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Applications

A Possibility for the Investigation of Dissolved Oxygen Quantity in a Laboratory Aeration Module with a Computer System

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Abstract: *The paper presents a computer system integrated with laboratory aeration module and a possibility for real time accounting of information characteristics of the aeration process with respect to dissolved oxygen quantity in wastewater aeration. The main goal of this investigation is to give a possibility for better and detailed research of the aeration process and to serve for testing and parameters optimization of the existing and new solutions for diffusers in relation to the process of dissolving oxygen in wastewaters.*

Keywords: *a computer system, fine bubble aeration, fine bubble diffuser, oxygen transfer.*

1. Introduction

The enrichment with oxygen up to some defined norms is in the basis of all developments concerning the problems of treatment of domestic and industrial wastewater with the purpose to regain their biological properties. The addition of air to water results in the increase of the level of the air dissolved in the water environment. This process is called aeration and it may be accomplished in natural and in artificially constructed water basins [1, 2, 3].

The aeration system is the basic and key element in bio-chemical treatment of wastewater with active sludge. It is proved that 50-90% of the total energy expenses in wastewater cleaning are consumed in the process of aeration while performing the main purpose of the aeration system – to supply the necessary amount of oxygen for the bio-oxidizing processes. Hence, the aeration process is the main energy consumer in wastewaters treatment. The increase of the energy cost increases the interest towards the way of aeration systems design, their optimization and control. In this connection the basic direction is towards the design and improvement of the aeration systems – the searching for new possibilities, providing high efficiency of the process at possibly lowest expenses.

The aeration system consists basically of an air compressor, air-distributing pipe network, located at the bottom of the aeration basin and diffusers mounted at given distances from each other above the pipes. The process is accomplished as the air, fed by a compressor, passes through the pipe network, after that it enters the diffuser, passing through a non-return valve and a porous membrane, as a result of which it is dispersed in the water environment in the form of small bubbles.

The diffuser is the active and the most essential element of the aeration system and thus its design, geometric dimensions and size of the membrane pores define to a great extent the efficiency of the aeration process with respect to the oxygen dissolved. On its hand the aeration efficiency increases when dissolving a greater volume of oxygen for a given time at minimum quantity of the energy consumed. This fact directs the attempts and the investigations in the development of aeration systems towards new solutions of the diffusers design aimed at optimization of the parameters in relation to efficiency in water saturation with oxygen [4-11].

In order to solve the problems above mentioned, a concept has been accepted in the last years for the study and modelling of the aeration processes under laboratory conditions using computer systems, which account the information characteristics of the process. This is particularly necessary in testing and optimizing some new designs of porous membranes and diffusers.

Similar conditions allow also a better study of the aeration process with respect to the increase of the possibilities for saturation of the water environment with oxygen, and as a consequence of this – the decrease of the energy expenses in practice.

The entire control of the aeration process in relation to oxygen dissolution in water in real stations for wastewater cleaning implies further development of the computer systems integrated with laboratory aeration equipments [12-15].

The purpose of the present paper is to develop a computer system integrated with a laboratory aeration module for real time registering of the information characteristics of the aeration process in oxygen dissolution in water environment and the optimization of the parameters of some existing and new types of diffusers. A modular computer system is suggested in this connection designed for monitoring and control of different parameters. The processor module has got digital and analogue inputs and outputs, and besides them, transducers and sensor modules connected to the microprocessor module, are used for the different parameters.

2. A computer system for investigation of dissolved oxygen quantity in laboratory

A variety of sensor types, different communication interfaces and the need to measure the data close to the measured object require the development of a modular microprocessor system with network architecture.

The system presented is developed to respond to the requirements above said. It is based on the up-to-date hardware components and it is flexible and multifunctional.

All sensors are connected using an interface, called 1-Wire Bus and specially designed by Dallas Semiconductor Inc.

In general, the system consists of a microprocessor module, sensors and a personal computer, working as an operation station.

For the correct work of the system, specially designed software is developed.

