AUTOMATIC GENERATION OF SEQUENCE CONTROL PROGRAMS

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Abstract

This paper describes the automatic generation of sequence control programs for DCS (Distributed Control System), PLC(Programable Logic Controller) and so on. Since there is no same manufacturing process, it is difficult to standardize sequence programs.
We propose the automatic sequence control program generator which is CAD software using knowledge engineering technique.

1. Introduction

Sequence control designers understand a plant using the operational specifications and the plant diagrams(P&ID, process flow etc.).
This understanding needs the knowledge on actuators, the knowledge about the plant and the knowledge about plant control, therefore the design quality depends on the experience in sequence control design. To realize this design by computers the method to implement the knowledge to the computers is an important problem.

Operational Specifications are divided into the descriptions on materials, the description on actuators, and the descriptions on actions. The information on the materials actuators and can be obtained from the plant diagram. Using the above infomation, the sequence control programs are automatically generated, which is finally written in IFC (Instrumentation Flow Chart)(IFC is an instrumentation-oriented flow chart language which is the extension of the PC programmig language SFC authorized by IEC)

This automatic generation method uses natural language processing, knowledge base and model matching method.

2. Back Ground

First of all, we analyze the design method of sequence control programs. There are three basic information for sequence control programs design.
First one is process flow and P&ID (Piping and Instrumentation diagram), which presents relation and route of equipments, piping and instruments.
Second one is I/O list (Inputs/Outputs list) which presents inputs and outputs points, types of control signal, and so on.
Third one is operation method which presents sequence, conditions and logics of process operation.
Making the basic specification from above three information is next step.

The basic specification indicates operation specification of equipments and instruments(TAG list), Common specification of sequnce control such as interlock, abnormal processing and interface specification to human interface or computer.
The sequence flow chart is made from the basic specification. Sequence control program is completed from the basic specification, coding or CAD input and compiling.

Items for sequence specification

1) Understanding for sequence and conditions of equipment, and flow of process flow and P&ID
2) Operation method of equipments and instruments
3) Interruption of operators or computers.
4) Action for abnormal condition of equipments and instruments

It is required experience and skill of designer for detailed sequence flow chart from specification, and it affects design time and quality. In addition to this, process know-how is also required for design.
There is big difference between skilled engineers and unskilled engineers for design as a result.
We develop this system for solving of this problem.

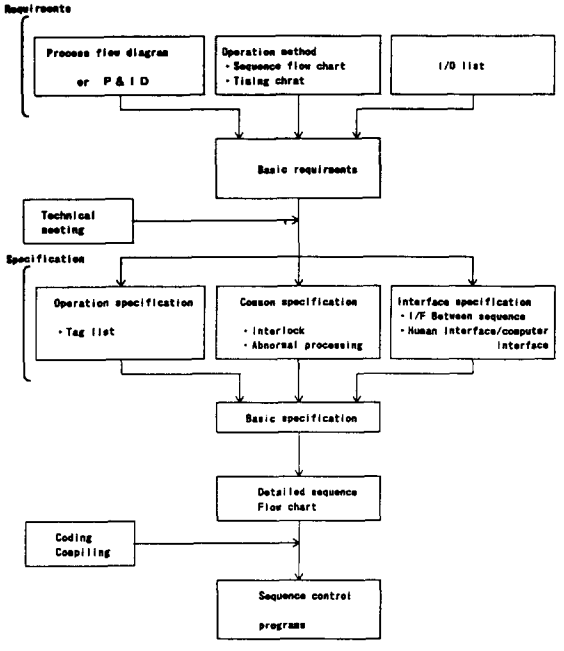

Fig.2-1 Design flow of sequence control programs

3. Summary of System

Automamtic generation system of sequence programs is built on EWS(Engineering Work Station)AS-4000. Fig.3-1 shows the system configuration.

