FCC Unit’s Operator Training System (OTS) built using Aspen HYSYS helps refinery in its path to operational excellence

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Summary

• Introduction
• Process Overview
• OTS Solution
  • First Principle Model
  • OTS Architecture
• Operators Training
  • Procedures Verification
  • OTS Supporting Operation
  • Training Program
• Benefits
Inprocess in brief

**Independent** from any ICSS or simulation software provider

*Founded in Barcelona by domain experts*

*Our core business* is Process Simulation

*Keen to share its knowledge with clients*

**Mission:** accompany our clients in their success in achieving safer, greener, more reliable and more profitable industrial operations
Our Services and Products

Lifecycle Modelling
- Feasibility studies. Selection of alternatives
- Dynamic simulation studies before plant construction
- Validation of control philosophy
- Operational procedures development/enhancement
- Process trainer - Emulated OTS - Early OTS
- DCS check-out
- OTS for operators' initial and continuous training
- Support during commissioning and start-up
- Operations & Maintenance support (Digital Twin)

Training & Knowledge Transfer
- Process simulation courses
- Technology courses
- Knowledge Improvement Program – KIP
- Training for plant operators / technicians

Process Simulation Studies
- Steady State Analysis
- Dynamic Simulation Studies
- Integrated Flare Systems Analysis
- Flow Assurance Studies with OGLA
- Utilities Network Models
- On-line models
- Operations Staff Training
- O&M Support

Applications & Software Development
- IPSI: Inprocess Infrastructure Suite
- IPSV: PID's database
- ITOP: Inprocess Training for Operators
- ICCM: Inprocess Competence Management System
- IFLOW: to link process simulators with OGLA
- IPSA: Pressure Swing Absorption simulator
- OTS Web Access: e-learning options
- Extensions for process simulators
YPF works to generate efficient and reliable energy by developing and producing oil and gas from conventional, unconventional and renewable sources such as wind, solar, geothermal and hydropower.

YPF produce fuels, petrochemicals and lubricants at three industrial complexes

- La Plata
- Luján de Cuyo
- Plaza Huincul

Strong business presence in the retail, agriculture, industrial and LPG market sectors.
FCC Process Overview

**YPF FCC Process**

The FCC feed is a low-value product

The load is mainly made up of heavy gas oil (GOP) from topping, vacuum and cokes.

The FCC product

- High level of conversion to products of high demand and commercial value.
- This naphtha contributes the highest number of octanes to the naphtha pool.
- Higher LPG production.

**YPF FCC OTS Objective**

The original objective of this application was limited to the training of operators, while after the completion of the OTS based on first principles dynamic model the application expanded to include helping process Engineering department and Optimization and Control department in analysis for process improvements and diagnoses.
Challenges

How to fully test and improve the Operating Procedures?

How to increase the plant’s availability and process uptime?

How to test new logics implementation or modification before activation in the real system?

How improve the competence of inexperienced operators?

How to train experienced CRO’s in operation conditions in the limit of the cause & effect?

Are equipment protected?
First-principles (FP) models use understanding of the system underlying chemical and physics to derive its mathematical representation. The value and advantage of this approach are:

- **Thermo Packages** are consistent with the Steady-State Design models. Data is introduced once and the model is used along the phases of the lifecycle.

- Detailed Equipment data is available and refined as the project evolves. Additional process units can be incorporated as needed in the application.

- Control Room Operator’s (CRO) will expect realistic process responses. This is the key to replicate/verify/improve operating procedures, pre-tune controllers and define alarms limits.

- Extrapolate process conditions far from nominal. Model will help to determine the settings to maximize production, reduce flaring and improve its controls.

- The dynamic model can be re-used with minor modifications for other purposes.

- Model update workflow is defined to keep the model alive and synchronized with the process, control and procedure changes.
FCC OTS Objective

**Purpose:**
Develop OTS application using first principles dynamic model of the FCC unit
- Training new and experience operators
- Improve the plant operation
- Validate the effectiveness of the control system
- Verify the operating procedures after a control update and process modification

**Focus:**
Operators training in not frequent operations, detect possible system instabilities, potential overload conditions, validate the operating procedures.

**Typical Scenarios**
- Emergency shutdown scenario
- Start-Up
- Typical Upsets
- Ramp-Up /Ramp-down
- Change operating mode

**Areas of Interest:**
- Retain process knowledge
- CRO* generational change
- Overall Operability
- Max/Min Pressures & Temperatures
- Control Valves behaviour
- Pressure Controllers behaviour
- Driver Overload protection
- Slide Valve Behaviour
- Post Combustion Detection

* CRO- Control Room Operator
In process industry, Operational Excellence is the operation of the plant in efficient, reliable and agile manner to achieve optimal profitability of the plant operations over the full lifecycle.

- **Process Optimization** Optimizing yield, energy and throughput
- **Improve Decision Support** enable and speed-up the decision making with right time information
- **Enhance Process Operation** Integrate data and process knowledge to operators interface
- **Operation Knowledge Management** Improve the knowledge retention and increase operators competence and risk control by training programs based on lessons learned
The Operators training system based on first principle simulation is an enabling technology in the way to achieve the Operational Excellence.

