Training in Operating Plant with DCS in the Romanian's Refineries

CRISTIAN PATRASCIOIU[1], NICOLAE PARASCHIV[1], MARIAN POPESCU[1],
ANTOANETA MANEA[2], TUCU GHEORGHE[3], MIRCEA GHENOIU[4]
[1]Computer and Control Department, [2]Chemical Process Department
[1]Petroleum-Gas University of Ploiesti,
[2]Petrobrazi Ploiesti, [3]Honeywell Romania, [4]Petroconsult Ploiesti
Bd. Bucuresti 39, Ploiesti
ROMANIA

Abstract: The Distributed Control System (DCS) represents the modern control equipment for refinery. The radically changes of the operator's job have need the knowledge of the DCS equipment, refinery processes and process control. In this context, one of the objectives of the Romanian educational system is the development a flexible structure, which to obtain a good qualification of the refinery engineers and operators. This paper presents the efforts and achievements of the Research Center Advanced Chemical Process Control of Petroleum-Gas University of Ploiesti, in the creation of a training laboratory for distributed control systems operation. The first element of the training system consists in hardware of laboratory, development software for DCS and PLC and training software using emulated DCS. Training program is the second element needed for development of a training system. The authors present the elements of the Romanian training system: the syllabus of the training courses, the training manuals and testing assessments. It is also presented the experience within the training program dedicated to Romanian operators from the Petrom OMV–Petrobrazi Subsidiary and to Vietnamese operators from Dung Quat Refinery.

Key-Words: - refinery, DCS, training, software, course.

1 Introduction

The Distributed Control System (DCS) represents the modern control equipment for refinery. Starting from the 1990's the DCS is the most important equipment for the refinery control systems. The implementation of DCS equipments has change the operation personal structure of the chemical plants. The new job DCS operator is beginning. These radically change of the operator's job have need the knowledge of the DCS equipment, refinery processes and refinery process control. In this context, one of the objectives of the educational system is the development a flexible structure, which to obtain a gut qualification of the refinery operators [1]. This paper presents the joint efforts of Petroleum - Gas University of Ploieşti, SC Petrom – Petrobrazi Subsidiary, SC Petroconsult Ploiesti and SC Honeywell Romania representatives in order to build up a training system in the distributed control system field.

2 Architecture of training laboratory

The training system is composed by the following subsystems: a laboratory room dedicated to training and research, software simulators of some distributed control system, devices for studying the real distributed control systems.

2.1. The hardware of laboratory

The laboratory has six training stations and a server dedicated to training and multimedia presentation of the courses, figure 1. The training devices of laboratory are: the distributed control equipment HC900 (Honeywell) and Programming Logic Controller OCS IC300CS053 (Fanuc).

Fig. 1. Image from training laboratory.

The HC900 is a process control system made by Honeywell [2]. The equipment has a modular structure which permits the adding of the I/O modules: analog and digital input, analog and digital output. The HC900 system is equipped by C30 processor, 8 analog inputs, 4 analog outputs, 8 digital inputs and 8 digital outputs, figure 2.

Fig. 2. The HC900 distributed control system (Honeywell).

The HC900 system has the following communication ports:

- RS232 for connecting to host computer where runs SIMULINK or a real time software package;
- RS485 for Operating Interface connection;
- Ethernet connection to configuration computer.

The Programming Logic Controller is characterized by:

- an input-output module with 8 digital inputs and 8 digital outputs;
- RS232 serial port;
- keyboard and LCD monitor (2x20 characters);

The OCS IC300CS053 Programming Logic Controller is presented in figure 3.

