SLOVAK UNIVERSITY OF TECHNOLOGY IN BRATISLAVA

FACULTY OF CHEMICAL AND FOOD TECHNOLOGY

DEPARTMENT OF INFORMATION ENGINEERING AND PROCESS CONTROL

ANNUAL REPORT

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CONTENTS

I PREFACE

Department of Information Engineering and Process Control has at the Faculty of Chemical and Food Technology of the Slovak University of Technology more than forty-year tradition. In the frame of the study branch Chemical Engineering and Process Control on the specialization Process Control, it educates high-qualified specialists in the field of process control for design, implementation and processing of control systems.

Nowadays, information technologies and process control with using microprocessor based control technique represent important and acknowledged scientific branches. These branches more and more influence the economic and social growth in the whole world and successively also in our country. The chemical, food and pharmaceutical industries with their technologies are no exceptions. No technology is able to be successful in the competition without optimization and advanced control systems or without using information technologies. In the connection with these facts, all our graduates have found their jobs without problems during the whole history of the department. It confirms also, that the education of the specialists in the information engineering and process control has been very attractive and its significance is even growing. The graduates of the department do well not only in the companies and institutions oriented on design and supplying of control systems for various technologies but also in the bank sector and they found their own firms respectively.

Teaching and research activities of the department are oriented on process control, identification and modeling of systems, adaptive control, construction and testing of measuring devices and equipment, and on development of software packages for intelligent control systems. Second branch is devoted to information technologies, data management, and Internet programming.

Assoc. Prof. Dr. Ing. Miroslav Fikar

II INTRODUCTION

This report summarizes the teaching and research activities at the Department of Information Engineering and Process Control at the Faculty of Chemical and Food Technology at the Slovak University of Technology in Bratislava during the period 1 January – 31 December 2004.

Department of Information Engineering and Process Control of the Faculty of Chemical and Food Technology of the Slovak University of Technology was constituted from the Department of Measuring and Control Technique of the Faculty of Electrical Engineering of the Slovak University of Technology in 1962. Because of the specific control problems of the processes and systems in the chemical and biochemical technologies, the specialization Process Control in the frame of the study branch Chemical Engineering and Process Control has been established. Students and postgraduate students have been educated since 1964. So far, more then three hundreds specialists and almost thirty PhD students have been graduated here and two professors and nine associated professors have been appointed.

The first head of the department was Prof. Daniel Chmúrny, PhD, DSc in 1962 – 1986. Prof. Ján Mikleš, PhD, DSc headed the department in 1986 – 1994 and in 1998 – 2003. The head in 1995 – 1997 was Assoc. Prof. Alojz Mészáros, PhD and Assoc. Prof. Dr. Ing. Miroslav Fikar has headed the department since 2003.

Department of Information Engineering and Process Control is one of the 22 departments at the FCFT STU, where the students obtain specialization in various branches of chemical technology or chemical engineering. Approximately 1000 students are currently enrolled in the three-year bachelor programs leading to the Bc. degree and two-year master programs leading to the Ing. degree, which is equivalent to the MSc. degree. The best of them continue in the three-year doctor programs leading to the PhD degree.

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IV TEACHING AND RESEARCH LABORATORIES

IV.1 Teaching Laboratories

Laboratory of Process Control
Laboratory of Control Systems
Laboratory of Measuring Instruments and Techniques
Computer Laboratory (PC - Windows, Linux)
Computer Laboratory (Solaris)

IV.2 Research Laboratories

Laboratory of Control Theory
Laboratory of Modeling and Simulation
Laboratory of Identification
Laboratory of Optimization
Laboratory of Neural Networks
Laboratory of Chemical Reactor Analysis and Control
Laboratory of Biochemical Process Analysis and Control
Laboratory of Distillation Column Analysis and Control
Laboratory of Computer Aided Design (Siemens-SIMATIC S-7 300, FOXBORO)

V. EDUCATIONAL ACTIVITIES

V.1 Bachelor Study

2nd semester (spring)

