Development of an Instrumentation System for Process Parameter Monitoring of Green Tea Production

[1] Debashis Saikia, [2] P. K. Boruah, [3] Utpal Sarma
Department of Instrumentation and USIC
Gauhati University, Assam- 781014, India

Abstract*— This paper presents an instrumentation to monitor different process parameters of green tea production. In case of green tea production, monitoring the pan firing stages (roaster and trough temperature) and dryer temperature is a vital issue. This work is an attempt to design, fabricate and test a monitoring and data logging system suitable for green tea production which can monitor the temperature of the pan firing stage, inlet and outlet temperature of dryer. Seven sensor nodes are required to monitor temperature of different phases of the tea factory with two dryer, one roaster and two troughs. An extra sensor pair is placed to monitor the temperature as well as Relative Humidity(R/H) of the factory environment. For dryer temperature monitoring a K type thermocouple based measuring system is developed. An R/H to voltage converter and Temperature to voltage converter type sensor is used to develop the R/H and Temperature monitoring sensor node. The sensor nodes for different stages are connected in RS 485 network. Data are logged into hard drive of a personal computer and the data acquisition software is developed in NI Lab VIEW.

***IndexTerms*— Thermocouple, Tea dryer, Green tea, RS 485**

I. INTRODUCTION

Several Tea processing stages like Withering, Fermentation and Drying etc are incorporated in finished tea production. Tea is manufactured by a variety of processes producing a range of finished tea variants. The three major varieties according to their manufacturing process are 1) unfermented Green tea 2) Partially fermented oolong Tea 3) Fully fermented Black tea. [1]. In most tea factories, proper monitoring and control of different tea process parameters like temperature, relative humidity, moisture content at different level is either not done by proper modern methods or it is done by manual means and often decisions taken by guesswork which finally affects the quality of tea produced.[2]

Among the three varieties given above, green tea is more significant due to its health benefit. The green tea is rich in antioxidants and may have a protective role in certain conditions such as cardiovascular disease, chronic gastritis and some cancers, by inhibiting the formation of cancer causing compounds. Green Tea production stages are given in the Fig 1. This work includes design, fabrication and testing of a monitoring and data logging system suitable for green tea production at various manufacturing stages

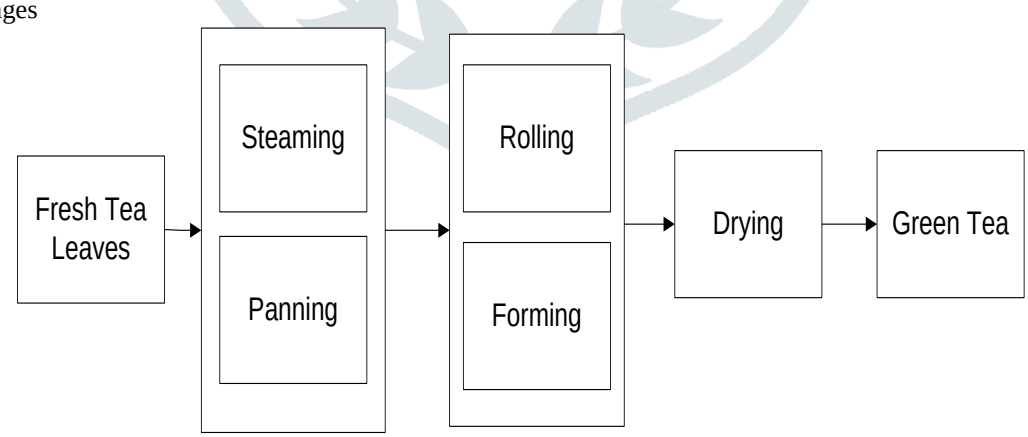

Fig 1: Block Diagram of Green Tea Production

II. SYSTEM DESCRIPTION

The Block diagram of the proposed Instrumentation system to monitor tea process parameter of green tea production is given in Fig 2. Seven sensor nodes are required to monitor temperature of different phases of the tea factory with two dryer, one roaster and two troughs. Only one sensor node is placed to monitor the temperature as well

as R/H of the working environment. For temperature monitoring a K type thermocouple based measurement system is developed. The block diagram of the sensor node is given in Fig 3. An R/H to voltage converter (HIH 4000) and Temperature to voltage

converter type sensor (LM 35) are used to develop the R/H and Temperature monitoring sensor node. The block diagram is given in Fig 4.

