Simulation of control loops of pulp bleaching section using distributed control system – An experimental study

S C Sharma¹, Sanjeev Gupta²*, Chhaya Sharma¹ and Raj Kapoor³

¹Department of Paper Technology (IIT Roorkee), Saharanpur 247 001
²Sardar Vallabhbhai Patel Institute of Technology, Vasad 388 306
³Instrumentation Section, Ballarpur Industry Ltd., Yamuna Nagar

Received 06 February 2006; revised 15 December 2006; accepted 16 January 2007

Day by day requirement for better quality of paper in terms of brightness and strength is arising. To meet the changing requirements, the bleaching sequences and process conditions need to be modified. For implementing these modified conditions, to increasing the reaction rate and to reduce the chemical wastage control loops need to be redesigned. The process engineer working in the mill must know the design procedure of control loop on DCS. Keeping this in mind, control loop for changing demand of hot water flow used at C/D washer for water spray and temperature of hot water of pulp bleaching section have been designed and simulated offline. Later on these loops were installed, commissioned and tested on-line using DCS (MP 200/1). The results are reported in manual and auto mode of operation.

Keywords: Bleaching, Distributed control system, Flow control, Temperature control

IPC Code: D21C9/10

Introduction

Indian paper industries are in an interesting stage of entering global market in a big way. Bleaching process makes the pulp suitable for the manufacture of printing, fine paper, tissue and other grades of paper. Time and temperature are the important factors for regulating the chemical reaction rate for the desired delignification process. If time is short or temperature is too low than the chemical applied is not totally consumed and as a result residual chemical remains at the end stage¹. Distributed control system (DCS) has achieved global acceptance because of its fast response, good controllability and capability to handle complex problems and is essential for the success of any plant operation²³. For the present work, the Masterpiece 200/1 DCS has been used.

Proposed System

DCS is a programmable⁴ system for control and supervision of process and equipment in the industrial environments. It offers sophisticated operator interface, regulatory control capabilities and a high-speed sequential and logical control functional. The operating station of DCS is known as advent station, which is a reduced instruction set computing (RISC), based workstation offering high performance, and built in networking, high-resolution graphics and the power flexibility of UNIX operating system. The advent station is a man-machine interface (MMI) that includes high-resolution monitors, keyboard and a mouse. It provides true interface between the process and operator. The engineering station is used to configure and commission the system both on line and off line.

The proposed scheme controls hot water flow used at C/D washer for water spray and temperature of hot water of pulp bleaching section by using the capabilities of MP 200/1 DCS supplied by ABB (Fig. 1). First these loops have been designed offline (Fig. 2) and tested by simulating them using standard current source. Thereafter loops have been placed in the auto mode and tested on mill side.

System Program

Man-Machine-Communication (MMC) consists of presentation and order functions (Fig. 3). Both MMC and PC parts use a data base element with configuration...
Fig. 1—Proposed diagram of hot water temperature and hot water flow control

Fig. 2—Block diagram for offline design

Fig. 3—Structure of system program
constants and dynamic data. System normally exchanges signals with a process via input and output. Current data for these units are stored in the database. The PC program can read, for each channel on a board, information such as the channel value, if there is any blocking of the data value etc. The module for process communication performs reading data in and out, between process and database.

**Operational Function of I/O Block**

Input/output (I/O) connection of MP 200/1 (Fig. 4) is connected by ribbon cable, which is used for I/O boards intended for current under 1 amp and voltage under 60 V. I/O board converts incoming signals from the process, so that these can be processed in CPU. Outgoing signals are adapted to their function in the process. Digital input signals are optically isolated from the system potential, while digital output signals are galvanically isolated by relays. There are 32 channels on analog I/O board, which accepts 4-20 mA signal from field.

