AUTOMATED CONTROL SYSTEM OF THE TARGET SYSTEM FOR PET RADIONUCLIDES' PODUCTION

P.A. Gnutov, M.L.Klopenkov, R.M.Klopenkov, A.N.Kuzhlev, A.A.Melnikov, A.P. Strokach,
JSC "D.V.Efremov Institute of Electrophysical Apparatus", St. Petersburg, Russia
B.V. Zabrodin, the St. Petersburg State Polytechnical University

Abstract

An automated control system of target system for production of PET-radionuclids has been designed. The system allows on-line obtaining of the data on the status of the target system and remote control of loading, irradiation and evacuation of the activity to synthesis modules.

According to algorithms available in the software, this system makes possible emergency situations to be prevented and incorrect actions of the operator to be blocked.

INTRODUCTION

Nowadays, the method of positron-emission tomography (PET) is widely used for diagnostics and in medical-biological investigations. This method is the most informative when observing the processes occurring in a human organism [1].

Short-lived and ultra-short lived radionuclides with the lifetime from 13 min to 2 hours are used for PET investigations. Such radionuclides can be produced on proton accelerators located directly in clinics. Cyclotrons of the CC-series [2, 3] designed and manufactured in NIIEFA in its radiation characteristics as well as in overall dimensions completely meet the requirements imposed today on cyclotrons intended for PET. However, until recently, these machines were not equipped with target systems.

At present, our Institute has delivered the 1st model of completely automated target system with the CC-18/9M cyclotron to JSC "NIITFA", Moscow. Fig.1 shows the general view of the target system with the cyclotron.

Figure 1: General view of the target system and cyclotron.

This target system is designed for 5 targets, 3 water and 2 gas, however, delivery with any set of targets is possible. The target system was tested at a beam current of 50 µA, and the target pressure was not more than 8 barr, which confirms a high efficiency of this system. In future, this will allow us to increase the intensity of the proton beam for production of radionuclides. When irradiating $H_2{}^{18}O$ with beams of accelerated 18 MeV protons, the calculated activity yield was 280 mCi/µA.In measurements, the activity yield of 200 mCi/µA was obtained for a 3-ml water target. Below in Table 1 are given activity yields of commercial target devices of leading world manufacturers.

Table 1: Activity yields bading world manufacturers

Manufacturing Companies	Activity Yield
IBA	240 mCi/µA
NIIEFA	200 mCi/µA
Triumf	200 mCi/µA[4]
Kirams	180 mCi/µA[5]
Syntra	137mCi/µA

Characteristics of the target system produced in NIIEFA satisfy the world requirements for yield ranges of such systems. In future, when testing the system we plan to increase the target pressure up to 20 barr, which will allow the beam current increase up to 100-120 µA.Works have been started on widening the assortment of water targets; production of 1-ml, 2-ml and an experimental 5ml targets are planned.

AUTOMATED CONTROL SYSTEM OF THE TARGET SYSTEM

The automated control system (ACS) of the target system consists of an operator's workstation and controller unit.

The Mitsubishi GT1275 panel was chosen for the control console of the operator's workstation, which allowed a high-quality user-friendly intuitive operator interface to be designed in the Russian language (see Figs. 2 and 3).

This interface allows remote loading of targets with target materials, unloading of the activity to hot cells and rinsing the target and capillaries connecting the target with hot cells. In the left part of the window, the execution of these programs can be observed in real time, i.e. valves' position, readiness of hot cells, filling of

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syringe and target can be seen. In addition, all necessary data are displayed in real time:

- Availability of water and helium cooling
- Target pressure
- Helium pressure in the loop
- Helium flowing in the loop
- Time of target irradiation
- Time for activity unloading

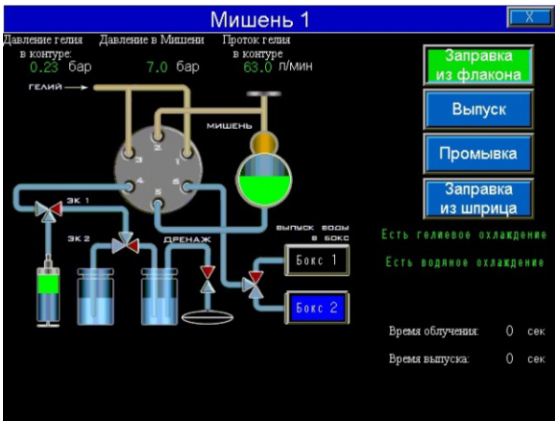

Figure 2: Window for operation with water target.

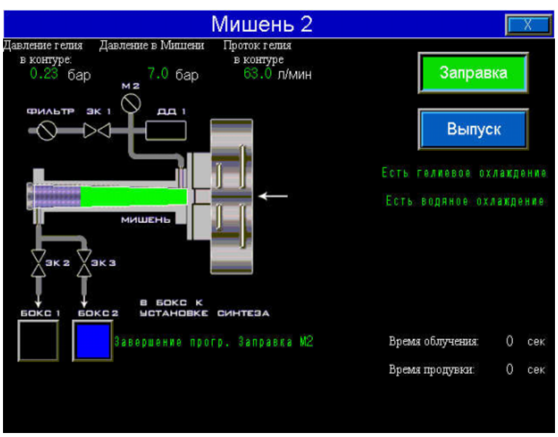

Figure 3: Window for operation with gas target.

The information about the termination of the program and failure messages are displayed at the bottom of the window. The control program interface is developed in the GT Designer3, which is included in a standard delivery set of the Mitsubishi software.

The controller block is the host device of the automated control system. It serves for acquisition, processing and analysis of the data on the status of the target system. The controller prevents emergency situations and disables incorrect operator's actions in accordance with an algorithm of the controller software.

The Mitsubishi FX3UC was chosen as a controller of the automated control system. Reliability, simple maintenance, high performance, relatively low cost and small size were governing factors for its choice. It was also taken into account that automatic control systems of the CC-series cyclotrons are also built on the basis of Mitsubishi FX controllers. Choice of these controllers makes simpler maintenance of both systems and reduces the time needed for the software development due to application of practical experiences used in ACS of the cyclotrons.

The control program of the target system was developed in the GX IEC Developer 7.03. The label diagram language (LD) was chosen as a programming language. Visualization of the status of the system and its components makes much more simpler both programming and putting into operation as well as troubleshooting in the equipment connected to the controller. In addition, use of functional units in the program makes it universal and allows the number and type of installed targets to be changed sufficiently simply.

CONCLUSIONS

When designing the ACS of the target system, the main criterion was reliable long-term operation of the equipment maximally simple in control and widely using visualization means. This ACS of the target system can be to be operated by personnel without special training in the field of ACS for sophisticated engineering systems. Due to control of target remote replacement, the efficiency of using the "beam on" time of the cyclotron is higher, and radiation exposure of the attending personnel is lower. On finishing the irradiation process, a target is removed from under the beam and replaced for another loaded target ready for irradiation. The produced activity of the 1st targetis unloaded to hot cells, and then this target is loaded with new target material. The ACS developed provided stable operation of the target system, which allowed us to obtain he activity yield ranges competitive on the world market.

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