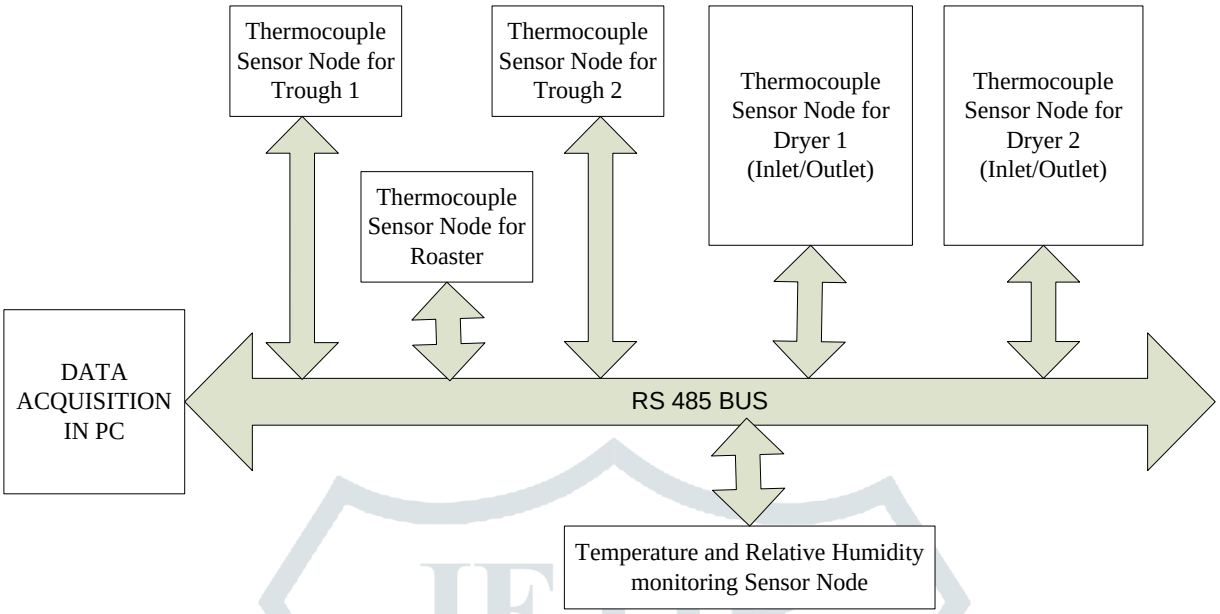

Fig: 2 Block Diagram of the Instrumentation system for green tea factory

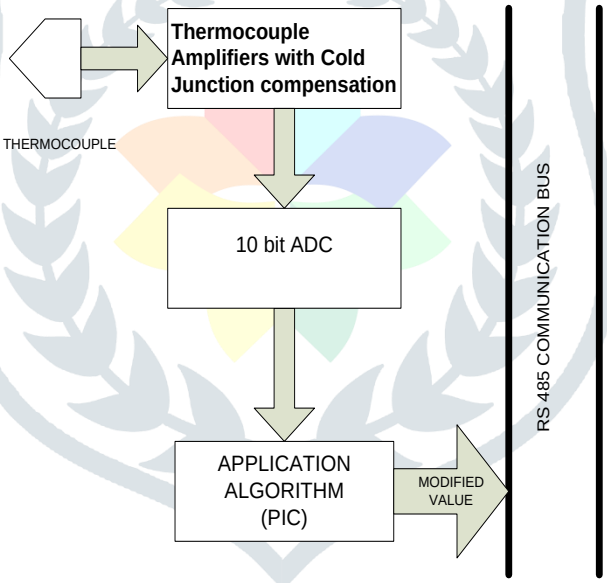

Fig 3: Block diagram of the thermocouple based temperature monitoring system

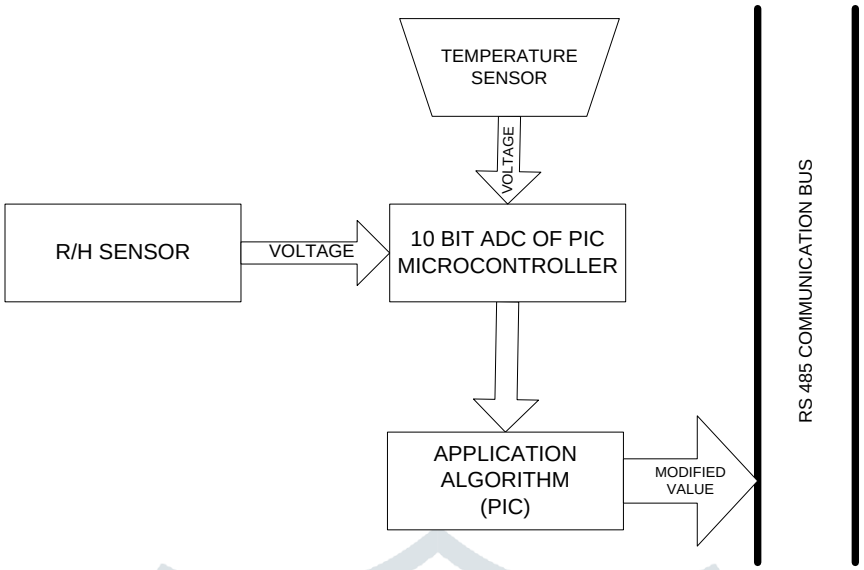

Fig 4: Block diagram of R/H and Temperature monitoring system

The signal conditioning for thermocouple is achieved by AD595 [3] which offers complete instrumentation amplifier and thermocouple cold junction compensator on a monolithic chip. It combines an ice point reference with a pre calibrated amplifier to produce a high level (10 mV/°C) output directly from a thermocouple signal. Pin-strapping options allow it to be used as a linear amplifier-compensator or as a switched output set point controller using either fixed or remote set point control. It can be used to amplify its compensation voltage directly, thereby converting it to a stand-alone Celsius transducer with a low impedance voltage output. The output of the AD 595 is connected with a 10 bit built in ADC of the PIC microcontroller [4,5,6]. The application algorithm embedded in the PIC microcontroller is used for data correction and communication through RS 485 network bus [7].

The temperature is sensed by the sensor LM 35 (temperature to voltage converter) [8] and the voltage is read by the 10 bit built in ADC of the PIC microcontroller. The analog signal from the humidity sensor [9] is fed to the same microcontroller and analog to digital conversion is done by another 10 bit built in ADC. The system is calibrated and the digital data is converted to its corresponding temperature and R/H [10, 11, 12, 13]. These values are sent to PC via RS485 communication. All these correction and communication is done by the application algorithm embedded in the microcontroller. The transceiver for RS 485 communication in both the cases is MAX 485.

