CENTRO de TECNOLOGÍA AZUCARERA

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A Simulator of Sugar Factories for Operator Training

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2. Training simulator
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   - Architecture
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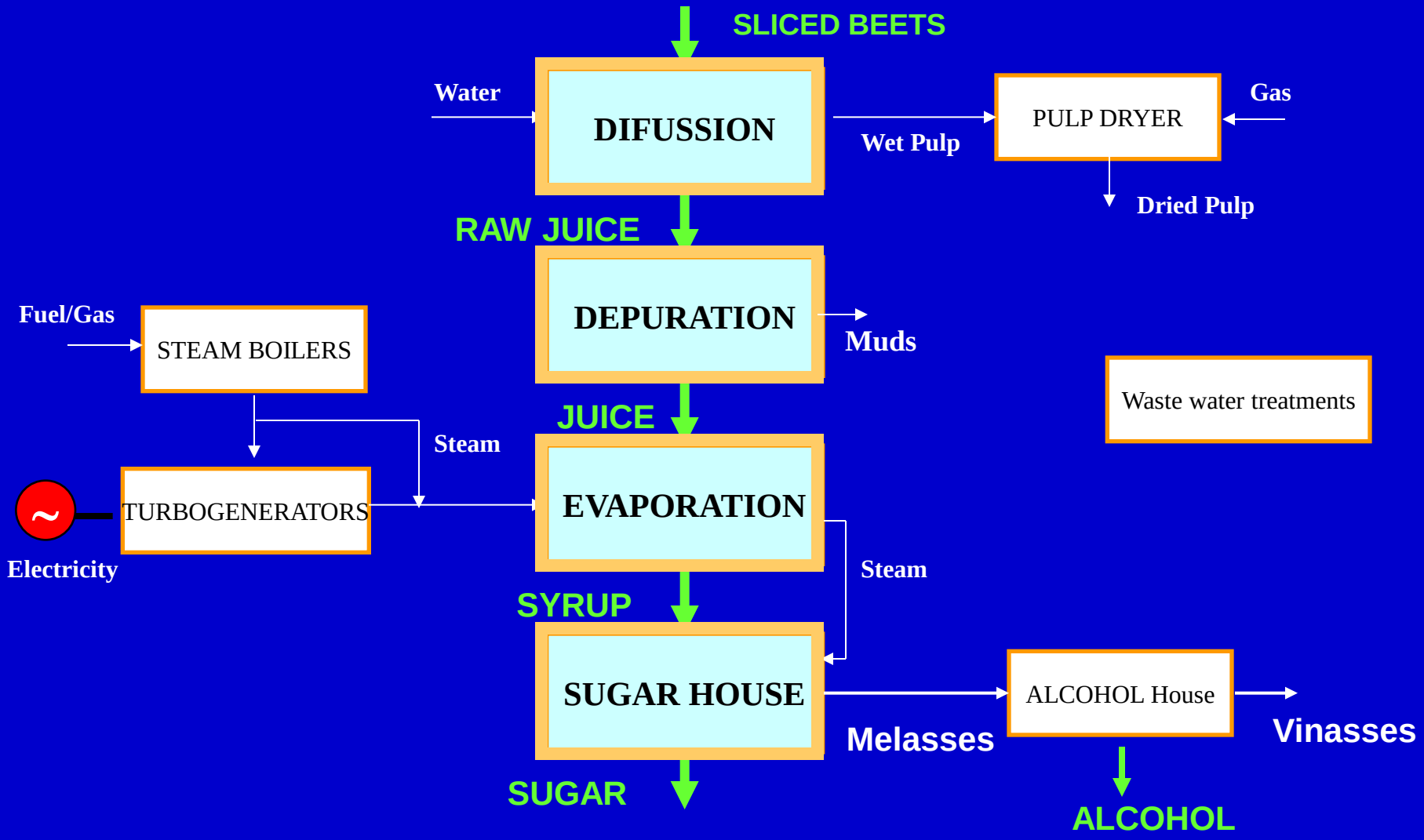
BEET SUGAR FACTORIES

- Complex factories, including a wide variety of processes
- High degree of automation
- Limited number of operators

BEET SUGAR FACTORY

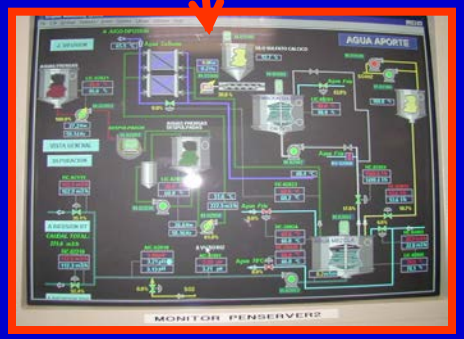


BEET SUGAR FACTORIES

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

- Receives data from tranmiters and Laboratory.
- Computes control signals to the actuators
- Provides a MMI for supervision of the process

CONTROL ROOM OPERATORS.



