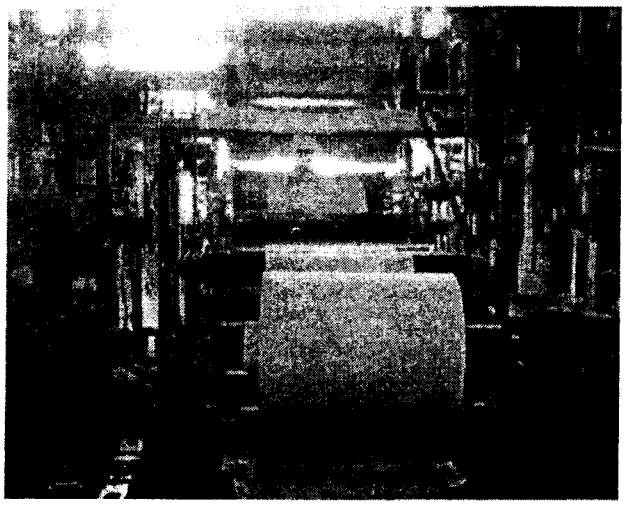

Fig. 2: Scanner frame with coat weight sensor

The coat weight sensor, which uses backscattered measuring technique, is fixed to a scanner. This scanner is located immediately after the air-knife and coating station. The scanning operations of the frame can be controlled by the operator through the scanning controls provided on the frame (perferred) or from the central control room.

The two optical edge detectors, attached to the sensors, will help to sense the edges of the paper and ensure the scanning across the web in both forward and reverse direction. The sensor has gone through rigorous trials in the field and worked satisfactorily in the mill in that harsh environment

The scanner frame and the sensor are shown in Fig.2 and 3 respectively.

Fig. 3 Coat weight sensor

Fig. 5 Coat moisture sensor

Coat Moisture Measurement

Coat moisture is the other important parameter that requires monitoring and control. The coat moisture measurement is done just before the rewinding roll. The moisture sensor is also IR based and uses backscatter technique.

The edge sensors installed to the moisture sensor will ensure the scan operation only to the web size. Both the coat weight and coat moisture sensors are fixed to the scanning frame and their scanning operations are controlled by AC drives.

Coated paper passes through a series of dryer hoods so that the coat applied to the paper gets solidified after drying. The scanner frame and the moisture sensor are shown in Fig. 4 and 5. It is desirable to maintain predefined profile for moisture control. A specific product dependent drying profile is to be maintained at each dryer to attain the set final coat moisture. This profile will state how much of moisture is to be removed from the paper at the end of each dryer hood. There are five air dryer hoods used in the mill where field trials were conducted. The dryer hoods, mounted above the moving sheet, impinge hot air with a fixed air velocity to dry the paper.

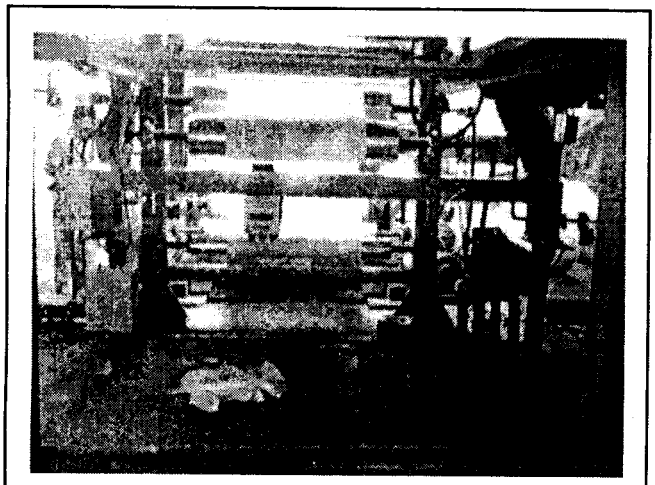

Fig. 4 Scanner frame with coat moisture sensor

The paper drying will depend on the air temperature, air velocity, speed of the paper and the gap between the dryer and the web.

