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AUTOMATED CONTROL SYSTEM FOR PAPER MANUFACTURING

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Abstract: *Sheet products are manufactured, in general, using fluid state material and making it to flow onto a conveyer. This paper presents a paper manufacturing control system designed to obtain a constant thickness for the resulting paper. The control system is composed of a number of Modbus compatible actuators, a Siemens PLC, a scanner and a Honeywell Da Vinci Quality Control System. The Honeywell system receives information about thickness from the scanner, analyzes it and sends new actuator positions to the PLC. The PLC controls the actuators' position to ensure that the thickenss is constant.*
Key words: *paper manufacturing, automated control, modbus*

1. INTRODUCTION

In general, sheet products (paper, plastic, metal, etc.) are manufactured by making the material, in a fluid state, to flow in a controlled fashion onto a conveyer or something similar. For example, sheet plastic is often manufactured by extruding heated plastic through a die onto a conveyer belt. Paper is almost always produced by causing paper pulp slurry to flow from a head box onto a moving wire.

In sheet materials manufacturing, a thickness regulating member is normally used to insure that the thickness of the produced material is uniform both in the direction in which the material travels and in the direction perpendicular on the travel one.

In the case of paper, the thickness regulating member is named "slice lip" and in the case of plastics, this thickness regulating member is usually called "die". In both cases, the position of the thickness regulating member is controlled by actuators, which in the case of paper manufacturing include slice rods.

The application teaches a system to control a thickness regulating member used in the manufacture of sheet products. The position of the slice lip is controlled by a number of actuators connected to the slice lip and to the head box and spaced apart from one another along the length of the slice lip.

Our main research is referring to interconnecting two different types of systems: Siemens with Honeywell QCS and also Siemens with the Modbus actuators. The data exchange between the two systems (Honeywell QCS and Siemens) is made using a Siemens DataBase addressed identically on the PLC an on the OPC Server. The Honeywell system can read/write this DataBase which is then automatically updated on the PLC.

2. PRESENTATION OF THE APPLICATION

The entire system architecture can be seen in Fig. 1. This application was developed to improve paper quality by automated control of cellulose launching profile. The system starts with a certain launching profile (a specified position for the actuators' canes) that represents the lip deformation. After going through the wet pressing machines and the drawer, paper reaches the wrapper. Before it, a scanner, for measuring paper thickness and humidity, was mounted. This scanner sends humidity and thickness data to a Honeywell Quality Control System (QCS). This QCS processes the data received from the scanner and, according to an algorithm, computes the new launching profile.

The Siemens PLC has a permanent connection and communication with the actuators using the Modbus protocol (Margineanu, 2005). As long as the actuators current position is the same with the desired one, the PLC only reads information from the Modbus Slave Actuator Controller. This information is: slave device address, real position, working temperature, working voltage and error messages.

When the QCS changes the cellulose launching profile and modifies the actuators' positions in the PLC's database, the PLC computes the number of steps needed to be executed and sends this number with sign to the Slave Actuator Controller. The sign represents the movement direction. The Slave Actuator Controller controls the step by step motor and, after the position has been reached, resets to 0 the memory location that contains the value received from the PLC. The PLC will send another positioning command only after the previous one had been finished (value 0 in the corresponding memory location).

The data exchange between the QCS and the PLC is made through an OPC server (Commissioning PC Stations – Manual and Quick Start, 2005). Both the QCS and the PLC's program are designed to protect the lineal against permanent deformations. This is made by not allowing a difference of more than 300 microns between the positions of two consecutive actuators.

One of our goals was to develop a fail safe, secure system using Modbus communication for reading and writing the system variables needed for configuring it. Using this technique the work for creating the hardware infrastructure (connection wires, etc.) was easier. The communication cable (2 wires) was the only cable needed to connect to the actuators and the other components of the system. In comparison, a standard control system composed of LVDT sensors and actuators, would require for each pair of sensor and actuator a number of 4 connection cables.

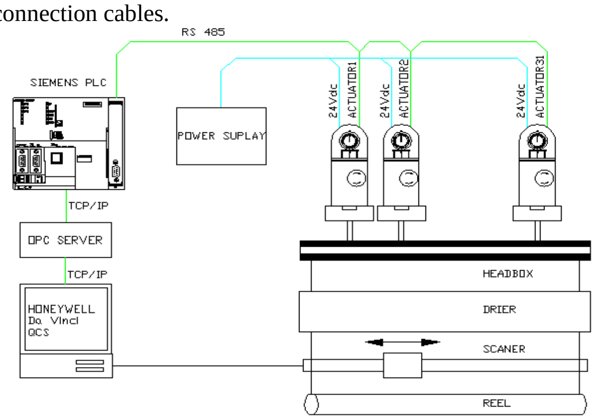

Fig. 1.System architecture

3. QUALITY CONTROL SYSTEM

Da Vinci is Honeywell's Quality Control System (QCS) for the Pulp & Paper industry.

