IMPACT OF PACKAGED SOFTWARE FOR PROCESS CONTROL ON CHEMICAL ENGINEERING EDUCATION & RESEARCH

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IN AUGUST 1982 THE Department of Chemical Engineering, Teesside Polytechnic, UK, took delivery of a Ferranti Argus 700GL process control computer system. The system was supplied in accordance with a detailed enquiry specification which defined precisely the objectives and scope of the system (Table 1). The objectives of the system are

- **To assist departmental research into varied chemical engineering topics by providing a comprehensive and flexible data logging and plant control system**
- **To provide a teaching facility for the department by live demonstrations of plant monitoring and control applications, simulation, and implementation by students of control strategies.**

The availability of packaged software transforms this situation, enabling the engineer (student or practitioner) to produce useful process control software in a matter of days rather than months.

It is now timely to report on the extent to which these objectives have been realised. At the time this paper is being written, the system is capable of controlling two pilot plants and has also been substantially integrated into our teaching programmes. Computer control is now taught

TABLE 1
Enquiry Specification

1. Objectives and scope of the system
2. Extent of supply
3. Exclusions from supply
4. Functional specification
   - Data acquisition
   - Data logging
   - Pilot plant control
   - Operator interface
   - Data links
   - Development facilities
   - Teaching facilities
5. System hardware configuration
   - Configuration
   - Equipment specification
   - Control system description
   - Maintenance facilities
   - Availability/reliability
6. Supply of software
   - Standard systems software
   - Standard packaged application software
   - Special to project software for a) plant control b) data links
   - High level language
   - Operator facilities
   - Management/engineer facilities
   - Failure/recovery
   - Expansion capability
7. General electrical & electronic design requirements
   - Equipment housing
   - Power supplies
   - Cable schedules
   - Environmental requirements
   - Safety requirements
   - Expansion capability
8. Acceptance tests
   - System hardware/software
   - Packaged software
   - Application software
   - System robustness
   - System loading
9. Installation and commissioning requirements
10. Documentation
11. Project time schedule
12. Maintenance and training requirements
13. Project management
    - Project organisation
    - Project communications and control
14. Commercial requirements

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in all the higher education courses offered by the department

- **Higher Diploma**
- **BEng Honours Degree Courses**
- **Post Graduate Degree Courses (MSc and PhD)**

as well as providing a key facility for our postgraduate research teams.

It is emphasized that all the teaching programmes involve a substantial proportion of practical experience on the computer system coupled with live demonstrations of on-line computer control. It has been found that this new approach to teaching process control stimulates considerable interest from the students who are readily able to relate to these practical situations. Furthermore, the experience gained on such systems is much more directly applicable to the industrial environment than the classical control theory or the modern control theory commonly taught in higher education courses.

The configuration of the computer system is illustrated in Fig. 1 and defined in Table 2. Sufficient industrial interface equipment has been purchased to enable the system to control several pilot plants simultaneously. It also provides connection to simulation equipment.

The simulation equipment facilitates both teaching and testing of research software. The monochrome VDU's may be sited alongside pilot plants to provide local operator display and control facilities. Software development may also take place at these locations if required. Further colour graphics terminals will be added to the configuration in the future.

The pilot plants are accommodated in three module rooms. These rooms extend from the ground to the top floor of the building and can ac-

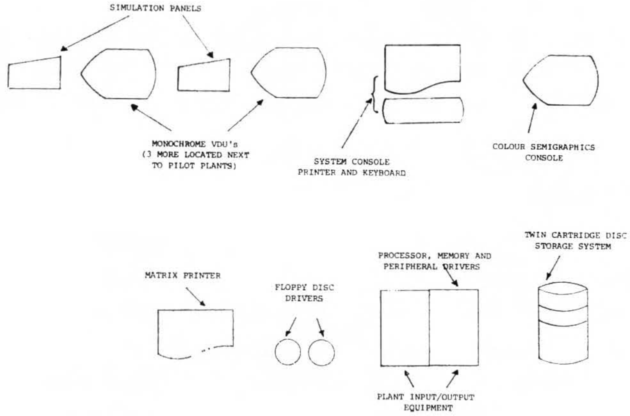


FIGURE 1. Computer System Configuration.