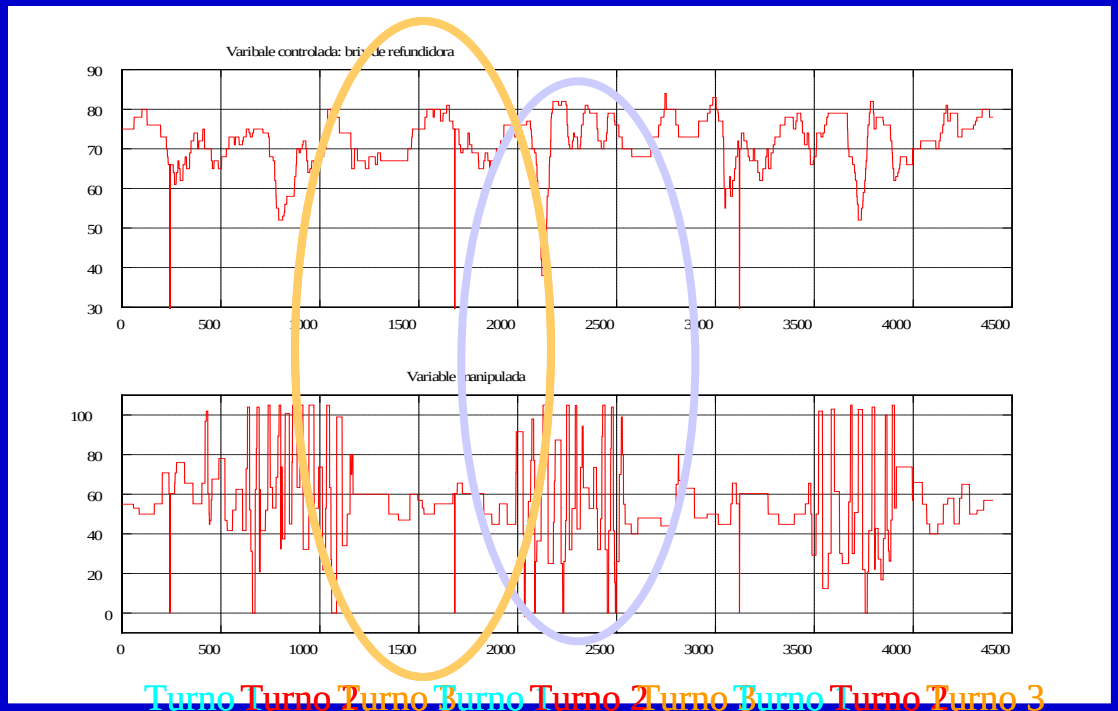
DCS screens

Images of some strategic points

- ✓ 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

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

Real process

Simulator

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

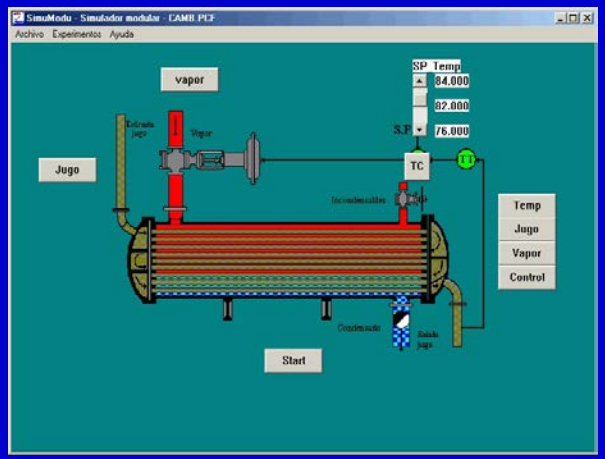
- ✓ It allows learning by “experimenting” on the process , What happens if...? What should I do for...?
- ✓Experiments on the real process can be dangerous expensive, slow, not always done in the proper conditions,...
- ✓Simulation can be performed faster or slower than real time
- ✓ The efect of a change 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 estrategies or control estructure

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 behavoiur of the process, both in normal and abnormal operating conditions

