PROCESS AUTOMATION FOR RADIATION PROCESSING FACILITIES

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Rezumat. *IFIN-HH deține singurul iradiator industrial cu surse gamma din România. Acesta funcționează din anul 2000 şi oferă servicii de sterilizare şi scădere a încărcăturii microbiene în special pentru industria medicală şi farmaceutiăa. Acest articol prezintă modul de funcționare al sistemului de comandă şi control în vederea realizării tratamentului cu radiații ionizante. În anul 2013, sistemul de comandă şi control a fost actualizat, trecând de la operarea pe PC la operarea pe PLC. În acest fel, s-au introdus elemente noi, care contribuie la o operare mai facilă şi eficientă a iradiatorului. Obiectivul articolului este acela de a descrie particularitățile şi noutățile automatizării procesului de tratament cu un sistem PLC.*

Abstract. *IFIN-HH holds the only industrial gamma irradiator in Romania. It has been functioning since 2000 and offers services of sterilization and bio-burden reduction especially for the medical and pharmaceutical industry. This paper presents the automation of the command and control system for the radiation treatment. The command and control system was up-graded in 2013, switching from PC operated to PLC operated. In this way, new elements were introduced and contribute to an easier and efficient functioning of the irradiator. The objective of this paper is to describe the particularities and novelties of the new PLC automation system.*

Keywords: industrial irradiator, process automation**,** PLC, efficiency.

1. Introduction

Radiation sterilization is very popular in the medical and pharmaceutical industries were approximately 40% of single-use medical products such as surgeon's gloves, syringes, sutures, catheters, etc. are sterilized [1]. Also, bio-burden reduction is used for biological raw materials (herbs, algae, starch), excipients and colorants, gelatine capsules, enzymes, plants extracts, etc. Medical and pharmaceutical industry plays a significant role in today's people health. New drugs, medical devices, treatment methods, etc. are developed constantly in order to save lives, increase the comfort of living and prolong life.

One real need for the medical and pharmaceutical industry is the safety of products from the sanitation point of view. There is a stringent requirement that the medical device that comes in contact with fluids be sterile and also that pharmaceuticals not to cause illnesses due to poor hygienic state. One option for mass sterilization of medical devices and raw materials is the use of commercial

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industrial radiation facilities. There are three types of technologies that use the same principle – radiation treatment of materials: electron beam accelerators, X-ray accelerators and gamma ray processing. The first two use electrical power in order to generate radiation and the third uses radioactive materials like Co-60.

Nowadays, radiation technologies are systems with very high scientific and technical standards [2]. They operate under safe operating modes and reliable quality control methods of the process. Process automation is generally used to enable greater efficiency, leaving to the operator the task to command, control and supervise the system and minimize the variability of processes in general [3]. It is also required to determinate the optimum operating modes and process parameters with respect to quality assurance, quality control and compliance with national/international standards for radiation processing [2]. Today's automation systems further help operators allowing them to focus on production and quality issues [3].
Industrial processes convert raw materials into finished products ready to be used. The equipment used in the conversion differs depending on industry segments such as paper, chemical, oil and gas, pharmaceutical, steel, power, water treatment, etc. The automation system involves instrumentation, actuation, controllers, computers, operator displays, data storage, alarm management, safety systems, drives and so on [3].

Radiation processing with gamma rays is just another industry were process automation was required along with technological advancement and the need of better, safer and more reliable products. Also, the dynamics of the pharmaceutical and medical domain determined a constant increase in product demand compelling industrial radiation facilities to work more efficiently by automating their processes.

The radiation processing in Romania is concentrated at IRASM Radiation Processing Centre under the administrative umbrella of IFIN-HH (National Institute of Physics and Nuclear Engineering – Horia Hulubei). IRASM holds the only industrial irradiator in Romania, operating since 2000, a result of a technical cooperation project between IAEA (International Atomic Energy Agency) and the Romanian Government under the name "Multipurpose Irradiation Facility".

2. Process Operation of Gamma Industrial Irradiator

IRASM's industrial irradiator SVST Co-60/B is a category IV gamma irradiator with a panoramic wet source storage in which the radioactive source is stored and fully shielded in a pool of water. The software of the PLC was designed especially for SVST Co-60 taking into account its particularities. Nevertheless, the system fully complies with the latest requirements of Radiation Safety of Gamma, Electron and X Ray Irradiation Facilities, IAEA Safety Standards Series No. SSG-8 (2010).

Radiation processing takes place inside the irradiation room when the radiation source is moved into working position. In order to keep the surrounding safe for people and personnel, the irradiation room has 2 meter thick concrete walls and a maze shape. The basic principle of radiation treatment is rather simple. The first step is to load the products into containers of 480x480x900 (mm) and send them inside the irradiation room with a system of automatic carriage on a 2 level/ 2 sided conveyor. The maximum capacity is around 10 cubic meters that fit into 52 containers fully loaded. The second step consists in raising the racks loaded with radioactive materials and start moving the containers around it using pneumatic pistons. Each movement has set a certain amount of time in order for each container to receive the same dose. After the total time has elapsed, the containers are moved out by the same carriage and on the same path but taking care not to mix the processed products with the unprocessed ones.

