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LABORATORY HOT-AIR STAND INSTRUMENTATION AND ITS PROGRAM SUPPORT

INSTRUMENTACE LABORATORNÍHO TEPLOVZDUŠNÉHO MODELOVÉHO AGREGÁTU A JEHO PROGRAMOVÁ PODPORA

Abstract

The paper deals with instrumentation and program support for experimental control tasks with laboratory model Hot-Air Stand (HAS) solved at the Department of CSI 352 of the VŠB-TU of Ostrava. This model represent the heating part of air-conditioning unit with possibility to control the temperature and volume of hot air flow, including of their disturbance simulation.. It allows realizing interesting measurement and control tasks: - identification of static and dynamic HAS subsystems and sensors characteristic, - experimental verification of controller synthesis results, - synthesis of the new control algorithms (ON-OFF algorithm, PID, fuzzy, neuron nets). Lab stand HAP is supported with simulation program tools (for instance MATLAB-Simulink or WinSIPRO) and mainly with own program module WinCTRL (version 2.0) for real time control of physical function models. Properties and results obtained by this program module with last version of HAP 2004 are also presented. The presented results have been obtained with the financial support of the GAČR, during of completing the research project *No.* GAČR 101/03/0625.

Abstrakt

V příspěvku je popsána technická a programová realizace nové verze laboratorního fyzikálního modelu - teplovzdušného stendu (HAS), navrženého na katedře ATŘ 352, VŠB-TU Ostrava. Model HAS představuje ohřevovou část klimatizační jednotky s možností řízení teploty a průtoku horkého vzduchu, včetně simulace jejich poruch. Model dovoluje realizovat zajímavé měřicí a řídicí úlohy: - identifikaci statických a dynamických vlastností výkonových částí jednotky (ohřev, vzduchotechnika), vlastnosti snímačů teploty a průtoku vzduchu, dále o experimentální verifikaci výsledků syntézy regulačních algoritmů (2-polohová, PID, fuzzy, neuronové sítě). Programová obsluha experimentálního modelu je zajištěna z univerzálního simulačního systému MATLAB-SIMULINK a WinSIPRO nebo pomocí vlastního programového modulu WinCTRL (verze 2.0) pro regulaci v reálném čase. Jsou zde prezentovány vlastnosti a výsledky získané s podporou programového modulu WinCTRL. Prezentované výsledky byly získány za finanční podpory GAČR, při řešení projektu GAČR 101/03/0625.

1 INTRODUCTION

Laboratory physical stands allow easy understanding the principles of the real industrial plants parts, measurement and control instrumentation, signals character, noise, dynamic responses and easier crossing to the real technological systems. Experimental verification of the theoretical knowledge responds to need for accelerated acquisition and adoption of "best practice" techniques and methods and it increases the quality of engineering education.

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Basic demands for design and experimental stands education application for laboratory exercises are [YOUNG, 1997], [HORÁČEK, 2000], [SMUTNÝ & ŠKUTA, 2004a.]:

- Similarity of physical laboratory model with the real industrial devices (plants).
- Good dynamical responses of output signals (quick reaction, short time constants).
- Unified input and output electrical signals (U = 0-10 V, I = 4-20 mA).
- Good possibility of connection with miscellaneous computers or alternative control unit (Programmable Logic Controller - PLC, Industrial PC - IPC, Industrial microcomputer - IMC).
- Availability of model function parts and their reasonable price.
- Miniaturization of dimensions, power input, etc.
- Cooperation of students on design and production of laboratory stand.
- Easy production in the condition of Department Mechanical and Electronic Workshop.

On the Department of Control Systems and Instrumentation, VŠB-TU of Ostrava were designed and produced a set of laboratory experimental stands, models and education aids for measurement and control tasks in former times [SMUTNÝ & ŠKUTA, 2004b]. They are utilized for practical exercises in specialization subjects, mainly connected with subjects *Measurement and Sensors, Means of Automatic Control, Microcomputer Measurement Systems, and Design of Process Systems.*

2 THE HOT-AIR AGGREGATE STRUCTURE - HEATINF PART OF CLIMATE UNIT

Stand lab HAS presents function module of air conditioning unit and it is used on the experimental laboratory education for all study forms, not only on the Faculty of Mechanical Engineering VSB-TU of Ostrava, but also on other seven technical faculties at Czech Republic. Stand HAP allows to realized all directions of real laboratory education with all-important tasks connected with:

- Identification of static and dynamic system and sensors properties,
- Intuitive approach and experimental verification of controller synthesis results,
- Verification of the new control algorithms (fuzzy, robust, neuron, genetic, ...)

