

Applied Informatics in Automatic Control Education

VLADIMÍR VAŠEK, PETR DOSTÁLEK, DAGMAR JANÁČOVÁ,
KAREL KOLOMAZNÍK, MARTIN ZÁLEŠÁK

Department of Automatic Control

Faculty of Applied Informatics

Tomas Bata University in Zlin

Mostní 5139, 760 01 Zlín

CZECH REPUBLIC

<http://web.fai.utb.cz>

Abstract: - The computer control is one large area of applied informatics. Today's control systems are mostly based on the different types of computers and their communication in more level systems is also defined by the computer communications rules. 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 focused 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 the using of 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 is time delay model. In this contribution are described experiences with the using of this model computer control in the education process.

Key-Words: - Time delay, Physical model, Real-time computer control, Software interface, 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 null 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 Fig.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, 6]. The exchanger makes it possible to establish variable heat dissipation thus creating a disturbance. On the Fig.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 TD1, time delay due to three-way valve medium flow setting to the pipeline TD2 and time delay due to alternatively placing of the thermometer in the pipeline TD3 or TD4. There is possible the whole system dynamic properties to describe by the help of transfer function which is written on the Fig.2.

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.

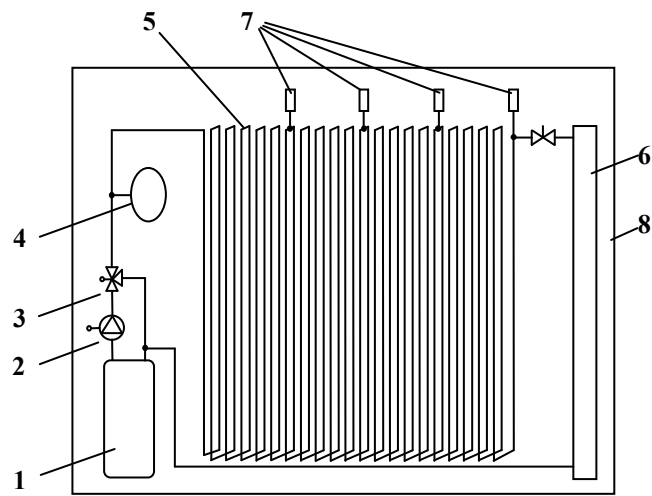


Fig.1 - Time delay model scheme

Including of the physical model to the control loop is shown in the Fig.3 and the real image of the model you can see on the Fig.4a, b.

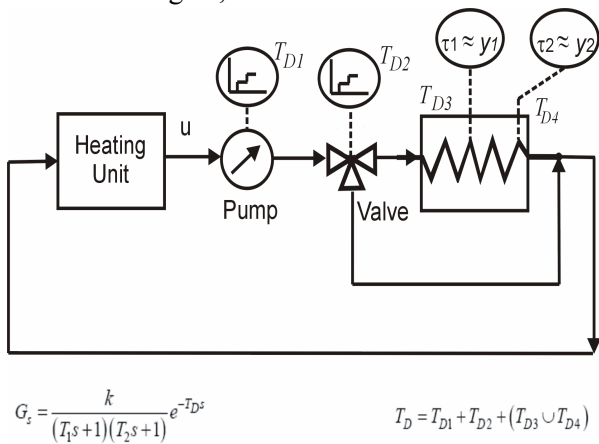


Fig.2 - Time delay creating

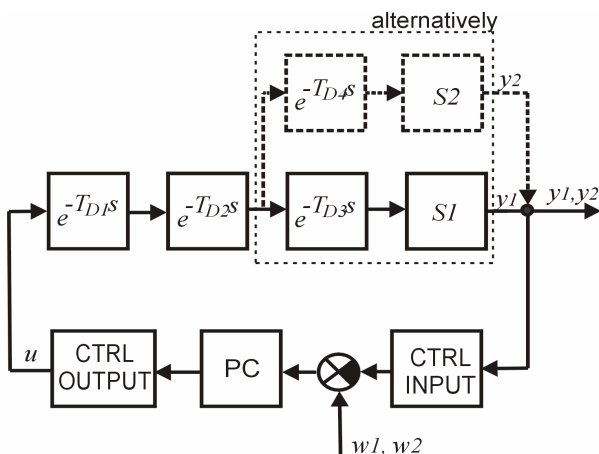


Fig.3 - Control loop

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 Fig.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.

