SIMATIC PCS7 WebLab

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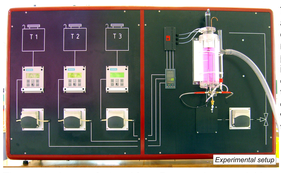
At the University of Cambridge, UK, we have designed, built, used, and evaluated a new Internet accessible laboratory experiment (weblab). The weblab uses Siemens hardware and the SIMATIC PCS7 operating system for operation and broadcasting to the Internet.

1. Motivation

- Reactors a core competence for Chemical Engineers
- Remotely controlled processes used in industry and research
- Weblabs offer up-to-date technologies for remote operation
- Sharing of experiments

2. Experimental Setup

- Chemical reactor
- Variable volume
- Variable, ideal – non-ideal
- Three controllable feed streams
- Temperature controlled
- Variable stirring
- Dosing of tracer
- Spectrophotometer



Experimental setup

The reactor and its ancillaries are mounted in a cabinet for convenience and safety. The reactor itself and the peristaltic pumps are mounted in the front face of the cabinet, whereas supply tanks, flow meters, heater, dosing unit etc are enclosed with easy access provided through rear doors.

The reactor is manufactured from Perspex, has a variable volume of 100-300ml and can be operated at controlled temperatures up to 50ºC. A dead-zone can be created in the bottom of the reactor by a movable effluent pipe and by varying the depth and speed of the stirrer. Three feed streams can be controlled individually by Siemens Coriolis flow meters and peristaltic pumps.

Sodium Hydroxide (NaOH) and Phenolphthalein in dilute aqueous solutions are used as reactants. One of the products is bright pink, and the progress of the reaction is monitored by measuring the intensity of light at 550nm passing through a flow cell with a spectrophotometer. For residence time experiments, Rose Bengal, which absorbs light at the same wavelength, is used.


Supply tanks and Coriolis flow meters

3. Siemens Hardware

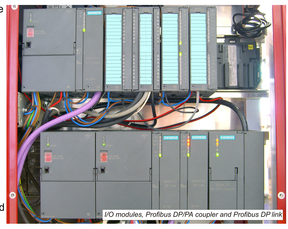
- Intelligent Devices
- Profibus PA
- Analogue **I**nput/**O**utput (I/O)
- Digital **I**nput/**O**utput (I/O)
- Profibus DP/PA coupler
- Profibus DP link
- S7-400 **P**rogrammable **L**ogical **C**ontroller (PLC)
- Industrial PCs


Profibus couplings

The Siemens Coriolis flow meters are so called "intelligent devices" communicating with the system, together with the temperature probes, via a Profibus PA network. These devices are easier to install and configure, and can provide a lot more information than traditional devices. The peristaltic pumps and the stirrer are connected to an analogue output module and the relays for the dosing unit, heater element and heater circulation pump to a digital output module.

The intensity signal from the spectro-photometer is entered into the system via an analogue input module. The Profibus PA signal is converted to a Profibus DP signal in a DP/PA coupler and all inputs and outputs are then communicated to the S7-400 PLC via a Profibus DP link.

To program, broadcast and operate the system, three industrial PCs are used. On the engineering station the operating system is programmed and the operating interface designed and uploaded to the PLC.

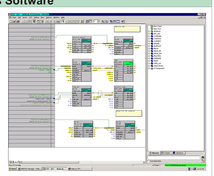

I/O modules, Profibus DP/PA coupler and Profibus DP link

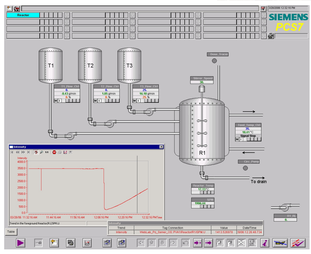

Siemens industrial PCs

The operating system server communicates with the PLC and broadcasts the operating system to the local Ethernet network. The web server runs a html based version of the operating system and broadcasts this to the Internet.

4. Siemens Software

- Configure and network PCs
- SIMATIC manager
- Commission devices
- **C**ontinuous **F**low **C**harts (CFCs)
- Mimic
- Block Icons



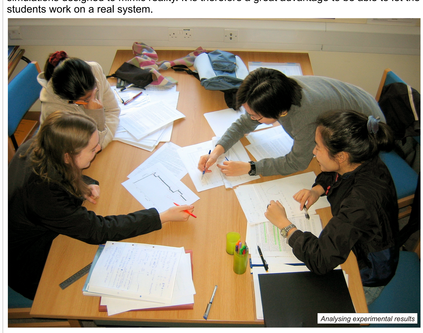


After configuring and networking the PCs, connections are established between the devices in the experimental setup and the controller using the SIMATIC manager. In the CFCs the properties and controls for the devices are configured. The corresponding Block Icons are combined with a visual representation of the experimental setup in the Mimic, the working area for the operator.

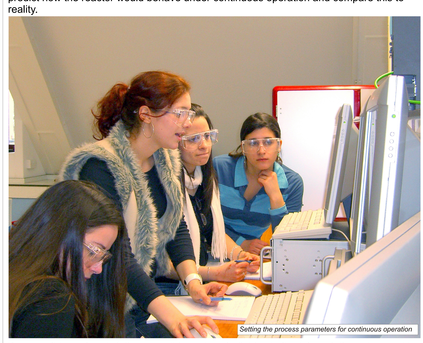
5. Teaching

- Ideal and non-ideal reactor behaviour
- Process Control
- Students can perform experiments as part of project work
- Remote access ideal for demonstrations during lectures
- Remote access allows any institution to take part

Continually assessed project work forms a core part of the Chemical Engineering curriculum at Cambridge. The assignments run for several weeks and are designed to bridge the gap between half-hour exam questions and year long projects. Traditionally, these assignments have taken the form of pen-and-paper exercises, often with computer simulations designed to mimic reality. It is therefore a great advantage to be able to let the students work on a real system.


Analysing experimental results

For their first assignment using the new equipment, the students performed experiments in small groups, analysing results from batch experiments and residence time distribution tests to diagnose the non-ideal behaviour of the reactor. They then used their models to predict how the reactor would behave under continuous operation and compare this to reality.


Setting the process parameters for continuous operation

Because this system is fully accessible and controllable via the internet, it can be used by any institution, without the need for any costly software or hardware. The experiment has already been used for demonstrations on non-ideal reactor behaviour at MIT (US) and Birmingham (UK), and on process control at Imperial College (UK).


Checking on the progress of the reaction

6. Evaluation

The students' opinion regarding the experiment was evaluated by issuing questionnaires assessing different aspects of the learning experience.

- Usability of information, experiment and interface
- Working in a group
- Meeting educational objectives
- Comparison to other exercises

7. Future Work

- Develop additional assignments for various chemical engineering topics
- Use the MIT iLabs shared architecture to handle users, scheduling, authentication and storage of experimental data
- Start collaborations with more universities on broadcasting and exchanging experiments

Technology is available and stable to perform educational experiments over the Internet
User friendly and logical operating system appreciated by the students
Experiment also being used at MIT (US) and Imperial College London (UK)

Acknowledgements:
Siemens Automation Cooperates with Education (SCE)
The Cambridge-MIT Institute (CMI)