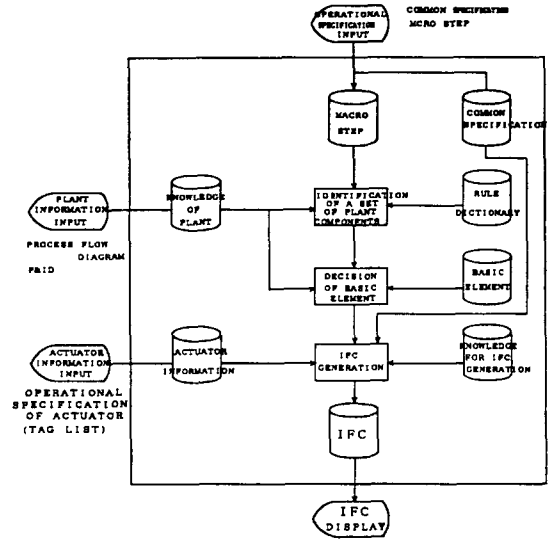

Fig.3-1 Automatic generation system of sequence programs

3.1 Input of specification

The generation way of the sequence program are consist of the following three steps.

- Operational Specification
- Plant Information(process flow diagram, P&ID)
- Actuator Information

the explanation of each item is as follows

(1) Operational specification

Operational specification is divided two items of "Macro step"and "Common specification"

1) Macro step

Macro step is the configuration unit as control unit of material or equipment. Macro step is composed with actuators and instruments, and their control actions are decided according to their combination. For example, sequence control of beach reactor of petrochemical plant is composed with some macro steps, such as "PURGE", "CHARGE", "REACTION", "DISCARGE", etc.

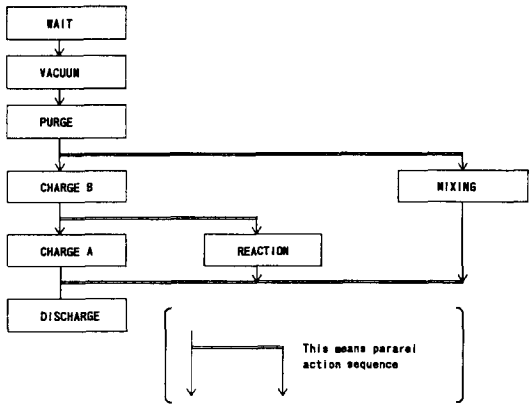

Fig.3-2 Macro sequence flow

2) Common specification

This means common specification of sequence control systems

Items of common specification

- Action when start interlocks are not realized
  1. No action
  2. Output guidance
- Detailed operation step display
  1. Non
  2. Do
- Down Load request
  1. Non
  2. Do
- Action when failures are happened
  1. continue sequence(without FMT)
  2. continue sequence(with FMT)
  3. set M mode(with FMT)
  4. Do reverce action and set M mode(with FMT)

  * FMT is function of alarm
- Alarm suppression
  1. Non
  2. Do
- A mode check of DIO loop
  1. No action
  2. Stop after confirm
  3. Continue after confirm
- Interlock confirmation for each macro step
  1. Non
  2. Do

(2) Plant information(process flow diagram & P&ID)

Fig.3-3 shows an example of process flow diagram. Process flow shows piping, control loop of plants and position of actuators and instruments. And it shows scope of process that are objects of automatic programming for sequence control.

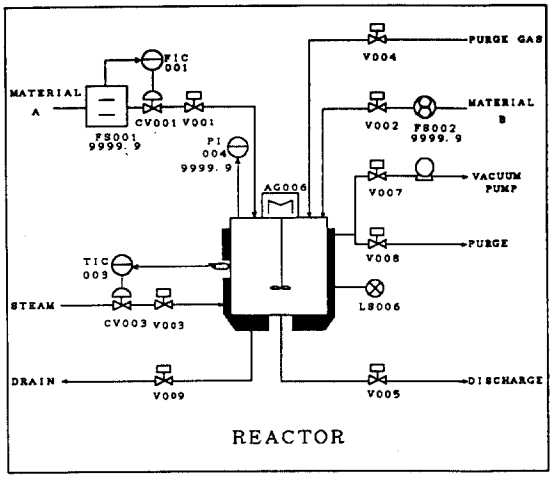

Fig.3-3 Process flow diagram

(3) Plant element information

This information means that of each element of process flow diagram.

Contents of information or TAG-No (Tag means name plate of actuators or instruments), kind (pump, valve, tunk, sensor, etc.), and actuator name, etc.

The output is a sequence control program written in IFC. IFC (Instrument Flow Chart) is sequence programming language that form is flow chart. Fig.3-4 shows an example of IFC.

