

# Process Automation System Development of Lyocell Staple Fiber Plant Based on PlantPAx

Yongwei Li<sup>1,a</sup>, Kuan Yu<sup>2,b</sup>, Bo Zhu<sup>3,c</sup>, Ronghuan Han<sup>1,d</sup>,

Yubo Li<sup>1,e</sup>, Jianlong Wang<sup>1,f</sup>

<sup>1</sup> Shandong Yingli Industrial Co., Ltd, P.R.China

<sup>2</sup> School of Material Science and Engineering, Shandong Jianzhu University, P.R.China

<sup>3</sup> School of Material Science and Engineering, Shandong University, P.R.China

<sup>a</sup> liyongwei@sdonly.com, <sup>b</sup> 13605314535@139.com, <sup>c</sup> zhubo@sdu.edu.cn,

<sup>d</sup> hanronghuan@sdonly.com, <sup>e</sup> liyubo@sdonly.com, <sup>f</sup> wangjianlong@sdonly.com,

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**Abstract:** A process automation system based on PlantPAx platform was developed for a lyocell staple fiber plant with annual capacity of 15000 tons. The system has realized simple operation and optimization of the plant, full-automatic startup and shutdown of the plant units, control and diagnostics of malfunctions, logging and documentation of all operation sequences and process data. With the application of distributed architecture, redundant technology and Ethernet/IP industrial Ethernet, it has shown high performance and high reliability during the pilot production in 2015.

## Introduction

Lyocell is a form of rayon which consists of regenerated cellulose fiber made from dissolving pulp using dry jet-wet spinning. Since there is little waste product during the manufacturing process, lyocell is called the Green Fiber of 21<sup>st</sup> century.

A lyocell staple fiber plant with annual capacity of 15000 tons has been building in Shandong, China since 2013. There are more than 5000 control points in the plant, as listed in Table 1.

Table 1. Control points list

	Analog Input	Analog Output	Digital Input	Digital Output
Instruments & Valves	720	244	841	499
Motors(Direct Start)	0	0	2167	580
Inverters	404			

So an autonomous, high-performance process automation system must be designed to achieve the required automation degree.

## System Architecture

The process automation system was designed based on Rockwell Automation's PlantPAx platform. It has a modular multi-layer structure to ensure the performance, scalability and reliability, as shown in Fig. 1.

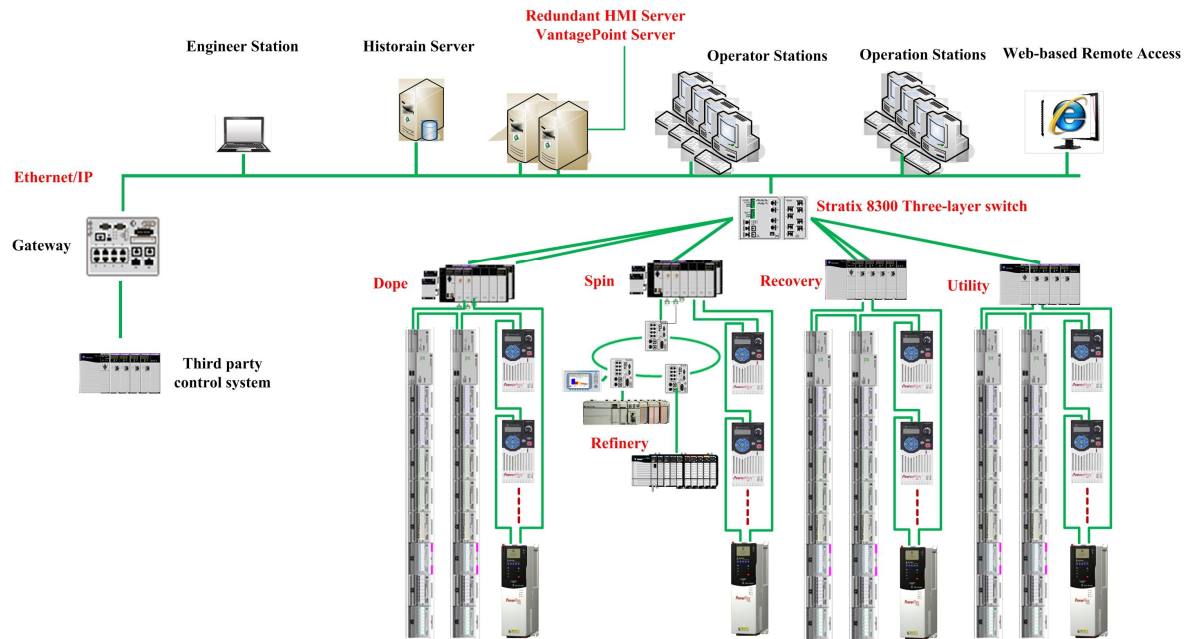


Fig.1 System architecture

The management level consists of six operator stations (computers with FactoryTalkView SE Client installed), two redundant HMI servers (servers with FactoryTalkView SE Server installed), one historian server (server with Historian Server and Vantagepoint Server installed) and two engineer stations (laptops with FactoryTalkView Studio and RSLogix5000 installed)<sup>[1]</sup>.