The air temperature is controlled by either steam pressure or steam flow. Usually, the speed of the machine is fixed based on the product. Gap between dryer and web is maintained constant and so is the velocity of the impinged air. Therefore the drying is totally based on air temperature. Since the drying has to take place in a predefined drying profile, air temperatures of individual hoods are to be controlled individually. By controlling the steam pressure or steam flow of that hood controls air temperature of each hood.

Coat Moisture Control

Coat moisture is one of the important parameters that should meet the customer specifications. Therefore there is every need for this parameter to be controlled. By controlling the impinging air temperature of each dryer hood can attain the desired Coat moisture value. Controlling the steam flow rate/steam pressure to the air dryer hoods controls the air temperature. When hot air is impinged on the paper both heat and mass transfer operations take place. The paper coat moisture is removed mainly through convection. Here each dryer

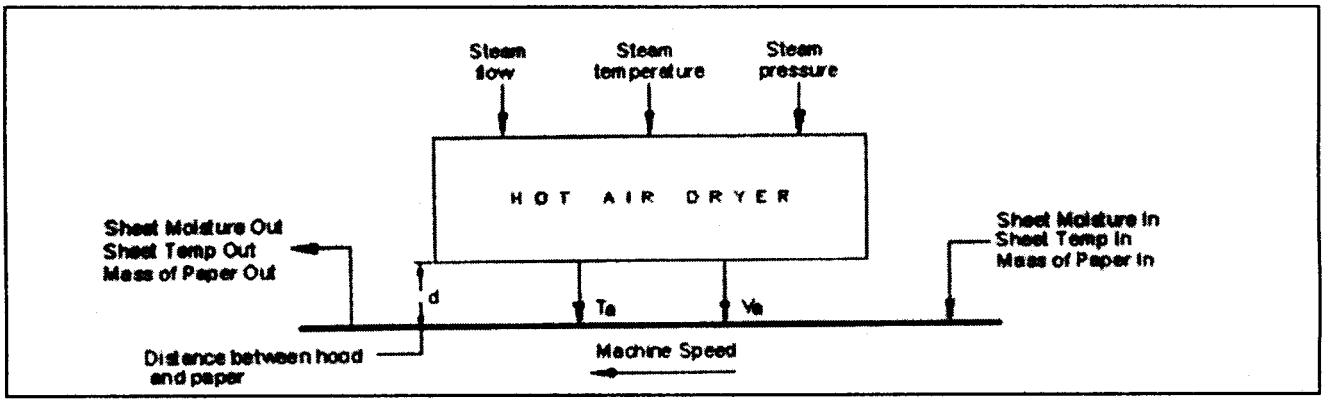

Fig. 6 Input/output model of a single stage in paper coating process

hood is individually controlled to maintain the moisture drying profile specific to the product to achieve the final moisture.

Each dryer hood receives steam supply from common source. The steam flow rate determines the temperature of the impinging air of each of the hood. The temperature of the hot air impinging on to the moving paper web determines the drying rate. The hot air is blown on to paper through nozzles. The state variable input/output model for each hood is shown in Fig.6 and is identical for every stage.

By following the moisture profile of each individual hood, the final moisture of the coated paper can be controlled. Therefor, to achieve the product dependent moisture profile, the steam flow rate of each hood is to be controlled so that the moisture profile can be maintained at the end of each hood by controlling the impinge air temperature, with constant steam pressure and steam temperature. The system has the provision to control the individual hoods through conventional controllers like PID etc.

System Hardware and Software

The Electronic system hardware is built around a standard DCS system. All the three frames are interfaced to the system whose scanning operations are controlled by the system asynchronously. The system software has been developed using the proprietary software of the DCS manufacturer.

The MIS information and MMI interfaces were developed using Intouch software. All the DCS modules are housed in a 19-inch industrial rack.

DCS System and the Operator workstation are shown in Fig. 7 and 8.

