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# TRAINING SYSTEM FOR DISTRIBUTED CONTROL SYSTEMS

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**ABSTRACT**. This paper presents the efforts and achievements of members of the research center *Advanced chemical process control* from Petroleum-Gas University of Ploiesti, in the creation of a training laboratory for TDC3000 distributed control systems operation. It is presented the training system's structure, the training software DSS-100 produced by Simtronics Corporation and training hardware component developed by *Advanced chemical process control* research center. It is also presented the experience within the training program dedicated to operators from the S.C Petrom – Petrobrazi Subsidiary.

## 1. INTRODUCTION

The distributed control system represents a current tool in controlling chemical plants from modern refineries. In the last years, the distributed control systems were distinguished as leading technology in control system structures for chemical and petrochemical plants of Romanian refineries. After implementing these control systems, it took place a change in the structure of plants operating staff. Thereby, the operators that worked on instrument panel were transformed in distributed control system operators. If in the past a panel operator used to be responsible for a certain sector of the plant, usually of 20 control loops, in the present a distributed control system operator takes care of the entire plant. This radical change of operating tasks needed an advanced degree of knowledge, both in the construction and functioning of the distributed control system and in controlling the entire operating process.

In this context, one of the higher education tasks must be the creation of a flexible structure that enables the requalification of the operating personnel of chemical plants and assures an ongoing training. Till recently, there was not such a structure that enables in an organized and professionally manner, an ongoing training in the distributed control systems field.

The present paper presents the joint efforts of Petroleum - Gas University of Ploieşti, SC Petrom – Petrobrazi Subsidiary and SC Honeywell representatives in order to build up a training system in the distributed control system field.

## 2. THE TRAINING SYSTEM

The training system is composed of the following subsystems: a laboratory room dedicated to training and research, software simulators of some distributed control systems, devices for studying the real distributed control systems, as shown in Figure 1.

The laboratory room has a 45 $m^2$ area, being arranged at the current standard level in the computer aided training field. The lab has 6 training stations and a server

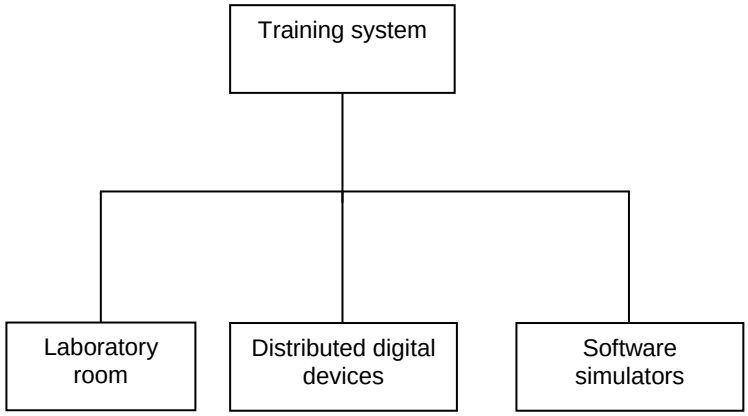


**Figure 1.** The training system structure.

dedicated to training and multimedia presentation of the courses, as shown in Figure 2. The numerical training devices are composed from a distributed control equipment HC900 (Honeywell), a server and a process control computer (ASTI). The software simulators are programs that simulate the distributed control with TDC3000 of some process units and chemical plants.

## 3. THE SOFTWARE SIMULATORS

The software simulators are dedicated to training the operating personnel, process engineers, foremen and operators from chemical plants. The training simulators are program systems that numerically simulate both the dynamic functioning of a process unit and the functioning of a certain distributed control device.

The simulated process units are: mixing fluids, heat exchangers, distillation column, air-blown cooler, tubular furnace, centrifugal compressor, overheating steam boiler, batch reactor, perfect stirring continuous reactor, and tubular reactor.

The simulated petrochemical plants have enhanced complexity and the available simulated plants are: fluidized catalytic cracking unit, atmospheric-vacuum distillation unit, gas processing unit, coker (delayed) gas desulphurizing unit.

The simulated distributed control systems available in the training program systems are: Honeywell TDC3000, Yokogawa Centrum, Fisher-Rosemount, Bailey, Foxboro, ABB.

In the training system framework from Petroleum - Gas University of Ploieşti were developed two software products specific to the distributed control system TDC3000*. The two simulators are provided by Star Simulation (2000 variant) and Simtronics Corporation (2005 variant).

The Simtronics Corporation product DSS-100 is a software tool dedicated to real-time simulation of dynamic processes. DSS-100 includes a series of algebraic

**Figure 2**. Image from training laboratory.

and differential equations that mathematically describe in dynamic regime the operating process or a control device. These 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. DSS-100 is equipped with display and control system of industrial processes. The controls and displays presented by this software are typical for the TDC3000 used in industrial processes, Figure 3.

DSS-100 is composed by two software modules: System module and Process simulation module.

The system module has the following components:

– Various numerical displays and graphics that indicate the status of the particular simulated process that allow the user to interact with the process by changing various operating parameters. Using a database, these displays can be easily configured in the case of the simulated process.

– The graphical facilities allow the user to see the way in which any variable of the simulated process evolves in time. These displays are automatic and the sampling period is easy to tune.

– The simulation of typical elements such as on/off switches and PID controllers. The controllers are easy to tune for the simulated process.

– Programming tools and subroutines that allow various developments of process simulations.

– Post-simulation tools that allow the simulation analysis for process analysis or operator evaluation and certification.

The process simulation module consists in a mathematical model of a particular industrial process. These process simulations can be easily interchanged. A library for standard process simulation is available for base, medium and advanced training levels.

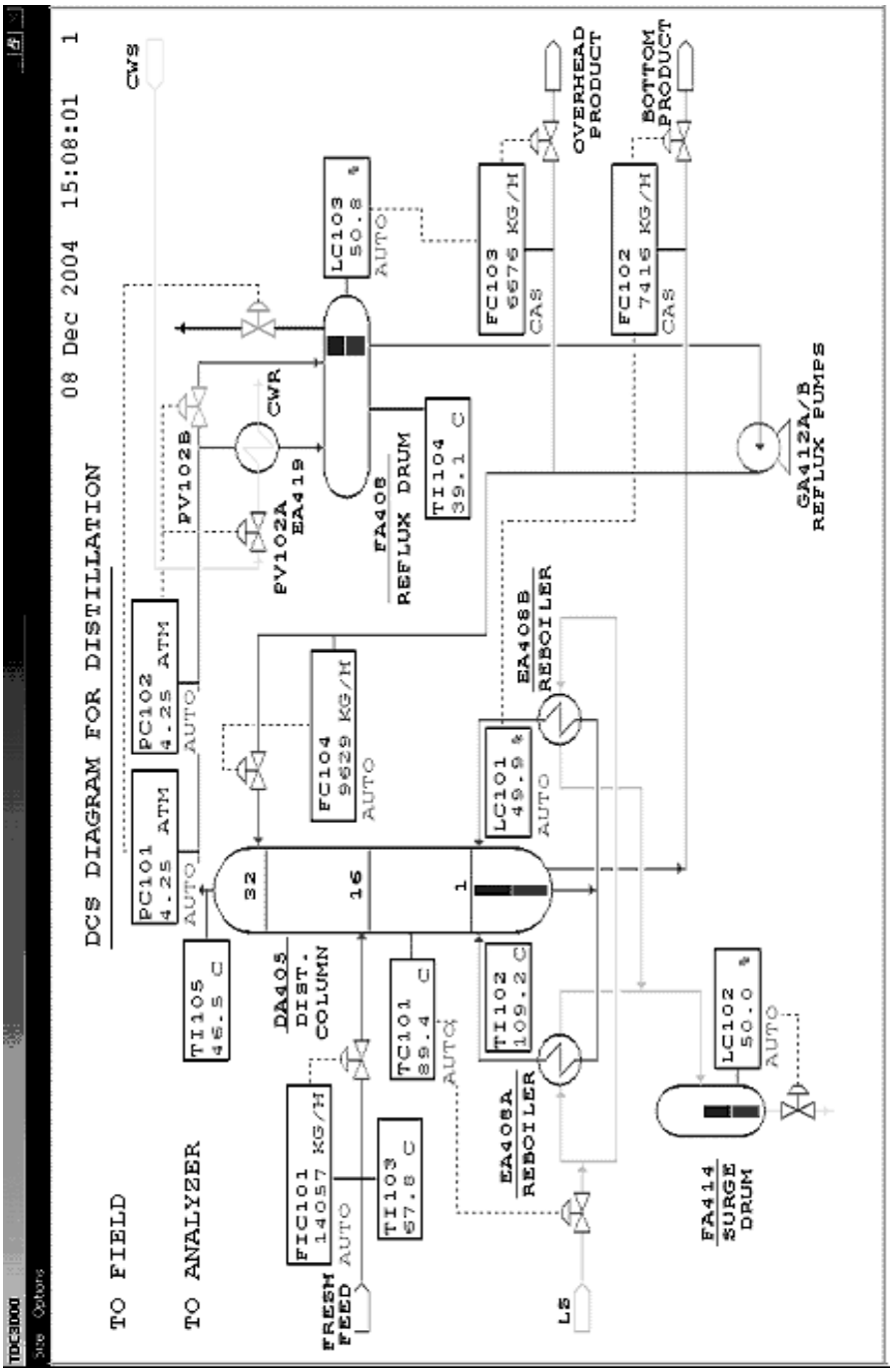


**Figure 3.** The training system for a distillation column

DSS-100 is composed of three modules: SPM-Series (Standard Process Models), PSU-100 (Performance Evaluation Software) and NSS-10 (Network Simulator System).

SPM is a Standard Process Module library, that contains the fundamental models of the processes such as tubular furnaces, pumping systems, intermediary models such as distillation, compressor, co-boiler and advanced model such as fixed bed reactor or perfect stirring reactor.

PSU-100 is a post-simulating tool that quantifies the performance of each trainee, for each process model and for each exercise corresponding to the desired standards. PSU-100 realizes a 0-100% evaluation by six performance criteria.

NSS-100 is the network system files administrator for network simulation. With NSS-100 a trainer can configure the exercises from a single station and can send those exercises to the other training stations. The trainer can find the results of the numerous training sessions and can interpret the results.

The software simulator also contains an industrial keyboard, which is a specific device of the emulated distributed control system. In the case of the distributed control system TDC3000 a personalized keyboard KBD-100 is used, which allows the replacement of the QWERTY keyboard with another one that resembles the main popular DCS operating interfaces. Using keyboard patterns, KBD-100 allows the training of the operators with an interface that resemble the real life control room without the necessary hardware costs for control room.

## 4. DIGITAL DISTRIBUTED EQUIPMENTS

The real distributed control system can be studied using small digital devices dedicated for this purpose. The real distributed control system is composed by a process computer, that simulates some technological processes, field lines of 4-20 mA, a minisystem of distributed control HC900 and a server, Figure 4.

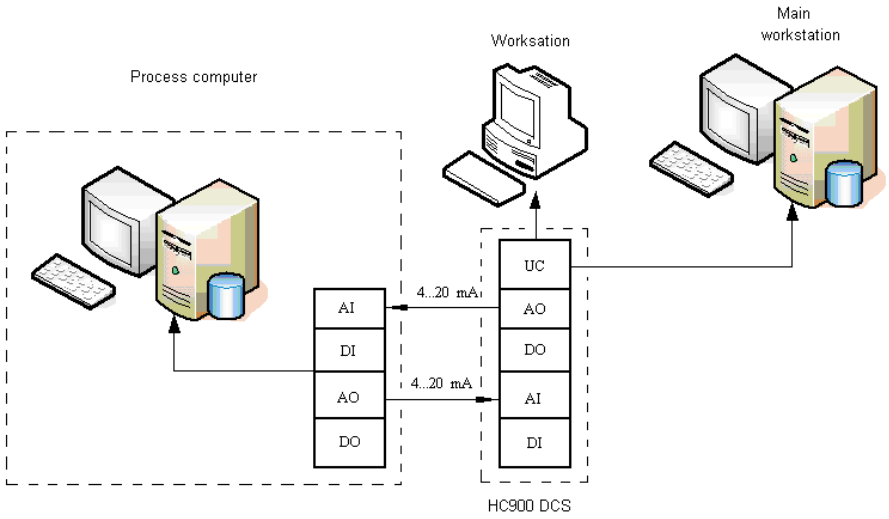


**Figure 4.** The distributed control system structure.

The process computer is equipped with analogical/digital input output interfaces and serial communication interfaces RS 485. The main features of these interfaces are presented in Table 1.