TABLE 2
Computer System Configuration

EQUIPMENT	QUANTITY
• Argus 700 GL processor	1
• Semiconductor stores (256 Kb)	2
• Monitor and control console	1
Peripherals	
• Monochrome VDU's (15 inch display heads and keyboards)	5
• 20 inch colour monitor and functional keyboard	1
• Matrix printers (180 cps)	2
• Keyboard for printer	1
• Plus drive cards for all peripheral devices and serial input/output cards for data links	
Storage Media	
• Twin cartridge disc storage system (10 Mb) (one exchangeable, one fixed)	1
• Twin floppy disc storage system (1.0 Mb)	1
Industrial Interface Equipment	
• Analogue inputs	176
• Analogue outputs	72
• Digital inputs	64
• Digital outputs	64
• Pulsed digital outputs	8
• Plus usual power supplies, fans, packaging, etc.	

commodate large column type processes. A pair of reactor bays is also provided on each floor of the building. Multicore cables have been laid to link the computer to pilot plants in all of the above locations.

CONTROL PACKAGES

The standard system software P.M.S. (Process Management System) encompasses all the facilities required to implement, operate, and manage a computer controlled process. Software packages have been provided by the computer manufacturer which greatly assist the engineer in building the application software required to operate his particular plant. It is this facility which enables the teaching of the subject within the time scale and context of a higher education course.

Prior to the availability of control packages, the general approach of computer system suppliers was to provide "tailor made" software for a specific application in the form of a so-called "turn key" contract. The software was written in

Ferranti computer control system.

a real-time high level language such as CORAL. This meant that engineers were either required to learn in depth a high level language and the associated operating system of the host computer system, or to define their system requirements to a programmer, who in turn implemented the required functions in software. Either of these options was time consuming, costly, and therefore inefficient. The time scale required to learn such programming skills can be measured in months, rather than weeks, of dedicated work, which makes it impossible for it to be incorporated as part of a higher education course.

The task of the engineer is then to select which operations are needed for a specific case and to link them together accordingly.

The availability of packaged software transforms this situation, enabling the engineer (student or practitioner) to produce useful process control software in a matter of days rather than months.

Specifically, the packages assist the engineer in implementing the following functions in software

- **Interfacing of plant signals to and from the computer**
- **Continuous control**
- **Sequence control**
- **Operator interface: a means of display and modification of process and control information.**

All are clearly essential for the commissioning of any computer control system. The packages are based on the principle that certain operations are common to all process control applications, while the order in which they are applied is specific to the particular application in question.

The task of the engineer is then to select which operations are needed for a specific case and to link them together accordingly. The package provides considerable assistance with this linking "construction" by providing a conversational facility for the engineer in the form of displayed messages (prompts). The task is then reduced from one of detailed programming to one of deciding on a control strategy and then defining a series of operations and associated parameters to implement the strategy. Thus, virtually no programming skills are required and the problem of programming errors which normally arise in the programming of complex software is largely avoided.

TEACHING PROGRAMS

In the context of control packages, the teaching of control system design, from initial strategy to implementation and testing of software using hardware and software simulators, is entirely practicable.

Every opportunity has been taken to incorporate our computer control facilities in our teaching programmes. These include

- **Laboratory Practicals for the Higher Diploma** students: e.g., interfacing of plant measurements. This requires that the student generate the software to condition and convert electrical signals into engineering units. The operation of the software is then tested by means of simulation panels.

- **Short Course (10h) for the final year of the BEng course. The course includes several practical sessions on building software to interface signals, continuous control loops, and operator displays. The project used to assess the students in the current academic year requires that the students work as a project team to generate the entire software to monitor, data log, and control a fermenter. The facilities will include sequence control of the plant and a colour graphic display of the process providing a live mimic of the plant operation. This is no artificial project since the software produced by the undergraduates will ultimately be used by the department's biotechnology research team to implement computer control on a newly acquired fermenter.**

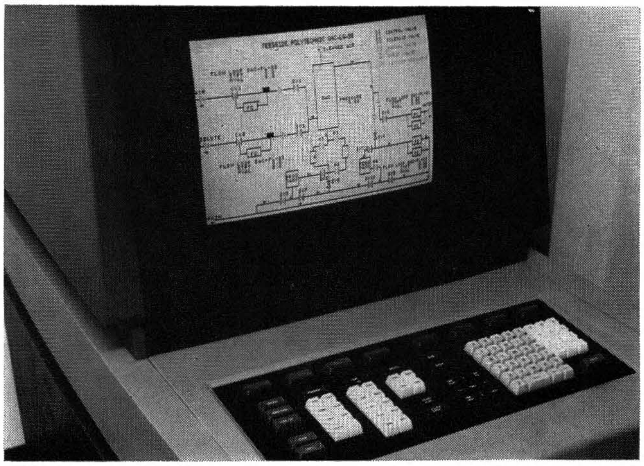
Mention should also be made of the allocation of a limited number of research projects to second-year degree students which involve the computer control of laboratory scale apparatus. Current projects involve the control of pH and level.

