MONITORING, MEASURING AND CONTROL SYSTEMS FOR REAL EQUIPMENT CONTROLLED BY PLC IN EDUCATION

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Abstract: This paper is focused on education in the field Measurement and control of technological processes. In one part of this sphere students obtain theoretical knowledge in an application of commercial systems for measurement, visualisation and control of technological processes. The system is control and data are measured via a programmable controller (PLC) and as the superior systems the system InTouch, Wizcon and ContolWeb2000 were used. All systems were tested on the real equipment. The programmable controller controls the system and at the same time is a data source for master applications that are designed for the systems InTouch, Wizcon and ContolWeb2000.

Keywords: monitoring, PLC, visualisation, education.

1. INTODUCTION

Students of our university attend several different courses specialized in the control theory:
- Automation Control Theory I, II, III
- System Simulation
- System Identification
- Measurement and Control of Technological Processes

With that they pass the courses in which they apply its knowledge from preceding courses. It is:
- Microcomputers and Its Application
- PLC (Programmable Logic Controller)

In this application courses students have to know the measurement method, they must know types of sensors for temperature measuring, pressure, speed, power and liquid level measuring.

The teacher determinates the control method and students have to make the controller proposal. At first in Matlab environment and then they can to implement it into real equipment control software. They must to choose device for control system. It can be microcomputer, personal computer, PLC and so one. It is necessary can its programming system and its programming language.

If the application appears functional the students have to do project in some visualisation software.

The typical task is to propose of some controller and to apply different monitoring and control systems to control of the water level in two coupled tanks model or furnace model.

1, 2 - two calibrated vessels
3 - the tender
4 - the motherboard with the water pump
5, 6 - two water level sensors
7 - water pump
8, 9 - overfall
10 - interconnection with water cock
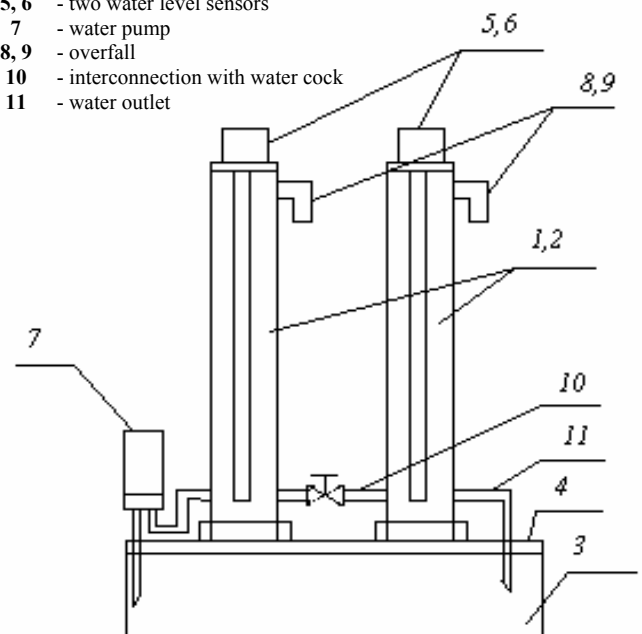11 - water outlet

Fig. 1. The model of the coupled tanks.

2. MODELS USED FOR EDUCATION

There are several models in a laboratory for real process control education. Some of them are describe in this contribution.

2. 1. Coupled tanks model

This model consists of these parts: two calibrated tanks, the tender, the motherboard with the water pump, two water level sensors, overfall, interconnection with water cock and water outlet. The pump power is controlled by voltage of the pump motor. It is possible to input the disturbance into the system. We can to do it by the profile change of the interconnection of the tanks. The change size depends on the water cock shift.

The water level is measured by capacitance sensor and its output is connected to the I/O (input/output) module of the PLC (10-bit D/A converter).

2. 2. Furnace model

The furnace model consisted of two main parts: a temperature sensor and the heating coil. The PLC was controlling the temperature inside the furnace by acting on the dissipated heat in the coil.

The SCADA system Control Web 2000 was used to monitor of the process. A schematic diagram of the whole system is shown in Fig. 2.
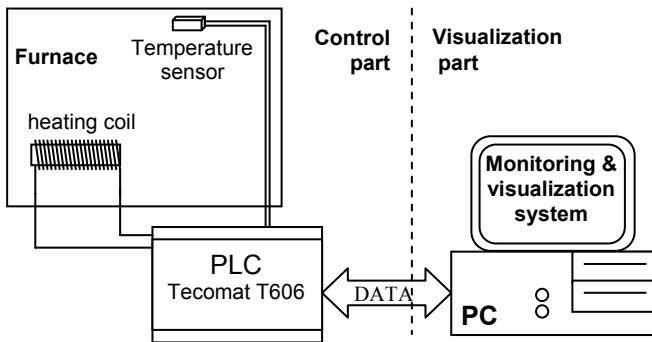

Fig. 2 Schematic diagram of the furnace model.

2. 3. Rail yard model

The next one is a model of rail yard in scale H0. See figure 3. There are three rail circuits in this model and the main task is to control ride or movement of trains on all circuits. The model contains more then 70 measuring and controlling point. We get the position of trains and we can control train velocity and direction, switches, traffic lights, crossing lights, rail way station lights, etc. Proportions are approximately 2 m (length) and 1 m (width).

