Advanced Control System – Industrial Results and New Challenges

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Summary
Advanced Control System

- Introduction
- Industrial Results
- Challenges
- Conclusions
Due to increasing demand for high performance units, Advanced Control and Optimization Technologies will play an important role in industries in coming years.

**Increase Profitability**

Operate safely on the constraints
Advanced Control Objectives

- Maximize the production
- Ensure the specification of products,
- Minimize energy consumption,
- Minimizes the process variability which increases safety and minimizes the flare (prevent loss of products)
Methodology for Implementation of Advanced Control

- Functional Design (What are the goals of ACS?)
- Check the Instrumentation and Regulatory Control
- Pre-Tests and Inferences (virtual sensors)
- Plant Test and Identification of dynamic models
- Configuration and commissioning of the controller
- Tuning the Advanced Control
- Monitoring Advanced Control System performance
- Training of operators and Documentation
Advanced Control System
Industrial Results
Gas Processing Plant

- Improved Regulatory Control

New control strategy

Variations in pressure means that we lose products
Implementation of Advanced Control

Identification Tests

Obtaining the dynamic models

Operator interfaces in DCS
Economic Benefits of ACS

Regulatory Control was responsible for 35% of the gain obtained

NGL Production (m3/d)

31% increase in production of NGL

$$Indicador = \frac{Vazão de LGN produzido}{Vazão de Carga} \times \frac{10^6}{Teor de C_{3+} na carga}$$
Losses Reduction

End of Regulatory Control Improvement

Commissioning of the Advanced Control

Loss of NGL in the gas

07/2006

11/2007
Other examples of the importance of advanced control systems for industry
Improvements in regulatory control are fundamental.

About 400 control loops analyzed.

- About 50% of the control loops had tuning problems.
- The number of control loops with a good performance rose from 29 to nearly 70%.
New control strategy minimizes the flare

Before

- Reduced loss of products by 40% in the flare
- Reduced emissions by about 230 tons/year of CO$_2$

After

Reduced loss of products by 40% in the flare

Reduced emissions by about 230 tons/year of CO$_2$
Variability Reduction

Greater stability Fundamental to the advanced control

Figura : Comportamento da 2600-TC-009 antes e depois das ações corretivas
Instabilities in the propane refrigeration system

- Limitations due to low thermal exchange area were generating saturation in the suction pressure control.

The pressure setpoints were increased to facilitate condensation.
Greater stability has allowed the identification tests.

It was impossible to obtain good models.

New operating point of the propane compressor.
Control strategy problems

Many trips due to high pressure in the column

Regulatory control in a Natural Gas Plant

PID Control always operated in manual mode

It was difficult to choose a setpoint

After a turbo-compressor's shutdown, the PID acts incorrectly
Regulatory control in a Natural Gas Plant

Typical example of a control strategy designed without a dynamic simulation

- Suction pressure under control
- Discharge pressure under control
- Expander and compressor flow under control

There are no degrees of freedom for the compressor
New Regulatory control for this Natural Gas Plant

There is a degree of freedom, the discharge pressure of the compressor is free

Now, the setpoints don't change if the turbo-compressor is operating or not
New Regulatory control for this Natural Gas Plant

PID now operates in automatic mode

Reduction of 33% in the undesirable shutdown

Reduction
Shutdown Time
Increases in energy efficiency

- There are two levels of energy consumption at this unit depending if we are or not regenerating.

Reduced the amount of fuel gas to the furnaces by 18% (Decreased emissions by about 1600 tons/year of CO$_2$)
Profitability Gains

- Increase of 1.59 m³/h in the production of LPG (Liquefied petroleum gas) due to improvement of regulatory control
  - US$ 1,806,913.50 por ano
- Increase of 1.7 m³/h in the production of LPG (Liquefied petroleum gas) due to the advanced control system
  - US$ 2,163,015.47 por ano

Regulatory Control was responsible for 45% of the gain obtained
Advanced Control System Challenges
Regulatory Control

- Regulatory control is essential for the success of advanced control systems and it is responsible for important gains.
- Why we don't see many industrial projects using dynamic simulation and other methodologies for design a good control strategy?
- Why do we still have many control loops with a bad PID tuning? Many tools don’t deal with MIMO approach for design and tuning decentralized PID controllers.
Advanced Control in Oil&Gas Industries

- New technologies to accelerate the deployment and maintenance of advanced control systems are required.
- There is a significant gap between the recent MPC technologies development in the academy and those systems effectively used on industrial plants.
Virtual sensor - Critical Point

Use of rigorous dynamic simulators, or statistical methods for better inferences using less laboratory analysis data.

Validated process simulators + Neural nets
Dynamic model Identification

- Process identification of complex processes is still a hard task, where a significant part of the effort on MPC implementation is spent.
- Researches and developments for the identification methods are still necessary, and they can bring great economical earnings.
MPC Tuning

- Controller tuning still consume time and is a critical point for controller performance
  - Different tuning scenarios depending on which constraints are active.
  - How to define the priorities in the several operating points of the controller?
  - Is it possible to use dynamic simulation to get plant model and to define MPC tuning?

*Trial and error methodology*
MPC Maintenance is a big challenge

- MPC performance can decay throughout time due to:
  - Changes in the units operational objectives;
  - Equipments efficiency losses (fouling);
  - Changes in the feed quality;
  - Problems in instruments and in the virtual sensors;
  - Lacks of qualified personnel for the controller’s maintenance.
Conclusion

- Control technologies are an important tool for increasing energy efficiency, profitability and sustainability of industrial processes.
- The process of implementing an advanced control system is very rich because it allows to rethink how to operate the equipment available, to question the paradigms, constraints, etc.
- Importance of the multidisciplinary interactions (control experts, process engineers, operators) in order to have a successful implementation.
Conclusion

- Engineers should know very well the process in order to define and implement good control and optimization system.
- Human Resource: formation and train of engineers is the greatest challenge for the universities in the advanced control and optimization area.
- Better tools are necessary but they will not substitute a good control engineer.
[Besch et al., 2009], “Resultados da fase de implantação de controle avançado em uma unidade de processamento de gás natural”, V Congresso Rio Automação 2009, IBP, Instituto Brasileiro de Petróleo. (Portuguese)

[Campos et al., 2007], “Ganhos econômicos devidos à melhoria no controle de uma planta de processamento de gás natural”, IV Congresso Rio Automação 2007, IBP, Instituto Brasileiro de Petróleo. (Portuguese)


Thanks for your Attention