Chemical engineering also offers service teaching to other Polytechnic departments. The opportunity has, therefore, been taken to offer computer control of a pilot plant as a case study. This academic year, students from both the Computer Science Department (Information Technology MSc Course) and the Department of Electrical, Instrumentation and Control (BSc2), have received a concentrated study on computer control of a specific pilot plant. Like the other courses offered, the courses include a substantial proportion of practical experience on the computer system and live computer control demonstrations.

POST GRADUATE RESEARCH

With regard to research, the main thrust has been directed toward the commissioning of direct digital control of a gas absorption column. This work involved the use of adaptive control (the self tuning regulator) which has been used to optimise the operation of a cascade loop on the column. This research is reported in a separate paper [1] and will not be considered further here. However, it is worth noting that the speed with which this research was implemented owes a great deal to the availability of packaged software on the system. While the self tuning regulators were in fact programmed in a high level language, the interfacing of this software with the control packages (which are responsible for all other control facilities) was straightforward and rapidly achieved. It should be noted that apart from this one specialized application, all our software requirements to date have been easily implemented by the control packages.

Future research effort will be directed to the implementation of computer control on a novel catalytic reactor which has been developed within the department over a number of years [2]. The control system will facilitate prolonged operational runs and assist in further research into commercial application and scale up of this unique reactor. The plan is to apply the adaptive control techniques (recently proven on the gas absorption column) to this reactor. This process lends itself particularly well to these techniques in view of its time varying nature due to the decaying catalyst. This is the main target for the research team.



Graphics display of gas absorption column pilot plant.

In conclusion, it is clearly important to recognise the potential of packaged software in the teaching and research environment. (There are also considerable implications for the industrial applications, but that is beyond the scope of this paper.) Packages are rapidly gaining recognition as vital tools for the modern chemical engineer. In an environment of continuously falling computer hardware costs, coupled with the ever-rising costs of producing "tailor made" software, it is essential that the engineer makes full use of commercially available packages. The cost of plant design, implementation and operation of chemical processes and their associated automation systems can be considerably reduced by judicious use of

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Another important refinement is to modify the impeller in the "mixer" which is a small centrifugal pump that blends together the reactant streams entering the reactor tube. In our particular reactor geometry, the impeller of the pump sent rapid pressure pulses back to the dye rotameter causing violent fluctuations of the bead in the dye rotameter. Our solution was to replace the impeller blade with a flat disc. The rotation of the disc generates sufficient shear to blend the streams.

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these packages. To this end an increased student awareness and familiarity with these facilities can only be beneficial. □

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1. "Control of a Gas Absorption Column using the Self Tuning Regulator," C. K. Goh, J. C. Cheow, P. R. Bunn, and B. Buxton. Paper presented at Institute of Measurement and Control Symposium "Application of Multivariable System Techniques", 31 October to 2 November 1984, Plymouth, UK.
2. Annual Research Meeting, Bath, 4 April 1984. Heat Transfer, Catalysis and Catalytic Reactors, 247. Heavy Oil Cracking. S. Acey, J. C. K. Lee, J. R. Walls.

PROCESS LAB
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to bad habits as soon as they stop writing regularly.

The feedback from the students has been extremely positive. They fully enjoy the opportunity to work on what they regard as their own problems. We have not come across a course which puts so much demand on the students but receives so few complaints. (The actual lab work extends well over the regular six hours per week scheduled in addition to the time required for report writing and preparing oral reports.)

The support from industry has also been encouraging. We continually receive financial aid and equipment donations as well as new ideas for experiments. In the next year we expect to receive an industrial scale CVD reactor, a spin coating apparatus and an experiment to perform membrane separation of gasses. Our lab course would not have been so successful without this continued support. □

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other new topics added to the first edition such as an analysis of overtime costs, information on rework costs, and the handling of back charges. These topics are illustrated by actual industrial examples. Additional new information on bulk material control, monitoring construction field labor overhead, labor productivity, and forecasting direct labor are illustrated with other industrial examples. The chapter on contingency estimating and its application to cost control has been rewritten to reflect recent developments. The treatment of estimate types and accuracies likewise has been updated. Because of the omnipresent computer, an introduction to computerized estimating has been added since the first edition. Advice is provided on how to go about computerizing routine estimating tasks.

This edition is the first book in a planned series of about 20 which concern cost engineering and related topics. Of the twenty, six have already been published. This series will cover the whole gamut of cost engineering topics for the student and for the practicing cost engineer. □