

Roadmap for the control based optimization of ammonia & urea units

Christiaan Moons, IPCOS NV, Technologielaan 11/0101, B-3001 Leuven, Belgium
Tel: +32/16/393083; Fax: +32/16/393080; email: Christiaan.moons@ipcoss.com; website: www.ipcos.com

1 Introduction

IPCOS staff has visited many fertilizer companies throughout the whole world. IPCOS engineers have executed many feasibility studies, have installed, if appropriate, Advanced Process Control systems and offered many troubleshooting projects. It was during these visits that our staff noticed that the best road towards control based optimization is not always clearly understood. Several companies were clearly on the wrong road. This wrong road leads very often to unsuccessful projects or a least projects that did not match all the expectations of the customer. In some cases the expectations were met for only some months/years. Once an optimization project is finished the customer will get the benefits every year provided some maintenance is done on these applications. This is very often not considered during the investment discussions. It is proven by IPCOS in the past all over the world, that this optimization combines a low cost with a high benefit, provided it is being organized in a proper matter.. Based on our experience we want to show everybody that the best road towards this kind of optimization is through a masterplan.

The full scope optimization project will allow fertilizer producers to e.g. increase the ammonia plant throughput by 0.5% to 2% and in the mean time reduce the specific energy consumption by 0.5% to 1.5%. This is done by optimizing the controllers in the process computers (DCS) and by installing supervisory control systems on top of the current control system. For the urea plant similar results apply (throughput increase range up to 3%). It is not mandatory to implement every step of the masterplan. Several scenarios are possible as shown in Fig. 1. Sometimes it is better to execute only the first part of the masterplan. Every project phase will be explained below in detail.

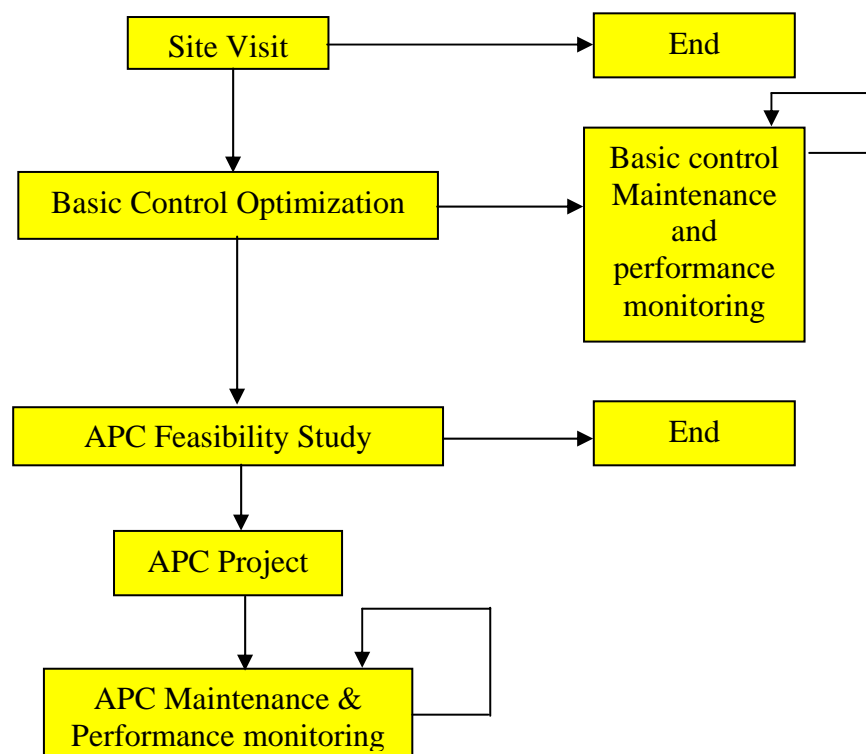


Fig. 1: the ideal road to process optimization.