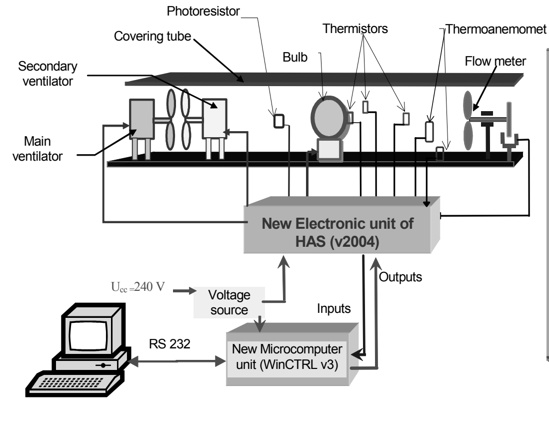

Fig. 1 Block schema of experimental model HAS (Hot-Air Stand), version 2004

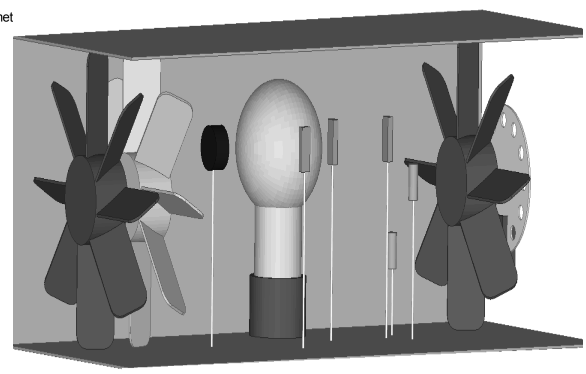

Fig. 2 3D schema of experimental model HAS, version 2004

For computer communication between Electronic units of model HAS (see Fig. 1) there are utilized microcomputer unit CTRL (v. 1995) from UTIA AV (now Informatics Institute, Academy of Science CZ) with 12 input and 4 output channels, voltage range 0 – 10 V. Second possibility there is AD 512 (A/D converter board from Humusoft). Serial external unit CTRL there were substituted on the final version with new design unit CTRL v3 (2004) with only 4 analogue inputs and 2 outputs and 4 digital I/O [Smutný, 2005] – see Fig. 3 and Fig. 4.

Fig. 3 Laboratory stand HAS (v2004) with new miniaturized electronic unit, voltage source and MCU CTRL v3.

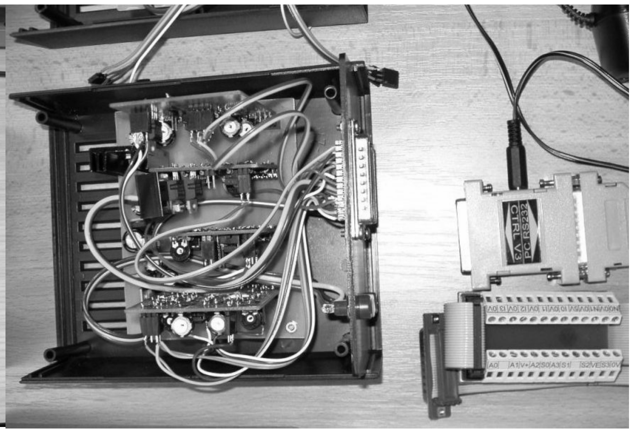

Fig. 4 Detail view of HAS (v2004) electronic unit with pulse width voltage modulation of current input for bulb control.

3 PROGRAM SUPPORT OF CONTROL TASK

Laboratory stands need for effective utilization good level of program support, connecting with measurement, diagnostic and control tasks solution. For these purposes are utilized well-known program systems as a Lab View (National Instruments), VEE (Hewlet Packard), simulation program systems with Real Time support for instance MATLAB-Simulink (Mathworks) or WinSIPRO (VSB-TUO).

On the Department CSI of VŠB-TUO there was design program module for collaboration with external measurement unit CTRL (UTIA AV Prague) and computer PC - module WinCTRL 2.0. This version supports cooperation not only with CTRL units, but also with A/D/A converters cards (for instance AD 512 (Humusoft Prague).