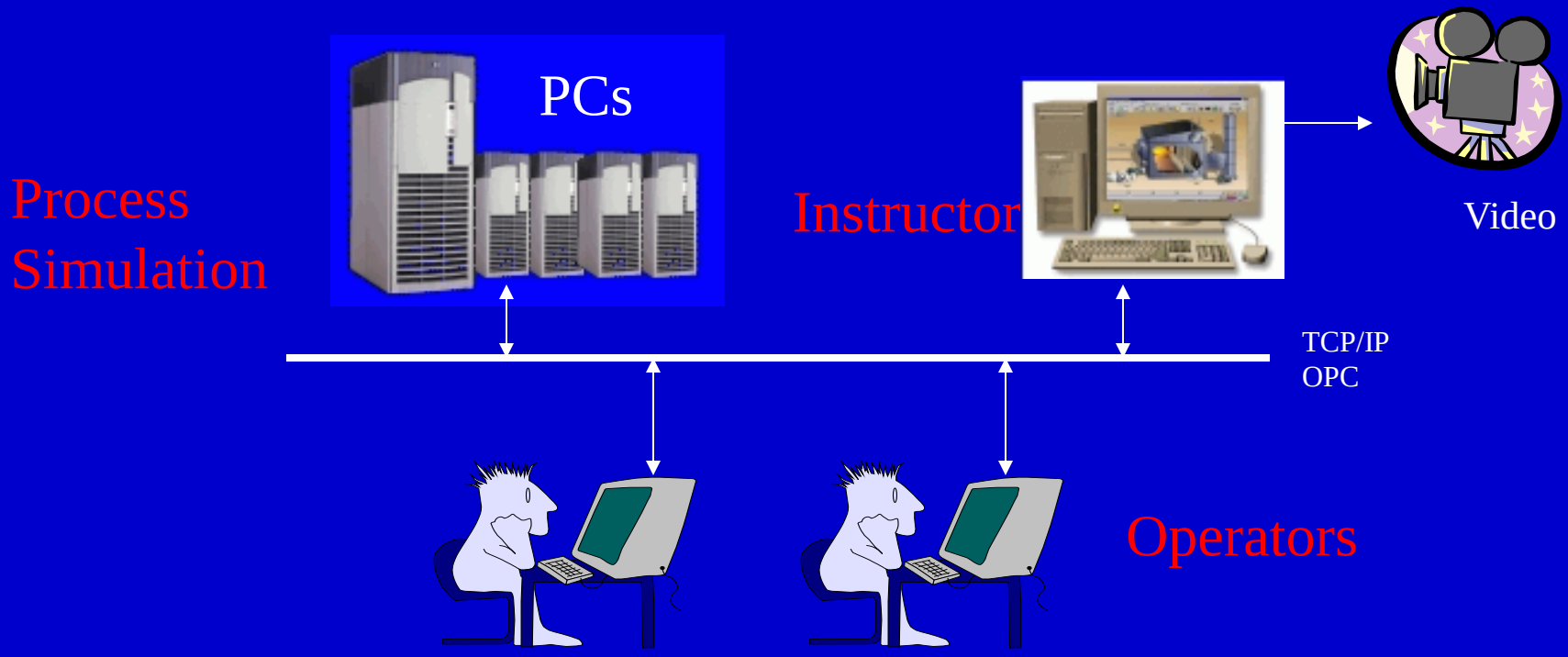
✓ Provide a set of predefined operating problems and malfunctions that are adequate for the training

✓ Real time (or acelerated) operation

ARCHITECTURE OF THE SIMULATOR

- Four main modules:
  - Dynamic process simulation (EcosimPro)
  - Distributed Control System (SCADA)
  - Supervisor console
  - Real time Comunication system
- PC based under Windows with OPC

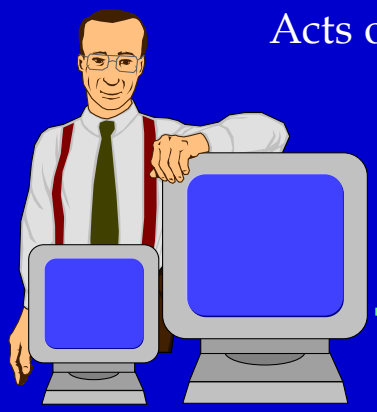
ARCHITECTURE OF THE SIMULATOR



Two versions:

- Full scope
- Single user in a PC

FUNCTIONS



Acts on the process

SIMULATION = PROCESS

Acts on the DCS

SCADA

INSTRUCTOR

OPERATOR

Manages the simulation

Activates problems and malfunctions

Selects training sessions

Operates the DCS

Reacts to problems and aims

Training Simulator

INSTRUCTOR

MODELING

Detailled 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 predifined 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++ clases, allowing them an easy integration with other software components