The process level is divided into five groups according to the process flow, including:

- Dope: process area 10-20, cellulose pre-treatment and dope preparation.
- Spin: process area 30-40, spin, take-up, tower washing and cutting.
- Refinery: process area 50-60, after-treatment, cross-linking and drying.
- Recovery: process area 70-80, purification and evaporation.
- Utility: process area 90-110, auxiliary process.

Each group has one or more ControlLogix5571 program controller as the process kernel. Distributed 1794 Flex I/O modules which provide Removal and Insertion under Power and module level diagnostics have been used for the I/O level.

Compared with traditional Profibus-DP, Ethernet/IP has faster speed, better anti-interference ability and lower cost. Compared with other industrial Ethernet, Ethernet/IP realizes real-time control without modifying standard TCP/IP protocol. So we choose Ethernet/IP as the bus system between management level, process level and I/O level.

Any third party control system that doesn't support Ethernet/IP can communicate with the process automation system via gateway.

Various redundant technologies have been adopted in this plan to realize high reliability, including redundant controllers, redundant HMI Servers, Ethernet/IP DLR (Device Level Ring), REP (Resilient Ethernet Protocol) etc.

### Ethernet/IP Network Configuration

Since Ethernet/IP has been adopted as the system bus and field bus, all the operator stations, servers, program controllers, 1794 Flex I/O adapters and inverters exchange data with each other via Ethernet/IP.

The overall Ethernet/IP network configuration is shown in Fig. 2.



**Program Controller Software Development.** Program controller software was developed using Rockwell RSLogix5000. The key of program controller software includes inverter speed control, analog signal control and sequence control.

**Inverter Speed Control.** Powerflex series inverter can be inserted into an RSLogix5000 project as a new hardware module, and related tags will be automatically generated [3]. By assignment to a tag or reading a tag value, we can get the inverter status and control inverter speed.

For take-up machine and tower-washing machine, torque control is preferred. If the active torque is equal or larger than torque settings, the inverter speed will automatically reduce to avoid machinery damage.

**Enhanced PID Control.** Enhanced PID (PIDE) Control is mainly used for analog signal control, such as temperature, pressure and liquid level. The PIDE uses a velocity form algorithm of the PID equation that the loop works on change in error to change the output. The velocity form algorithm is much easier to apply for more advanced applications such as adaptive gains or multi-loop selection [4-5]. This algorithm is shown as Eq. 1.

$$CV_n = CV_{n-1} + K_p \Delta E + K_i E \Delta t + K_d \frac{E_n - 2E_{n-1} + E_{n-2}}{\Delta t} \quad (1)$$

Where:

CV= Controlled Variable

E=Error

$\Delta t$ =Update time

Kp=Proportional Gain

Ki=Integral gain

Kd=Derivative gain

The Enhanced PID also supports cascade/ratio control, as shown in Fig. 4.

