EXPERIENCES WITH THE PRACTICAL AUTOMATIC CONTROL EDUCATION

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ABSTRACT

Practical laboratory training is very important part of education process in the area of technical engineering. It is necessary to verified theoretical knowledge with the real technological processes – if it is possible, or at least on the real models of technological processes. At the Tomas Bata University in Zlin, Faculty of Applied Informatics there are in the range of study branch Automatic Control and Informatics several disciplines focussed to the problematic of automatic control theory. Control theory is lectured from the fundamental principles to the modern approach to the computer control systems and methodology. For the laboratory training were built new models for using many different synthesis methods and many possibilities to solve computer and hardware configuration of the control system. From the microcomputers applications thorough the PLC to the special PC control systems. One from these models was from the point of view of technical construction and electrical control system presented on TMT´ 2005 conference – time delay model. In this contribution are described experiences with the using of this model in the education process and experiences with the concrete laboratory exercises from the problems of the time delay systems.
Keywords: Time delay, physical model, real-time computer control, education

1. INTRODUCTION
Frequently solved task in the field of control algorithms and system proposal there is synthesis of the industrial manufacturing systems presenting smaller or larger time delay. For such systems there are many methods available to approximate time delay and these approximations included to the control algorithms synthesis. Tasks from this area it is possible to solve partly by the simulation way on the simulation program environment basis, for example Matlab-Simulink system, partly on the real equipments or at the least on the physical models with this property. In our case we have produced physical heat-interchanging model which allows on the basis of its construction to realize the plant with the time delay variable from 0 to seven minutes.

2. MODEL DESCRIPTION
The time delay is realized by measuring the temperature of the media at several places in the interconnecting pipeline [1]. Schema of the model is shown in Figure 1. The model contains hot water source 1 with electric heating and thermostat-based regulation in the range 30 to 85 °C. Hot water is transported by variable-speed pump 2 into the interconnecting pipeline 5 connected with the exchanger 6. The pipeline is connected through intercepting valve 3 where the flow is divided between the pipeline and a reversing coupler. The pipeline itself is composed of several meanders where it is possible to place thermometers 7 and thus obtain various values of the time delay. The time delay can also be affected by changing the speed of the pump and position of the valve [2,3]. The exchanger makes it possible to establish variable heat dissipation thus creating a disturbance.

On the Figure 2 we can see the ways the quantity of the time delay generation as a sum total of the time delay due to pump speed choice T_{D1}, time delay due to three-way valve medium flow setting to the pipeline T_{D2} and time delay due to alternatively placing of the thermometer in the pipeline T_{D3} or T_{D4}. There is possible the whole system dynamic properties to describe by the help of transfer function which is written on the Figure2.
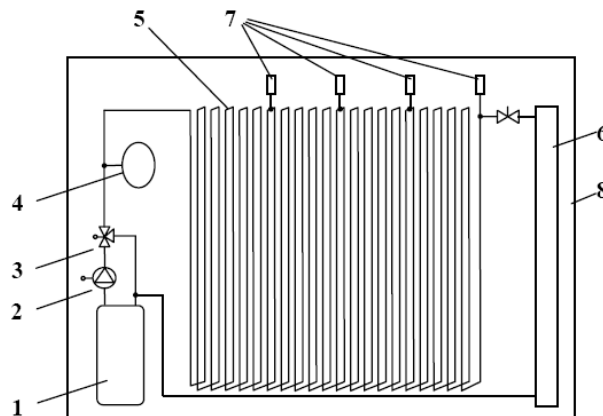

Figure 1. Time delay model scheme

All input and output quantities are transformed to standard signals in an electronic unit. This unit can be connected to control computer systems. For the introduced collection of models the system will be connected using the electronic unit CTRL to a computer with the MATLAB-SIMULINK program system. For this environment the algorithms for identification and also for controlling the temperature in defined location of the model pipeline will be implemented. Including of the physical model to the control loop is shown in the Figure 3. The real image of the model you can see on the Figure 4.
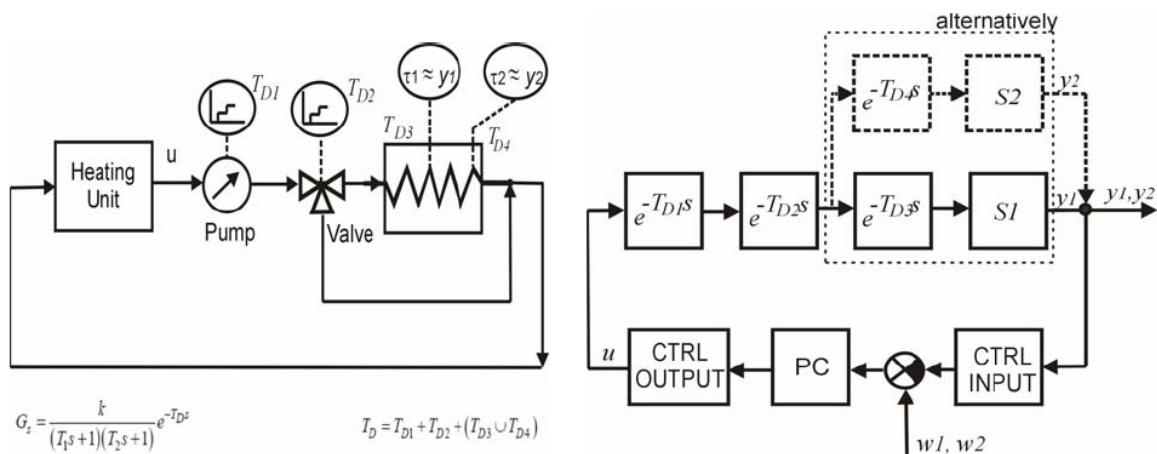

$$G_s = \frac{k}{(T_1 s + 1)(T_2 s + 1)} e^{-T_D s}$$

$$T_D = T_{D1} + T_{D2} + (T_{D3} \cup T_{D4})$$

Figure 2. Time delay creating   *Figure 3 - Control loop*

3. SYSTEM IDENTIFICATION

For the temperature model dynamic properties were measured the step responses for the several setting up of the model parameters. Parameters variability is given by the settings of the pump speed and the valve position and from this value consequents quantity of medium flow to the bypass.