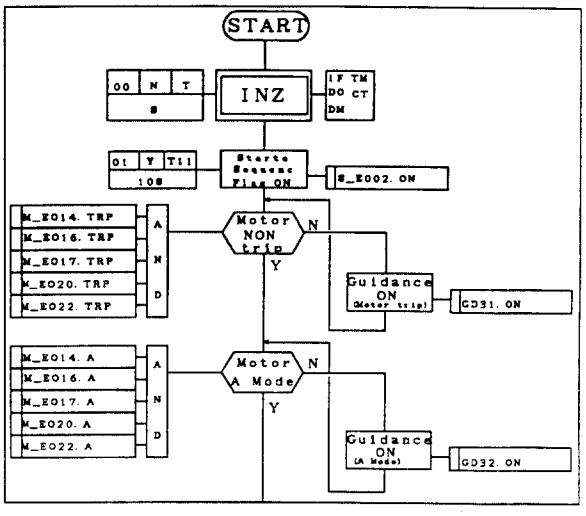

Fig.3-4 I F C

3.2 Function

We explain the function of automatic generation systems of sequence programs in detail.

(1) Input of plant information

Plant information can be input with process flow input screen(Fig.3-5). Each actuator (valve, pump, sensor. etc.), equipment(tunk, reactor etc.) is selected from menu window, and set on the screen. These are connected with line. The direction of the flow of material is drawn by symbol "→".

(2) Input of plant element information

Actuators and equipments information are input from process flow diagram input screen. We select each parts of actuators or equipments, and display input window screen, and input information of actuators.

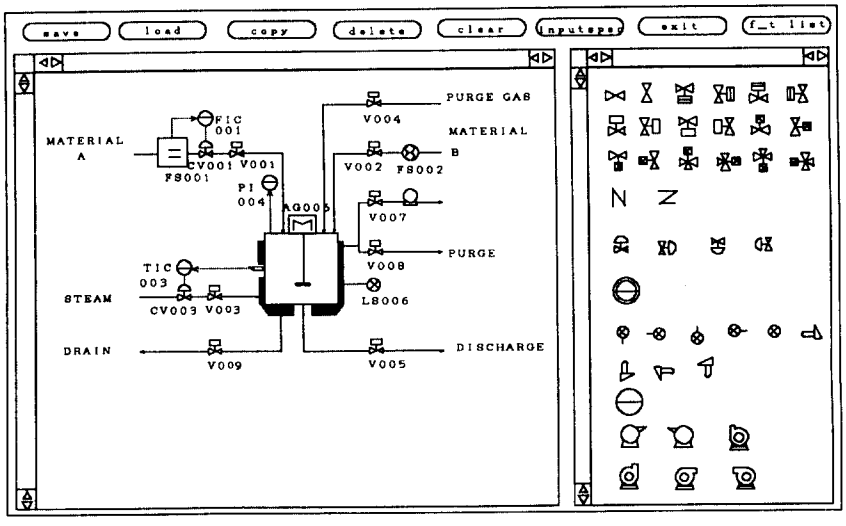

Fig.3-5 Process Flow Diagram Input Screen

(3) Input of operational specification

1) Input of macro step

We input macro step with screen(Fig.3-6). Each macro step are set in order and coneccted each other, and we input macro sequence name in each macro step.

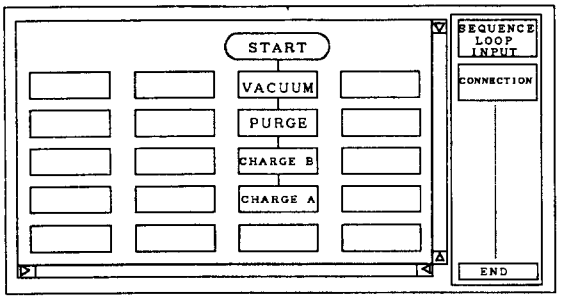

Fig.3-6 Macro step input screen

2) Input of common specification

Common Specifications are input with menu screen (Fig.3-7) We select each items and display window, and select function.

