

Advanced Process Control Implementation in Ammonia Plant



Rashtriya Chemicals & Fertilizers (RCF) of India successfully implemented an Advanced Process Control (APC) upgrade in their 1,500 TPD Ammonia Plant in October 2003. RCF realized a significant reduction in energy usage and steam to carbon ratio.

Benefits

RCF successfully implemented Honeywell's Model Predictive Control (MPC) solutions to achieve these key benefits:

- 3% reduction in steam to carbon ratio from 3.59 to 3.48.
- Significant energy savings by reducing excess oxygen in flue gas by 20%
- 95% reduction in the recycle stream of the naphtha de-sulphurization section.
- Exceeded the guaranteed 50% reduction in the specific energy consumption for the ammonia line 1 plant. Delivered a 0.6% reduction compared to the promised reduction of 0.4%.
- Stabilized loop hydrogen concentration by controlling the hydrogen to nitrogen ratio.
- Increased plant load and operator acceptance in spite of the continued fluctuations in the natural gas feed flow, pressure and specific gravity.

Introduction

Rashtriya Chemicals and Fertilizers Ltd. (RCF), operates a large-scale urea-manufacturing complex with an annual capacity of 1.48 million tons. The urea is manufactured in three trains of equal capacity, and uses ammonia stripping technology supplied by Snamprogetti, Italy. Two trains of ammonia plants, each with a capacity of 1,500 tons per day (TPD), produce the ammonia and carbon dioxide necessary for urea production. Haldor-Topsoe, Denmark supplied the technology for the dual feed of naphtha and natural gas.

Each of the ammonia plants is comprised of the following units:

- Hydro desulphurizer
- Primary reformer
- Secondary reformer
- Synthesis reactors
- Carbon dioxide removal section
- Methanator
- Ammonia synthesizer

The Challenge

RCF's objectives for the APC implementation were:

- Minimization of specific energy consumption.
- Stabilization of plant load – in spite of fluctuations in natural gas pressure, flow and quality.
- Optimization of the naphtha stripper column operations with respect to steam consumption in the reboiler.
- Minimization of hydrogen circulation by maintaining the minimum hydrogen to naphtha ratio in the de-sulphurization reactors.
- Maximization of natural gas, against naphtha, in the total feed to the plant. This is subject to the availability of natural gas.
- Minimization of steam consumption by optimizing the overall steam to carbon ratio in the feed to primary reformer.
- Minimization of excess oxygen in the flue gas flow from reformer furnace and steam superheater.
- Minimization of methane slippage from secondary reformer.

The Solution

Honeywell's Profit Controller (Robust Multivariable Predictive Controller – RMPCT) was used in this project to meet the above objectives. Considering the plant's constraints, a combination of advanced regulatory control strategies and model-based advanced controls were implemented.

Advanced Regulatory Control (ARC) strategies were implemented by using Application Module (AM) based Control Language (CL) programming. These regulatory level strategies, detailed below, facilitate the functioning of Profit Controller-based strategies.

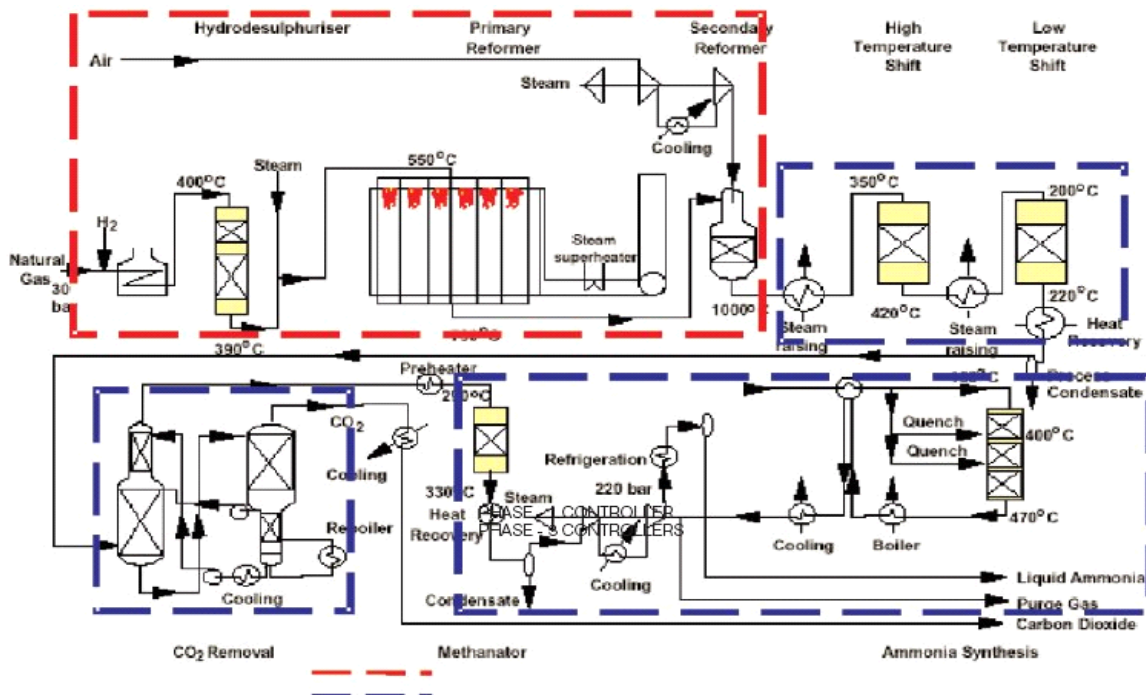
- Steam to feed ratio controls were implemented to achieve the desired value of steam mixing with feed, based on the ratio set from Profit Controller. This regulates the overall steam to carbon ratio in the feed to primary reformer.
- Primary reformer outlet temperature was previously controlled in manual mode. A soft controller was implemented in the AM, to regulate the fuel to the primary reformer. Naphtha flow, natural gas – flow & specific gravity and purge gas flow were considered as feed forward signals. Implementation of this strategy facilitated the control of methane % in the reformed gas mixture at the outlet of the primary reformer.

