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INTEGRATED CONTROL SYSTEMS FOR THE CHEMICAL INDUSTRY

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1. FOREWORD

In recent years, in the chemical industry, consumer needs have increased and the demand for higher and more stable quality has become severe. Moreover, the rise in the labor prime cost and the labor shortage are also superimposed and manpower and labor-saving must be advanced. Under such condition, not only automation and rationalization, but also integrated control systems that cope with variable type, variable amount production, short delivery period, high quality, and other diverse market needs are demanded. In other words, there is a need to develop to total FA (Factory Automation) and CIM (Computer Integrated Manufacturing).

This paper describes the recent tendency of integrated control systems and delivery examples in the chemical industry.

2. TENDENCY OF CHEMICAL INDUSTRY

The contents especially demanded as the most recent market tendency are:

(1) Variable type, variable amount production system
(2) Higher quality products
(3) Short product delivery time
(4) Work labor saving
(5) Unmanning of operation
(6) Adjustment of work environment

Table 1 Shape and image of future chemical plant

Number of questionnaires: 101

Item	(%)	Remarks
Automation, FA, robot	31	
Clean, closed, recycle	19	Energy: light
Use of AI (Artificial Intelligence)	17	Multiple product production
Human center	8	
Naturalized plant	5	Pipeless
High efficiency plant	5	Small area, multiple type production
Safe plant	2	
Maintenance-free facility management AI	2	
Normal temperature, normal pressure combination	1	
Sanitary and bright	1	
Feeling of cooking in a kitchen	1	
Others	6	

Furthermore, the results of a survey on the image of the future chemical plant conducted by the Chemical Engineering Society with 100 manufacturing, research, and planning departments as the objective is shown as reference in *Table 1.*

As manufacturing technology, multipurpose plants which directly operate reaction tanks and build processes without using pipe advancing.

Against such a background, the need for an integrated system aimed at the fusion of PA and FA is rising rapidly to perform production scheduling, optimum operation planning by recipe management, and efficient operation.

To improve quality, improve productivity, and save labor, a system incorporating AI (Artificial Intelligence) is also being promoted positively. The number of cases which use fuzzy control and other AI software, in addition to data analysis and modeling, for plants which are difficult to pattern control is increasing.

3. INTEGRATED OPTIMUM SYSTEM

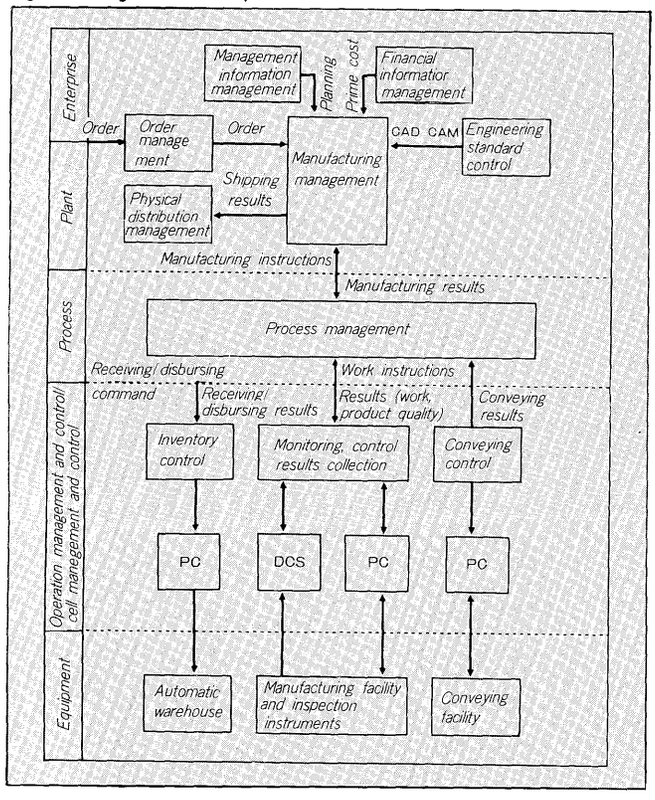
An integrated system centered about a distributed control system (DCS) matched to the demands of the chemical industry is described below.

The integration concept is shown in *Fig. 1.*

Roughly speaking, the management levels production management from raw materials receiving to product shipment, process management for optimum operation in the plant, operation management and control, and cell management and control. An optimum system is built by organically connecting these. The integrated functions table is shown in *Table 2* and the system configuration is shown in *Fig. 2.*

As configuration, process management is performed by by minicomputer A series and process control is performed by MICREX (PCS-500, HDC-500, OCS-1500, DBS-1500) and these are connected by a dataway (DPCS-F). Inventory management, conveying, robot, inspection machine, and other FA use FA personal computer and programmable controller (MICREX-F250) and are connected to PA by

Fig. 1 Integration concept



a FUJI network circuit (P-link) to fuse PA and FA. An integrated system is constructed by connecting these to an A series computer by a universal LAN (Local Area Network).