Informatics	1/0/2	Šperka, Vasičkaninová

5th semester (autumn)

Computer Based Data Processing	0/0/2	Calík, Dermíšek, Hirmajer, Karšaiová, Ondrovičová, Puna, Vasičkaninová

6th semester (spring)

Automatic Control Fundamentals	2/0/0	Bakošová, Fikar
Laboratory Exercises of Automatic Control Fundamentals	0/0/2	Bakošová, Calík, Danko, Dermíšek, Fikar, Hirmajer, Jelenčiak, Karšaiová, Ondrovičová, Vasičkaninová
Bachelor projects	0/0/4	Bakošová, Čirka, Danko, Fikar, Mikleš, Ondrovičová, Vasičkaninová

V.2 Master Study

1sth semester (autumn)

Process Control	1/0/2	Mészáros
Process Dynamics	2/0/0	Bakošová
Operating Systems	1/0/1	Fikar
Control Devices and Systems	2/0/1	Danko
Computer Programs	1/0/2	Čirka
Laboratory Projects	0/0/8	Bakošová, Čirka, Fikar, Karšaiová

2nd semester (spring)

Optimization	2/0/1	Dvoran
Control Theory I	2/0/2	Čirka, Mikleš
Laboratory Exercises of Control Theory I	0/0/2	Čirka, Mikleš
Experimental Identification	2/0/0	Fikar

Laboratory Project II	0/0/6	Čirka, Danko, Dvoran, Mikleš, Ondrovičová
Modeling and Control of Polymerization Processes	2/0/2	Dvoran
Process Dynamics	2/0/0	Bakošová
Laboratory Exercises of Process Dynamics	0/0/1	Bakošová

3rd semester (autumn)

Control Theory II	2/0/0	Mészáros
Laboratory Exercises of Control Theory II	0/0/2	Mészáros
Intelligent Control Systems	2/0/0	Dvoran
Semestral Project	0/0/10	Čirka, Dvoran, Karšaiová, Mikleš, Ondrovičová
CAD Systems	2/0/0	Karšaiová
Industrial Applications of Process Control	2/0/0	Mikleš, Ondrovičová
Control of Technological Processes	1/0/2	Čirka, Vasičkaninová

4th semester (spring)

Diploma Theses	0/0/27	Bakošová, Čirka, Danko, Fikar, Mikleš

V.3 PhD Study

Topics in Control Theory	2/0/0	Mikleš
Intelligent Control Systems	2/0/0	Dvoran
Modeling and Simulation of Processes	2/0/0	Mészáros
Software and Hardware of Control Systems	2/0/0	Danko

V.4 Course contents

V.4.1 Lectures in Bachelor study

Automatic control fundamentals (2h/week, 6th semester)

Introduction to automatic control fundamentals. Modeling of special types of processes of chemical technology. Static and dynamic behavior of controlled systems. Closed loop for control of technological processes. Controllers. Dynamic behavior of closed loops. Stability of systems. Synthesis of controllers.

Control of special types of processes of chemical technology. Basic principles of devices and methods for measurement of technological quantities.

V.4.1 Lectures in Master study

Process Control (1h/week, 1st semester)

Introduction to process control. Various forms of mathematical description of linear continuous-time systems and their connections. Input-output differential equation, transfer function, frequency-response function, state-space equation and its solution, mathematical description of systems with time delays. Frequency responses of linear continuous-time systems, responses on arbitrary signals. Internal properties of linear continuous-time systems: stability, controllability, reachability, observability, properness, stabilisability. Stability of feedback control loops. Controller synthesis. Mathematical models of linear discrete-time systems. Discrete PID controller.

Process Dynamics (2h/week, 1st semester)

Basic approaches to process modeling. System classification according to accepted mathematical models. Linearization of nonlinear models. Nonlinear and linearized models of serially connected tanks, the static and dynamic behavior. Dynamic behavior of processes with heat exchange: tank heat exchangers with ideal mixing of media, tube heat exchangers, down-stream and upstream cases. Dynamic behavior of processes with material exchange: plate distillation columns, stuffed distillation columns, stuffed absorption columns. Dynamic behavior of processes with chemical reactions: continuous-time stirred tank reactors, tube reactors without or with catalyst.