Fig. 3. Rail yard model.

Trackage is divided in ten sections. In each section we can control direction and velocity of the train separately.

The train position we get by means of dry-reed relay. There are 24 sensors on the trackage. On the train

undercarriage is placed magnet and if the train is coming through position sensor the magnet generates logical signal. As a signal voltage 0/5 V (TTL logic) is used. This signal is converted to 0/24 V and it is used as input into PLC. These voltages are the same for all inputs and outputs.

The train route is controlled through switches. Logical signal High means "directly" and logical signal Low means "turn". Control of other model elements is easy and it is very similar. There are 17 semaphores, 8 switches, 3 railway crossing and 1 gate on the model. [1]

Table 1. List of active model elements:

Model element	Label	Low signal	High signal
Track section	U1 – U10	"stop"	"go!"
Switches	V1 – V6, K1	"directly"	"turn"
Rail way station lights	N1, N2, OD	"turn off"	"turn on"
Semaphores	S1 – S16	"red light"	"green light"
Railway crossing	P1 – P3	"off"	"blink"
Gate	O39	"up"	"down"

2. 4. Fountain model

The second model is a model of fountain. It is not exactly model; it is real small fountain controlled by PLC. See Figure 4.
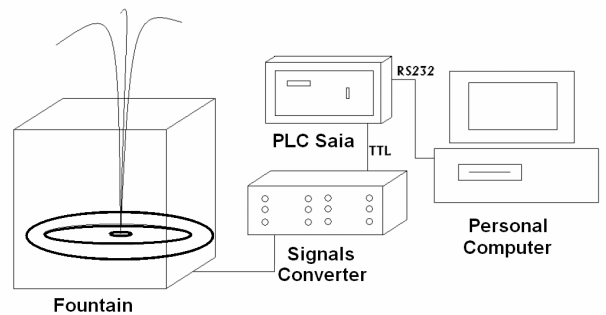

Fig. 4. Scheme of a small fountain system.

Whole system contains a fountain, a signals converter, a PLC Saia and computer. The computer is used for PLC programming only and for visualization of the process.

Fig. 5. Cubical aquarium with three circuits with nozzles

The fountain is created by glass cubical aquarium (1 x 1 x 1 m) and there are three water pumps and three circuits of

pipe with different numbers of nozzles on tangential bottom. The main task is to control in real time the elevation of water column above nozzles in each circuit. The signal converter changes voltage for pump power from 5 V (TTT logical signals) to 230 V (voltage for pump control). There is one nozzle on the first – central circuit, four nozzles on the second-middle circuit and eight nozzles on the third – outer circuit. [2].

3. CONTROLLER DESCRIPTION

For water level control and temperature control three controllers designed in different ways were consequently applied. The two-position controller [3], the PID-controller [4] and the pole-placement controller [5]. Best results were achieved with the third order pole placement controller.

4. PLC TECOMAT DESCRIPTION

All programmable logic controllers are designed for technology control in a broad range of fields including machine industry, food industry, traffic, power engineering, building materials production etc. [4].

Fig. 6. Programmable logic controller Tecomat TC606

The TECOMAT PLCs are made in a compact design and in a modular design. The advantages of the compact PLCs are a low cost and an easy mounting. The compact PLCs are used in small applications according to number of inputs/outputs. In the modular PLC category wide ranges of freely combinable peripheral units are available as well as power supplies [5, 6].

5. MONITORING AND VISUALISATION SYSTEMS

The programmable controller control models and at the same time it is a data source for master applications that are designed for the systems InTouch, Wizcon or ContolWeb2000.

5. 1. *InTouch*

InTouch is one component of -based MMI system that gives users access to a full package of automation tools - FactorySuite 2000. It is the first fully integrated suite of software for industrial automation.

It provides a single integrated view of all your control and information resources. InTouch enables engineers,

supervisors, managers and operators to view and interact with the workings of an entire operation through graphical representations of their production processes.

It gives users many significant advantages and improvements over previous releases. Distributed alarm performance has been greatly improved, and the new display allows greater flexibility. The new alarm architecture in InTouch replaces NetDDE with TCP/IP for increased performance and decreased network loading. In addition, SuiteLink timestamping has been added as the alarms occur to enable better alarm analysis and the new Distributed Alarm System allows you to configure a secondary backup Alarm Provider to establish a fail-safe system.
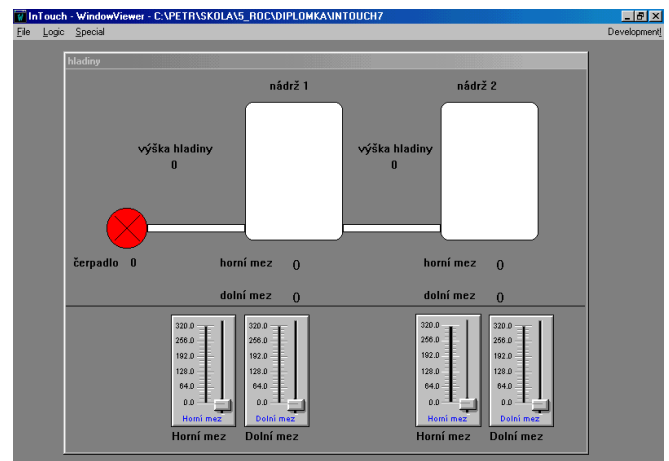