Figure 1 presents the diagram which illustrates the radiation process of materials.

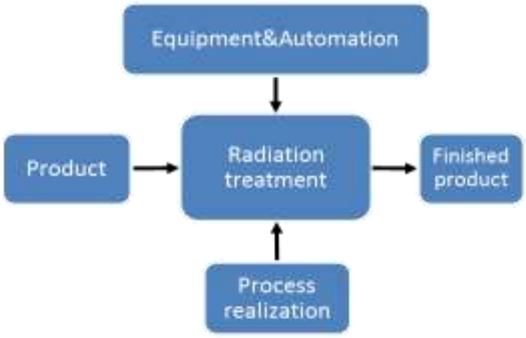

Fig. 1. Realization of process treatment.

SVST Co-60 has two main operation processes: loading/unloading of products and radiation treatment. PLC automation improved the treatment process by providing a unique identification number for each process. This number is automatically recorded and stored into the PLC’s internal memory and cannot be deleted or modified. It provides traceability for every process, making it easy to verify the records. The system has also the possibility to save the record on a USB key and afterword move and store it on a PC or another device.

The PLC has two status screens for loading/unloading: storage transportation system (STS) (Fig. 2) and goods maze transportation system (GMTS) (Fig. 3). These screens are used to check in real time the system’s parameters and also to command manually, when needed, parts or components e.g. pneumatic pistons. STS is a semi-automatic system where some motions are performed by the

operating personnel and others by PLC using pneumatic pistons. The operators have the task to place manually the products into the containers therefore the fluent and correct operation needs their constant attention.
Figure 2 presents the loading/unloading schematic process where on the left side the products are loaded and on the right side they are unloaded.

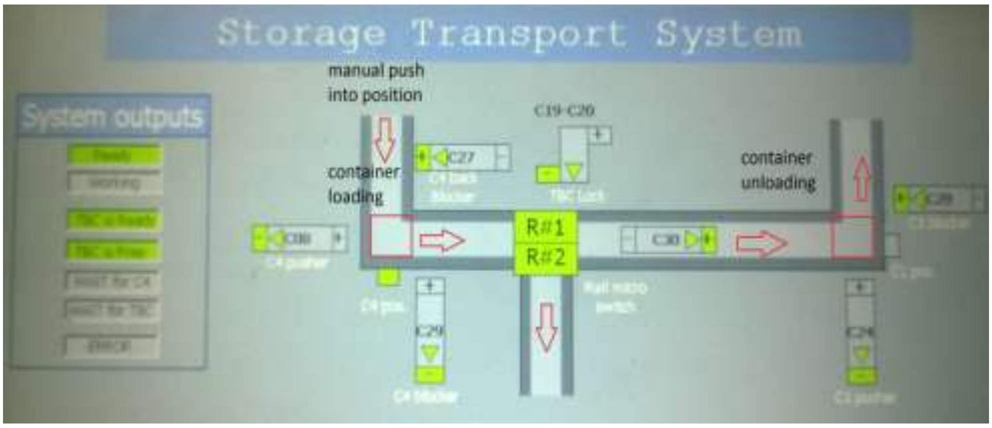

Fig. 2. STS schematic screen.

The automatic loading/unloading process has the following sequence: the operator pushes manually the container into position and the PLC acknowledges it by position sensor “C4”. Piston “C08” positions the container on the carriage “R1R2”. At the same time, another container is pushed out by piston “C24”. The row from piston “C08” to piston “C24” must be occupied by containers as the process functions by pushing a container by another container. This mode of operating has two advantages: 1) if there is no container pushing “C4” sensor the process will automatically stop; 2) it is not possible to mix the treated with untreated products.

GMTS represents the transportation system (carriage and its equipment: sensors, pistons, electric motor, etc.) that moves the container from the loading area (STS) to the internal conveyor (SPM). It is fully automated and uses position sensors placed on the railway track to identify the position of the carriage and decrease the speed when it reaches STS and SPM.

The loading/unloading process was optimized by software programming, decreasing the total time by 15 minutes from a total of 2 hours and 30 minutes. It has only one process parameter which represents the number of cycles. Having just one process parameter is an advantage because it limits the area in which personnel can make mistakes. Basically, it has 52 cycles according to 52 containers, the maximum that fit on the internal conveyor. If only 20 containers must be filled in, then only 20 cycles are required leaving the other 32 containers empty. This feature contributes to process efficiency decreasing the time according to needs.