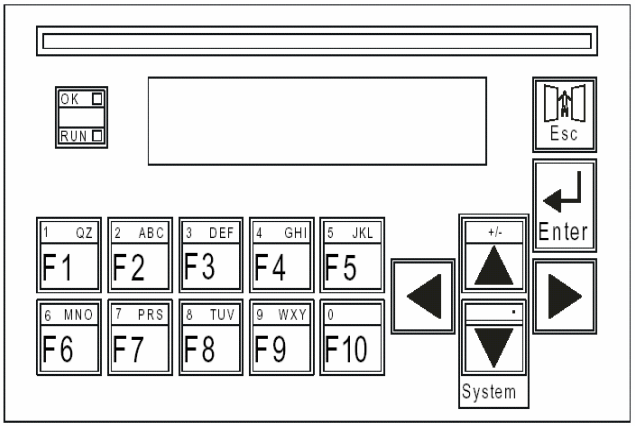

Fig. 3. The OCS IC300CS053 Programming Logic Controller (Fanuc).

2.2. The training software

The software simulators are dedicated to training the operating personnel and process engineers from chemical plants. The training simulators are program systems that simulate numerically both the dynamic functioning of a process unit and the functioning of a certain distributed control device. In 2004-2006's period, Petroleum-Gas University of Ploiesti has acquisitioned the Simtronics Corporation software simulators [3].

The Simtronics Corporation product DSS-100 is a software tool dedicated to real-time simulation of dynamic processes. The operator display facilities are: Alarm, Group, Help, Instrument, Operator, Overview, Schematic and Trends windows.

The Simtronics Corporation simulator DSS-100 has an extensive library of Standard Process Models (SPM). These modules create dynamic composition profiles of all internal process phenomena and include liquid and vapor traffic, chemical composition and ongoing reactions, heat and mass balance, and thermodynamic equilibrium. The differential equations are expressed related to time and are solved at regularly spaced time periods. At the end of each integration step, the numerical values and the graphical evolutions are updated, indicating the system state at a particular moment in time. The SPM of refinery processes of Petroleum-Gas University of Ploiesti are: SPM-2400 (FCCU), SPM-2700 (ADU&VDU) and SPM-700 (Distillation Process). In figure 4 is presented an example of FCCU control diagram.

The third component of the Simtronics Corporation simulator is an Emulated DCS Keyboard (KBD-100) that allows supplementing QWERTY keyboard with one that resembles more closely those of several popular DCS Systems: TDC3000, INFI90 and Centrum CS. The KBD-100 keyboard interface approaches the realism of the control room without the expense of actual control room hardware.

2.3. The DCS software

The Hybrid Control Designer is the specific software from Honeywell. This software makes: the controller configuration; the operator interface configuration (RS485 port); the monitoring of the equipment and the application programming.

The Hybrid Control Designer Interface is specific Windows software, figure 5. Using the Hybrid Control Designer the authors have created the software programs dedicated to laboratory applications. In figure 6 is presented a software program for PID control system. The basic operations of this program are: the acquisition data using the first analogical input channel; the conversion in the engineering units; the calculus of the output controller using PID algorithm; the conversion of