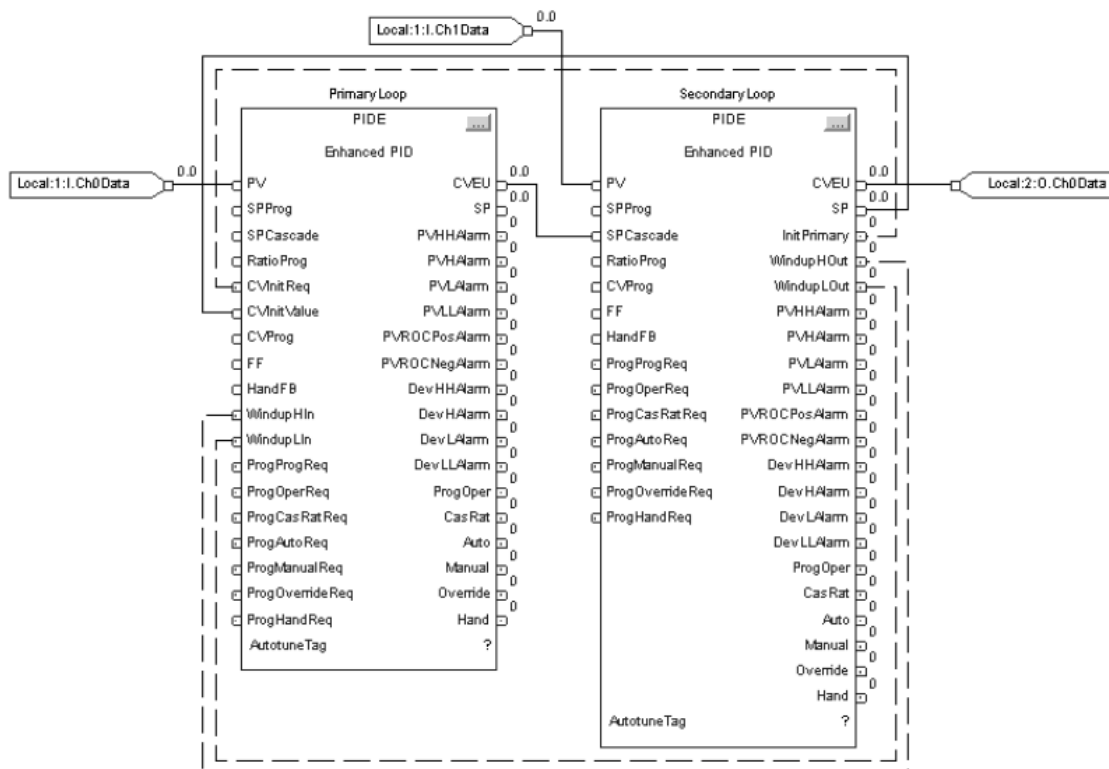


Fig. 4 PIDE cascade/ratio control

**Sequence Control.** Sequence control is applied in the following process area, such as process water preparation, pulper, enzyme preparation and pulp dewatering. We realized sequence control by using Rockwell Automation Sequencer Object (P\_Seq) [4], as shown in Fig. 5.

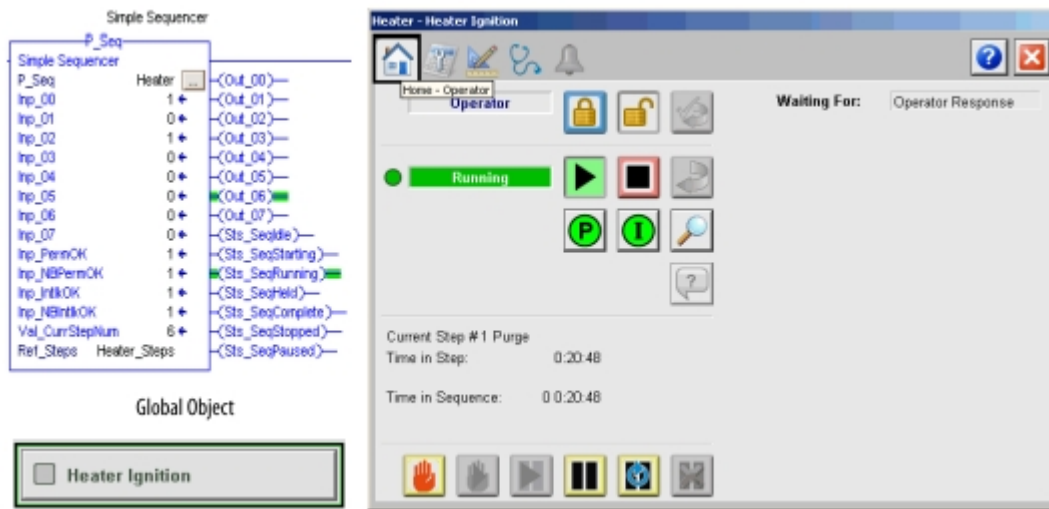


Fig.5 Sequence control

PlantPax platform provides perfect and powerful library for advanced process control, so some traditional complex problem (such as sequence control, modular multivariable control) can be solved easily.

## Conclusions

The process automation system has been put into operation since March 2015. The pilot production has shown that:

- (1) This design has shown high performance, reliability and scalability.
- (2) This system realized simple operation and optimization of the plant, full-automatic startup and shutdown of the plant units, control and diagnostics of malfunctions, logging and documentation of all operation sequences and process data.
- (3) PlantPax platform is powerful and easy to use, and can shorten development cycle of process automation system.

## References

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