A Simulator of Sugar Factories for Operator Training

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• Complex factories, including a wide variety of processes
• High degree of automation
• Limited number of operators
BEET SUGAR FACTORIES

Process Operation is done by means of a distributed control system (DCS)

– Receives data from transmitters and Laboratory.
– Computes control signals to the actuators
– Provides a MMI for supervision of the process
CONTROL ROOM OPERATORS.

- They are in charge of process operation.
- They must understand how the process and its control system work.
- They must detect and solve faults and malfunctions.
- They should provide a smooth and optimal operation.

DCS screens

Images of some strategic points
CONTROL ROOM OPERATORS

Operation of a sugar melter by several shifts

Differences in the behaviour of the operators reflect on the process performance

Operators training is a key factor in process performance
TRAINING SIMULATORS

Mimic the environment and functionality of a control room
The process is replaced by a real time dynamic simulation
TRAINING SIMULATOR AIMS

✓ Facilitate the knowledge of the process and its control system
✓ Achieve uniform operation among shifts
✓ Learn how to operate the process in an optimal way
✓ Learn how to react in unfrequent but difficult situations
✓ Identify faulty situations and learn how to correct them
ADVANTAGES OF A TRAINING SIMULATOR

✓ It allows learning by “experimenting” on the process, What happens if...? What should I do for...?

✓ Experiments on the real process can be dangerous expensive, slow, not always done in the proper conditions,...

✓ Simulation can be performed faster or slower than real time

✓ The effect of a change can be seen in isolation if needed, this is not the case in the real process

✓ Simulation gives access to all variables of the process

✓ Study the best operation strategies or control structure
TRAINING SIMULATORS

Different simulators according to its aims and range:

- **Full scope:**
  - Plant wide
  - Real time

- **Specific process units**
CHARACTERISTICS

✓ Mimic the control room environment + DCS

✓ Mimic the dynamic behaviour of the process, both in normal and abnormal operating conditions

✓ Provide a set of predefined operating problems and malfunctions that are adequate for the training

✓ Real time (or accelerated) operation
ARCHITECTURE OF THE SIMULATOR

• Four main modules:
  – Dynamic process simulation (EcosimPro)
  – Distributed Control System (SCADA)
  – Supervisor console
  – Real time Communication system

• PC based under Windows with OPC
ARCHITECTURE OF THE SIMULATOR

Two versions:
- Full scope
- Single user in a PC
FUNCTIONS

INSTRUCTOR

Acts on the process

Manages the simulation
Activates problems and malfunctions
Selects training sessions

OPERATOR

Acts on the DCS
Operates the DCS
Reacts to problems and aims

SIMULATION = PROCESS

SCADA
Training Simulator

INSTRUCTOR
MODELING

Detailed dynamic process models based on first principles

Include normal behaviour and faults

Different classes:

- Concentrate / Distributed parameters
- Continuous / Batch
- Digital Control functions
DYNAMIC SIMULATION

Simulation Tool: ECOSIMPRO

- Object oriented modelling tool with no predefined computational causality. It allows re-use of the models and hierarchical constructions.
- It generates simulation code after symbolic manipulation of the model equations in order to adapt them to the operating context.
- Good numerical solvers (DASSL sparse)
  - Models are generated as C++ classes, allowing them an easy integration with other software components.
LIBRARIES OF MODELS

GENERIC
- Physico-chemical properties
- Ports
- Control elements
- Flow elements
- Basic process units

SECTIONS
- Destilery
- Boilers
- Sugar end
- Evaporation
- Depuration
- Difussion
- Dryer

EcosimPro Model
**OPC / DCOM servers**

Compiled Simulation
Includes executables and source files with the C++ classes that contains the simulation.

Server generator

OPC server

Simulation modules encapsulated as OPC/DCOM servers

OPC client
Information:
- Process Schematics
- Tables of variables
- Alarms
- Trends
- Historic trends
- Bar graphs

Operation:
- Change set points / MV
- Man / Auto
- Tuning
- Alarms recognition
SCADA CONFIGURATION.

OPC Server

SCADA Configuration Programs

SCADA Configuration

CI Configuration
Distributed simulation

Data Interchange Program
(Data Interchange & Synchronization)

5 PC under W
INSTRUCTOR MODULE

On top of the operators console functions, the one of the instructor includes:

- **Modifies process variables**
- **Activate/ Deactivate faults**
- **Selects pre-defined training sessions** (changes in production levels, faults...)
- **Starts in different operating conditions**
- **Timing of the simulation**
Operating the Simulator

DEMOS

Start the simulator

Navigate in the screens

How to use the operator screens....

.... And the toolbars
Operating the Instructor console

DEMO

Instructor console
A TRAINING SESSION

1. Lecturing in the classroom on the process units, process fundamentals, process operation and control basis.

2. Simulators of process units

3. Practical work in the full scope simulator

4. Evaluation
Classroom.

Lecturing on:

- Process
- Fundamentals of process units
- Process operation
- Control system
- How to operate the simulator

Manuals + Slides
Process units simulators

Dedicated process units simulators, aimed to allow practicing on the process unit behaviour and operation of its control system

Friendly user interface
Fast response
Process Units

Models:

- Heat exchanger
- Evaporator
- Filter
- Carbonatation tower
- Vacuum pan
- Boiler
- Dryer
- Storage tank
- Destillation column
OPERATION OF THE SIMULATOR

DEMO

How to operate the process

Example:
- OPERATION: Change the output brix of the evaporation station
- FAULT DETECTION: Non-condensable gases valve closure
Evaluation.

- Storage / Recovery of system states for:
  - Analysis
  - Repeat situation
- Supervision by the instructor
- Discussion of alternatives
Documentation

- Operating the simulator
- Operating the different sections of the factory
Conclusions

✓ Tested at factory director level and undergraduate students
✓ At present is under evaluation at the factories
✓ Key points:
  ✓ Close links with users
  ✓ Rapid adaptation, Development times
  ✓ Degree of accuracy / general
  ✓ Real time / accelerated time
  ✓ Advanced control
  ✓ Predictive simulation
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