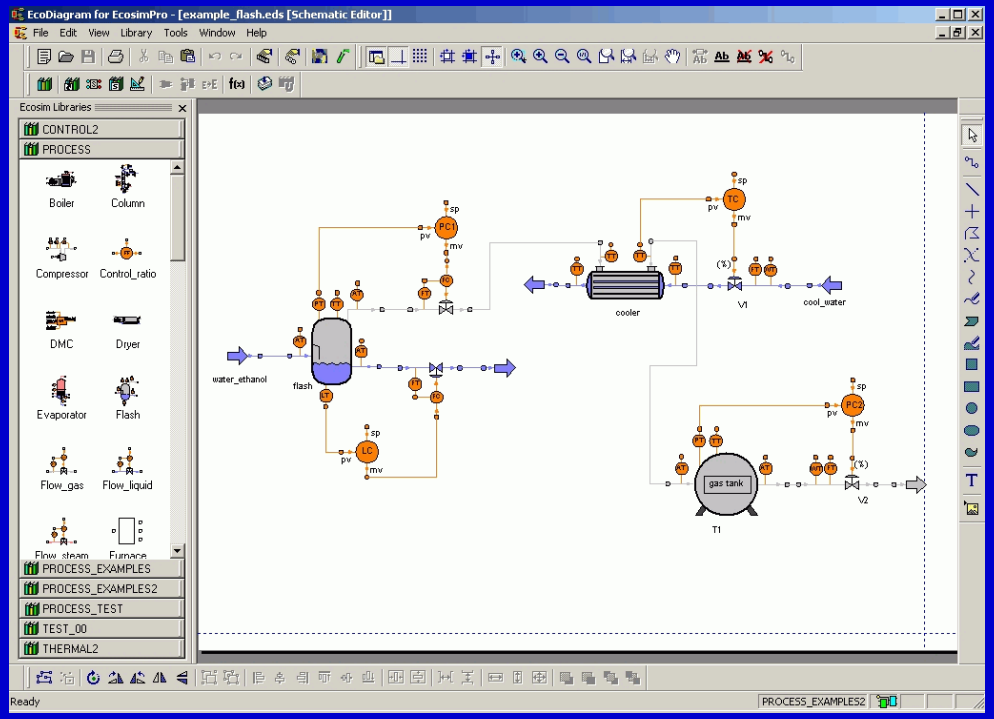
LIBRARIES OF MODELS

GENERIC

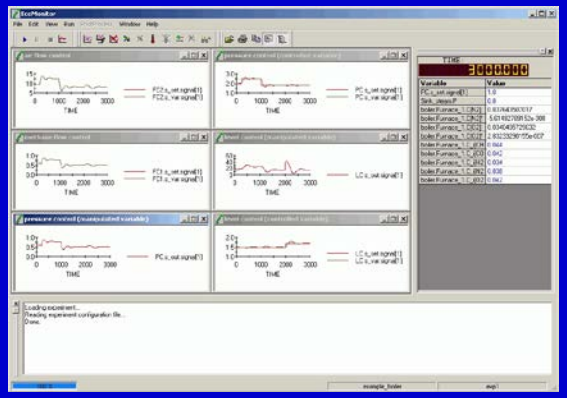
- Physico-chemical properties
- Ports
- Control elements
- Flow elements
- Basic process units

SECTIONS

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



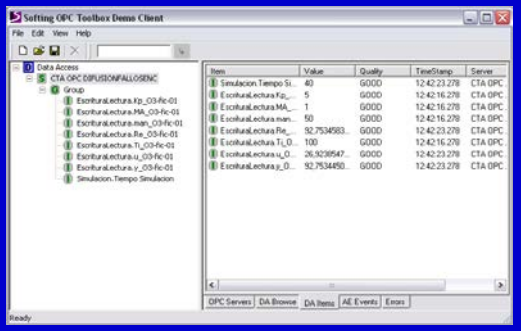
EcosimPro Model



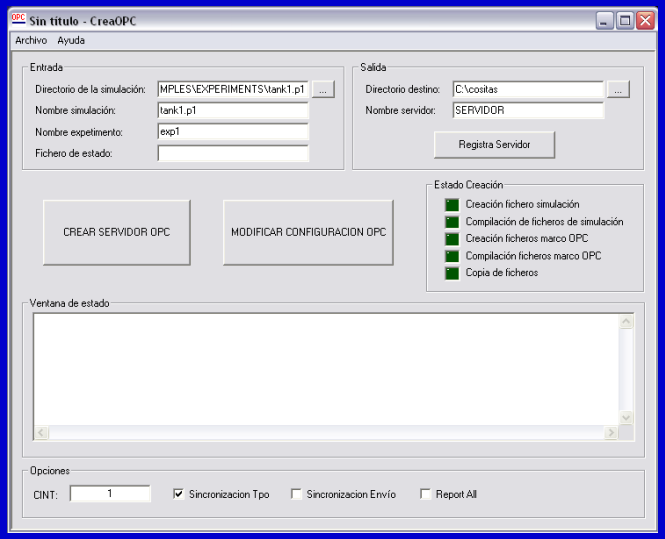
OPC / DCOM servers

Compiled Simulation

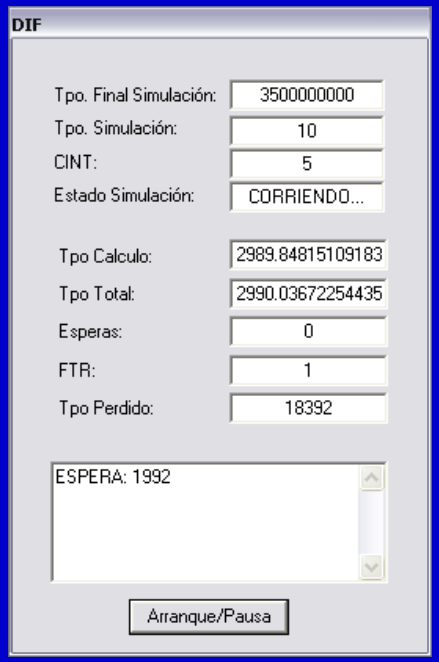
Includes executables and source files with the C++ classes that contains the simulation.