a)



b)



Fig.4a, b - Real model

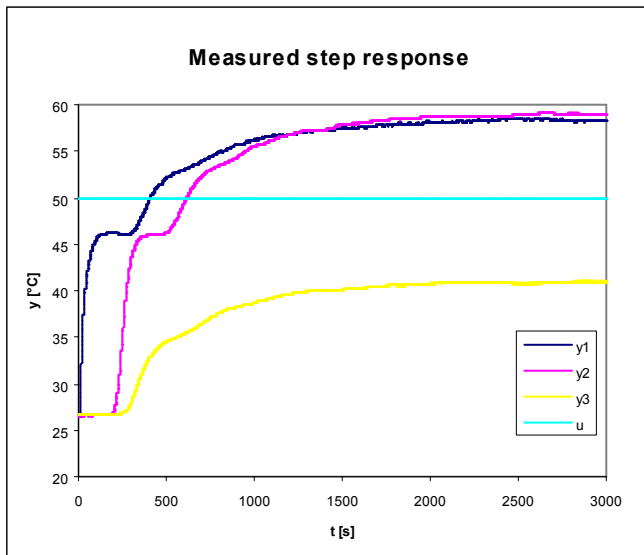


Fig.5 - Step response for the 50% medium flow to the bypass

For the y_2 course on the Fig.5 there is possible to use the mathematical description in transfer function form:

Model 1

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

or Model 2

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

4 Software System

In the two levels control system is included microcomputer transformation unit as a interface between technological environment and a control computer on the basis PC. Software on the microcomputer is running in the loop to guarantee data transfer between A/D and D/A converters on the one hand and control computer on the second one.

For the comfortable using this model experiments there was built the friendly software system running in 6.5 Mathlab environment for the second level of control system – PC. This software use the graphic interface as is shown on the Fig.6.

This simple interface enables following measuring possibilities:

- step response characteristic,
- control of the select value,

- selection of the control algorithms from occasions PS, PSD or general linear discrete controller,
- all data are saved to the file in text format available for following processing in Microsoft Excel,
- special function for physical model setting up for next measuring when is the medium temperature stabilized to the base value by the help of setting full enforcement cooling ventilators and maximal medium pump speed.

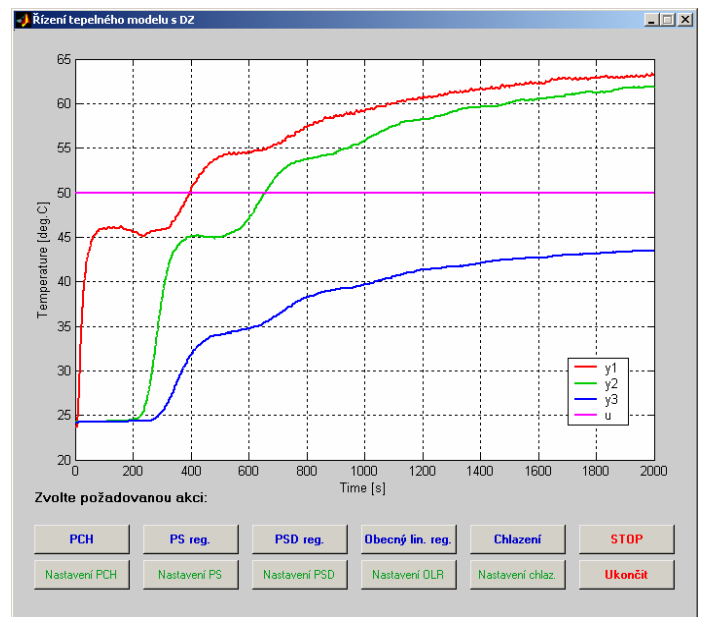


Fig.6 – Graphic user's interface of the software system

5 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 ($T_w = 800s$) – Fig.7,
- Pole placement general discrete controller – Fig.8.

