Optimising Process Control for Higher Productivity in Fiberline Operations at ITC PSPD., *Unit* : *Bhadrachalam.*

Keshav Dutt Sharma and Ranjit Kumar K

ABSTRACT

Increasing competition and tougher economic conditions are the challenges for the paper industry in the post globalization era. Increasing operational efficiency is the call of the day for sustaining profitability and survival. Operations have to run at best of their capacities to achieve higher productivity, more availability and best quality. Novel technologies have to be adapted in achieving these objectives . Advanced Process Control is one such tool which will reduce standard deviation of the process variables and shifts the mean closer to hardware constraints. Application of Multi Variable Process Control (MVPC) tool which has the built in intelligence to look simultaneously at two or more process variables and to choose, in a given situation is advisable. The advance control techniques push the processes to their constraints and extract the maximum from the process unit without compromising on product quality and safety. The advanced control algorithm balances performance and robustness objectives against process economics to minimize costly process movement. The implementation of advanced process control in a plant reduces process variability and allows plant to run closer to their operating constraints which in turn reduces energy use, as well as raw material and waste processing costs. It also improves product yield and quality, safety and productivity while lowering emission levels. In this direction ITC PSPD, Unit: Bhadrachalam has gone for APC and reaping the benefits.

INTRODUCTION

In an environment of increasing international competition where countries with lower production costs quickly catch up technologically, new thinking is required in order to meet the competition. A proactive way of meeting the increasing competition is to focus on maximising the utilisation of existing technology and, faster than the competitors, being able to continuously introduce and make use of new technology. This means much more than just investing in new equipment. The ability to optimise or improve a process is dependent upon the ability to control the process. The ability to control the process is dependent upon the access to reliable and valid measurements. While many components of the chemical industry have rapidly exploited model-based methods for improved operation, the pulp mill operation has lagged behind. The pulp mill process is comprised of several important material and energy recycle loops, which lead to highly interactive multivariate process behavior among different unit operations. This characteristic of the process motivates a plantwide approach to both control and optimization problems.

BACKGROUND

The pulp mill in ITC PSPD, Unit: Bhadrachalam is the first mill in india to adopt ECF technology and was commissioned in September 2002 with a capacity to process 330 MT of blown pulp per day. Several focussed improvement projects have been taken up in due course for debottlenecking and enhance Productivity and Quality. Frequent minor shutdowns in the Washing section due to tripping of BSW's and variations in final Brightness of bleached pulp due to fluctuations at back end have been a concern and the driving force to go for APC. The main object of the project is to increase the thruput in the washing section and reduce the standard deviation of the brightness and pH of the pulp.

The Fiber line unit consists of the following sections:

- **Hot Screening and Washing**
- **Oxygen de-lignification**
- **Post ODL Washing**
- **Bleaching**

WHAT IS ADVANCED PROCESS CONTROL

The traditional control philosophy, what is called "instrumentation" in the chemical industries, is based on single-loop control (sometimes called SISO-single input, single output). Each process operation has a number of independent or single loops for feedback control of temperatures, pressures, flows, liquid levels, and sometimes compositions. The term "single loop" means there is one measurement, one controller and one final control element, usually a valve. A process plant has thousands of such control loops. The controllers usually have little or no logic circuitry to tie the many loops together. As a consequence the operators must perform some of the operations with the control valves switched to "manual", and has to implement process logic by switching in and out of "automatic" mode. To avoid the limitations of single loop design and to provide more flexible and sophisticated process operating logic than can be implemented by human operators, an approach called ***"multivariable control"*** is used. A multivariable control or APC, is one that has the built in intelligence to look simultaneously at two or more process variables and to choose, in a given situation, the best of several programmed strategies (algorithms) for manipulating one or more control valves (or other final control elements).

APC can be defined as ***"Use of logic, predictive algorithms, thermodynamics, calculations, real-time control models and other control techniques to achieve economically related plant operating targets".***

The Multi-variable controller (MVPC) enables handling of process disturbances smoothly, reduction of transient time and at the same time keeping the product qualities within the

ITC Ltd., PSPD, Unit : Bhadrachalam
Vill. Sarapaka-507 128, Dist. Khammam (A.P.)

specifications (constraints). Instead of having operators manually adjust control units for specific variables, APC provides generalized models that automate regulatory and constraint control. These models are dynamic models of the process that can predict how the process will respond over time to changes in basic operating conditions. They allow operators to prepare in advance for possible violations of operating limits, to take advantage of constraint relaxation to maintain process conditions as close as possible to their optimum. Hardware permits APC to automate the process control with speed, precision, and reliability that are completely beyond the capabilities of human operators.