Profit Controller (RMPCT) strategies - Two RMPCT based applications were implemented to allow independent functioning of the following sections.

- **Profit Controller for naphtha de-sulfurization section.**
The Profit Controller designed for this section accomplished the minimization of:
 - Consumption of stripping steam by manipulating steam flow, while operating within the minimum reflux flow constraint
 - Hydrogen to naphtha ratio by manipulating the hydrogen rich synthesis gas flow, in both of the reactors.
- **Profit Controller for steam reforming section.**

The RMPCT application for this section accomplished the following:

- Maximization of feed subject to upstream pressure, availability of natural gas and carbon dioxide flow/slippage from the absorber.
- Minimization of overall steam to carbon ratio in the feed to the primary reformer by manipulating the ARC-based ratio controllers for the feed—both natural gas and naphtha.
- Minimization of excess oxygen in flue gases from primary reformer furnace and superheater by manipulating combustion air.
- Minimization of methane slippage from secondary steam reformer by manipulating the primary reformer outlet temperature, steam to carbon ratio, and secondary reformer process air.
- Optimization of hydrogen to nitrogen ratio in the feed to the synthesis reactor by manipulating the process air.



Benefit Evaluation: The baseline data was collected and consolidated from three continuous days in November 2003. The post APC implementation data were gathered during March 2004.

To arrive at the accrued benefits from the minimization of specific energy consumption, the two sets of data were compared.

The following table summarizes the comparative study of some critical parameters.

SI No	Controlled Variables	Nov 2003 (Pre PC)	Mar 2004 (During official test run)
1	Average NG throughput	26.4 TNCH	31.96 TNCH
2	Average Naphtha throughput	6.87 TNCH	4.51 TNCH
3	Average Specific Gravity	0.59 (0.0075)	0.63 (0.0063)
4	S/C ratio in the inlet of Primary Reformer	3.5967 (0.0453)	3.487 (0.047)
5	O ₂ % in the flue gas exit Primary Reformer	2.387(.2473)	1.847(0.2207)
6	O ₂ % in the Flue Gas exit Secondary Reformer	1.133 (0.563)	1.1 (0.204)
7	CH ₄ % in the Gas exiting Secondary Reformer	0.21 (.031)	0.25 (0.021)
8	Recycle in Naphtha Desulfurization unit	6.03 TNCH	0.3 TNCH

Comparative study of Specific Energy

SI No	Date	Production (T)	Specific Energy
1	14th Nov., 2003	1508	9.007
2	15th Nov., 2003	1516	9.05
3	16th Nov., 2003	1502	9.025
4	1st March, 2004	1515	8.871
5	2nd March, 2004	1515	8.999
6	3rd March, 2004	1525	8.856
7	4th March, 2004	1480	8.955

Summary

Start-up Date: October 2003

Honeywell's Profit Controller solution for RCF is another example of Honeywell's ability to deliver more than customer's expectations. The Profit Controller implementation on Ammonia Plant Line-1 at RCF yielded considerable improvements in the stability of plant operations. Furthermore, critical production parameters have been optimized while operating within the plant constraints. Based on the results, RCF decided to proceed with the implementation of the remaining phases and increased the scope of the project. RCF will not be including any guarantees from Honeywell for the subsequent phases.

More Information

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