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A Step-By-Step Approach toward Advanced Process Control System in Petrochemical Industry

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Abstract: APC (advanced process control) system was successfully applied to aromatics, ethylene and PP (polypropylene) processes of STC (Samsung Total Petrochemicals). The plant performance such as production rate and energy consumption was highly improved by several percent and quality consistency was secured especially for PP process. This implementation will be a base of future plant intelligence system constructed by connecting with ERP (enterprise resource planning) and SCM (supply chain management) systems.

Key Words: Advanced process control system, Petrochemical industry

1. INTRODUCTION

Recently, petrochemical industry has been undergoing a drastic change in its operation mode and APC system now comes into the spotlight not only as an efficient process operating tool but also as a part of CIM (computer integrated manufacturing) system which also includes ERP, SCM, and RTO (real-time optimization). With cumulated experience and well developed commercial software packages, it is not surprising news that APC has been successfully implemented in petrochemical processes. STC also endeavoured to make the APC system as a company's standardized tool of plant operation and successfully implemented APC to its main processes such as ethylene process, aromatics process, and PP process since the year of 2002. In this paper we are going to briefly describe how APC systems were implemented in the main processes of STC.

2. COMMERCIAL APPLICATION

2.1 Ethylene and Aromatics Processes

STC's ethylene and aromatics processes are integrated through feed, by-products and utilities. The key aspects that APC system is controlling to increase the productivity and efficiency are as follows:

- Ethylene process

1. Cracking furnace severity (propylene/ethylene ratio): Feed stock composition is analysed with NIR (near-infrared) system and on-line cracking furnace yield calculator keeps estimating effluent composition. APC system follows its economic severity target which RTO system has sent.

2. Compressor power: The capacity of three main compressors (charge gas compressor, propylene refrigerate machine, ethylene refrigerate machine) in ethylene process is one of the key factors which decide process throughput. One top supervising controller checks all sub unit status and push the throughput to its possible limit.

3. Quench section stability: Heat recovered in quench section is big source for other unit. Stability of this section is key aspect for whole process operation variation. APC system reduces this variation. It makes process productivity increased and energy consumption decreased.

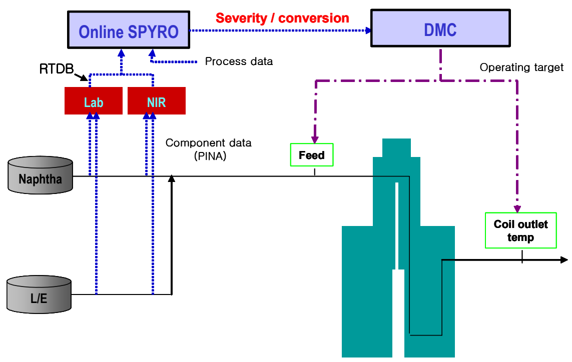

Fig. 1. Block diagram of APC system for ethylene process.

- Aromatics process

1. Reformer aromatic conversion: Feed stock and reactor effluent composition are analysed with NIR system and amount of coke formation, reactor tube temperature, catalyst pinning margin in reactor are estimated with on-line application. APC system maximizes its throughput and conversion target by RTO system obeying those key constraints.

2. Feed stock variation: STC's imported feed stock varies its contents with its origin. This gives a big disturbance to process. APC system reduces this variation. It makes process productivity increased and energy consumption decreased.

3. Distillation column: Separation processes, mainly distillation columns are highly integrated though Pinch Project and use over 50% of total complex utility. One

column unstable operation may cause many other column instability and energy inefficiency. APC system controls those columns spec tightly and handles disturbance so that large amount of utility usage can be reduced.

And STC is now developing optimization system integrating those two processes so well developed APC system could support the system.

The performance of APC system applied to aromatics and ethylene process is summarized in Table 1.

Table 1. Summary of APC performance for aromatics and ethylene processes.

Aromatics		Ethylene	
Increase of throughput	3%	Increase of throughput	2.5%
Decrease of energy consumption	3%	Decrease of energy consumption	1%

APC system performance is checked weekly with RTDB (real time database) application by formulated KPI (key performance index) which shows the process deviation from its control target. Operation status monitoring and adjustment is possibly done through web-based application.