The system includes the modules listed below:

• A communication module transforms RS232 interface in RS485 or RS422 for connection to the personal computer. This module is necessary in one of the following cases:

– When the microprocessor module is far off from the personal computer (the operation station) – more than 10 m. In this case it is impossible to use RS232 for data transfer from the controller to the computer. In this case it is appropriate to use RS485 or RS422 and the communication module is used to transform signals from RS232 to RS485 (RS422). This is the way to use the standard ports of the personal computer.

– When a difficult object is managed and it is necessary to use more than one microprocessor controller.

In both of the cases, the communication module is arranged close to the personal computer (it serves as an adaptor to the serial port) and it is connected by a cable to the microprocessor module.

• OCTOPORT is a microprocessor controller, supporting 8 buses, realizing protocol 1Wire Bus (Dallas Semiconductor). This module is connected to the other modules in the system using RS485, RS422 or RS232. Which interface will be used depends on the topology. The microprocessor module is based on AVR90S8535 microprocessor.

• An analog-to-digital converter (ADC) serves to receive signals from the aeration module. The ADC used is 16-bits, 4-channels and produced by Dallas Semiconductor. It is connected to the microprocessor module by interface 1-Wire Bus. The value from the sensor for oxygen measurement enters the inputs of ADC as voltage.

The microprocessor module is based on AT90S8535 microprocessor, produced by Atmel Co. This processor is based on RISC (Reduced Instruction Set Computer) architecture. This is a type of microprocessor that recognizes a relatively limited number of instructions. Until the middle of 80-ies, the tendency among computer manufacturers was to build increasingly complex CPUs that had larger sets of instructions. At that time, however, a number of computer manufacturers decided to reverse this trend by building CPUs capable of executing only a very limited set of instructions. One advantage of reduced instruction set computers is that they can execute their instructions very fast because the instructions are so simple. Another, perhaps more important advantage, is that RISC chips require fewer transistors, which makes them cheaper to be designed and produced.

The basic features of 90S8535 microprocessor are: 8K Flash memory, 8 MHz clock, 32 registers, 512 bytes SRAM, 512 bytes EEPROM. This processor has eight 10-bit ADC, but for measuring the oxygen quantity in waste water it is impossible to use these inputs. That is the reason for using an external ADC

Fig.1 shows a block diagram of the suggested system. The basic aim of the microprocessor system is using 1-Wire Bus to connect a lot of ADC equipped with aeration modules or other modules or sensors (produced by Dallas Semiconductor).