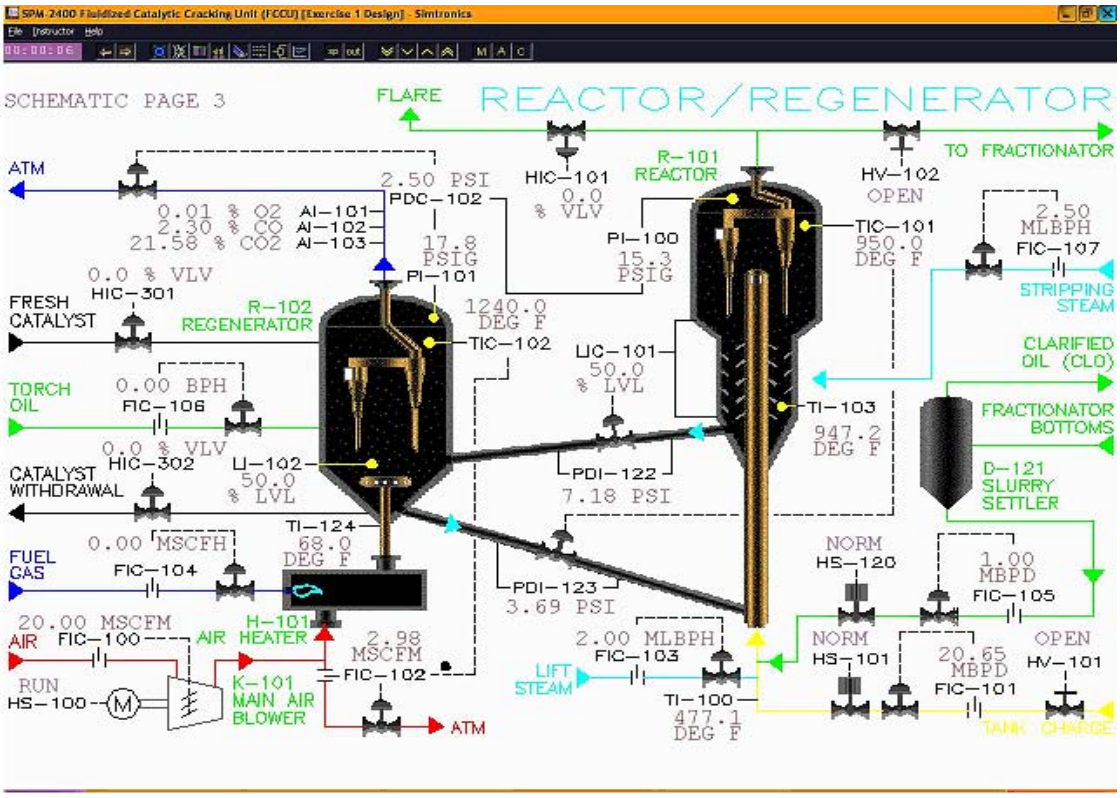

Fig. 4. The control diagram of the FCCU.

the numerical data into analogical signal using the first channel of the analog output device. The state of a digital variables is modified $(Off \rightarrow On)$ if is detected an abnormal function of the input or output devices.

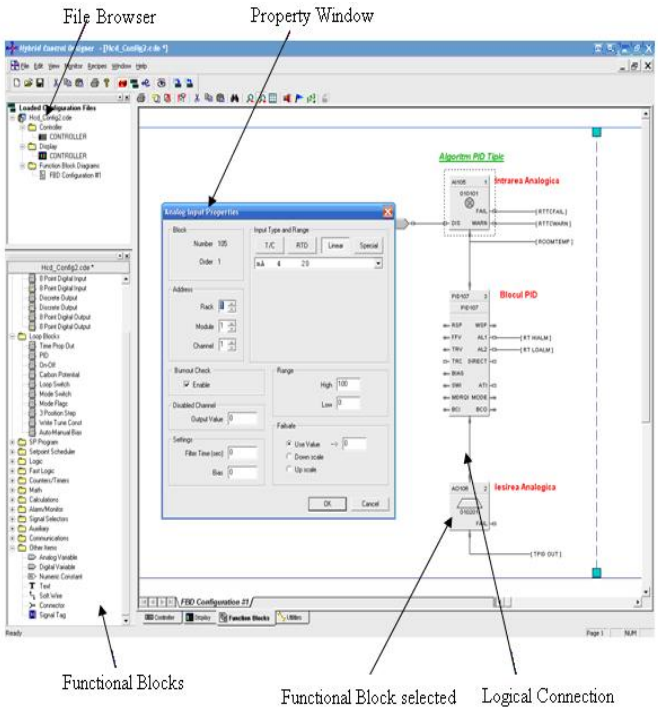

Fig. 5. The Hybrid Control Designer Interface.