• Learn from events through learning by doing.
• Easy way to apply lessons learned initiatives with the purpose of **analyzing, developing and implementing robust solutions to improve operations**.
• Improve the implementation of process safety management in operation procedures
• **Investigate/Root Cause Analysis in virtual environment**
• **Implement training programs** using learn by doing approach to increase operator competence and knowledge retention in the company
Inprocess Instructor Station connects all these items, and fills some gaps in certain architectures.
FCC Process Layout

Air compressors
Regenerator
Reactor
Furnace
Fractionator Sections
Wet Gas Compressor
- Chemical reaction in the riser
- Reaction in the regenerator
- Hydraulics in the riser and its interaction with the pressures in the reactor (split section) and the regenerator
- Gas dynamics
1. Reactor Yield shift + Flow Resistance
2. Reactor type CSTR + volume
3. Flow resistance + Slide Valve
4. Flow resistance + Slide Valve
5. Cyclone calculation block
6. Cyclone Calculation block
7. Volume
The dynamic model has been rated based on the heat balance calculated using plant data.
Operator Training System – Architecture

**Hypervisor Server**
- Domain Server
- Aspect Server
- AC 800M Connectivity Servers
- AC 800M Softcontrollers

**Operator Station-1:**
- ABB 800xA DCS Consoles

**Instructor and Simulation Station:**
- Inprocess Instructor station
- HYSYS® Dynamics

**Ethernet Network**
- DCS / Process Simulation interface
- OPC Protocol
- ABB Simulator Link Interface

**YPF Corporate Network**
- Aspen Hysys License Server
- Remote Connection Server
- Remote Connection Client

**Aspen HYSYS**
- Gateway computer

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Operator Training System – Architecture
Training Program Development

Theory Contents

Practical Contents

Training Contents
### Training Program Development

**Training Contents**

- **Theoretical Aspects**
- **Practical Contents**

**Operators Candidate**

**Operators Competence Level**

**TM Level 1:** Familiarization in Process and ICSS
- **TM Level 2:** Process Unit Start-up and shutdown
- **TM Level 3:** Overall Process Start-up and Shutdown
- **TM Level 4:** Events in operation, stress management
- **TM Level 5:** Knowledge Refresh
Procedures and Training Program Development

Review of Operating Procedures with timing and transitions conditions

**Scope:**
- Individual Units
- Overall Operation Procedures

**Combining Expertises:**
Mix of experienced Engineers / Operators know-how with realistic response of Simulated Process

- Verification of set point consistency between process areas
- Development of operational procedures and training materials with more realistic transitions taking into account unexpected events
  - Learn of control logic Interactions
  - Learn how to manage unexpected events
- Identifying the key parameters during the process operations
- Reduce the Shutdown and Start-Up time

This activity generate a consistent and structured document for the training and the plan for the training program based on the contents.
Turn-down and Planned Shutdown – Before Training

Time required 10 hours

Average flaring 30t/h to 50 t/h

Total emissions during the operation 27.7 t
**Turn-down and Planned Shutdown – After Training**

- Time required: 7 hours
- Average flaring: 4t/h to 6 t/h
- Total emissions during the operation = 11.3 t
OTS Training Main Results

Since 2019 250 hours of training for 15 operators.

Several retirements occur during the training period.

Operation improvement
- Turn down and shutdown 30% reduction in the requirement time
- Emission decrease by 60%
- Flow to flare peak decrease 36.2 t/h to 4.9 t/h (86% decrease)

New Operators acquire competence in 6 months before requires 2 years
As shown in the previous slide, using the first principles dynamic modelling approach provides increased added value to the OTS project itself. As it is based on a highly reliable first principles model linked with the actual ICSS.

A direct-connect OTS, based on a first-principles model, allows for:

- The evaluation of the controllability and operability of the plant under non design conditions (e.g. Start Up operations).
- The evaluation of the controllability and operability of the plant in unforeseen configurations, with minimum modifications.
- ICSS verification and improvement.
- The evaluation of potential plant limitations (i.e. Debottlenecking studies)
The Operators training system based on first principles simulation is an enabling technology in the way to achieve the Operational Excellence.

- Learn from events through learning by doing.
- Easy way to apply lessons learned initiatives with the purpose of analyzing, developing and implementing robust solutions to improve operations.
- Improve the implementation of process safety management in operation procedures.
- Investigate/Root Cause Analysis in virtual environment.
- Implement training programs using learn by doing approach to increase operator competence and knowledge retention in the company.
Benefits

- 250 hours training sessions spread over 15 people.
- Operation improvement (30% reduction in execution time)
- Emission reduction (in some operations the reduction is about 60%)
- Experienced operators refreshed knowledge (e.g.: delivery of atypical instruments for repair).
- The training session reduce stress manage in unexpected disturbances when training, and to develop confidence in the operation in critical safety events.
- New operators develop knowledge in 6 months that usually takes 2 years, and they develop the aptitude to be able to operate alone in front of the real console.
- It makes easy to transfer the process and operation knowledge by the instructor.
- Improve the collaboration between operators during the process operation and prevent communication problems during critical events.