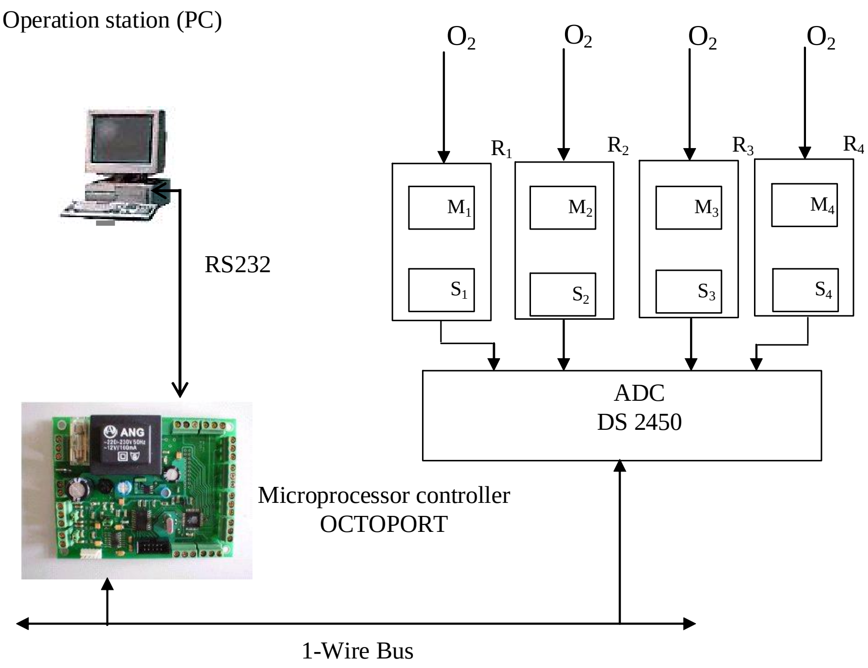


Fig. 1. Blockdiagram of the experimental equipment: $S_1 – S_4$ – oxygen sensors; $M_1– M_4$ – laboratorial aeration modules; $R_1– R_4$ – aeration module integrated with a sensor for oxygen quantity measurement; O_2 – oxygen

The specially designed software for OCTOPRT system consists of two types of software:

- user's software – realized in the personal computer;
- system software – it is resident in Flash memory of the microprocessor module.

The user's software is based on high level language Tcl/TK and it operates under Windows 95/98/2000/NT/XP.

User's software includes several modules (procedures, realizing special services):

- communication – realizes data transfer on different interfaces (RS232, RS485 and RS422);
- data base (using software extension for Tcl/Tkq especially for operating with data bases – Mk4Tcl);
- tables and graphics – realizes information visualization in tabular or graphic representation;
- printing module – it is in use for printing text and graphics;
- configuration – it is operation modes configuration (name and number of the channels, report modes, visualization mode, etc.;
- user's defined module – allows the use of defined functions (specific management of the information and additional interfaces);

• the system software is resident in the microprocessor module and it includes a set of procedures for services for specific periphery; it is developed on C and Assembler for AVR90S8535.

By this moment the real experiments with the system were made for temperature accounting and monitoring in: a cold store – working at low temperature; b) a firebox – working at high temperature; humidity accounting. Now it has to pass an experiment for functioning with an aeration module, described below.

3. A laboratory aeration module

Fig. 2 shows in detail block R_1 (Fig. 1), which is a laboratory aeration module with a built in sensor S_1 for measuring the quantity of the oxygen dissolved during the aeration process. The aeration module is designed to accomplish tests of different existing and new designs of diffusers with respect to their efficiency considering the dissolved amount of oxygen per unit of time at certain temperature of the water environment and exactly defined flow capacity of the air input through the diffuser [16, 17].

The laboratory module consists of a transparent reservoir **7** with dimensions – height of 70 cm, width – 40 cm and length – 60 cm. An air pipe is mounted in the reservoir with the possibility to attach to it different types of diffusers according to their mounting possibilities. For the example investigated a standard type of a diffuser **14** is mounted with a built in alterable porous membrane **4**, which is attached to the diffuser **14** with the help of a pressing ring **3**. A non-return valve is mounted in the basis of the diffuser **14**, which is a plastic body with a rubber membrane **2** attached to it. The air pipe **12** is connected to an air flow meter **9**, a regulating valve **10** and a compressor **11**. There is a sensor for oxygen **5**, which is attached to the reservoir, plunged in the water environment **8**.

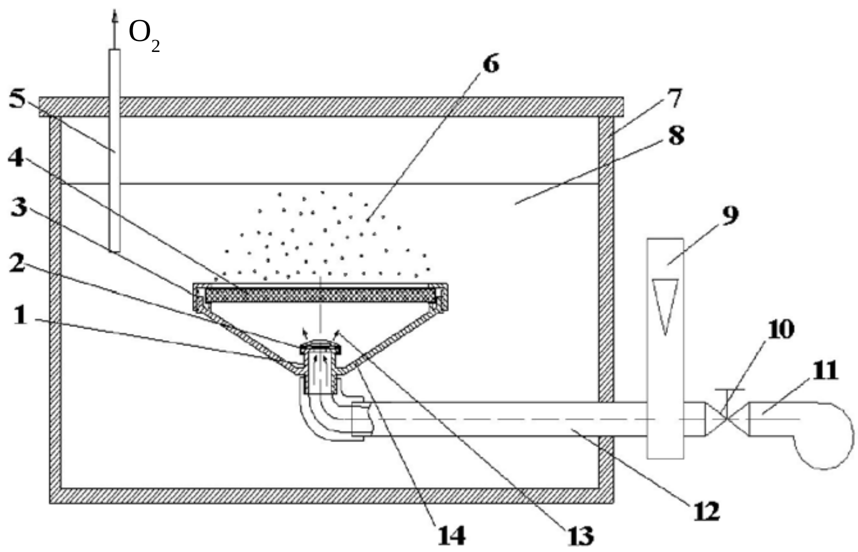


Fig. 2. A laboratory aeration module: **1** – a non-return valve; **2** – a rubber membrane; **3** – a pressing ring; **4** – a porous membrane; **5** – a sensor for oxygen; **6** – air bubbles; **7** – a transparent reservoir; **8** – water environment; **9** – an air flow meter; **10** – a regulating valve; **11** – a compressor; **12** – an air pipe; **14** – a diffuser

The construction of the laboratory module enables the realization of the aeration process by a diffuser with a porous membrane so that real time measurement of the amount of dissolved oxygen is possible at different flow capacities of the air input. The aeration process is accomplished by air input under pressure from the compressor **11** through the pipe **12**, establishing the necessary air flow with the help of the regulating valve **10** and the flow meter **9**. The air from the air pipe **12** enters the non-return valve **1** of diffuser **14**, the rubber membrane of the non-return valve **1** bulbs under the air pressure and allows air passing to the porous membrane **4**. After going through the porous membrane **4**, the air passes into the water environment **8** in the form of fine bubbles **6**. Information about the quantity of the oxygen dissolved is transferred from the oxygen sensor **5** to the computer system.

4. Applications

System TERMOCONTROL 01 is developed, based on the microprocessor module OCTOPORT and it is adapted for monitoring and control of temperature in fridges and cold stores.

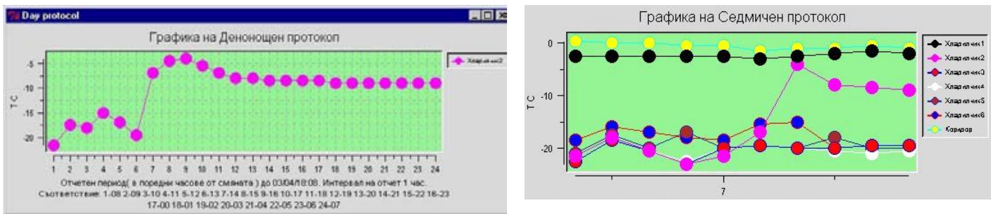
TERMOCONTROL 01 includes: an operation station (PC), a communication module, two modules OCTOPORT, a possibility for connection of up to 16 thermometers DS1820 (Dallas Semiconductor production) and special modules including EPROM memory and timers (Dallas Semiconductor production).

The communication between the operation station and the microprocessor controllers is based on RS422 interface, but the communication between the microprocessor controllers, thermometers and specialized modules is based on interface 1-Wire Bus.

The thermometers (sensors DS1820) measure the temperature from –55 up to +125 °C and they are assembled in fridges and the common length on the tire (1-Wire Bus) is up to 300 m. The length of the communication tire (from the PC to the most distant microprocessor module OCTOPORT) is up to 500 m.

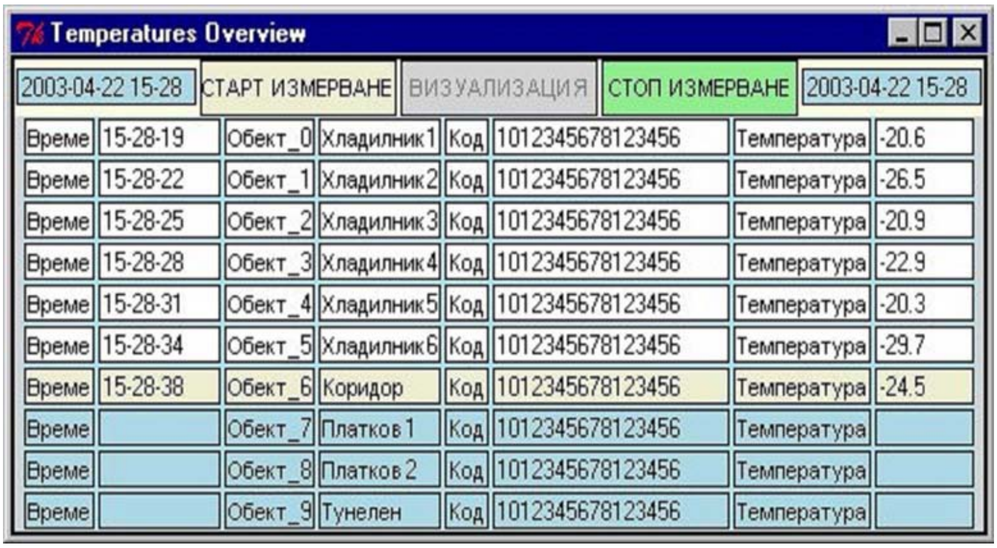
The specially designed software allows the monitoring of the measured temperature and several queries for temperature deviation in the objects monitored. It is possible to print results of the query. It is possible to make a report for the status of the objects (fridges) – for twenty-four hours and for one week.

Fig. 3 shows a display for graphic reports and Fig. 4 shows a general table with dynamic changes of the values.



a b

Fig. 3. Graphic reports for accounting values of the temperature (screens in bulgarian): for one fridge (a); general graphic report (for all fridges for 1 week) (b)



2003-04-22 15-28	СТАРТ ИЗМЕРВАНЕ	ВИЗУАЛИЗАЦИЯ		СТОП ИЗМЕРВАНЕ		2003-04-22 15-28	
Време	15-28-19	Обект_0	Хладилник1	Код	1012345678123456	Температура	-20.6
Време	15-28-22	Обект_1	Хладилник2	Код	1012345678123456	Температура	-26.5
Време	15-28-25	Обект_2	Хладилник3	Код	1012345678123456	Температура	-20.9
Време	15-28-28	Обект_3	Хладилник4	Код	1012345678123456	Температура	-22.9
Време	15-28-31	Обект_4	Хладилник5	Код	1012345678123456	Температура	-20.3
Време	15-28-34	Обект_5	Хладилник6	Код	1012345678123456	Температура	-29.7
Време	15-28-38	Обект_6	Коридор	Код	1012345678123456	Температура	-24.5
Време		Обект_7	Платков 1	Код	1012345678123456	Температура	
Време		Обект_8	Платков 2	Код	1012345678123456	Температура	
Време		Обект_9	Тунелен	Код	1012345678123456	Температура	

Fig. 4. Table for current measured temperature in all fridges (objects) (screen in bulgarian)

This system is developed, the experiments are accomplished and it is already in regular use.

5. Conclusion

The aeration process, which is fine dispersion of the air in water environment with the help of diffusers with a porous membrane, is the most efficient element with respect to the water saturation with oxygen, but at the same time the biggest consumer of energy in wastewater treatment. In order to create possibilities for optimization of the information characteristics of the aeration process in relation to the amount of oxygen dissolved at minimum energy expenses, the present paper presents a computer system integrated with a laboratory aeration module with the purpose of real time monitoring on the process of oxygen dissolution in water. The system offered enables the testing of existing and new designs of diffusers considering their efficiency and possibility for optimization. A further possibility and application of the computer system will be the complete real time control of the aeration process in some aeration systems for wastewaters treatment in practice.

Some other applications connected with the aeration control may be developed on the basis of the microprocessor system discussed:

- control of the water environment temperature;
- monitoring of the pressure drop when the air passes through an air pipe network and the diffusers located on it;
- control of the aeration process in fish breeding;
- control of the aeration process in bio-reactors.

The idea for further development of the computer system includes the use of wireless communication and the involving of new sensors designs. Development of different modules and the corresponding software for radio channel connection is foreseen.

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