ADVANTAGES OF ADVANCED PROCESS CONTROL

The advantages of implementing Advance process control techniques are manifold, few of which are as follows:

i). The advance control techniques push the processes to their constraints and extract the maximum from the process unit without compromising on product quality and safety.
ii). The advanced control algorithm balances performance and robustness objectives against process economics to minimize costly process movement.
Iii). Advanced control techniques allows tailoring of control performance to meet process needs.
iv). Advanced control algorithms provide optimum control performance for changes in both control targets and process disturbances.
v). Advanced control implementation reduces stabilization time during furnish change, which in turn results in minimum off quality product.
vi). The feed forward action of the advance control algorithms helps to safe the plant from possible damage by adjusting the operating parameters before the disturbance actually reaches downstream.
vii). Advanced control algorithms allows applying dead time compensation techniques to compensate for long delays in process response, permitting tighter control.

APPLICATIONS OF APC

Blown pulp is produced from conventional batch digesters. At the end of every batch the digesters are blown into blow tanks where pulp slurry is diluted to a level which can be pumped into a common tank called LC (Low Consistency) tank. Fibreline draws pulp from blow tanks and is a continuous process.

In washing section, it has been noticed during the base case study that there is lot of variations in LC tank consistency which directly affects the production rate.

The parameters affecting the consistency are:

i). Blow from the digesters, i.e., the feed pulp consistency
ii). Dilution in the blow tank from the black liquor buffer tank
iii). Dilution in the LC tank (FFIC5002)
iv). Line dilution (QIC5003)

At high LC tank consistency, BSW1 motor current shoots up and the plant gets tripped and while at low consistency, the production rate gets affected.

In ODL section, when the reactor feed standpipe level increases, the reactor pressure has to be released immediately; else the plant would get tripped. This has also been happening sometimes.

Brightness and pH are two critical parameter properties of the pulp which have to be maintained at every stage, i.e., PO1, D_0, E_{OP} and D_1. These properties are controlled by the use of some of the costly chemicals like ClO2, NaOH, and H2O2. It is important to note that these bleaching reactors are basically plug flow reactors and mainly catalyzed by H2SO4 or NaOH which helps to maintain certain pH. The frequency of measurement was 1 hour of pH and 2 hours for brightness. It has been found that there have been many cases of spec violation of these two properties due which the standard deviation was more. This results into off-spec generation of the final pulp and/or more chemical consumption in these stages so as to maintain the final pulp brightness

• Washing Section

o To maximize the plant thruput
o To reduce the variations in LC tank consistency
o To maintain the blow tank dilution ratios
o To maintain the BSW1 motor load and vat pressures of all the three BSW's and reduce the thruput if it exceeds the max limit
o To push the plant to the optimum set of operating limits

• ODL Section

o To maximize the pressure in both the Oxytrac reactors
o To maintain the BSW3 standpipe level and reduce the reactor-1 pressure if the level reaches the max limit
o To minimize the steam usage by maintaining the reactor-2 temp to the lower side of the limit
o To maintain PO1 pH and minimize the NaOH consumption by keeping the pH towards the lower limit
o To maintain the PO1 vat pressure

• Bleaching Section

o To maximize the thruput from PO2 press
o To maintain all the vat pressures of PO2, D0, Eop and D1 presses
o To maintain Eop tower level
o To maximize pulp consistency from the unbleached tower
o To maintain pH and brightness of the pulp at D0, Eop and D1 stages
o To reduce the chemical consumption while maintaing pH and brightness at each stage

APC IMPLEMENTATION METHODOLOGY

i. Kick-Off

The Project Schedule and execution methodology is fixed. Project execution team is introduced.

ii. Pre-Test

Various process parameters are tested for step response. The step response is observed by varying the process parameter, which is under observation, by pre determined units while keeping other parameters steady. Based on the response of the system the functional design specifications are made for the controller. Also various defective/faulty plant instruments are noted down to rectify the same before the Plant Step Test.

Table-1
The standard deviation for PO1 pH

	DCS Period (APC-OFF)	APC Period (APC-ON)
Min	9.5	10.34
Max	11.12	11.02
Average	10.64	10.66
Standard Deviation	0.206	0.133

Table-2

	DCS Period (APC-OFF)	APC Period (APC-ON)
Min	19.04	20.64
Max	31.58	30.87
Average	24.64	24.02

There is a net reduction of 2.5% or 0.6 kg/T of NaOH during APC-ON period.