4. DELIVERY EXAMPLE

A PC (polyvinylchloride) plant integrated system is described as an recent delivery example.

This PVC manufacturing process is the world's largest batch plant which consist of raw material supply reaction, recovery, and drying processes.

The system block diagram is shown in *Fig. 3.*

It consists of a distributed control system (OCS-1500, PCS-500) and management computer (A-50). An integrated system is built by connecting these with a dataway.

4.1 Distributed control system

A PCS-50 and OCS-1500 are installed at each group and each process to distribute the danger.

As a highly reliable system construction, the common parts (MPU, MEM, etc.) of each station have a duplexed configuration. Moreover, for the important control loops, the input/output cards are duplexed.

Table 2 Integrated functions table

	Function item	Description
Process management	Production schedule	• Plant operating plan is prepared and efficient operation is performed by production plan instructions from higher level computer. • Plant operation becomes more complex with the change to multiple product production. Efficiency operation is made possible by optimum plant operation plan.
	Physical distribution management	• Conveying management of raw material, product container, etc. is performed.
	Results management	• Manufacturing results data and utility data of each process are collected from DCS and management documents are prepared. • Lavor-saving is performed by batch management of voluminous data at a data base and preparation of each document. Moreover, data protection become easy and data reliability is improved.
	Maintenance management	• Manages the information related to plant maintenance. • Maintenance and management of the facility in the best state at all times is made possible and the lead time is shortened and product quality is improved by means of this.
	Quality control	• Quality is controlled by quality contents history study. • Quality is controlled by inspection data management (data base).
	Inventory control	• Receiving/disbursing control is performed for raw material, products, and containers.
Operation management	Recipe management	• The operation conditions, etc. are managed for multiple product recipes.
	Operation monitoring and operation	• The raw materials, conveying, and containers operation conditions and recipe operating conditions are monitored.
	Warehouse management	• Stock-in/stock-out management is performed.
Control	Process control	• Batch control, reaction control, program pattern control, PID control
	Sequence control	• Each sequence control is performed by time chart system for raw material feed, reaction, extrusion, etc.
	Physical distribution and conveying control	• Raw materials and product conveying conveyer, robot, etc. control is performed.
Advanced control	AI control	• AI (Artificial Intelligence) is used and advanced control which is difficult with control founded on conventional arithmetic models is performed. • The kinds of support software packages are shown below. * FRUITAX-UX : Fuzzy control system building tool * EIXAXD-UV : Process control use expert system building tool * ΦNET-UX : Physical distribution system building tool * COMEXS : Diagnostic type expert system building tool