OPC client



Server generator

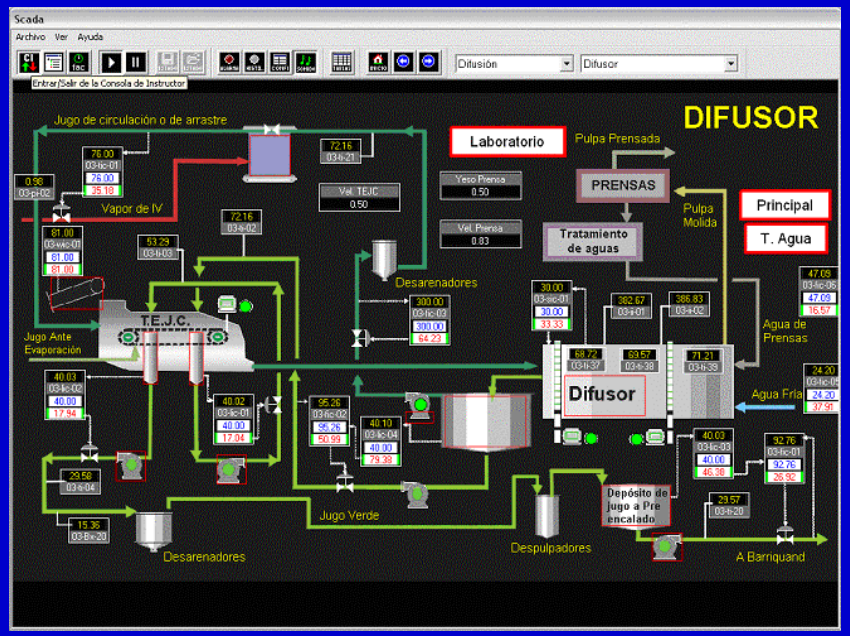


OPC server

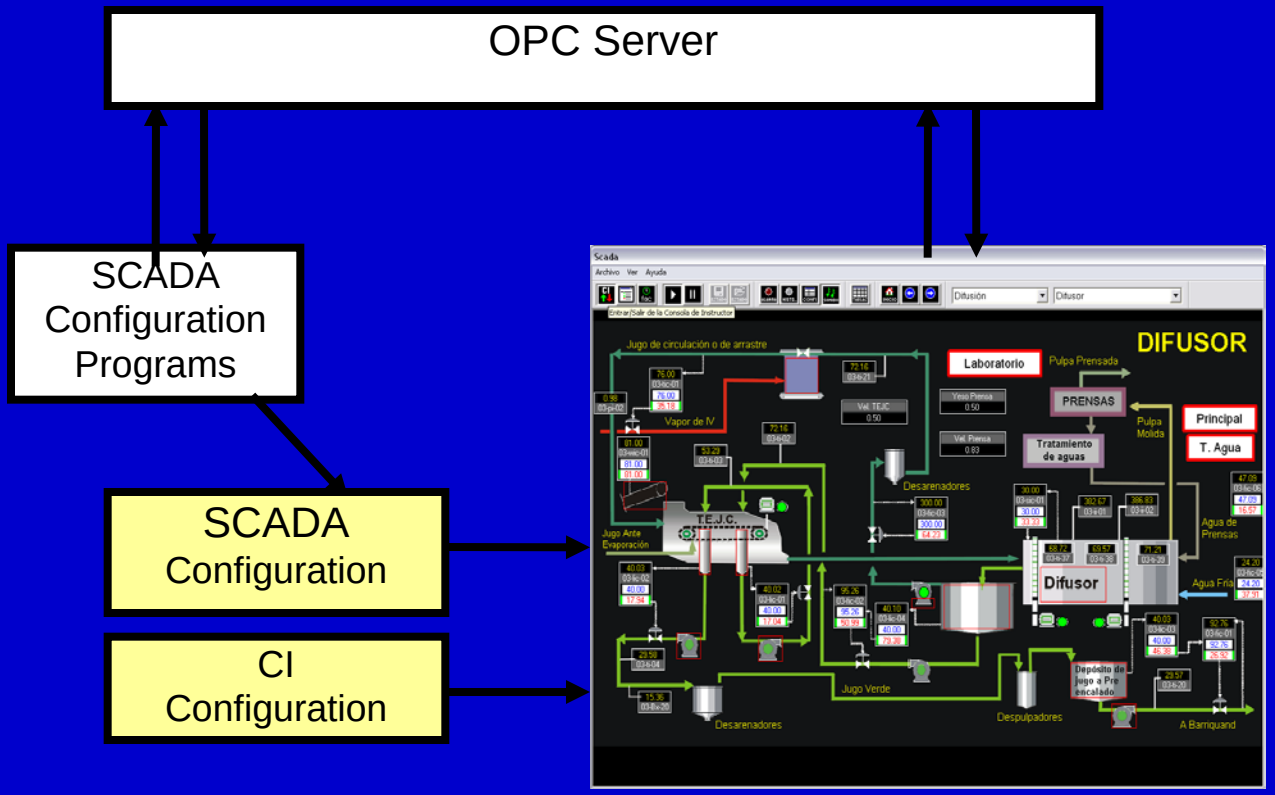
Simulation modules encapsulated as OPC/DCOM servers

MMI SCADA / EDUSCA.

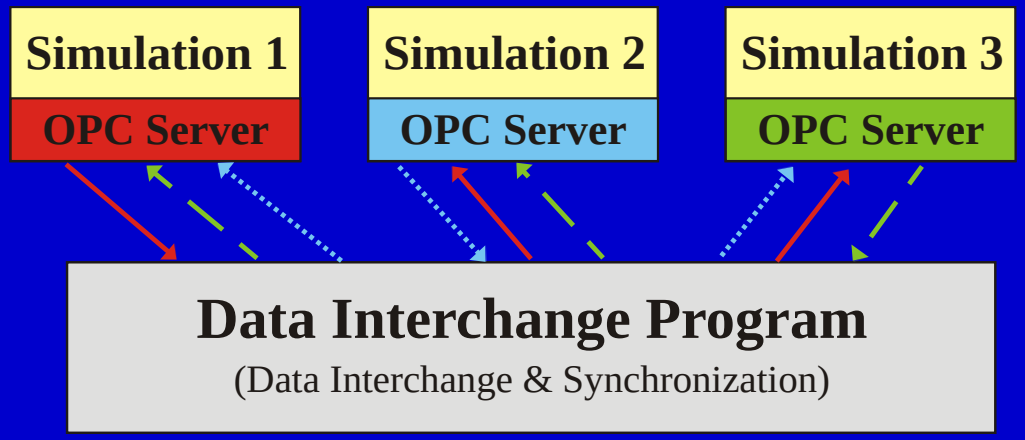
- ***Information:***
  - *Process Schematics*
  - *Tables of variables*
  - *Alarms*
  - *Trends*
  - *Historic trends*
  - *Bar graphs*
- ***Operation:***
  - *Change set points / MV*
  - *Man / Auto*
  - *Tuning*
  - *Alarms recognition*



