PROCESS CONTROL IN A SYSTEM OF SERIAL CONNECTED BIOREACTORS

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The anaerobia dissolution of organic leavings (known as metazoan fermentation) is a biotechnological process. It dissolves the organic pollutants with different origin. The anaerobia dissolution receives height interest in many European countries during the last years because it decides some energetic problems; problems tied with environment protection; dung in farms and so on. This paper concerns a method for improvement of the control process of the anaerobia dissolution of organic leavings.

Keywords: process control, bioreactors

1. INTRODUCTION

Anaerobic degradation is a biotechnological process for treatment of highly concentrated wastes from animal farms, municipal treatment plant sludge and agro-industries, resulting in production of a biogas. The anaerobic degradation is complicated process involving hundreds of possible intermediate compounds and reactions, each of which is catalyzed by specific enzymes. It is generally assumed that biogas consists of methane (CH_4) and carbon dioxide (CO_2). This process is generally considered to progress in three stages: hydrolyze and liquefaction of large, insoluble organic molecules by extra-cellular enzymes; an acid production stage, involving acidogenic bacteria and methane production stage. The low-molecular-weight acids produced in the acid production stage are further degraded to methane and carbon dioxide by highly specialized group of bacteria commonly referred as the methane production bacteria. How effective is the production of biogas depends on the way in which the man succeeded to create proper conditions for life of bacteria.

2. PROBLEM DEFINITION

The current paper presents development of a control unit and algorithms for monitoring and control of the work of bioreactors for biogas and recycling of dirty waters. There are two main criteria to be considered – the maximum amount of biogas produced and the best possible recycling of waters. Each of the criteria excludes the other, to be received maximum amount of biogas it is necessary the concentration of organics in the water to be high. When the concentration of the organics is high, the recycling could not be the best possible.

To solve this problem, a cascade of bioreactors could be used (figure 1). The first bioreactor receives the organics pollutants from feeding device and the output of this reactor is connected with the input of the next reactor in the cascade.

One of the most important characteristics of the biotechnological processes is that the objects that have to be controlled are live microorganisms. They have special properties and differ from other chemical or physical objects.

One of the main tasks that have to be achieved is the best possible economical result i.e. the greatest possible amount of biogas. For this task it is necessary to be provided optimal environment and conditions for life of microorganisms. The specifics of biotechnological processes often create problems what measures and parameters for control to be chosen [1]. These problems are due to insufficient knowledge for the matter of processes and the low level to which the biotechnological processes allow automation.

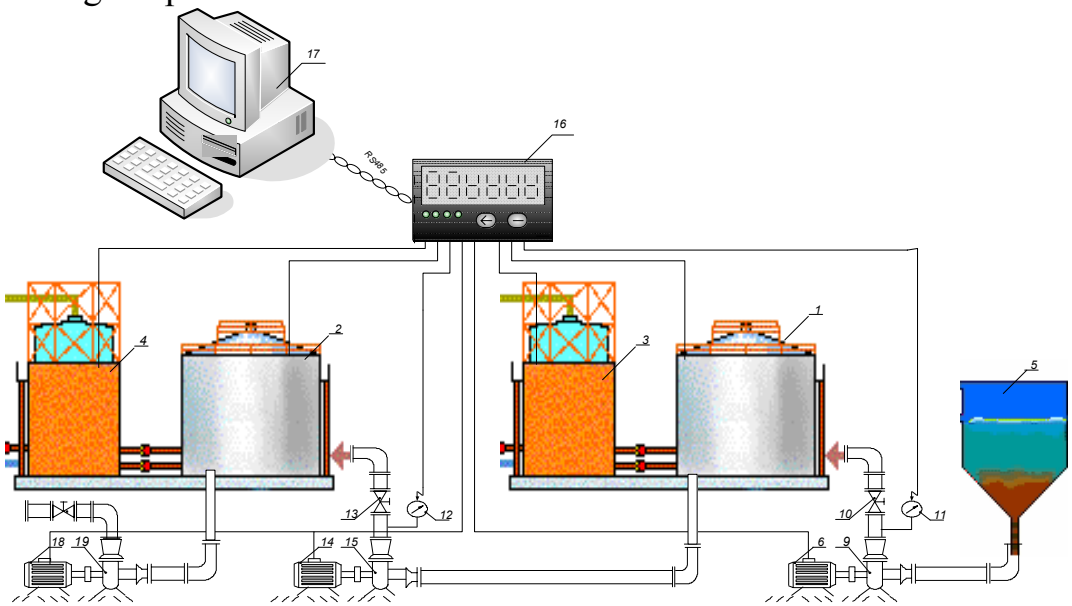

Fig.1. Cascade system of bioreactors, where: 1,2 – bioreactors; 3,4 – gasholders; 5 – feeding device; 9,15,19 – pumps; 6,14,18 – AC motors; 11,12 – pressure sensors; 16 – control unit; 17 – personal computer (PC), 10,13 – valves

A good control to exist it is necessary to be created a proper mathematical model of the system.

In practice are used mainly systems with only one bioreactor. To be improved the ecological properties and to be achieved maximum production of biogas, serially connected bioreactors have been used. It is trivial task to monitor and control single bioreactor. More difficult is to be built and implemented control system for cascade of bioreactors, which will be able to maximize the production of biogas and improve the level of recycling of water with organic substances. The current paper presents a microcontroller based unit for monitoring, analyze and control of cascade of bioreactors.

3. System Organization

The structure of system is shown on figure 1. The control system is based on intelligent controller and PC based software program for monitoring and

parameterization. The controller receives information for the status of biotechnological process from a set of sensors. The sensors provide information about the temperature of substrate in bioreactors, the pressure of biogas in gasholders, the pH status and the status of pumps.

First bioreactor prepares the substrate to be easy dissolved by the second bioreactor microorganisms and in such way to be produced maximum amount of biogas. Through one of the pumps, the organic leavings come into first bioreactor. The temperature of the bioreactor is control by heaters and the homogeneity is achieved by mixer device. The substrate is transferred in the second bioreactor after one defined period and after that the main production of biogas begins.

The algorithm of operation of this biotechnological system is implemented in the control unit. The memory of controller stores the different modes of operation. Every pump can be activated when appears occurrence of some of previously defined in the controller program conditions.

Because the volumes of the bioreactors are fixed, the controller cares not to be added a new amount of substrate when the bioreactors are full.

The control unit is based on 8-bit microcontroller – Microchip Pic16F876. For time synchronization, it is included a real time clock (RTC) DS1307. The parameters and modes of operation of controller are stored in two serial EEPROM memory chips.

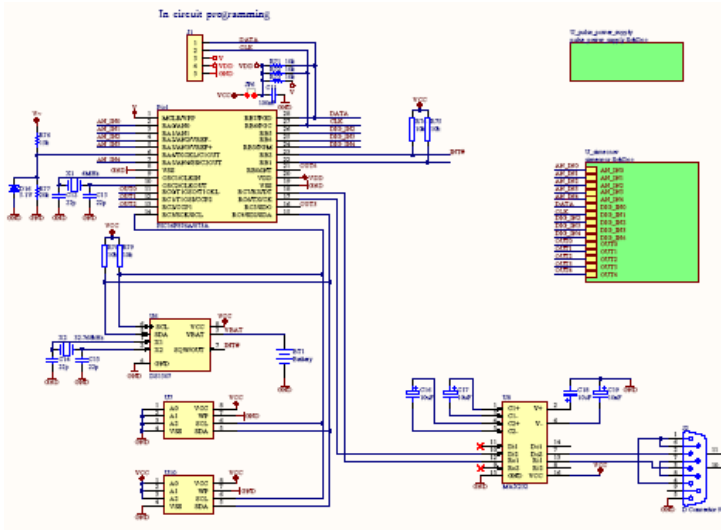

Fig. 2. Schematics of the control unit

The controller reads the status of analog inputs. After conversion of raw signals from internal 10-bit analog-to-digital converter and evaluation of real quantity, which every sensor measures, the actuators in the biotechnological system are activated. The controller checks the status of analog inputs, they show the status of actuators.

If one actuator could not begin operation, the controller after three attempts to switch it on, sends an error message to PC software.

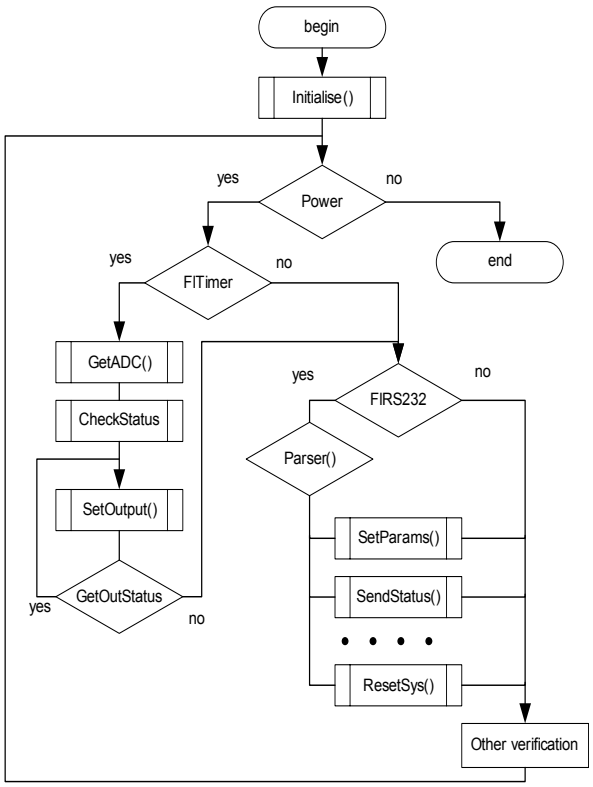

Fig 3. Algorithm of operation of control unit

The processes in a biotechnological system are very slow in time. This property allows the processes to be controlled by low cost unit with modest processing capabilities.