2 The approach step by step

2.1 Site visit

During a 2 -3 day visit a control specialist with process know-how will visit the plant. During this visit, he will investigate the current situation regarding operations, controls and instrumentation by interviewing main shift operators, process engineers, production managers, instrumentation and control experts of the plant. If possible, available historical data will be analyzed. This short visit will allow specialist to get a clear picture of the actual situation and to propose a possible detailed masterplan. At the end of the visit a short report will be generated. In case the plant has no DCS or computerized control systems, the control optimization ends. Optimization of panel controllers can be done but is most of the time not efficient.

It is important that up-to-date P&ID and PFD drawings of the plant are available and that qualified personnel (operators, process and control engineers and even the plant manager) is available in order to acquire all relevant information.

2.2 Basic control optimization

During this project the current control configuration (control algorithms) is examined in detail. This is done by interviewing plant personnel but mainly by data analysis. Not only the PID parameters and control structures need to be investigated but also the actuators (Pumps, valves, etc) and the instruments. Based on the analysis new control structures are proposed and documented. The control algorithms are implemented, tested in detail and then put online. All the relevant loops are then tuned (changing PID parameters if needed). This requires that some test like step tests are applied on the units. Projects executed in the past showed that the units that were optimized operated in a much more stable way. This resulted in less alarms, less upsets during feedstock changes (hands-off operation!), reduced process variations (range from a factor 3 to 10). This resulted already in significant constraint pushing. There are known cases where the benefits of this project phase are equal or even higher compared to the APC phase itself. A nice example of such optimization is the design and implementation of a duty controller in an ammonia plant. The idea is to control the

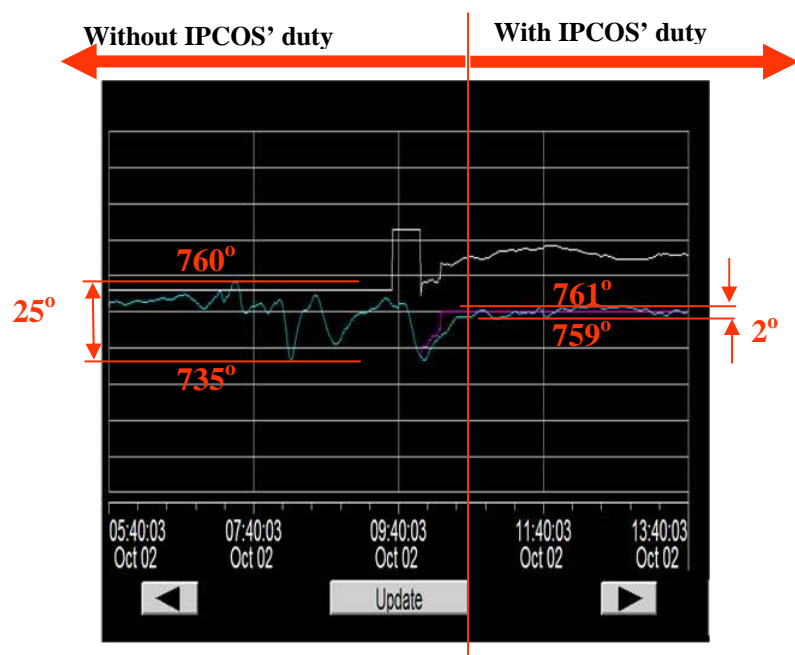


Fig. 2: Result of a duty controller.

feed and energy flows to the reformer based on feedforward models.