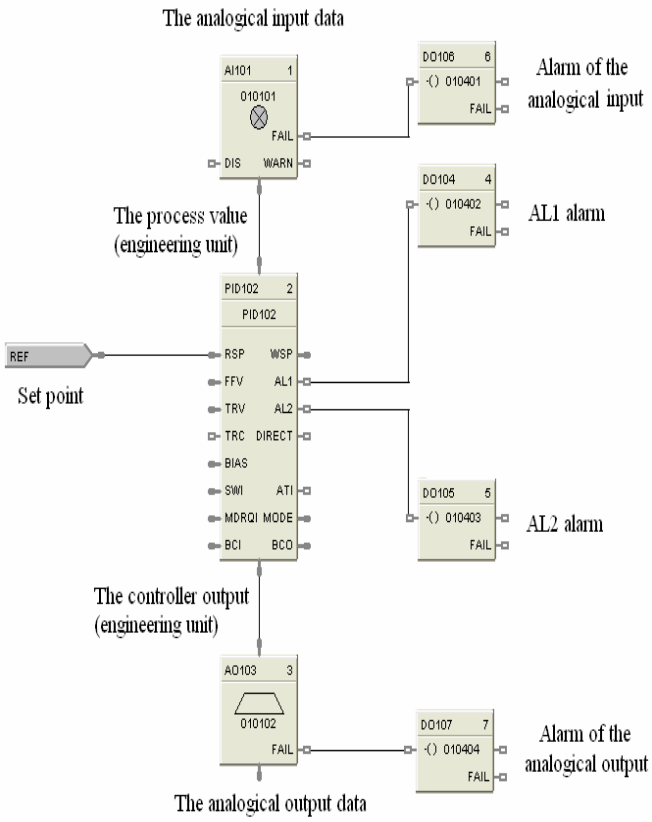

Fig. 6. The PID control program.

2.4. The PLC software

The Control Station Central Application Programming Environment (Cscape) is the PLC software for the Programming Logic Controller made by Fanuc Company.

The Cscape software includes [4]:

- the drag and drop program editor;
- the software module for controller configuration;
- the integrated software module for operator interface programming;
- the real time debugger.

In figure 7 is presented the main menu of the Windows Cscape Interface.

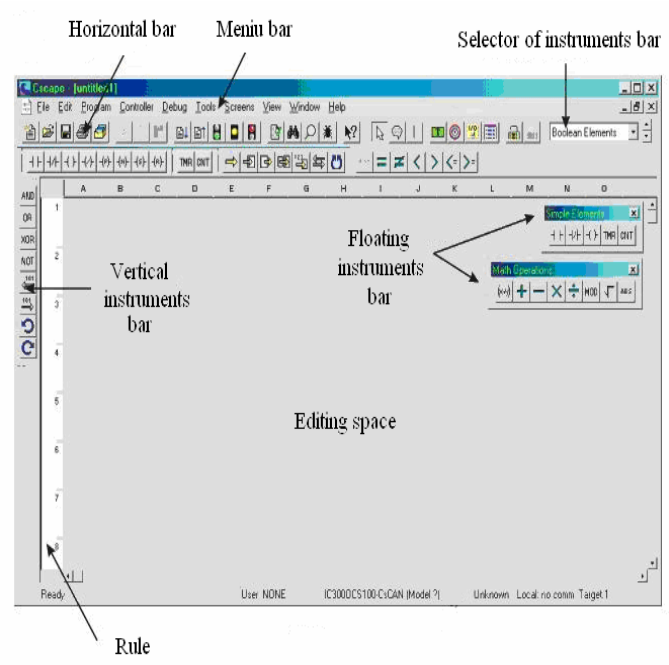

Fig. 7. The Windows Cscape Interface.

The protection system is an important application of the PLC. For the protection system of a natural gas treating plant the logical functions of the protection system are the forms [5]:

$$Z_1 = U_{1,1} = X_1 \cup X_2;$$

$$Z_2 = U_{1,2} = X_4;$$

$$Z_3 = U_2 = X_5;$$

$$Z_4 = U_3 = X_6 \cup X_7 \cup X_8 \cup X_9.$$

The significance of the variables of the logical functions is presented in table 1.