Fig. 2 Integrated control system block diagram

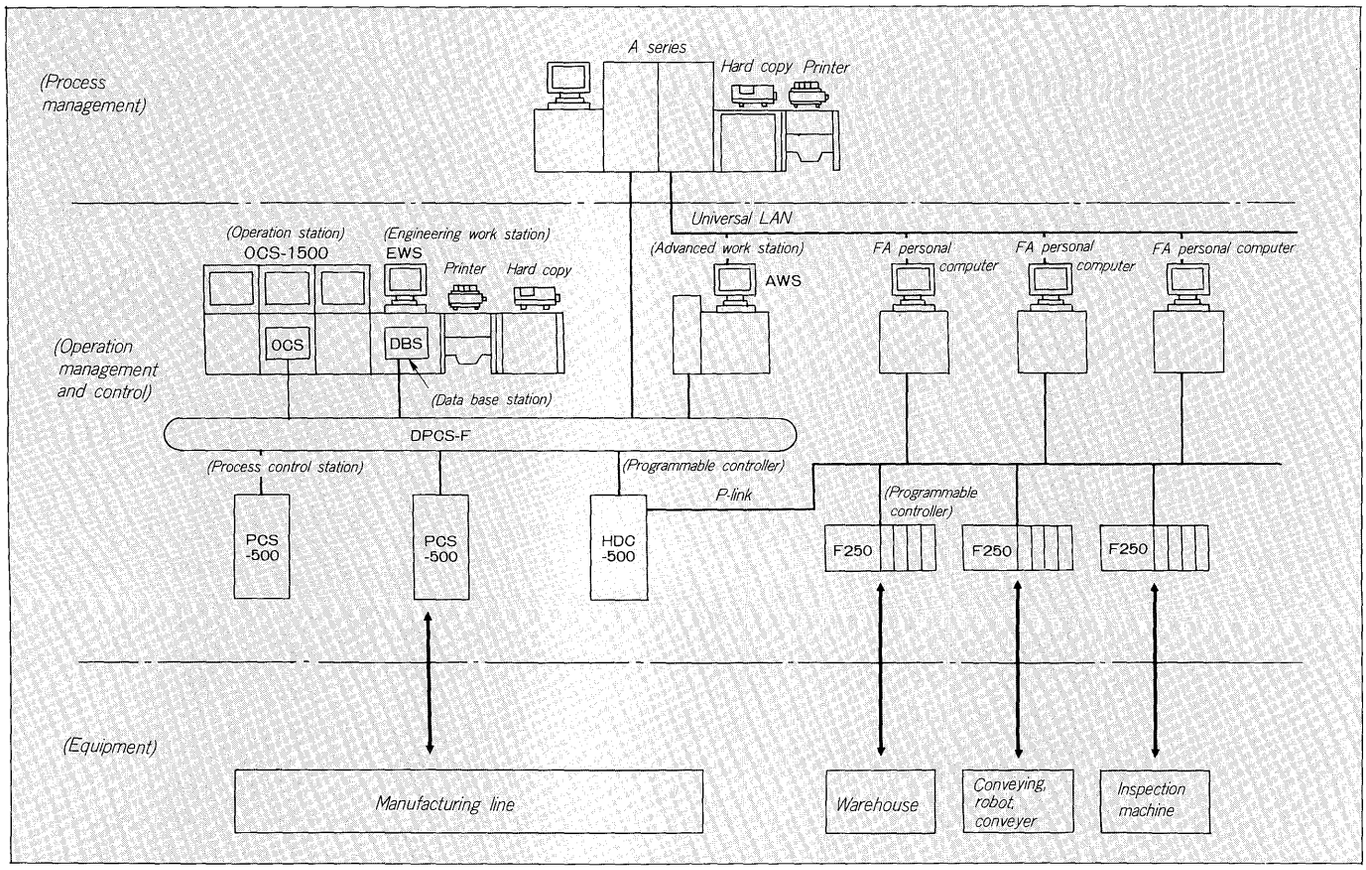


Fig. 3 PVC plant system configuration

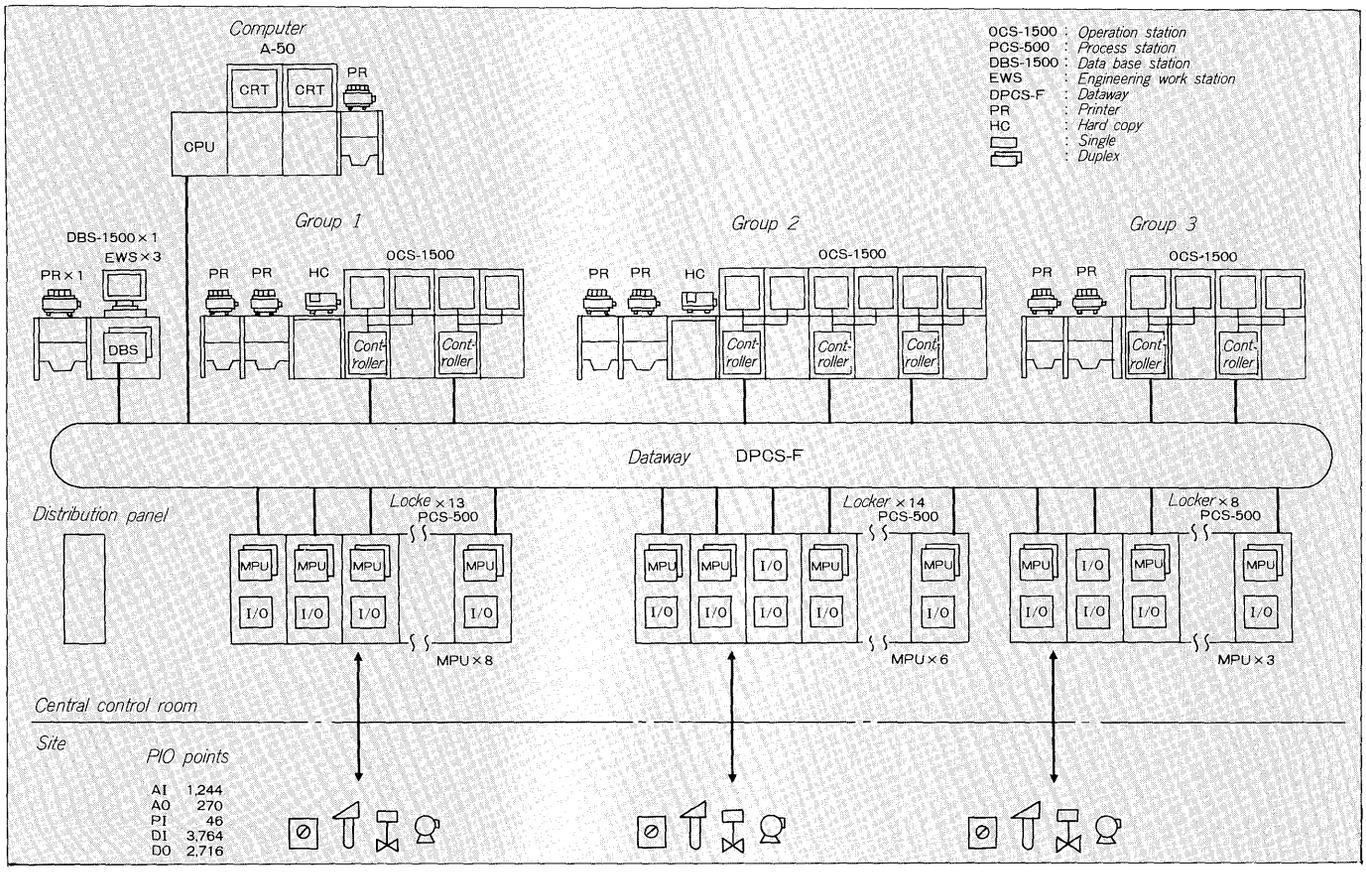
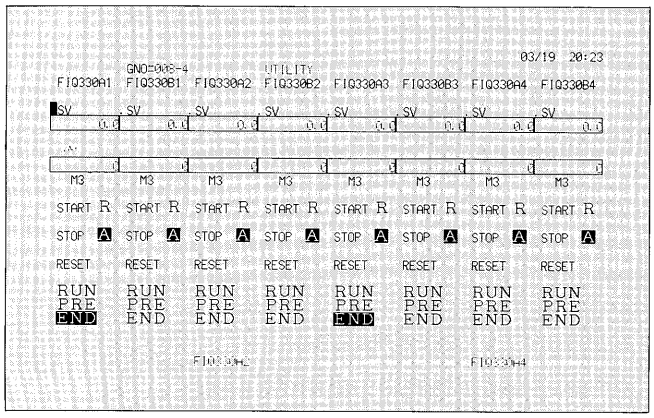