The measuring was engaged in several different levels of the heating elements power consumption. On the Figure 5 we can see the identification measuring results for the pump power 18 W and in the first case valve position inductive of 50% medium flow to the bypass. To the figures are put three courses corresponding with the three thermometers locating in the pipeline.
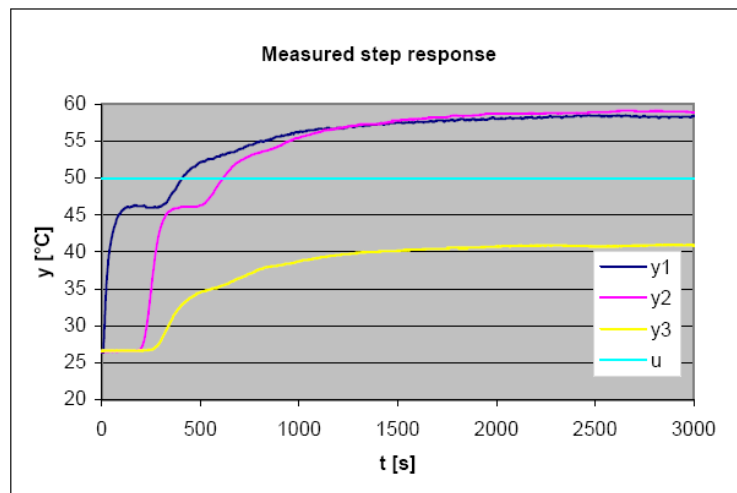
Figure 4 - Real model

Figure 5. Step response for the 50% medium flow to the bypass

For the *y2* course on the figure 5 there is possible to use the mathematical description in transfer function form:

Model 1

$$G_s(s) = \frac{0{,}633}{286s+1} e^{-185s} \tag{1}$$

or **Model 2**

$$G_s(s) = \frac{0{,}633}{(340s+1)(138s+1)} e^{-185s} \tag{2}$$

4. CONTROL EXPERIMENTS

For the experiments in the closed loop control there are shown three cases:

PS controller with the dynamics inversion method setting ($\kappa = 0{,}05$)

PSD controller with the dynamics inversion method setting ($Tw = 800$s)

Pole placement general discrete controller

PS controller with the dynamics inversion method setting
Sample period $Tv = 10s$
Controller transfer function:

$$G_R(z) = \frac{1{,}244 - 1{,}202z^{-1}}{1 - z^{-1}} \qquad (3)$$

PSD controller with the dynamics inversion method setting
Sample period $Tv = 10s$
Controller transfer function:

$$G_R(z) = \frac{9{,}75 - 18{,}5z^{-1} + 8{,}81z^{-2}}{1 - z^{-1}} \qquad (4)$$
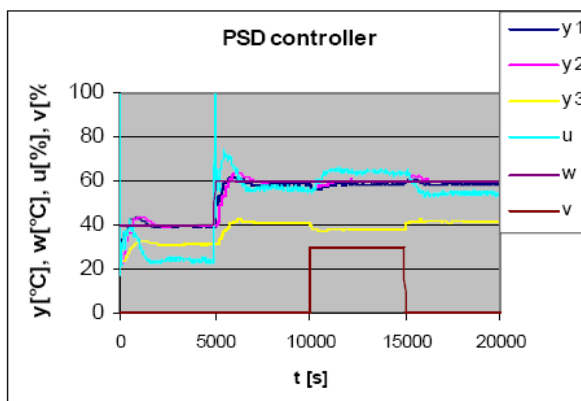

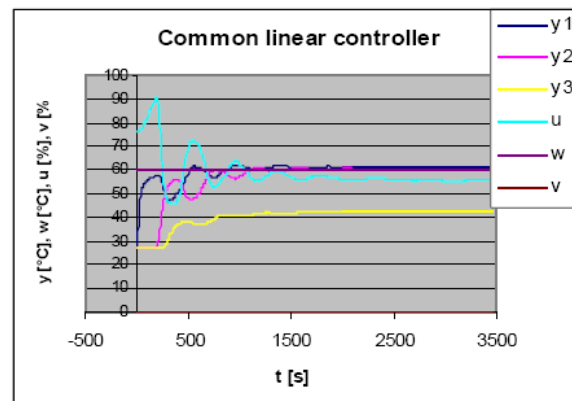*Figure 6. PSD controller with the dynamics inversion method setting*

Figure 8 – General linear controller

5. CONCLUSION

The new physical model for presentation of the systems with the time delay was produced. It is prepared for connecting with the computer on the basis PC and it is supposed the direct connecting with the Matlab-Simulink environment. For this connection will be used the new version of the CTRL signal transformation unit [3]. The model will serve as a tool for laboratory training in the main following areas of computer control applications

- Control of processes with substantial time delays
- Robustness control for variable time delays
- Identification of the systems with the indispensable time delay

This way defined tasks will be solved in the last year (2005) of the Grant agency project solution.

6. ACKNOWLEDGEMENT

7. REFERENCES

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