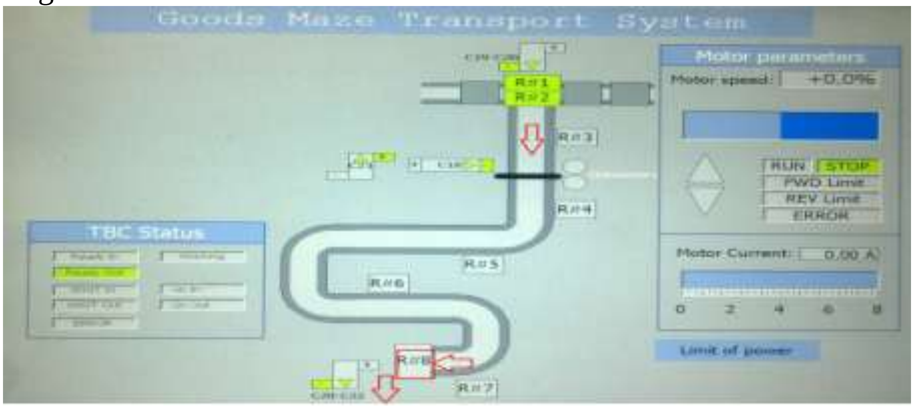

Fig. 3. GMTS schematic screen.

2. The PLC has only one status screen for the treatment process represented by the internal conveyor (SPM) (Fig. 4). It shows in real time the position of the pistons, their working sequence and their status: working, error, waiting, etc. This feature facilitates the control over SPM knowing at every moment the systems' status. The working principle is rather simple: the containers move around the radioactive source on 52 cycles according to the 52 containers. In this way the delivered dose will be distributed uniformly for every container. The operator introduces manually the total treatment time and the PLC calculates other variables like: the time per cycle (container) by dividing the total time by 52 (containers), the finish time and the time remaining to finish the process. Another feature of process automation is the introduction of an independent device from the PLC in the form of a backup timer. It protects against PLC errors that lead to SPM blockage.

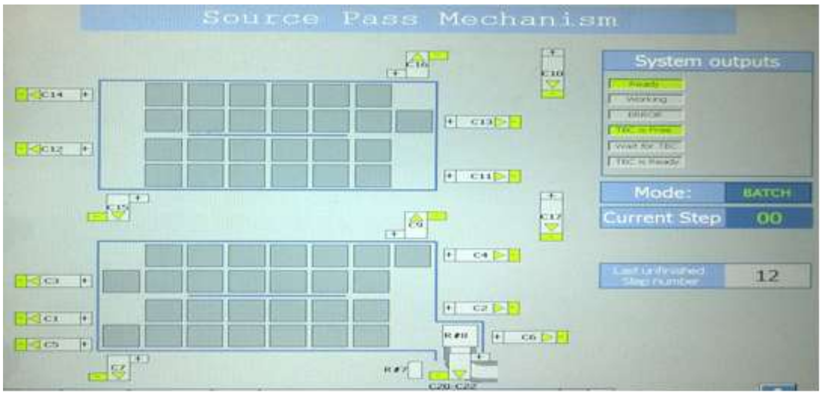

Fig. 4. SPM schematic screen.

The back-up timer counts the cycle time against a value introduced by the operator and stops automatically the process if that value is exceeded; it restarts automatically after every cycle and protects the products to be damaged from over-exposure to radiation.

Conclusions

This paper gives an insight of how the PLC operated system works for an industrial irradiation facility. It highlights the advantages and how the efficiency was increased by process automation.
Because the majority of industrial irradiators are company owned, there is no information and interest in describing the process automation and its particularities. Another reason is that most operating systems are custom made depending on the processed products, size, process characteristics, etc.

Process automation with PLC has increased the system efficiency and ease of operation and control by: decreasing the total operation time for loading/unloading processes, ease the command by limiting process variables, modular and animated screens, data record and storage, unique identification number for processes and independent back-up timer.
It has diminished the physical work of operators giving them the task to command, control and supervise the processes instead of manual labour and direct involvement in the process. Thus, automation decreased the number of errors and interruptions due to human mistakes and increased the operator's competences. Process automation increases also the control of the process by using positioning devices, sensors, records, unique identification numbers, etc.

In conclusion, process automation by PLC is a reliable solution which has been successfully adopted and adapted by industrial radiation sterilization facilities.

R E F E R E N C E S

[1] Gamma Processing – A Proven Way to Safeguard Health - Ella Korets-Smith, MSc, MBA, Global Brand Leader, Sterilization Technologies Nordion (Canada) Inc., www.nordion.com/hamma/resources_white_papers.html.

[2] Valentina Lazurik, Valentin Lazurik k's First Author, *Information System and Software for Quality Control of Radiation Processing* (IAEA, Warszawa, Poland, 2011), p. 7.

[3] Kevin Starr, *ABB Automation Services for the 21st Century*, https://library.e.abb.com/public/0bc4a24fa72a281385257c670065d6da/2013%20ABB%20Automation%20Service%20Solutions%20for%20the%2021st%20Centrury.pdf.