A. **The sensors:**

a) Sensing the temperature:

i. Thermocouple: A K-type thermocouple is used to measure the temperature of the Roaster, Dryer and trough of steaming.

ii. LM 35: It is an IC temperature sensor which gives 10mV/^{0}C output.

b) Sensing the R/H: For sensing Relative humidity, low power RH to voltage converter is used. It is basically a LASER trimmed, thermoset polymer capacitive type sensing element with on chip integrated signal conditioning. The accuracy of the sensor is ±3.5% at 25 ^{0}C with 5 Volt Dc supply. The output voltage (V_{OUT}) and RH can be expressed typically at 25^{0}C as:

$$RH = \left(\frac{V_{OUT}}{V_{SUPPLY}} - 0.16 \right) \times 161.29\,\% \text{ ---------- (1)}$$

B. Software:

The software required for the PC to send and receive data serially using the protocol RS 485 is developed in NI Lab VIEW. The raw digital data is also converted to temperature and relative humidity by this software.

III. Field Experience

The system described above has been designed, developed and successfully installed and operated in a tea factory near Mangaldoi, Assam, India after continuous testing for three months in the laboratory.

The system was used to monitor the process parameters of the tea production as mentioned above. In the industrial environment the performance of the system is found to be satisfactory. Fig 5 shows the dryer inlet temperature monitoring of a day with time which will indicate the validation of the developed system.