Table 1. The input variables of the protection system

Logical variable	Technological significance	Symbol
X_1	Pressure of column feed C-221	PT01
X_2	Feed flow rate of column C-221	FT09
X_4	Level column C-221	LT01
X_5	Pressure of reflux vessel H-222	PT03
X_6	Steam pressure of reboyler E-223	PT04
X_7	Flow rate of column reflux C-222	FT06
X_8	Level column C-222	LT04
X_9	Steam temperature of reboyler E-223	TT03

Using the Cscape software, the authors have elaborated a special program for the protection system. A partial aspect of the program is presented in figure 8.

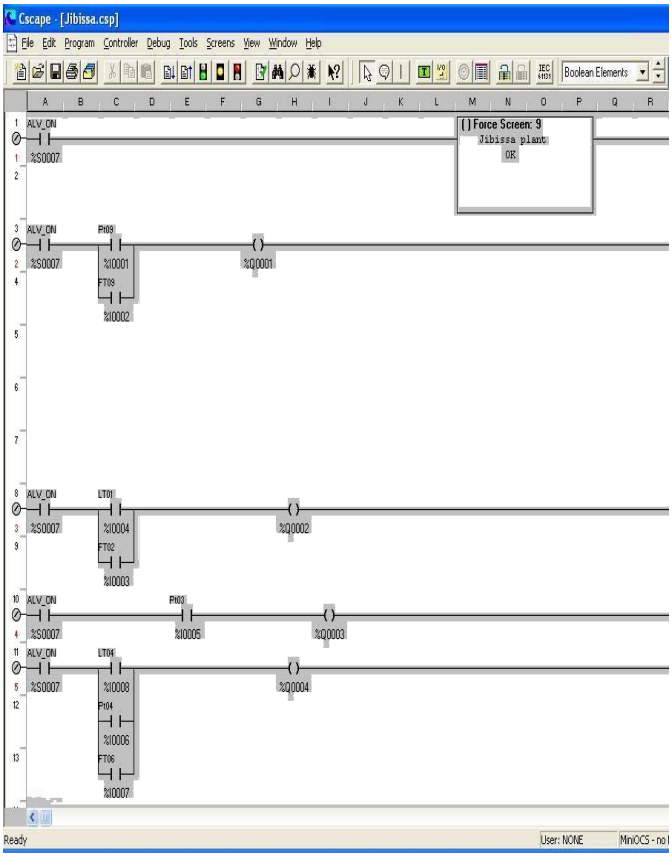

Fig. 8. Sequence of the program of the protection system.

3. Training program

Training program is the second element needed for development of a training system. To organize a training course for continuous education, the Romanian low requests are:

- Course subscription to the Ministry of Education and Research;
- Syllabus elaboration;
- Didactical functions assignment preparation.

3.1. Training syllabus

Starting with 2005, Petroleum-Gas University of Ploiesti is authorized to organize Distributed Control Systems training course. The syllabus of the course is presented in table 2. The total course period is 40 hours and it is finalized with practical and theoretical examination.

Table 2. Training syllabus

Discipline	Hours	
	Courses	Laboratory
TDC3000 equipment	4	-
Classical and advanced control algorithm	4	4
Process simulator	2	2
Normal operating process	2	6
Shutdown	2	6
Start-up	2	6
TOTAL	16	24
	40	

3.2. Training manuals

To sustain the training program, the authors in the Petroleum Gas University of Ploiesti have elaborated the specific manuals for all disciplines.

TDC3000 equipment discipline contains information about the concepts and the structure of the distributed control systems. In the manual are detailed the analog input interface, the analog numeric converter and the network system. In the course is presented the structure and the equipments of the TDC3000 distributed control system. A case of study is dedicated to TDC3000 control system implemented in crude distillation plant (Petrobrazi).