Operating Systems (1h/week, 1st semester)

Types of computers, basic hardware of computers, basic components and their classification, periphery equipment. Introduction to operating systems of computers. Multitasking, types of multitasking and their comparison. MS Windows, its versions and their comparison from the operating system point of view, configuration of MS Windows. Linux – operation system of UNIX-type, its installation and types. INTERNET and SANET nets. Communication tools telnet, elm, talk, ftp, gopher, www (lynx, netscape). LAN nets, their types and comparison. NetWare 3.x, 4.x, properties and philosophy. TCP/IP protocol, its configuration.

Control Devices and Systems (2h/week, 1st semester)

Continuous-time controllers, types and their static and dynamic behavior. Discrete controllers, their dynamic behavior and using in control loops. PC in the role of a controller. Servo-drives for electric and pneumatic control system. Control valves. Digital devices. Logic functions, electric devices for realization

of logic functions. Sequence loops. Hardware for control of technological processes. Analogue input modules, A/D, D/A converters. Digital input modules. Sources of inaccuracies in control loops.

Computer programs (1h/week, 1st semester)

MATLAB programming language: internal properties, variables, functions, data analysis, data visualization, data storing, programming in MATLAB. Simulink simulation language: simulation schemes, block parameter settings, simulation parameter setting, block libraries, s-functions. MATLAB/Control toolbox: simulation and control of systems. Origin – graphic software, data processing, data visualization, special functions. Word - text processor.

Optimization (2h/week, 2nd semester)

Static optimization, classification of problems, goal functions, boundaries. Extremum without boundaries – analytical methods. Single-dimensional case, multi-dimensional case, Hess matrix. Conditions for extremum. Extremum with boundaries – linear boundaries, direct method, method of Lagrange multipliers. Extremum with boundaries – nonlinear boundaries, Kuhn – Tucker theorem. Non-gradient methods – Box-Wilson method, flexible simplex method, method of cyclic exchange of parameters. Gradient methods – Regula falsi method, Newton method, Broyde method, DFP method, PARTAN method. Convergence of gradient methods. Heuristic and learning methods, genetic algorithms. Linear, dynamic, nonlinear programming. Optimal and strategic decision-making. Large-scale optimization tasks and their decomposition.

Control Theory I (2h/week, 2nd semester)

Continuous-time systems, discrete systems. Pole-placement method. State-space approach. Deterministic state estimate. Dynamic output feedback. Connections between state and input-output approach to control design. Pseudo-state. Asymptotic observer. Control law based on an observer for deterministic problem. Fractional approach, set of all stabilizing controllers. BIBO stability. Parameterization of stabilizing controllers. Bezaut equation. Dynamic optimization. Principle of minimum. Fundamental theorem of the variation calculus. Necessary conditions for the optimal control. LQC problem. Kalman linear (L), quadratic (Q) controller. Euler-Lagrange equations. Optimal control. Matrix Riccati equation. Output control. LQ controller with integral properties. LQ control. Connections between the state-space and input-output approaches. Spectral factorization. LQ control and deterministic state estimation. Polynomial solution of the problem. PI controllers and LQ controller design. Optimal LQ tracking of SISO systems, input-output approach. State and parameter identification. LQ state controller, LQG input-output controller. H_2 feedback control. Solution by using of two generalized algebraic Riccati equations. Connection between LQG and H_2 control.