Module WinCTRL offers measurement tasks (8 – 16 inputs) with minimal sampling period from 0,04 s (AD card) and 0,5 s (CTRL). Control tasks tender 4 types of algorithms for 3 channel outputs:

- On-off (2 position control)
- On-off (2 position control) with penalization
- PID control
- Fuzzy PI control

On the next figures we can see some screens from program module WinCTRL 2.0 and output charts from control tasks with HAS. On the Fig. 5 and Fig. 6 we can see the screens with setting of CTRL unit outputs in program module WinCTRL – fuzzy algorithm (Fig.5) and PID algorithm (Fig. 6).

Next picture – Fig. 7 there is a main screen of control task on Real-Time mode with inputs temperature (input 3), air flow meter (input 7), and outputs – voltage to bulb (output 1) and voltage to primary fan (output 2) or secondary fan (output 3).

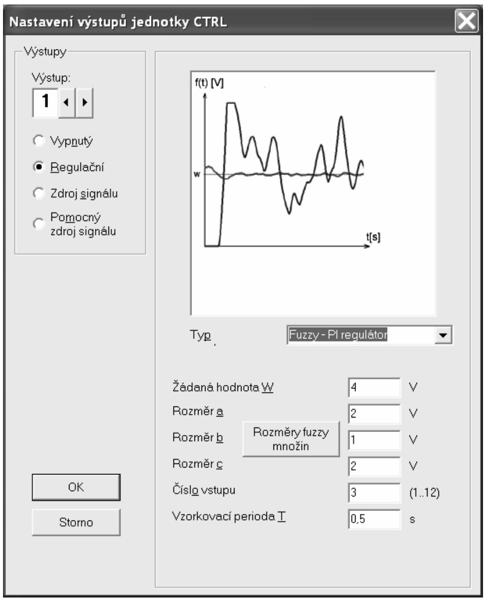

Fig. 5 Setting of outputs CTRL unit in program module WinCTRL – fuzzy algorithm

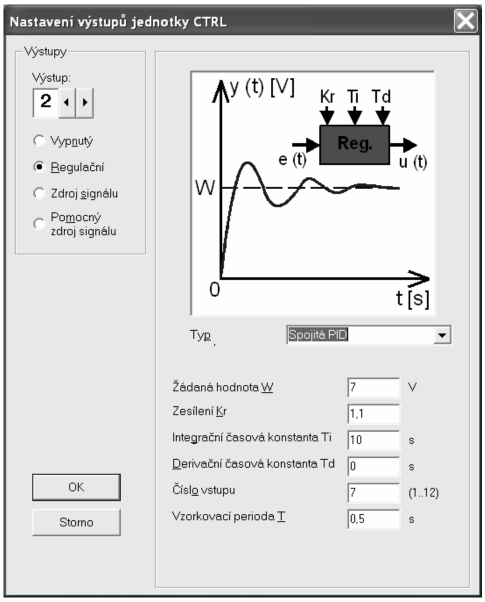

Fig. 6 Setting of outputs CTRL unit in program module WinCTRL – PID algorithm.

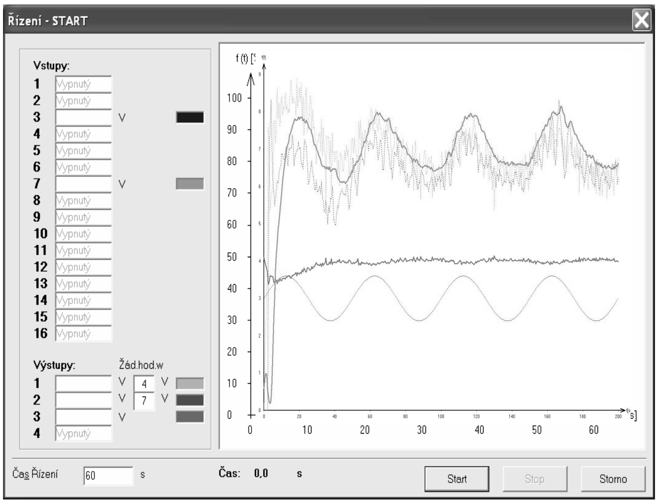

Fig. 7 Main screen of control task on Real-Time mode

On the pictures Fig. 8 and Fig. 9 there are the graphic output charts from experimental tasks for simultaneous temperature and air-flow control. On the Fig. 8 we can see the chart from program WinCTRL v.2 with the control course of temperature and air flow fuzzy control and on the next figure there is a PID control algorithm with 2 control outputs (temperature of bulb), flow of air, 2 control input variables (voltages on main ventilator, on bulb and on second ventilator).