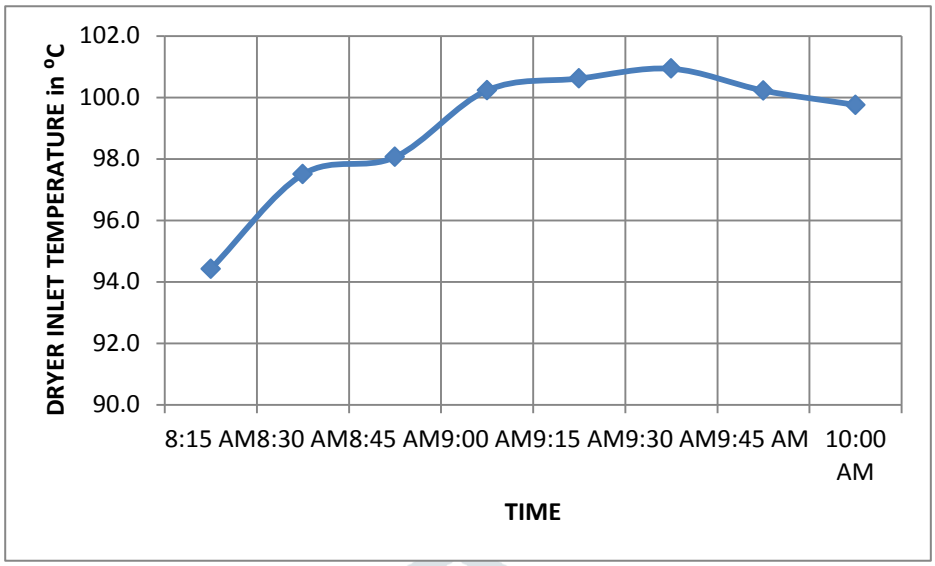

Fig 5: A sample of variation of dryer inlet temperature with time.

IV. Conclusion

A process monitoring system for green tea manufacture has been successfully developed and operated in a tea factory. This system is used for inlet and outlet temperature measurement of both the dryer, measurement of roaster temperature, trough temperature and temperature and RH of the factory environment. The communication through RS485 is found to be satisfactory in the industrial environment at a low cost where several sensors are required. The data acquisition system developed does not require skilled manpower for its operation and it will be highly useful for tea factories to improve their quality of production.

V. Acknowledgment

Department of Science and Technology, Govt. of India is acknowledged for providing INSPIRE Fellowship to one of the authors. The authors of the paper acknowledge the authority and staff of tea factory for their help and support. The authors of the paper acknowledge Dept of Instrumentation and USIC, GU for providing the facility to do the work. Mr. Manash Protim Goswami is also acknowledged for helping in installation of the instrument in the tea factory.

References

[1] Nabarun Bhattacharyya, Sohan Seth, Bipan Tudu, Pradip Tamuly, Arun Jana, Devdulal Ghosh, Rajib Bandyopadhyay, Manabendra Bhuyan, "Monitoring of black tea fermentation process using electronic nose" Journal of Food Engineering 80 (2007) 1146–1156
[2] S.L Sarnot, "Need of electronic instrumentation in Tea industries, Technical report"
[3] Datasheet of AD595 at http://www.analog.com/static/imported-files/data_sheets/AD594_595.pdf
[4] Datasheet of PIC18F452 at http://ww1.microchip.com/downloads/en/DeviceDoc/39564c.pdf
[5] Utpal Sarma, P.K.Boruah, Design and development of a high precision thermocouple based smart industrial thermometer with on line linearization and data logging feature, Measurement 43 (2010)1589-1594
[6] Utpal SARMA, Digbijoy CHAKRABORTY, Pradip Kr. BORUAH, "Design of a Low Cost Smart Dryer Temperature Measurement System for Tea Factories"
[7] The RS 485 design guide, application report < http:\\www.ti.com>
[8] Datasheet of LM 35 at www.ti.com/lit/ds/symlink/lm35.pdf
[9] Datasheet of HIH4000 at http://sensing.honeywell.com/index.cfm/ci_id/1/document/1/re_id/0
[10] D. Saikia, U. Sarma and P. Kr. Boruah , "Development of an Online Heat Index Measurement System for Thermal Comfort Determination" MAPAN-Journal of Metrology Society of India, DOI 10.1007/s12647-013-0066-9
[11] Debashis Saikia, P.K. Boruah, Utpal Sarma, "Development and Implementation of A Sensor Network to Monitor Fermentation Process Parameter in Tea Processing", International Journal on Smart Sensing and Intelligent Systems, vol. 7, no. 3, September 2014, Publisher: Massey University, New Zealand
[12] Debashis Saikia, P.K. Boruah, Utpal Sarma, "A Sensor Network to Monitor Process Parameters of Fermentation and Drying in Black Tea Production", MAPAN-Journal of Metrology Society of India, (September 2015) 30(3):211–219, DOI 10.1007/s12647-015-0142-4, Publisher: Spinger
[13] Debashis Saikia, Diganta Kumar Sarma, P.K. Boruah, Utpal Sarma, "An Ann Model to Estimate the Impact of Tea Process Parameters on Tea Quality", Journal of Circuits, Systems, and Computers, Vol. 24, No. 9 (2015), DOI: 10.1142/S021812661550139X, Publisher: World Scientific Publishing Company