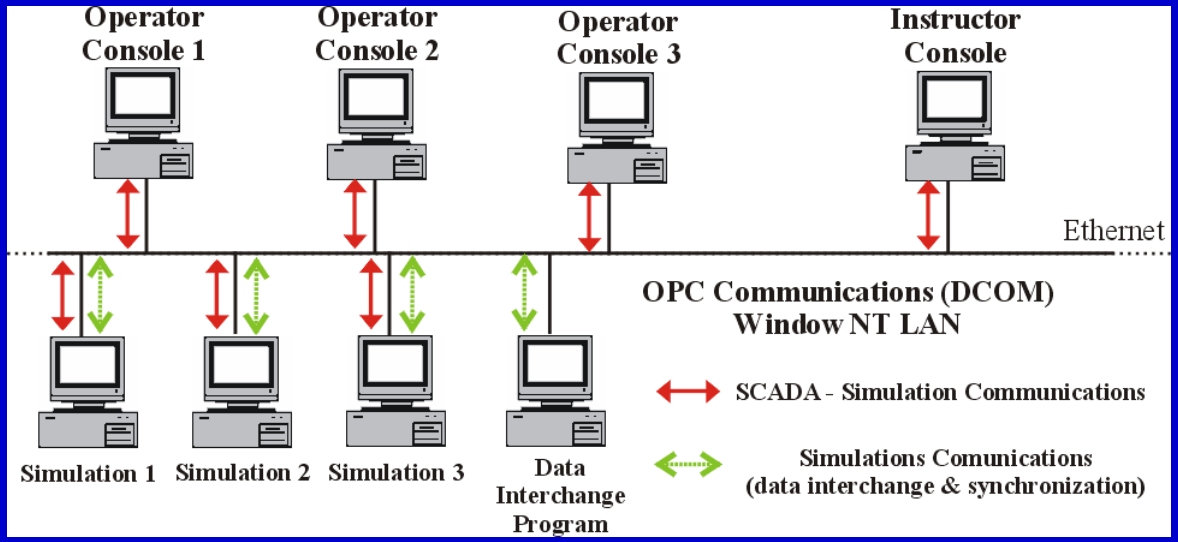
SCADA CONFIGURATION.



Distributed simulation



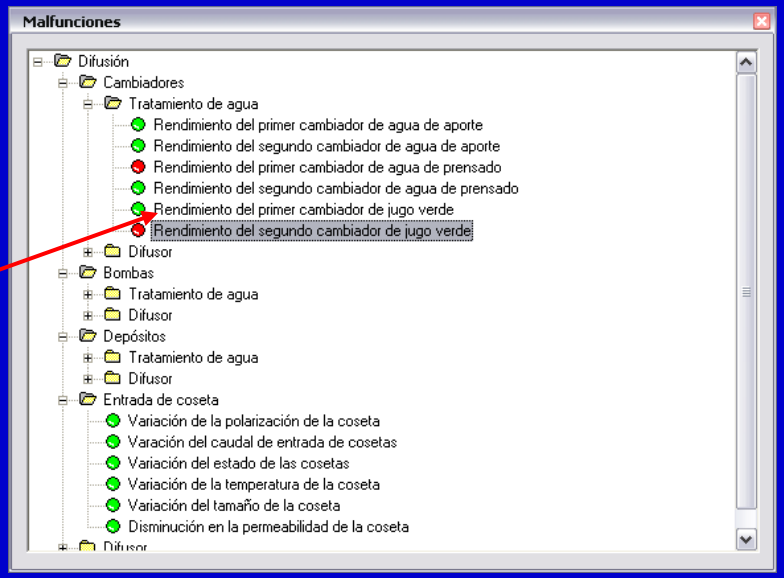
5 PC under W



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 condictions*
- *Timing of the simulation*



Operating the Simulator

DEMOS

Start the simulator

Navigate in the screens

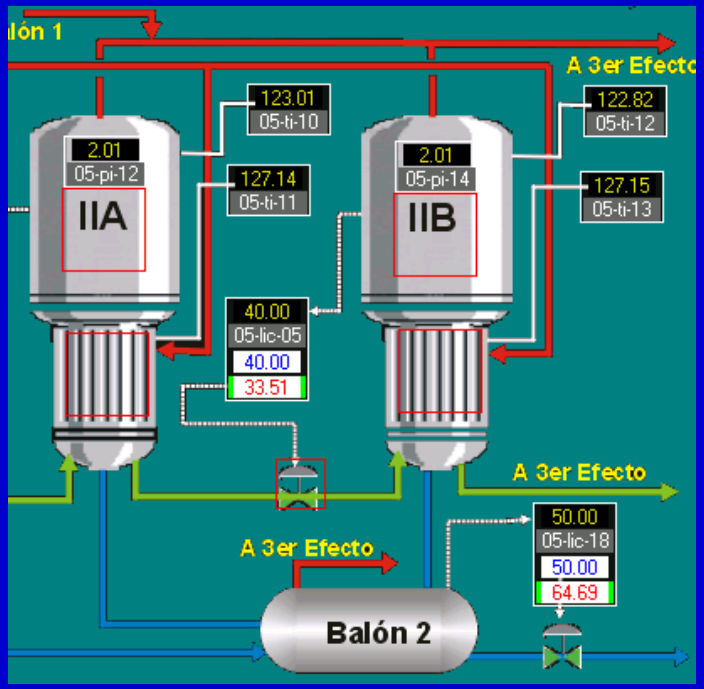
How to use the operator screens....