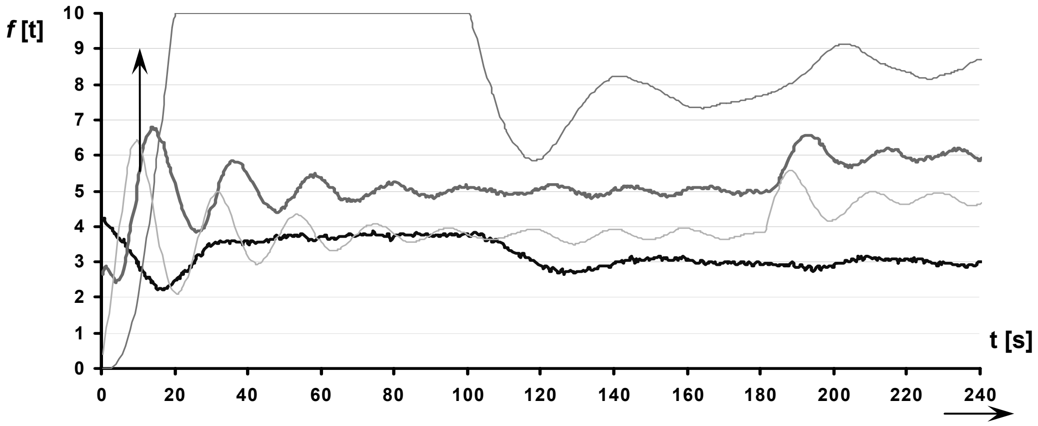

Fig. 8 Chart from program WinCTRL with the control course of fuzzy temperature and air flow control

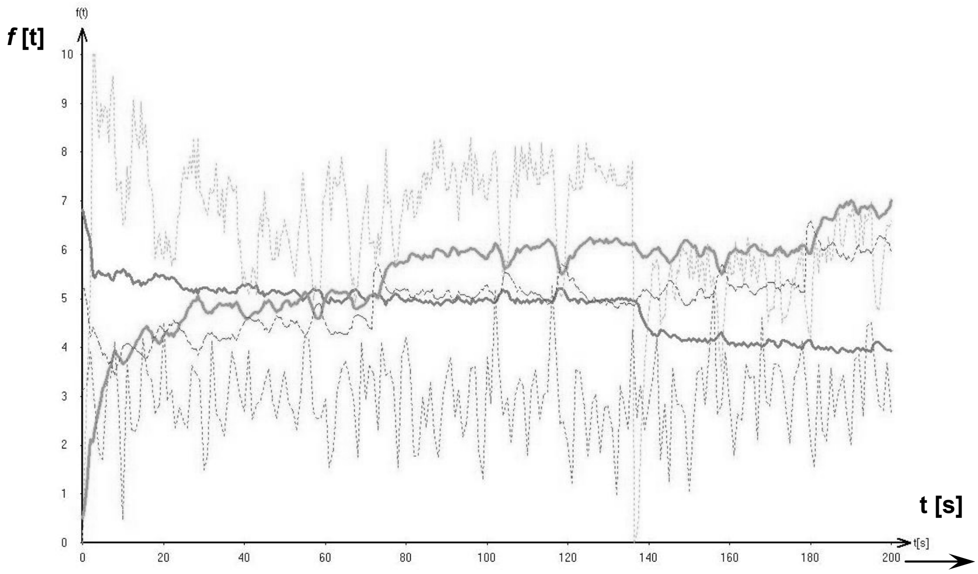

Fig. 9 The final chart of WinCTRL program module - PID control algorithm with 2 control outputs (temperature of bulb – grey line, flow of air – green line), 2 control input variables (voltages on main ventilator -blue line, on bulb – red line, on second ventilator – violet line).

4 CONCLUSIONS

Future progress of automatic control theory is closely linked with experimental models on which it is possible to verify results being theoretically developed. Verification of theoretical findings is important part of education process. Although increasingly significant methods are computer simulations, now typical with simulation programs aid (for instance MATLAB-SIMULINK, SIPRO), experiments with real physical models are not interchangeable.

Experimental stands allow easy understanding to principles of industrial plant parts, measurement and control devices, signals character, noise, dynamic responses and easier crossing to the real technological systems. The lab model “Hot Air Stand” as a part of conditioning unit is good example for demonstration of basic principles measurement, diagnostic and control tasks in the environment near the real industrial conditions, with good dynamical properties and typical nonlinearities and disturbances.

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