Fig. 4 Screen example



(1) Raw material fixed amount feed
(2) Facility alarm detection and alarm cause judgment
(3) Individual operation of valves and pumps

A constant amount supply module screen example is shown in *Fig. 4.*

The pulse signals from a flowmeter are integrated and compared to the fixed amount set value and large and samll valves are controlled by a two-stage output signal.

To improve integrating precision, temperature compensation operation is installed as a general expression which can deal with various chemical fluids.

4.2 Management computer

Facility management, results collection and trouble diagnosis by AI are performed for operation management.

The computer system is connected to a data base station (DBS) via a dataway.

To interface with the computer, a dedicated processor is installed at the DBS and data management is unified as an integrated system by installing industry value data transmission and state change detection transmission software.

4.3 Engineering

For this system, Fuji Electric performed training and support and the user performed software preparation and debugging.

The engineering work allocation is shown in *Table 3.*

MICREX allows the realization of simple screen preparation and control system preparation by engineering work station (EWS).

As the preparation technique, first typical functions were made screens and for the same functions thereafter, direct corrections were made at the EWS after software copying of typical patterns.

For plant unique functions and repetitive functions, software modules were supplied by Fuji Electric and software preparation efficiency was raised.

Table 3 Engineering work allocation

Work item	User	Manufacturer
Total system construction	–	○
Engineering		
◦ Operation plan	○	–
◦ Instrumentation flow sheet	○	△
• Input/output table	○	△
• Time chart	○	△
• Screen, document specifications	○	△
• Panel specifications	○	△
Detailed design		
◦ Development connection diagram	–	○
• Locker assignment and outline dimensions	–	○
• Panel outline dimensions	○	△
◦ Control design sheet	○	△
◦ Screen and document design sheet	○	△
• Software module	–	○
Software manufacture	○	–
Hardware manufacture		
◦ DCS	–	○
• Computer	–	○
◦ Panels	○	–
Debugging		
◦ DCS	○	△
◦ Computer	○	△
Site adjustment	○	△

○: In charge △: Support

5. CONCLUSION

The tendency of integrated control systems in the chemical industry and a recent delivery example were introduced above.

In the chemical industry, the footlights are on multiple purpose plants which should cope with variable kind, variable production and also with the rise in the demand for higher product quality and for labor-saving and automation to meet the labor shortage and the diversification of production facilities.

In the past, the automation of individual facilities was advanced, but integrated systems organically couple not only PA, but also physical distribution and conveyance automation and the production management system and are an important means of constructing a total FA system. In the future, we want to make more efforts in the realization of an optimum system.

Since software preparation and debugging were performed mainly by the customer to deal flexibly with the plant know-how flow out problem and operation modification.

The following functions were software mudulized for batch control: