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Developments for "Virtual" Monitoring and Process Simulation of the Cryogenic Pilot Plant

Carmen Maria Moraru, Iuliana Stefan, Ovidiu Balteanu, Ciprian Bucur, Liviu Stefan, Anisia Bornea, and Ioan Stefanescu

***Abstract*—**The implementation of the new software and hardware's technologies for tritium processing nuclear plants, and especially those with an experimental character or of new technology developments shows a coefficient of complexity due to issues raised by the implementation of the performing instrumentation and equipment into a unitary monitoring system of the nuclear technological process of tritium removal. Keeping the system's flexibility is a demand of the nuclear experimental plants for which the change of configuration, process and parameters is something usual. The big amount of data that needs to be processed stored and accessed for real time simulation and optimization demands the achievement of the virtual technologic platform where the data acquiring, control and analysis systems of the technological process can be integrated with a developed technological monitoring system. Thus, integrated computing and monitoring systems needed for the supervising of the technological process will be executed, to be continued with the execution of optimization system, by choosing new and performed methods corresponding to the technological processes within the tritium removal processing nuclear plants.

The developing software applications is executed with the support of the program packages dedicated to industrial processes and they will include acquisition and monitoring sub-modules, named "virtually" as well as the storage sub-module of the process data later required for the software of optimization and simulation of the technological process for tritium removal.

The system plays and important role in the environment protection and durable development through new technologies, that is – the reduction of and fight against industrial accidents in the case of tritium processing nuclear plants.

Research for monitoring optimisation of nuclear processes is also a major driving force for economic and social development.

***Keywords*—**Monitoring system, process simulation.

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Carmen Maria Moraru, researcher, ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail: mcarmen@icsi.ro).

Iuliana Stefan, researcher, ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail: istefan@icsi.ro).

Ovidiu Balteanu, researcher, ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail:- ovidiu@icsi.ro).

Ciprian Bucur, engineer, ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail: ciprian@icsi.ro).

Liviu Stefan, researcher, head of Cryogenic Pilot Plant, ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail: liviu@icsi.ro).

Anisia Bornea, senior researcher, Dr, ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail: anisia@icsi.ro).

Ioan Stefanescu, General Manager, Prof Univ. Dr., ICSI Rm.Valcea, Romania, Str.Uzinei nr 4, CP 10 (e-mail: istef@icsi.ro).

I. Introduction

THE system responds to the monitoring requirements of the technological processes specific to the nuclear installation that processes radioactive substances, with severe consequences in case of technological failure, as is the case with a tritium processing nuclear plant.

For lower the appearing of technological failure, for these nuclear processes, a performing software technological platform is developed, which, based on an identification program of the important parameters for monitoring systems, displays the real time process evolution trend.

In Romania, up to now, the concerns for developing such systems was modest. Those in need of a higher flexibility in the process monitoring tried to solve the matter on their own, without being able to reach the highest degree of integrating the instrumentation and equipment.

The beneficiaries of this project could be the nuclear plants as well as certain legal bodies (chemical and petrochemical works, experimental units and laboratories, etc.), considering that the proposed purpose is to develop a flexible system with a broad applicability range, especially for the technological units that require the optimization of the monitoring in case of emergency.

Considering the continuous development of the national nuclear energetic field and of the technologies used by it, the system is useful especially for the development and application of new concepts of monitoring "virtually", for minimizing the failure risk during operation.

The latest technologies and industrial process "virtual" monitoring methods are used, with a very high complexity due to the issues raised by the integration of a great variety of instrumentation and equipment into a unitary control system. Integrated systems with mathematical simulations of the process will be executed and simulated on software, all of which will be continued with the set up of the optimization system of the parameter monitoring system, by selecting some methods adequate and applicable to the technological processes within the detritiation plants. The route pursued for achieving the proposed goal was, primarily, based on the experience accumulated until the present, to develop a high-performance system specific to a certain type of detritiation plant, and to continue with the expansion of the system's possibilities and applicability for a broad range of plants, but especially for those used in the nuclear power plants.

II. ACHIEVEMENTS

The scanning of the measurements points on the plant are made with Field Point modules from National Instruments USA, Texas and through the optimization of the monitoring system the process simulation system in case of emergency will be set up; his system plays an important part in fighting the natural disasters and industrial accidents. In Figure 1 is related the capture screen of the monitoring software system in LabView, for isotopic exchange module from cryogenic pilot plant.

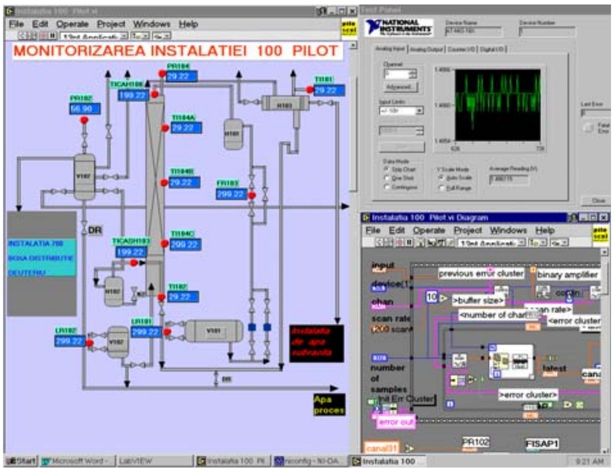

Fig. 1 Monitoring system of isotopic exchange module

The system also includes the control graphic part, which includes all the components monitored and surveyed during process, on-line [1].

Mainly, the process simulation is monitored in the tritium removal units, where the isotopic exchange reaction and the separation factor will be defined, as well as the basic equations of isotope separation.

A new element in this simulation system is the introduction into the automation system of a simulation part in which the main elements in the process will be monitored, in order to optimize their functioning in case some faults appear, and to identify faulty field elements.

Due to the software's universality, the program can be adapted, depending on the process requested by any industrial user, especially to the technological plants with a high degree of damage and accident.

For monitoring the cryogenic distillation's installation is necessary to control the temperature very carefully.

For that we made an automation system with data acquisition and control which provide all data for analyze and for simulating the temperature of the process.

The control is achieved using an array of sensors and controllers. The sensors used for monitoring the process are type J thermocouples, RTD and with platinum. The control system uses different sensors of the same type but better quality. The temperature control is achieved by controlling the electrical power fed to the heaters.

Besides sensing the fluid temperatures at various points, we also monitor the vapor pressure and the heavy water level in the isotopic exchange column, an important module for tritium removal.

We used the various DSC (Datalogging and Supervisory Control) [5] module tools to easily configure, view, and acknowledge alarms and events. An alarm is a specific type of event related to the value of a tag.

Events can be tag events, such as a change in Alarm State, or system events, such as a user login or Tag Engine launch.

The simulation and optimization method includes the analysis of control systems that explains functionally the behaviour of a combination of a temperature-sensitive mass.

Also, the structure and environment in which exists, the various disturbances to which the mass and the structure are subjected, and the physical and electrical arrangements of the thermal and electronic elements used to regulate the temperature of the mass.

The system error or system deviation describes the accuracy and stability of control and is the ultimate criterion for evaluating the performance of the temperature control system. A particular value of this error or deviation is the performance criterion that the control system and the simulation system are designed to meet.

The transient and steady state response of a certain variable to the stimulus of another variable is affected by the operations of other elements in the monitoring system.

Similarly, the response of the controlled variable to disturbances in the controlled system can be varied by changing the elements of any of the subsystem:

- The feedback, the control, or the controlled.

Elements used to effect such changes may be called compensation elements.

If the behavior of the control and simulation system can be describe mathematically, the responses of the system variables can be determined quantitatively [2].

Further more, the designer can dictate the operations of the elements of the system that will affect certain desired responses. Also it will be determined where in the system there should be the flexibility that will allow for compensation to be applied.

The new system has Field Point modules connected to the serial board, configured for RS-485 from computer. The real advantage is that we can connect all necessary Field Point modules to make the monitoring of entire installation. In this way we will reduce the costs and are easy to use.

The system realized has the main characteristics:

-System is flexible, easy to use and make improvements
-Low cost for equipment
-Can replace dedicated hardware and software
-The information, which is provided, is essential in the dynamic prioritization and conditioning alarm message
-Application design assure a good interface between hardware and software with high speed
-A friendly human - machine interface

In Fig. 2, is presented the optimization system with LabView Datalogging Supervisory Control Module software, which is connected to the data acquisition system.

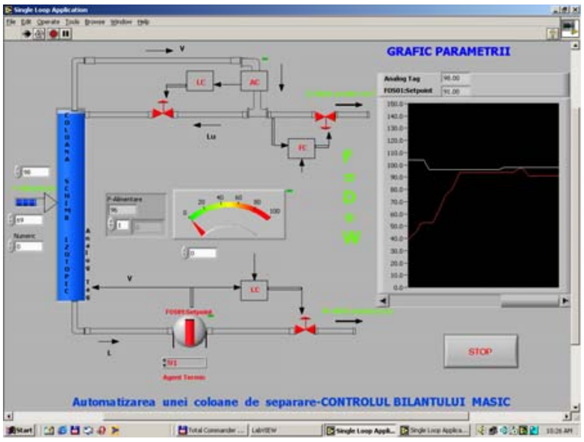

Fig. 2 Optimization system for isotope separation installation from tritium removal plant

We diagnose and solve control-related process performance problems, and monitor, improve and optimize industrial processes from cryogenic pilot plant by first gaining an in-depth process and operational understanding [3].

Was applying various techniques, such as optimal controller tuning and controller performance monitoring, off-line or on-line multivariate statistical analysis, statistical process control, and plant historical data acquisition, analysis and reporting using high-level tools [4]. The equilibrium constants for the various reactions inside the isotopic exchange column from tritium removal installation are calculated using the formulas:

$K1=4.0231-0.01951*T+5.91595*10^{-5}*T^{2}-6.69797*10^{-8}*T^{3}$;
$K2=12.64976-0.05189*T+1.51192*10^{-4}*T^{2}-1.67942*10^{-7}*T^{3}$;
$K3=1.1423-0.00599*T+1.85109*10^{-5}*T^{2}-2.11582*10^{-8}*T^{3}$;
$K=3.51363+0.00195*T-4.16545*10^{-6}*T^{2}+3.94311*10^{-9}*T^{3}$;
Where

K1,K2,K3 and K are equilibrium constants of the transfer reactions;
T-temperature in isotopic exchange column;
Fig. 3 shows the “front panel” from LabView and shows how the temperature is controlled and also how we calculate the equilibrium constants, as a function of the acquired temperature.

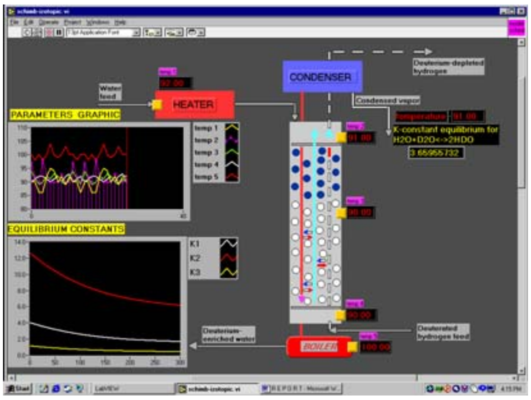

Fig. 3 Simulation system with processes analysis

Fig. 4 shows the “front panel” displaying the equilibrium isotherm and the operating line plot. The operating line of the column from cryogenic pilot plant is obtained from the measured deuterium and hydrogen (D/D+H) ratio in the liquid and gas phase at the top and the bottom of the isotopic exchange column.

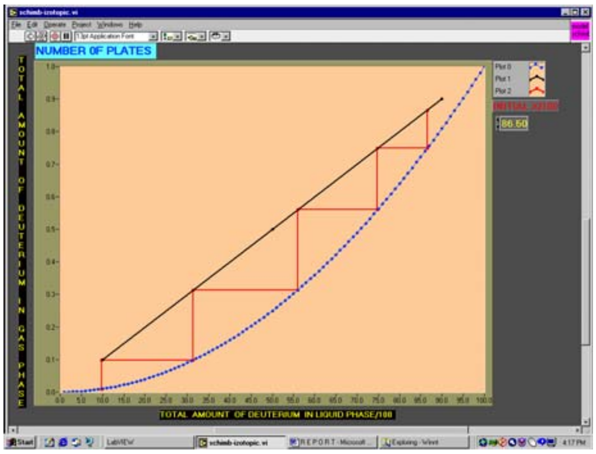

Fig. 4 Front panel in LabView for equilibrium isotherm

From the equilibrium isotherm and the operating line, the number of theoretical plates is determined following the Mc-Cabe-Thiele approach.

By implementing the system, we also focus on the proper compliance to the economy demands specific to the nuclear field, with involvement in the industrial security, meaning the fight against natural disasters and industrial accidents.

Using the web technology we developed a complete data base for increasing the level of information in operation process and also for automation and controlling performance’s.

In Fig. 5 is shown a print screen from data base software which is used in installation when is operated.