PS controller with the dynamics inversion method setting

Sample period $T_v = 10s$

Controller transfer function:

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

PSD controller with the dynamics inversion method setting

Sample period $T_v = 10s$

Controller transfer function:

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

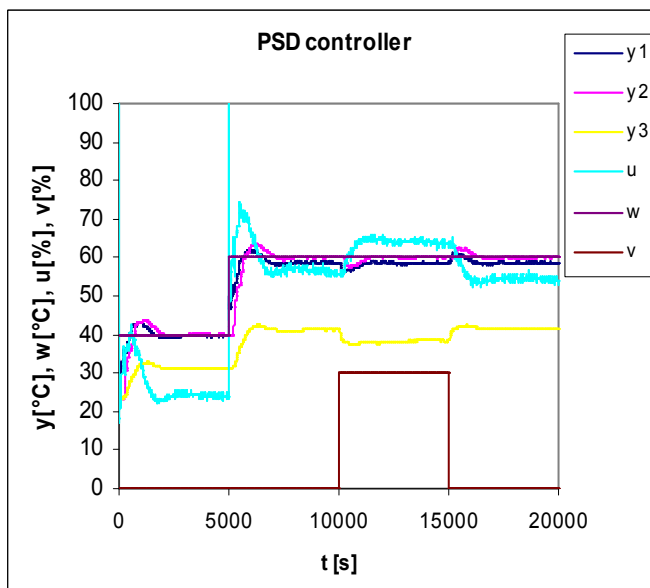


Fig.7 - PSD controller with the dynamics inversion method setting

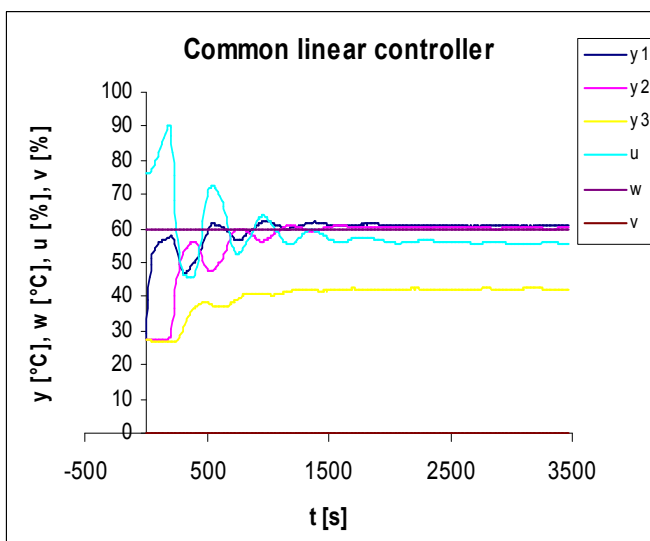


Fig.8 – General linear controller

6 Conclusion

The new physical model for presentation of the systems with the time delay was produced. It is connected with the computer on the basis PC thru the microprocessor conversion unit and it is connected with the Matlab-Simulink environment. For this connection was used the new version of the CTRL signal transformation unit [3]. The model serves 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 [5],
- identification of the systems with the indispensable time delay [4],
- software engineering of the real time system applications.

References:

- [1] Balátě, j.: *Higher Level Control Algorithms for the District Heating Systems*. (In Czech). Project Report of the GACR No. 101/01/0345, Zlín, Czech Republic, 2003.
- [2] Klán, P. - Modrlák, O. - Hofreiter, M. - Smutný, L. - Macháček, J. - Vašek, V.: *Consortial Approach to the Development of Experimental Models*. Project Report of the GACR No.102/03/0625. UTIA, Prague, Czech Republic, 2003.
- [3] Klán, P. - Modrlák, O. - Hofreiter, M. - Smutný, L. - Macháček, J. - Vašek, V.: *Consortial Approach to the Development of Experimental Models*. Project Report of the GACR No.102/03/0625. UTIA, Prague, Czech Republic, 2004.
- [4] Klán, P. - Hofreiter, M. - Macháček, J. - Modrlák, O., Smutný, L. - Vašek, V.: *Process Models for a New Control Education Laboratory*. In: Preprints of the 16th World Congress of the IFAC. Prague, 2005
- [5] Matuš, R. - Prokop, R.: *User-friendly MATLAB program for control and robust stability analysis of systems with parametric uncertainties*. In: Proceedings of the 13th Mediterranean Conference on Control and Automation, Limassol, Cyprus, 2005, pp. 1487-1492, ISBN 0-7803-8937-9.
- [6] Machů, M.: *Time delay thermal model testing*. (In Czech). Diploma work. Faculty of technology, UTB IN Zlín, 2005

Acknowledgement:

This work has been supported by the Ministry of Education of the Czech Republic, Project No. MSM 708352102 and Grant Agency of the Czech Republic projects No.102/03/0625.