2.2 PP Process

STC's PP process consists of successive two bulk slurry and two FBRs (fluidized bed reactors). Main product is hetero-phasic copolymer whose MFR (melt flow rate) ranges from 0.5 to 27 g/10min. The polymer properties to be controlled are MFR, ethylene content, ethylene propylene rubber content and intrinsic viscosity. To maximize production rate under safe operation, the level of overhead condenser for 1st slurry reactor, pressure difference between 1st and 2nd slurry reactors and powder discharge rate from 1st FBR have to be considered as constraints in the optimization of catalyst injection flow rate. Fig. 2 shows the overview of STC's PP process.

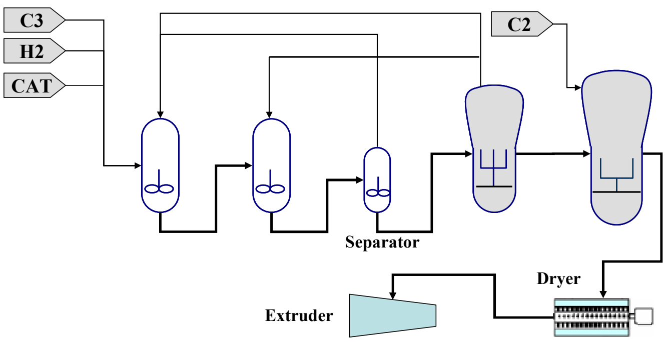

Fig. 2. Process flow diagram of STC's PP process.

Neural network process model was identified to estimate future behaviour of total 11 controlled variables. In the model identification, one year operation data including real lab analysis of polymer properties were used. The identified process model was also used in VOA (virtual on-line analyzer) system to provide controllers with estimated polymer properties every minute. A cascade control scheme was designed for effective control of PP process. QC controls polymer properties and production rate by optimizing controlled variables of GC. GC calculates the targets of temperature, pressure, and flow rates and then the targets are transmitted to DCS system every minute. Overall control scheme is illustrated in Fig. 3.

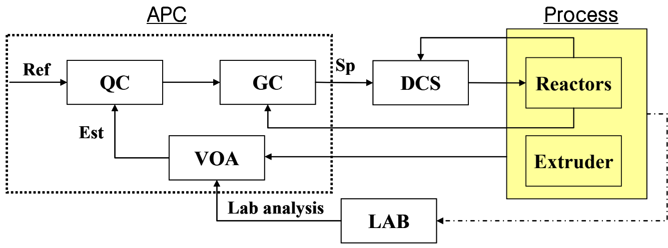

Fig. 3. Block diagram of APC system for STC PP process.

The performance of APC system applied to PP process is summarized in Table 2.

Table 2. Summary of APC performance for PP process.

Evaluation items	Result
Increase of production rate	3%
Improvement of quality consistency	50%
Increase of fluff feed rate into extruder	5.7%
VOA estimation error	±2.9%

The improvement of quality consistency can be confirmed in Fig. 4 which shows MFR deviation between production lots of the same grade produced before and after APC implementation.

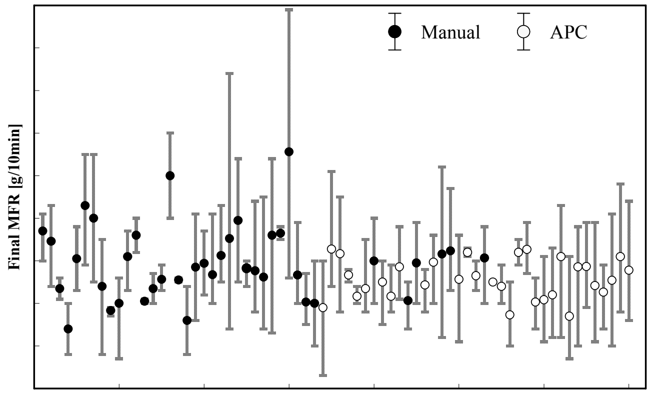

Fig. 4. Lot deviation before and after APC implementation.

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