.... And the toolbars

Operating the Instructor console

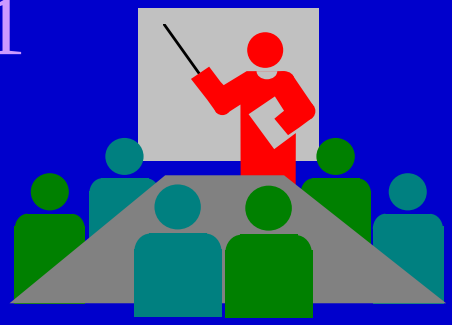
DEMO

Instructor console



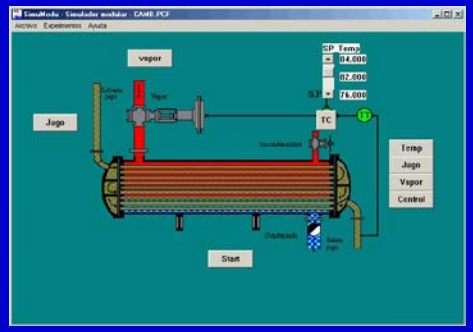
A TRAINING SESSION

1



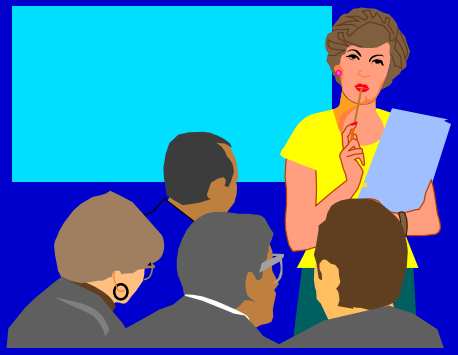
Lecturing in the classrooom on the process units, process fundamentals, process operation and control basis.

2 **Simulators of process units**



3 **Practical work in the full scope simulator**

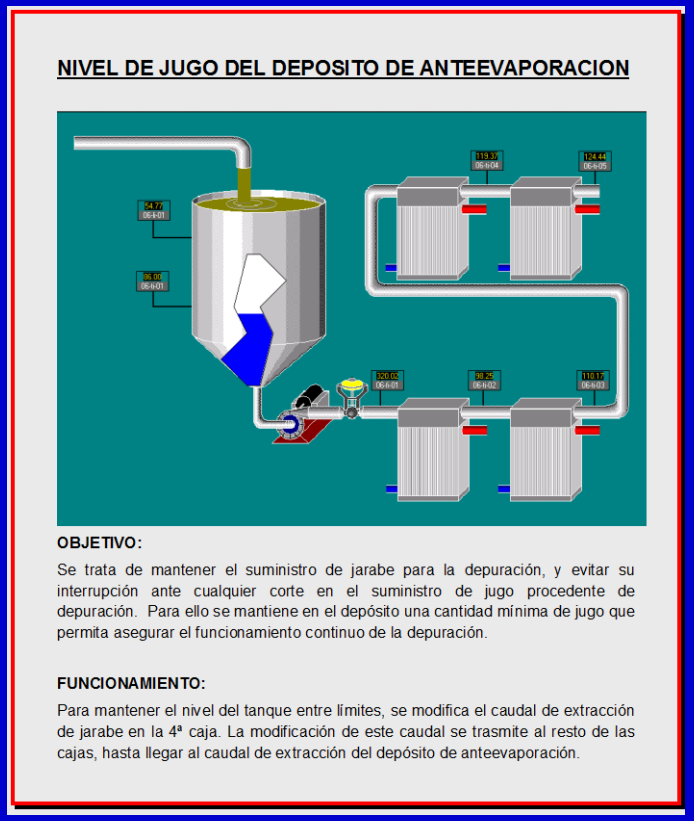
4 **Evaluation**



Classroom.

Lecturing on:

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



NIVEL DE JUGO DEL DEPOSITO DE ANTEEVAPORACION

OBJETIVO:

Se trata de mantener el suministro de jarabe para la depuración, y evitar su interrupción ante cualquier corte en el suministro de jugo procedente de depuración. Para ello se mantiene en el depósito una cantidad mínima de jugo que permita asegurar el funcionamiento continuo de la depuración.