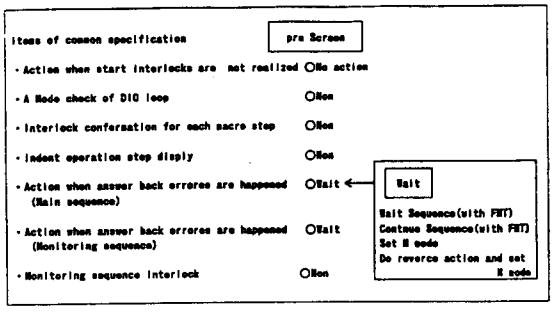

Fig.3-7 Common specification input screen

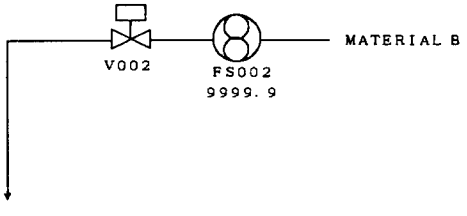

Fig.3-10 Process flow of CHARGE B

(4) Generation of sequence programs

Sequence programs are generated based on plant information, actuator information, operational specification and knowlege base.

Fig.3-8 shows generating flow.

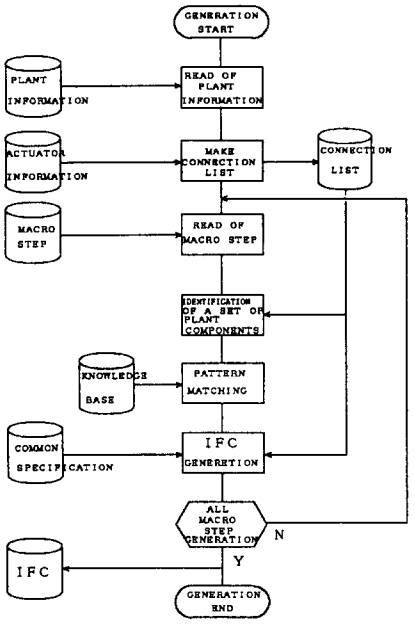

Fig.3-8 GENERATING FLOW

The main points of sequence generation are as follows.

1) Plant structure knowledge acquisition

The plant structure knowledge is acquired from the plant information (process flow diagram or P&ID). The connection list of each process control element is generated from process flow diagram by reading connection structure and feed material. Type name and attribute of each element are given by element information list(tag list) and those are added to the connection list. Consequently, this connection list has the information of control object element, that is type, name, feed material, connection structure and attribute.

2) Identification of a set of plant components for each sequence macro step

A macro step is an independant process-oriented sequential action within an operation and comprises of a varing number of instruction steps.

As a simple example, refer to macro sequence flow of Fig.3-2 and process flow diagram of Fig.3-3. Chose "Charge B" macro step from macro sequence flow. The process pattern of this macro step is real ized as the pattern of Fig.3-10.

3) Pattern matching

Pattern matching is the search of IFC sequence control flow chart those plant elements structure is same as the given process. IFC sequence flow chart of "Charge B" is shown in Fig. 3-11.

There are many variation of plant structure, therefore IFC pattern knowledge data base corresponding to plant structure is prepared, and if pattern matching is not satisfied, new pattern is added to the data base.

4) IFC generation

After the pattern matching is completed, common specifications of sequence control are joined together, detailed sequence flow chart are determined, then tag information is determined using those of connection list, and IFC sequence program of macrostep is generated. For each macro step, this procedure is recurred, and by combination of each macrostep, IFC sequence generation is completed.

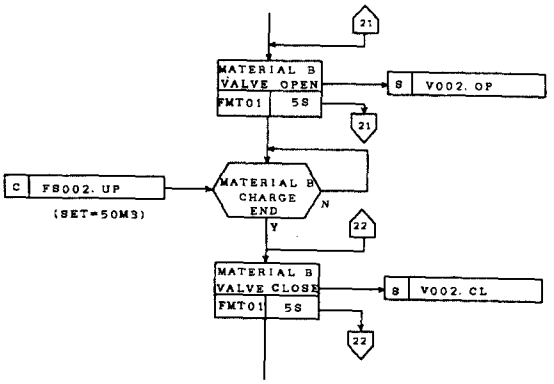

Fig.3-11 IFC of CHARGE B

4. Conclusions

This parper has discribed an automatic generation method for sequence control programs. The operation specification is a Flow chart written by macro steps. However, some operations may not be described by there macro steps, which is to be solved in the future. A macro step is transformed into a detailed IFC pattern using the information on hardware configuration. There are many IFC patterns, which will aggravate the performance. This is also to be investigated. A plant information is given by process flow plus knowlewdge on actuators. This will be improved using a customer's P&ID.

The knowledge base must be increased, which can be supported by some inductive learning.

This method has several probrems to be solved in the future. We improve this method to beapplied to a lot of plants.

We are now developing the prototype.

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