The Quality Control System (QCS) serves many purposes since it is providing continuous measurement of the product in real-time. Data from the QCS scanning sensors is processed to support the following functions:

- Management and process information reporting.
- Honeywell's Da Vinci system provides a wide range of advanced reports that are available for immediate use to document machine production and paper quality.
- Network Integration: It goes without saying that the Honeywell Da Vinci system is able to support the data requirements of other mill-wide and business systems with network OPC connectivity.
- On-line data Analysis.
- Supervisory Control functions receive the data from the scanning measurements and then control the process to optimize these properties of the sheet.

4. THE CP341 COMMUNICATION PROCESSOR

The Siemens CP 341 communication processor allows data exchange between programmable controllers or computers by means of a point-to-point connection (CP341: Point-to-Point Communication, Installation and Parameter Assignment, 2000).

The main functionalities of the CP341 communication processor are:

- Transmission rate up to 76.8 kbaud, half duplex.
- Integration of the most important transmission protocols in the module firmware: 3964(R) procedure, RK 512 computer connection, ASCII driver.
- Custom parameterization of the transmission.

As said before, for communicating with the actuators, a Modbus driver for the CP341 is used.

The transmission protocol used is the GOULD - MODBUS Protocol in RTU Format (Loadable Driver for Point-to-Point CPs, Modbus Protocol, RTU Format, 2003).

Data transmission is carried out in accordance with the Master-Slave principle. The CP341 initiates the transmission (acts as the Master on the RS485 network), and after outputting a request message it waits for a reply message from the slave for the duration of the reply monitoring time set.

The structure of Modbus messages is the following:

- Slave Address (Byte). The slave address can be within the range 1 to 255 and is used to address a defined slave device on the network (bus).
- Function Code (Byte). The function code defines the meaning and structure of the Modbus message.
- Data Field (nByte). The data field is used to transfer specific information according to the function code, such as: byte count, coil start address, register start address, number of coils, number of registers, etc.
- CRC Check (2 Byte). A Modbus message end is identified by the means on the CRC 16 checksum.

5. THE MODBUS SLAVE ACTUATOR CONTROLLER

The communication with this contoller is entirely based on reading from and writing on physical memory positions (RAM, EEPROM). Commands are constructed according to Modbus RTU specifications. Since all communications are based on register reads and writes only functions 3 and 16 of the Modbus RTU protocol are implemented.

All registers are handled as 16-bit variables as requested by the Modbus RTU protocol (Modbus Protocol Reference Guide, 1996). Shorter variables have their hi-bytes set to all zeros. Writing to those hi bytes will have no effect.

Longer variables are located in successive registers and are written to and read from the most significant byte first and the least significant byte last.

Some of the registers available on the slave actuator controller and their meaning are:

- Bus address (bus address of the actuator). Addresses 1 to 240 can be used. Address 0 is broadcast address that is acted upon by all actuators but any actuator sends no reply.
- Motor speed. Sets motor movement speed together with Step Mode. Rotational speed for a 1.8°/fullstep motor [rps] = 96.15 / ((motor speed + 1) x 2^(Step Mode)).
- Step mode. The 2 lowest bits set the motor stepping resolution. This stepping resolution can be: 0 (full stepping. E.g. a 1.8°/step motor rotates a full 360° when stepped 200 times), 1 (half stepping. E.g. a 1.8°/step motor rotates a full 360° when stepped 400 times), 2 (quarter stepping. E.g. a 1.8°/step motor rotates a full 360° when stepped 800 times) and 3 (eighth stepping. E.g. a 1.8°/step motor rotates a full 360° when stepped 1600 times).
- Motor move. Signed 32 bit integer used to command motor movement. Writing a value causes the motor to be stepped "Motor move" times. The direction of rotation is reversed when the sign of the written variable is reversed. A write with motor moving will override previous movement.
- Temperature. Internal temperature measurement result. Actual temperature [°C] = Value x 0.4.
- Ext meas. 10-bit measurement of external analogue input. Full range 4.095V.
- Feedback. 16-bit feedback voltage measurement result. 0 = 0V, 65535 = 4.095V.
- CRC err ctr. CRC error counter. Incremented when an invalid message has been received.

6. CONCLUSION

The use of Honeywell's Da Vinci Quality Control System and of the PLC driven Modbus compatible actuators has resulted in a modern and reliable solution for a paper manufacturing line.

A considerable amount of process information is available. This information can be used to improve the entire system and also to detect any faults related to actuators or any other equipment of the system.

The launching system's increased speed has produced a considerable increase in paper quality.

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