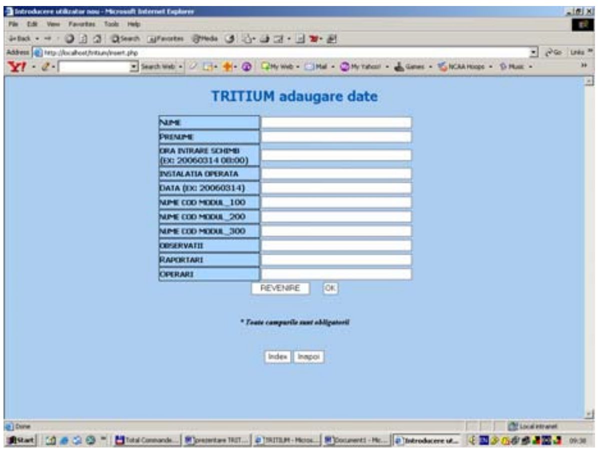

Fig. 5 Data base configuration

III. FUTURE WORKS

The results obtained until now in the area of process monitoring in LabView and of optimization proved the utility of this system and the significant performances obtained when used also for other types of industrial plants [5].

The experience obtained by the team to execute the system and the proper software will constitute as base for the execution of such systems upon the request of various customers and also for the execution of an "virtually" technological platform, a new concept in installation monitoring.

The new software in LabView 8 with Real Time module and Compact Field Point modules will be effectively verified on an existing plant, by simultaneously checking the parameter values (classic system – optimizing software system of the process and of the relevant monitoring system) [6].

The system will also include the software developed for mathematical modeling with the monitoring of all parameters and process analysis software for the main modules in the tritium processing plant.

In Fig. 5 is presented the starting of mathematical model for tritium removal process, which means the graphical representation of Entropy function by temperature for cryogenic distillation module from tritium removal installation.

In order to lower the technological failure risk, for the first time, an optimisation algorithm of the monitoring system by prediction will be established, using the gradient function and the process analysis with data base.

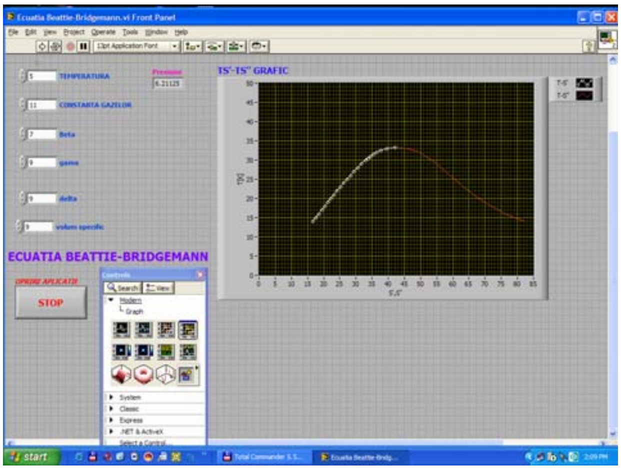

Fig. 6 Temperature-Entropy diagram in LabView 8 for cryogenic distillation module

IV. CONCLUSION

The system developed, offers a good standard of work including opportunities for study and improvement and technological transfer to less developed areas which need monitoring, where the security and protection architecture for special cases is included.

Another special feature is that such system improves the security degree and increases the intelligence level of the information systems of the nuclear industrial plants of tritium processing. The system has also the function of adjusting the technological process in the sense of adapting to variations of the input parameters. Thus, an optimized functioning of the plant is secured (products – levels – temperatures – pressures – flows) for various values that might appear for objective reasons in the input parameters.

Thus, the system represents the monitoring solution, with possibility for development of the mathematical model processes, in view of technological plants' operating under special condition.

REFERENCES

[1] Hall T.Martin&Meg. L. Martin–"*LabView for Automotive, telecommunications, semiconductor, Biomedical and other applications*", Prentice Hall PTR,Upper Saddle River,NJ 07458,2000,USA, pages 185-190,ISBN 0-13-019963-X.

[2] Stephen C.Gates & Jordan Becker, *"Laboratory Automation using the IBM PC"*, Prentice Hall,New Jersey 07632.

[3] N. Dragulanescu, P. Constantin, *"Electronica Industriala"*, Editura didactica si pedagogica, Bucharest 1983.

[4] Costin Cepisca, *"Masurari electrice si electronice"*, Editura ICPE, Bucharest 1997.

[5] "*LabView Datalogging and Supervisory Control Module*", Operation manual documentation ,2001, Texas, National Instruments Company.

[6] "*LabView 8 and Real Time Module*", Operation manual documentation, 2006, Texas, National Instruments Company.