System Features

• Online monitoring of Coat weight, and Coat Moisture with moisture control through DCS based

Fig. 7 DCS system

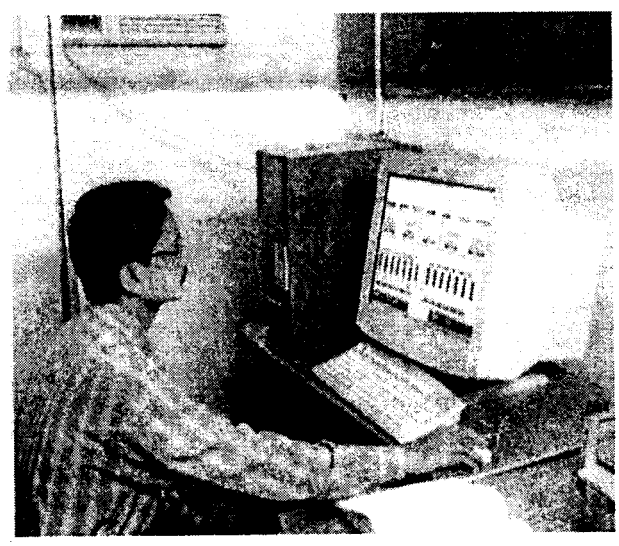

Fig. 8 Operator workstation

Electronic system.

• Direct bone dried coat weight measurement immediately after the coat station.

• Two separate and Independent scanner frames to monitor coat Weight and coat moisture (along with sheet temperature) respectively.

• Monitoring and logging of hood temperature, steam flow rate and steam temperatre in DCS system.

• User-friendly Human Machine Interface (HMI) software.

• Display of Real time trend and historical trend of all the parameters.

• All control and measurement information such as profiles, trends, sensor measurement and other process variables are clearly displayed dynamically on an operator workstation.

• Reel and grade change report to determine if coat weight and moisture targets are being met

Extensive field trials have been conducted to evaluate the system performance in a full fledged paper mill near Vapi, Gujarat. The results obtained from the system for Coat weight and coat moisture values were compared with the laboratory results. The system performance is evaluated for most of the products that are being manufactured.

Table-1 gives comparative results of DCS system and laboratory values of the coat weight measurements. The properties of Scan average coat weight and instantaneous coat weight for a typical product are shown in Fig.9 The moisture sensor readings are compared with the laboratory values. Table2 gives the comparative values for some products. These values are tested randomly

Table-1 Comparative chart of DCS and Laboratory coat weight values

Base Paper Weight (Gsm)	Coated Paper Weight (Gsm)	Average Coat Weight (Lab Values) (Gsm)	Average Coat Weight (DCS System) (Gsm)
95.00	113.00	18.00	18.90
260.00	279.50	19.50	20.30
84.76	105.80	21.04	21.06
97.20	144.50	17.30	18.10
87.00	106.50	19.50	19.00
90.10	113.60	23.50	22.80

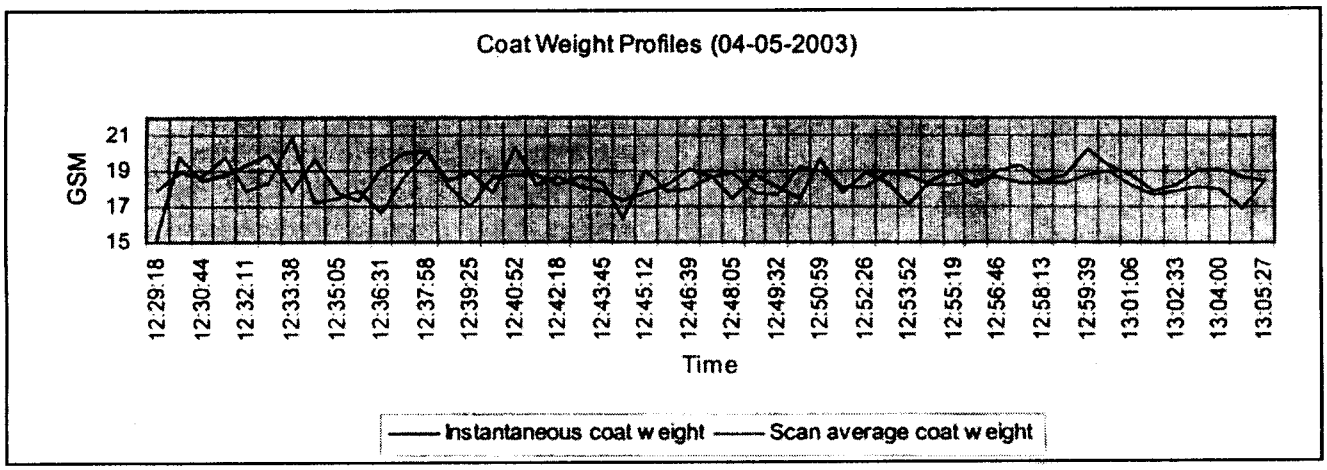

Fig. 9: Scan average and Instantaneous coat weight profiles

• Window NT based Operator workstation with 19" color monitor interfaced with DCS system through a Modbus communication.