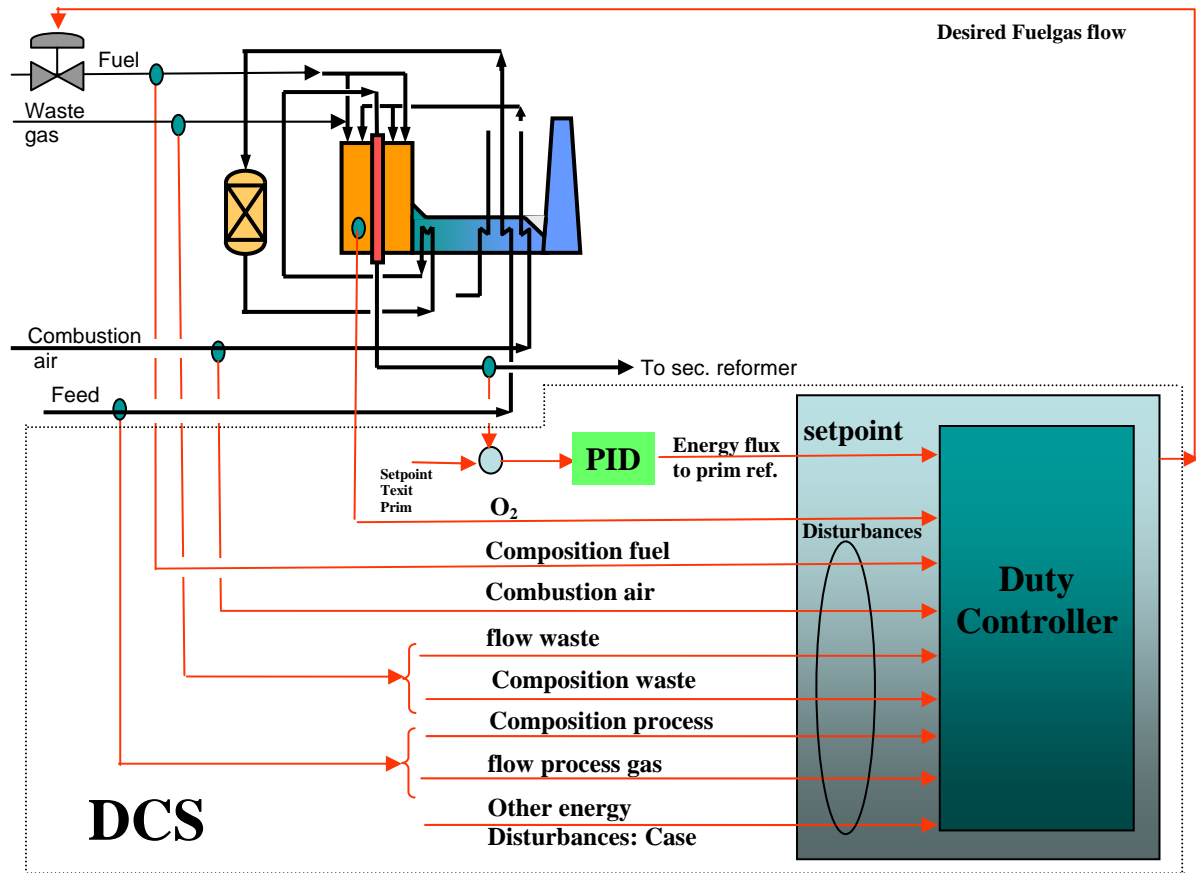


Fig. 3: Duty controller for a reformer.

This reduces the oscillation of the exit temperature primary reformer significantly as shown in figure 2. The diagram

2.3 Basic control maintenance and performance monitoring

PID loops that are perfectly tuned needs to be monitored on a regular base. The reason is that a plant is a living thing. E.g. On a regular base small adaptations are executed after failure of a certain component or device. After a major maintenance shutdown or revamp several larger units are replaced. Very often more powerful equipment replaces the old one. This equipment has another behavior that needs adjusted control parameters. Plant aging (fouling, catalyst efficiency decrease etc) is a continuous process that needs proper changing control parameters. Therefore it is mandatory that control engineers keep on monitoring the performance of the individual loops and adjust them when needed. Large plants like ammonia and urea units contain hundreds of loops. One can monitoring them manually on a regular base or based on demands of operators. A much faster and efficient way is to have an automatic system that does the performance monitoring 24 hours a day and seven days a week and generate reports on the actual performance. Based on these reports actions can be taken. Some applications like PlantTriage from Expertune even computes new control parameters in the background and provide them together with the reports. These systems need typically an OPC server on the DCS in order to operate. They can monitor units containing 25 loops up to 5000 loops.

2.4 APC Feasibility study

During a feasibility study APC specialists will investigate the potential benefits of further optimization by APC. It is possible to compute in advance what the benefits will be that APC will generate after the installation on the plant. This is done by investigating the current operations (interviews, data analysis). The results are prediction of increased throughput, reduction of specific energy consumption, increase in steam export, higher onstream factor, etc.