Classical and advanced control algorithm course presents the principles of the feedback control, the analogical and numerical relationship of PID algorithm and a study of the properties of PID algorithm using the SIMULINK software. The component of the advanced control algorithm course presents the principle of the Internal Model Control and the standard internal model control structure. A case of study is dedicated to gasoline stripping process control system, implemented in Petrobrazi refinery [6].

Process simulator course is dedicated to presentation of process (fractionation, crude distillation or FCC). The applications contain numerically simulations of these processes using PROII®, for fractionation and crude distillation, or special simulation program for FCCU [7, 8, 9].

The simulation course has five parts:

a) The presentation of the process (the disturbances, the manipulated variables, the output variables, the control loops). This part is specific to chemical process (fractionating, crude distillation and FCC).
b) The presentation of the TDC3000 emulator (the TDC3000 keyboard, the windows Overview, Control Group, Trend Overview and the windows dedicated to operate the controller). The functional keys are dedicated for the fractionating process, figure 9.

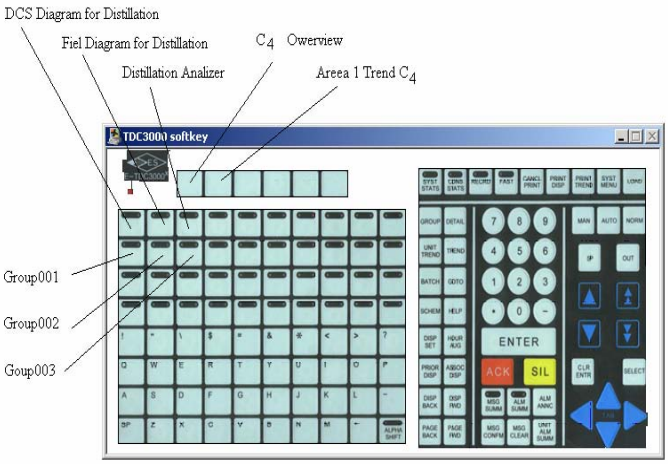

Fig. 9. The TDC3000 Keyboard (fractionating process).

c) The normal operating process presents the control structure of the chemical process, the targets of the control operation, the manipulated variables and the normal parameter values.
d) The start up part describes the specific operations associated to the plant start up (the scheduled operations, intermediary values, manually and automatic operations).
e) The shut down contains the feed reduction process, shutdown reboilers, reduction and shutdown reflux and decreasing column pressure and temperature.

3.3. Testing assessments

The training course is finished by theoretical and practical test. The theoretical test contains assessments about TDC3000 equipment, classical and advanced control algorithm and normal operating process. The practical test consists in 15 minutes of normal operating for each candidate. An example of theoretical test is presented in table 3.

Table 3. FCCU assessments example

Question	Code	Answer
To increase the gasoline flow rate, the operator will rise the set point of	A	FIC 101
	B	TIC 101
	C	FIC 103

4. National and international training course

In 2005 years, Petroleum-Gas University of Ploiesti, Honeywell Romania and Petrobrazi refinery was organized courses for the chemical engineers and chemical operators of the Petrobrazi refinery.

Between 2006-2007 years, Petroleum-Gas University of Ploiesti and Petroconsult Ploiesti have organized special courses for the operators of Dung Quat refinery of Vietnam. The courses had two parts. The first part was organized using the help of the Petro Vietnam Man Power College, Vung Tau (Vietnam) and it was consist in DCS operation courses. The second part was organized by the Petroleum-Gas University of Ploiesti (Romania). The organized courses were: PLC & System Network Architecture, Control Equipment Simulation and DCS Operation [10].

5. Conclusion

The authors have developed the first Romanian training laboratory. The training laboratory has two components: The first component consists in hardware of laboratory, development software for DCS and PLC and training software using emulated DCS. The second component is the training program. This consists in: the syllabus of the training courses, the training manuals and testing assessments.

The training program was application for Petrobrazi refinery (Romania) and Dung Quat refinery (Vietnam).

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