In the process computer there are simulated process units and more complex processes. The measurable variables of these processes are converted in 4-20 mA unified signals and sent as acquired measures to the distributed minisystem HC900.

**Table 1**

| Interface | Input/Output signals | Number of channels |
|---|---|---|
| Analog Input | 4-20 mA dc | 16 |
| Analog Output | 4-20 mA dc | 4 |
| Digital input | 24 V dc | 16 |
| Digital Output | 24 V dc | 16 |
| RS-485 | - | 8 |

The commands to the controlled process, also 4-20 mA signals, generated by the distributed minisystem HC900, are acquired by process computer using analogical inputs interfaces.

The real control system is configured for the simulated process characteristics using the process computer. The ditributed control minisystem accomplishes the specific functions of a distributed control system: data acquisition, monitoring, database updating, control etc. The main features of the miniDCS are presented in Table 2. A picture of HC900 device is shown in figure 5.


**Figure 5.** HC900 distributed system (Honeywell).

**Table 2**

| Module | Input/Output signals | Number of channels |
|---|---|---|
| Analog Input | 4-20 mA dc | 16 |
| Analog Output | 4-20 mA dc | 4 |
| Digital input | 24 V dc | 16 |
| Digital Output | 24 V dc | 16 |

**5. The training course**

The training course lasts for a week and contains 40 hours of courses and applications. The courses are taught exclusively by didactic staff from Petroleum - Gas University of Ploieşti. The topics are:

1. Computer functioning and architecture.
2. Distributed control structure concepts.
3. Presenting the distributed system TDC3000.
4. The startup, normal operating procedures and shutdown of distillation process using TDC3000 emulator.
5. Classical and advanced control algorithms
6. Process control devices
7. Total Plant Solution system presentation
8. Control structures for distillation processes
9. Simulation programs of distillation process

The courses are oriented to the specific of the operating process or chemical plant. Until now there were realized training courses in the field of operating distillation processes with DCS, courses named *distillation module*. In the future the training will be extended to operating catalytic cracking unit and atmospheric-vacuum distillation unit with DCS.

The courses manuals are distributed to each trainee, at the beginning of the training. The actual size of these manuals is about 250 pages that include every training course. The number of trainees in a training group is 6, being limited by the training stations. Until now, the training course was granted for two series of operators, from SNP PETROM, Petrobrazi Subsidiary.

**6. Performance criteria**

There are 6 performance criteria in the postsimulation PSU-100 tool. In the following are presented the senses and significances of each criterion.

1. *The duration* measures the time needed to fill the exercises. A well trained operator must be able to quickly and efficiently solve the problems.
2. *The procedure* analyzes the event operator file in order to verify if the operator really followed the established operating procedures.
3. *The safety* measures the time interval while the operator has exceeded alarm limits and the magnitude of this deviation. In correcting this problem, remaining in safety parameters is of great importance.
4. *The alarms* calculate the final number of alarm when an exercise is finished. This is a measure of the operator ability to correctly solve the problem.

5. *The deviation* measures the time and magnitude of the deviation in operating from the design conditions. This is a measure of operator ability to maintain product quality in unfavorable conditions.

6. *The quality* measures the amplitude of the deviations from setpoints when an exercise is completed. This is a measure of final product quality.

**7. Conclusions**

The paper presents the efforts and achievements regarding the creation of a training laboratory for distributed control systems operation. The training system was materialized through creation of a laboratory, implementation of a program training system for TDC3000 distributed control system and also numerical equipment integration used for investigation of a distributed control minisystem. The training system was completed with training textbooks specific to the fractionating process and to the TDC3000 distributed control system. The members of the research center *Advanced chemical process control* from Petroleum-Gas University of Ploiesti have gained experience within the training program dedicated to operators from the S.C Petrom – Petrobrazi Subsidiary.

## BIBLIOGRAPHY

1. * * * Training Simulators and e-Learning for the Process Industries, Simtronics Corporation, Little Silver, New York, 2004.
2. * * * Dynamic Process Training Simulator, Star Simulation, Houston, 2000.
3. * * * Sistem de instruire a personalului tehnolog in vederea operarii sistemelor de conducere distribuite, Universitatea Petrol-Gaze din Ploiesti, 2004.
4. * * * HC900 Hybrid Controller Documentation, Honeywell International Inc., 2002.