It is important to mention that APC feasibility studies need to be performed AFTER the basic control optimization. The reason is that a base case for APC is a plant with good basic control structures and parameters. Performing such a study before the optimization of the basic controls will provide very promising benefit forecasts. It is however very difficult to indicate if these benefits are coming from the PID optimization or from the APC itself.

During a feasibility study APC and process specialists will compute what shifts towards plant constraints can be achieved. E.g. how can the exit temperature of the primary reformer be stabilized and increased. How can the suction pressure of the syngas compressor be increased after the variations of this pressure are reduced by the APC. Based on static plant models these shifts are translated in less steam consumption, higher throughput and less specific gas consumption. These performance increases have to be combined with the economic data of the plant (cost of natural gas, selling price of steam, margins on ammonia etc). This of course under the assumption that the extra ammonia can be sold or can be send to the urea plant or nitric acid plant.

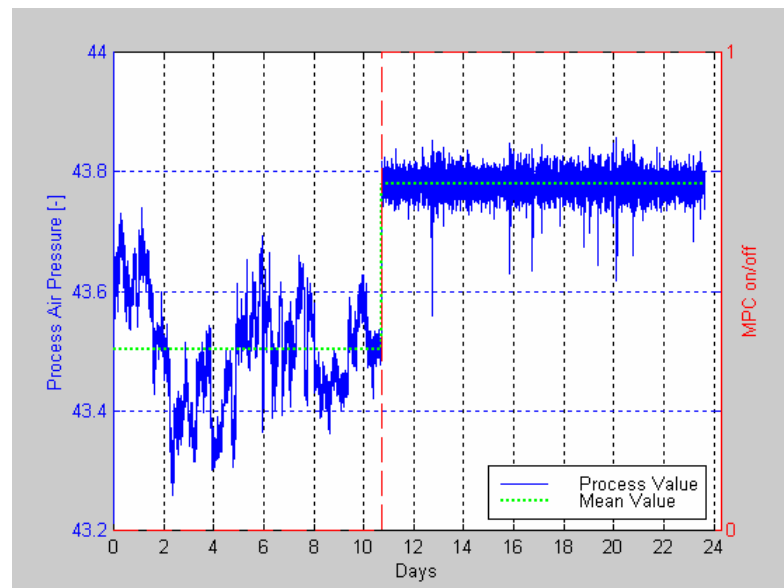


Fig. 4: APC is all about reducing variations and shifting towards the constraints.

The results of the feasibility study will allow companies to decide on future APC investments without any risk. In case it turns out that APC is not feasible other alternatives will be proposed (e.g. hardware changes) if any.

2.5 APC project

After a positive evaluation of the APC benefits a project is started. Typical benefits of APC systems on top of plants with good actuators, good instrumentation, optimal basic controls and control structures are:

- Throughput increase: range 0.5% to 1.5%
- Reduction specific energy consumption: range 0.5% to 1.5%
- Steam export increase: range 0.5% to 14%

APC projects are executed through a fixed trajectory:

- Kickoff: the project plan is agreed with the customer and the acceptance criteria are defined.
- Establish data communication
- APC control structure design and plant test plan
- Pre-tests
- Pre-test identification
- PRBNS tests
- PRBNS Test identification
- Controller configuration
- Factory Acceptance Test (FAT)
- Commissioning of the controller
- Site Acceptance Test (SAT)
- Training + After Care + Performance monitoring
- Reporting
- Documentation
- Setup maintenance system