• Coat weight and coat moisture sensor calibrations can be done from the DCS system as well as locally at the sensor.

by taking samples from the finished paper. The system is aimed for accurate coating qulaity parameters, ensure product quality, enery savings. Currently, the system is undergoing long-term field trials in the mill and the system will soon be evaluated in terms of quality improvements and energy savings after moisture control and coat

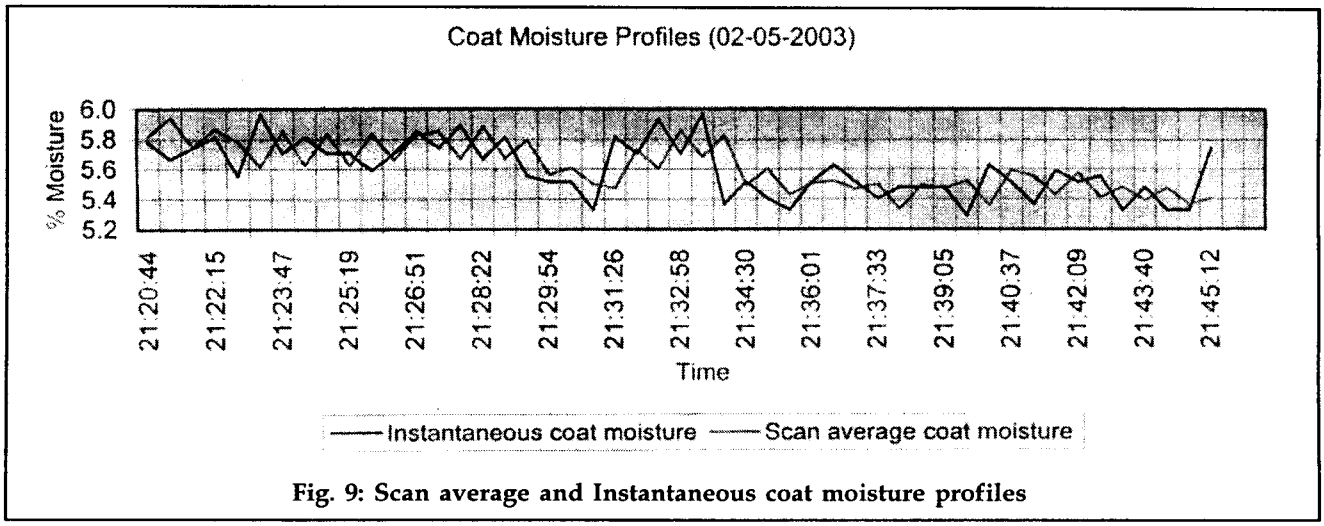

Fig. 9: Scan average and Instantaneous coat moisture profiles

Fig. 9: Scan average and Instantaneous coat moisture profiles

Moisture sensor values (DCS) (%)	Moisture sensor values (Lab) (%)
5.0	4.60
5.5	4.80
4.9	4.94
5.3	4.80
5.6	5.60
5.0	5.20
4.8	4.50

weight control loops are incorporated.

CONCLUSION

A DCS system that monitors the quality parameters of the coated paper has been developed and successfully field-tested. All the three frames are asynchronously controlled and provides animated process viewing. Calibrations of sensors are possible from the operator workstation. Though a provision has been incorporated in the system to control the coat moisture by controlling the dryer hood temperatures of each hood through steam flow, availability of instrumentaion in the mill for this purpose. Provision has been made in the system for controlling the coat weight. The system has expandable capabilities and can be installed in any paper converter mill with minimum charges and minimum instrumentation. The process and managerial information is provided using crystal reports. In the laboratory, the base paperweight is assumed to be constant through out the role.

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