**Database**

Database contains data for the following functions: I) Analog input board (AI); ii) Analog output boards (AO); iii) Digital input (DI); and iv) Digital output (DO). While writing software program for Analog input (AI) and Analog output (AO), tag number, range, converting parameters, type of input, limits, unit, dead band are defined as per the control loop requirement. Similarly for Digital input (DI) and Digital output (DO), tag number and level of input and output are defined in the program. In the data base parameter for master bus, data for display on operator station for different objects, function units like process controller, general objects, valves and group start objects are defined.

**Process Controller (PC) Program**

A process controller (PC) program contains all the arithmetic and logic functions with PIDCON elements as the smallest ‘building blocks’. A PC program is divided into function modules and several execution units. The interpreter organizes the program execution. PC program writing process involves PIDCON element insertion (to create PC program structure) and PC element connections. After insertion in program building input and outputs are defined. All input terminals of PC element are necessarily connected to some value/terminal, whereas the output terminal can be left blank during programming.

**Hot water Flow and Tank Temperature Control Loop**

Hot water flow control loop has been implemented using proper selection of orifice plate,
differential pressure transmitter, current-to-pressure (I/P) converter and control valve. For hot water temperature control Resistance Temperature Detector (RTD), Temperature transmitter, I/P converter and control valve have been selected. All the hardware components of both the control loop have been tested offline before putting it into auto mode for the smooth working of the system as per their ranges. Finally, both the loops were developed on MP200/1 DCS using its software programming. Database for AI, AO and PIDCON is created by using programming capabilities of DCS. In AI Configuration, database have been developed for display of tag number, range and conversion parameters, while AO is configured for display of tag number and range, and PIDCON configured for display of tags number, range, decimal point and gain. PC-element PIDCON configuration for display and internal connections is given.

Results and Discussion
Database for AI, AO, and PIDCON etc have been developed using capabilities of DCS and tested using manual and auto mode operation.

Manual Mode
(i) Online Simulation of Hot Water Flow Control Loop
Hot water flow control loop is simulated online using standard current source (4-20 mA). For this purpose, standard current source is kept at 8 mA (25% of the signal value), the flow (20 m^3/h) proportional to this signal is obtained. After that, current source is kept at 12 mA (50% of the signal value), the flow (28.2 m^3/h) corresponding to this signal is obtained. Following this, current source is kept at 16 & 20 mA respectively, corresponding to these values, flow of 34.0 m^3/h & 40.0 m^3/h is obtained respectively. These observations indicated that hot water flow control loop is successfully working on MP-200/1 DCS in the range of 0-40.0 m^3/h in manual mode.

(ii) Online Simulation of Hot Water Tank Temperature Control Loop
Temperature control loop is tested online using standard resistance source. Initially resistance in the standard resistance source is kept at 109.734 ohms (25% of the signal value), corresponding temperature of 25°C is obtained. Thereafter, standard resistance source is kept at 119.395 ohms (50% of the signal value), 50°C temperature obtained. Then, standard resistance source is kept at 128.984 ohms (75%) and 138.500 ohms (100%) respectively, corresponding to these values the temperature of 75°C and 100°C is obtained. These results verified that the hot water temperature control loop designed and simulated on MP-200/1 DCS, and it works successfully in the range of 0-100°C in the manual mode.

Auto Mode
(i) Online Flow Control of Hot Water
Hot water flow control is tested in auto mode at a set value of 38.0 m^3/h, which is obtained with a valve opening of 59.7%. The error (0.5 m^3/h) between set point value and process value is observed.

(ii) Online Temperature Control of Hot Water Tank
Hot water tank temperature controller is kept at the set value of 65° obtained with the valve opening of 11.7%. Thus, in auto mode process, value matches with set point value.

Conclusions
Hot water flow control loop designed on the DCS is able to control water flow (±0.5 m^3/h of set point value) in washers so as to reduce the residual acidity. Hot water temperature control loop designed on the DCS is able to maintain water temperature in washers at the set point value. This helps process engineers to have optimum utilization of ClO₂ to obtain a particular degree of delignification by increasing the reaction rate and thereby reducing the residual chemical.

References