Fig. 7. A project made in system InTouch

5. 2. *Wizcon for Windows and Internet*

Wizcon for Windows and Internet provides all of the tools users need to efficiently build effective operator interface and supervisory control applications. Productivity is further enhanced with Wizcon's online engineering which lets users design and run applications within a single environment. Users can make changes online and see the results immediately, minimizing initial configuration time and on-site installation efforts.
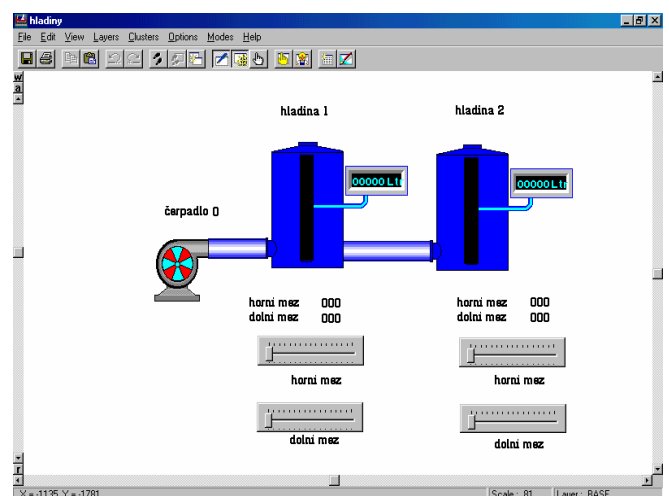

Fig. 8. A project made in system WizCon

Wizcon's Application Studio offers easy access to all of the application's components

It provides a powerful Image Editor to create and view the Images that enable the operator to visualize part or all of a control process. An image consists of objects, which are geometric figures or text. Geometric objects can be either open or closed, and all objects can be filled with specified patterns and displayed in unlimited colors.

Using Wizcon.s Multilanguage support, tag descriptions, alarm text and image field text can be created in one language and exported to an ASCII file. This easy-to-handle file can be translated to another language and re-imported into Wizcon. The same procedure can be applied to multiple languages. During runtime, a user can choose the required language. For example, users can enter an alarm description in English when they configure the application, but display it in French during runtime. Support for different languages is dependent on the operating system and its support for that language.

5. 3. *Control Web 2000*

Control Web is a component, object-oriented system for the development and operation of visualisation, measurement, control, regulation and communication programs and programs for the collection, archiving and processing of data. Similarly, the application can control a machine or technological line in real time and simultaneously be incorporated into a large company information system.

The Control Web environment enables you to create programs using symbolic descriptions of the designed system. If you do not want to study all the advanced features of the system you can simply develop your own application as if you were actually creating the indicator and control panel on a distribution board or control room. You are using the *virtual models* instead of real instruments which brings about incomparable means of expression and potential for creativity.
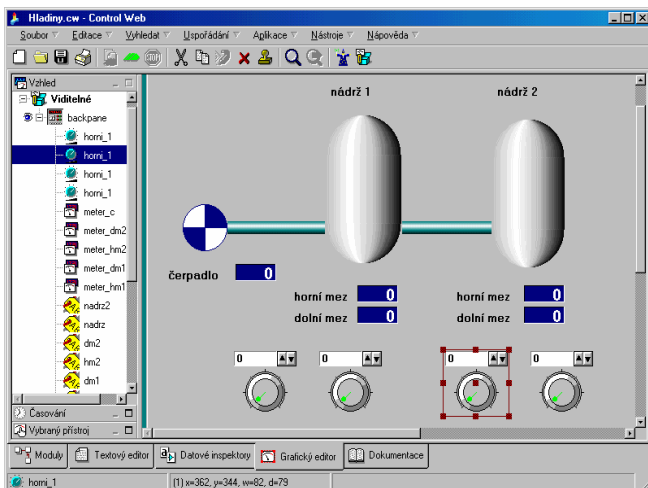

Fig. 9. A project made in system ControlWeb

Based on *visual programming* you can very easily create your own application by arranging the objects with the mouse. All you have to do is to capture the relevant icon, which is a graphical representation of the required instrument, and insert it within the structure of the

application you are developing. The data concerning the inserted instrument are automatically transferred into the application source text.

Even programmers who are used to programming applications directly in source text can work in the text editor. The text that you enter via this editor automatically translates into the structures of the application you are developing. [7].

Examples of the projects made in different control systems are shown in figures no. 7, 8, 9.

In education process students have to create applications in described system.

6. CONCLUSION

The students are very interested in this course because:

- They apply theoretical knowledge in real application.
- It is easy to see if application is working correct.
- They are prepared for implementation of different systems in the factories, in industry, in their new job.

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