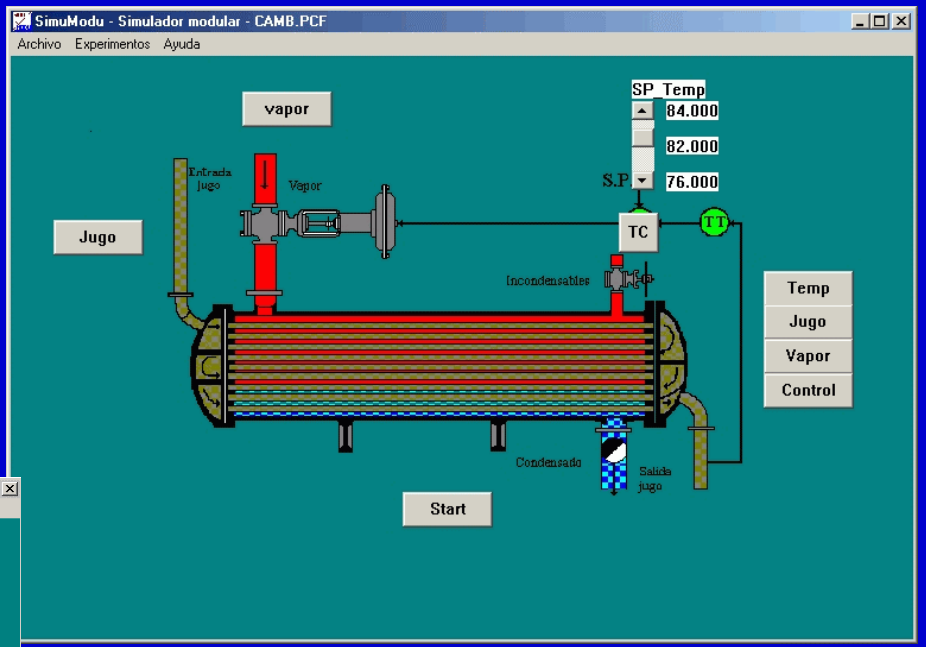
FUNCIONAMIENTO:

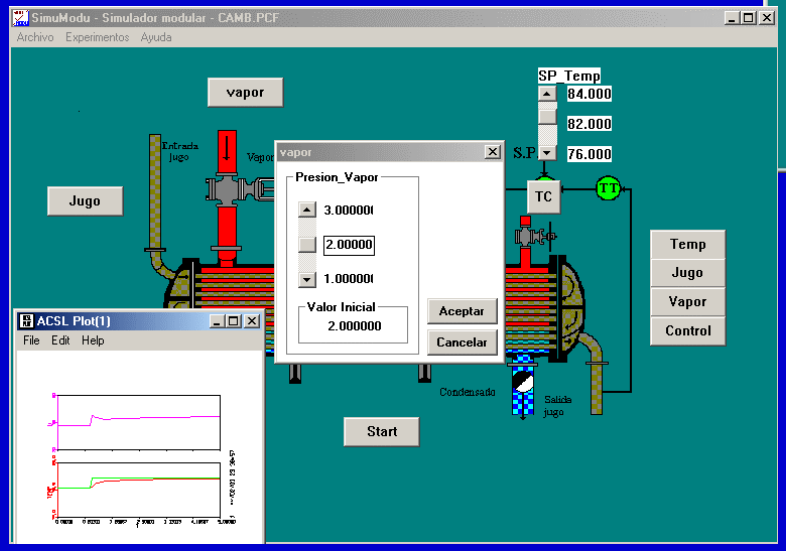
Para mantener el nivel del tanque entre límites, se modifica el caudal de extracción de jarabe en la 4ª caja. La modificación de este caudal se trasmite al resto de las cajas, hasta llegar al caudal de extracción del depósito de anteevaporación.

Manuals + Slides

Process units simulators

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





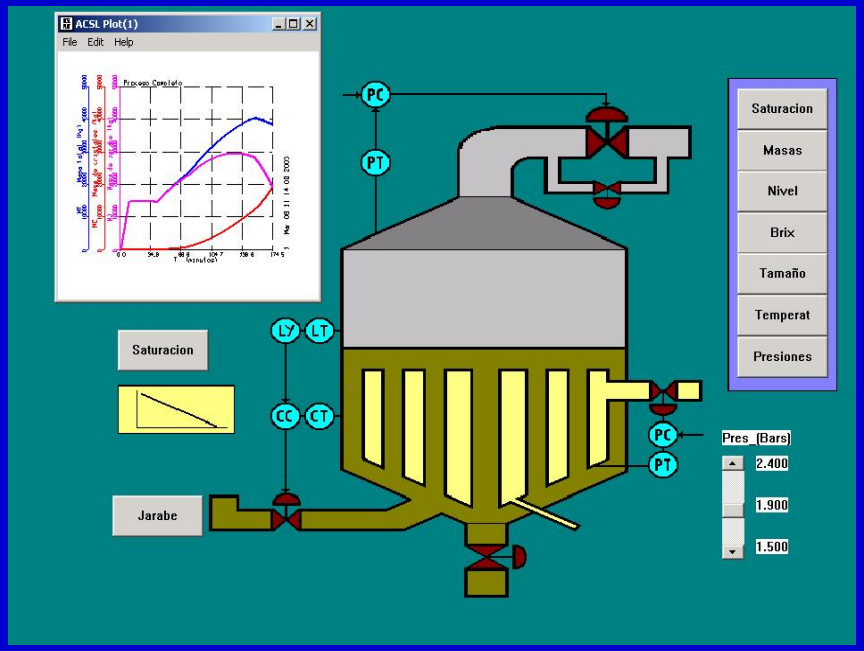
Friendly user interface

Fast response

Process Units

Models:

- Heat exchanger
- Evaporator
- Filter
- Carbonatation tower
- Vacuuum 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
- Discusion 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 / acelerated time
  - ✓Advanced control
  - ✓Predictive simulation

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