Table -3

	D0 pH		Eop pH		D1 pH	
	APC OFF	APC ON	APC OFF	APC ON	APC OFF	APC ON
Min	1.66	1.83	9.7	9.78	2.81	2.86
Max	3.11	3.67	11.86	11.71	4.7	4.3
Average	2.45	2.54	11.02	10.7	3.58	3.59
Standard Deviation	0.3074	0.2978	0.4081	0.428	0.3138	0.2410
Reduction in Standard Deviation	3.12%		-5.1%		23.2%	

iii. Functional Design

Based on the Pre-Test results the controller is designed. Also the complete design of the software/hardware layers are designed and submitted for approval. The design includes the number of controllers, control logics that will be implemented and MV (Manipulated Variable), CV (Control Variable) and FF (Feed Forward Variable) are specified.

iv. Primary Inferential Data Collection

During the Pre-Test the Lab data is collected for development of the inferential properties.

v. Inferential Development

Using the Lab data collected during the Pre-Test the Inferential Properties of various products are developed.

vi. Plant Step Test

Based on the design of the controller all the CVs are tested for the step response by varying the dependent variables, MVs. Also the response of the CVs for the changes of Feed Forward Variables (Also called as Disturbance Variable) is recorded. During this entire period the Lab samples are collected at regular intervals in order to get the capture the true model of the process plant.

vii. Inferential Fine Tuning

Using the Lab data collected during the Plant Step Test activities the inferential properties are fine-tuned.

viii. Model Simulate

Using the Step Response data the process models between the CVs, MVs and FFs are built using advanced software. These models represent the real picture of the process plant. Using the model the controller is built. The controller is then tested for the stability and proper functionality in simulation mode. If any discrepancy is found the model is rebuilt after through analysis.

ix. Commissioning the Controller

After the testing the controller, it is installed at the client site and tested for proper functioning by keeping it in open loop. After examining the controller performance it is taken in to line and commissioned.

CHANGES AFTER PRE TEST

Following changes were done in base layer control as a part of APC implementation project:

- The performance of PID loops related to consistency was reviewed and few loops were tuned again.
- The line size of inline dilution for LC tank consistency was changed from 50 mm to 80 mm and valve size was changed from 50 mm to 65 mm.
- The indication for inline dilution flow was also provided.
- The flow from FT2 tank to reject tank was stopped.
- The reject tank level control was cascaded with flow for LC tank ring dilution.

RESULTS

APC implementation has significantly improved the performance of the fiberline. Due to the improvement in process control and the operational convenience, the APC strategy has been well received by the operating crew.

Post implementation audit was conducted during October 2007 for quantification of the improvements in process contol achieved with APC. It was decided to compare one week data each for APC-ON and APC-OFF. The standard deviation was compared for the data segments with largely identical conditions during APC-ON and APC-OFF runs.

The results are summarized in below sections.

i). Washing Section

Savings

The total saving can be computed as below:

Avg Washing Thruput in DCS (May

Table 4., compares all the brightness statistics for two cases:
Table- 4

	D0 Brightness		Eop Brightness		D1 Brightness	
	APC-OFF	APC-ON	APC-OFF	APC-ON	APC-OFF	APC-ON
Min	58.2	57.5	72.1	72.2	84.0	86.2
Max	75.8	71.3	81.4	82.0	90.0	89.4
Average	66.86	64.31	78.05	76.77	88.02	87.74
Standard Deviation	3.7419	3.3123	2.025	1.9599	1.0649	0.8276
Reduction in Standard Deviation	11.48%		3.21%		22.28%	

end data) = 14.36 T/hr

Avg Washing Thruput in APC (Oct data) = 14.73 T/hr
Washing Thruput increase = 0.35 T/hr = **8 TPD**

ii). ODL Section

The below figure shows the PO1 pH with one week data in each case.

It can be seen that there is a reduction of 35% in standard deviation of PO1 pH during APC-ON period as compared to that of APC-OFF period.

Savings

NaOH is used to control the pH at PO1 stage. The consumption data of NaOH is shown in table 2.

iii). Bleaching Section

It can be seen that the variation in D1 pH are very low during APC-ON period compared to that of APC-OFF period.

The standard deviations for two periods are shown in table 3 for all the pH.

It can be seen that the reduction in standard deviation of final stage (D1) pH is very significant which goes to the papermaking process.

It can be seen that there is a significant reduction of standard deviation in final stage (D1) brightness which would result in a better stabilized product and less generation of Off-spec bleached pulp.
The post implementation audit results into:

- 8 TPD of thruput increase in washing section
- 35% reduction in standard deviation of PO1 pH
- 11% reduction in standard deviation of D0 Brightness
- More than 22% reduction in standard deviation of D1 Brightness and D1 pH

CONCLUSION

The comprehensive and flexible optimization opportunities provided by the APC has proven to result in improved productivity, reduced standard deviation of pulp brightness. This directly translates into equivalent savings and increased profitability.

ACKNOWLEDGEMENT

The author acknowledges his sincere thanks to the Management of ITC. Ltd., PSPD
Unit: Bhadrachalam, for permitting to present the paper at IPPTA Seminar/AGM 2008.