Flags, set by occurrences, and parameters written in EEPROM memory, determine the execution of program. The communication between controller and personal computer is based on string commands The parser, embedded in the software of controller, determines the type of command - to parameterize the control unit or to send report to PC.

The application software, which runs on PC side has the following properties: it is able to parameterize the controller, monitors and controls the bioreactors, shows the current state of the biotechnological process, processes and analyses gathered information, stores the data in files, generates reports. Figure 4,5 and 6 shows screenshots from PC program.

The program accomplishes the following actions:

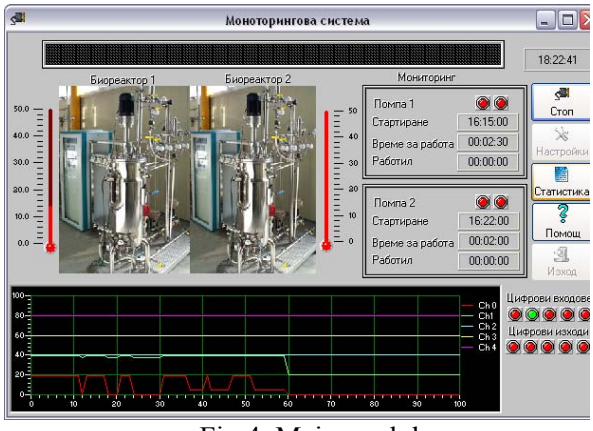

Fig.4. Main module

- It sets the parameters of the controller;
- Real time supervision of the processes that take pace in the technological object.
- Visualization of the current state of the process;
- Processing and analyzing of received data.
- Realtime control of the processes ;
- Storage of measured and analyzed data sets.
- Supporting of database with information of the process status.
- Data analyzes and prediction of the future state of process;
- Generate information reports and others.

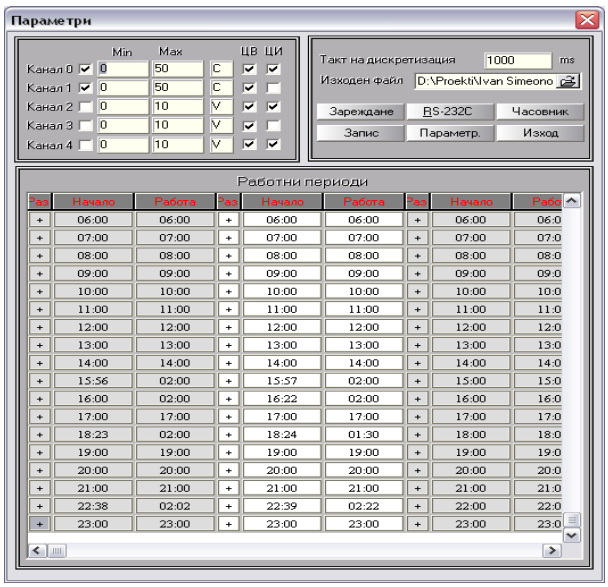

Fig. 5 Adjustment of the controller

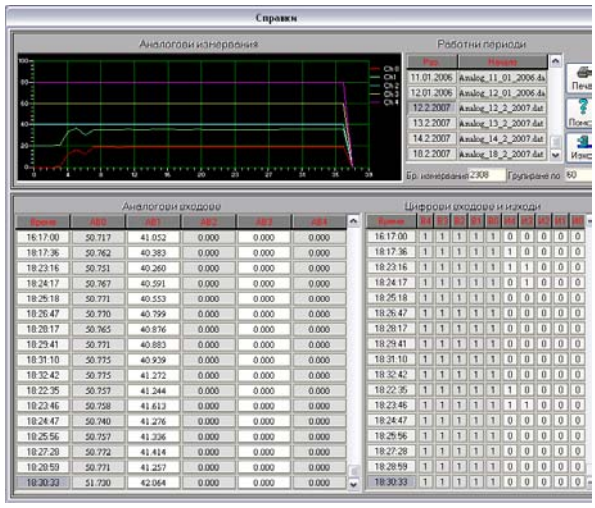

Fig.6. Checked of the system state

The control unit and PC software were tested and are currently in use in the Microbiology Institute of Bulgarian Academy of Sciences, where they are used to control a cascade of laboratory bioreactors

4. CONCLUSIONS

The proper control of cascade of bioreactors could maximize the production of biogas. To be achieved this purpose it is necessary to be developed hardware and software algorithms, which are able to solve this problem. Current paper presents a control unit specially designed for control of cascade of bioreactors and software for monitoring, control and visualization of processes in bioreactors on PC.

The results are satisfying and the control system could be used for control not only of laboratory equipment but also of real biotechnological installations.

5. REFERENCES:

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