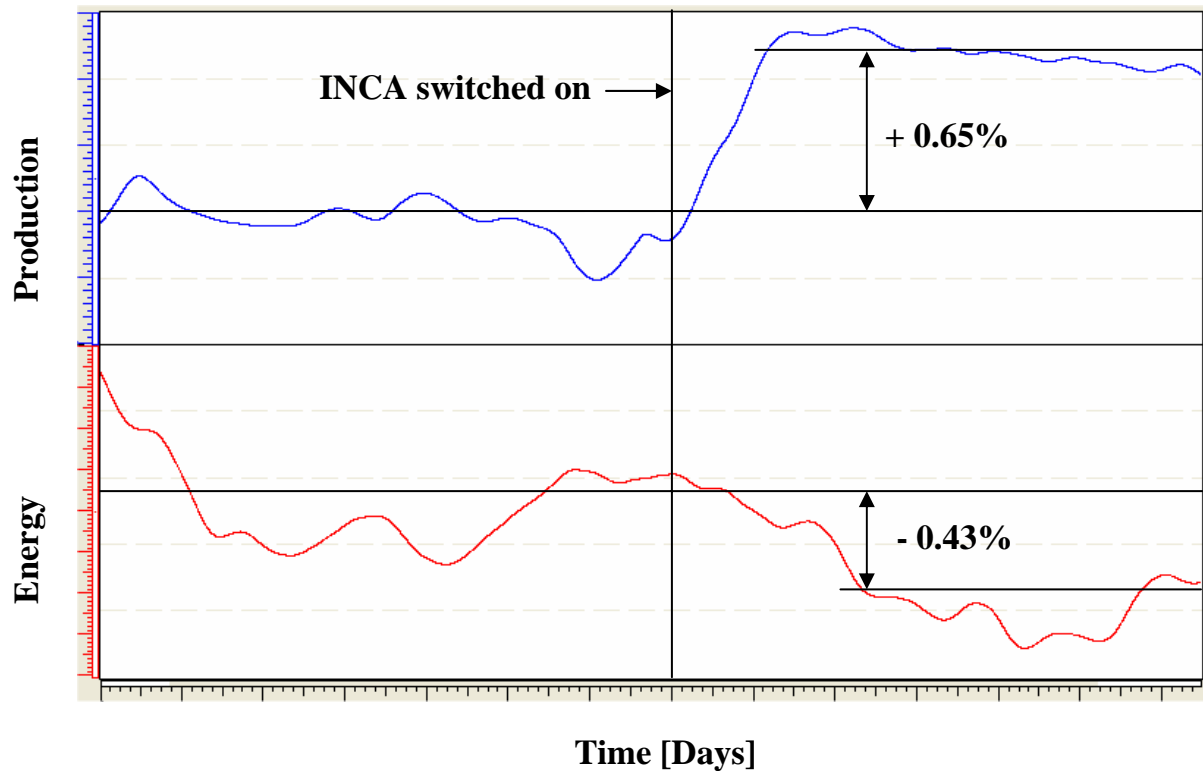


Fig. 5: Result of APC on an ammonia plant.

2.6 APC maintenance and performance monitoring

As with basic control equipment, APC systems need also maintenance. This guarantees that the APC system together with the plant performs optimally. Plant changes due to replacements, revamps and even plant aging will force APC users to change the APC system now and then a little bit. APC is a model based technology. If the plant changes, the model has to change also. APC is also a constraint pusher. If the constraints change after a revamp the APC system needs to be changed to take the new constraints into account.

The best way is to check the performance of the APC system during the first year after installation on a monthly basis. That will help to fine tune the system for new situations. After one year a less frequent check is needed. Nevertheless we are convinced that at least 3 times a year someone should spend a few days at looking at the performance. After a major revamp it is mandatory to check it during a longer period.

Modern communication systems allow that APC suppliers do remote performance checks and perform customer support. There are enough systems on the market that guarantee a safe communication between the APC specialist office and the APC computer at site.

It is also important that at least one control engineer is trained at the site that can give first line support (startup of the APC system, solving some interfacing problems, making backups, restoring backups etc.)

3 Conclusions

Advanced Process Control is a proven technology that has generated proven benefits in the fertilizer business. Amongst the guarantees for success is the correct step by step approach. The correct approach starts with a screening and optimization of the current control equipment (DCS, instrumentation and actuators) installation. The next step is the computing in advance what the APC system will bring. After a detailed technical and economic study the decision is made to apply APC or not. Only then the APC project will be successful. After finishing the project, a maintenance strategy should be defined and thoroughly executed.