Experimental identification (2h/week, 2nd semester)

The identification of dynamic systems from their step responses of the 1st and 2nd order, Strejc, Šalamon, Hudzovič, Söderström methods. Statistical identification methods. Classification of models for experimental identification. Least-square method, recursive least- square method, lemma about the matrix inversion, REFIL, LDFIL, LDDIF algorithms. Prediction error method and auxiliary variable method. Using of recursive identification methods for identification of multivariable and continuous-time systems. Aspects of the least square method and identification of static models, passive and active experiment. Correlation methods of identification, stochastic signals, correlation functions. Wiener-Hopf equation and its using for identification. Filtration and prediction of signals. State estimation and observability – Lueneberg observer, Kalman filtration. Using of identification for modeling and control of technological processes.

Modeling and Control of Polymerization Processes (2h/week, 2nd semester)

Principles of modeling of processes of chemical technology. Analytical and experimental approaches to modeling. Identification of static models based on the least square method. Recursive identification of discrete dynamic models. Analysis of synthesis, modification and production of polymers from the measurement and control point of view. Analysis of fiber production from the measurement and control point of view. Analysis of tire production from the measurement and control point of view. Analysis of processes of polygraphic technology from the control point of view. Analysis of processes of pulp and paper technology from the control point of view.

Control Theory II (2h/week, 3rd semester)

Algebraic theory of linear control, mathematical basement. Using of algebraic theory for continuous-time and discrete controller design, pole-placement, dead beat. Adaptive control. Self-tuning adaptive systems, recursive identification. Continuous-time and discrete adaptive control. Model reference adaptive control systems (MRAS), principles, MRAS according to MIT, MRAS in the sense of Ljapunov theory of stability. Predictive control. Robust control, H_2 and H_∞ control.

Intelligent Control Systems (2h/week, 3rd semester)

Expert systems – knowledge based systems. Knowledge representation. Basic features of expert systems, structure and processing. Diagnostic expert systems. Planning expert systems. Expert systems based on rules, frames and logical programming. Programming tools for expert systems – programming languages LISP and PROLOG. Fuzzy systems. Basic principles of fuzzy sets and fuzzy

logic. Fuzzy decision processes, fuzzy modeling and identification. Design procedures for fuzzy logic controllers. Rule based fuzzy controllers, model based fuzzy controllers. Neural nets. Basic principles of artificial neural nets (ANS). Representation of dynamic systems using feed-forward and feedback neural nets. System identification based on using of neural nets. Parameter estimation and neural net training. Controllers based on using of neural nets. Adaptive control based on using of neural nets, direct and non-direct. Genetic control algorithms. Control of textile production.

CAD systems (2h/week, 3rd semester)

Classification of automatic control systems, types of control algorithms. Automatic control system design. Feedback control loops – simple, composed. Control loops for flow rate, pressure, level control. Control loops for heat exchangers, distillation, absorption, extraction columns, batch and continuous-time chemical reactors. MIMO control of distillation columns. Large-scale systems – analysis, modeling and control.

Industrial Application of Process Control (2h/week, 3rd semester)

Introduction to industrial application of process control. Problems connected with control system design and control system application in practice. Hardware and software of industrial control systems, programming of industrial automata, data processing and visualization. Control of a chemical reactor for a decomposition of H_2O_2. Control of a binary plate distillation column. Solving of control problems for chemical industry.

Control of Technological Processes (1h/week, 3rd semester)

The course is given for students of specialization Organic Technology and Petrochemistry. Course content is following. Introduction to control of technological processes. Principles of control of technological processes: feedback and feedforward control. Simple feedback control loop. Methods for controller synthesis. Complex control loops: time-delay compensation (Smith predictor), cascade control, feedforward compensation of disturbances, flow-ratio control. Control of tanks, control and controlled variables. Control of heat exchangers, controlled and control variables, control loops. Control of distillation and absorption columns, controlled and action variables, control loops. Control of chemical reactors, controlled and action variables, control loops. Basic principles of devices and methods for measurement of technological quantities: liquid level, temperature, pressure, flow rate, concentration.

V.4.3 Laboratory exercises in Bachelor study

Informatics (2h/week, 2nd semester)

MS Windows 2000 operating system. MS Excel as a tool for data processing, data processing by tables, data visualization by graphs. MS Word – text processor.

Computer based data processing (2h/week, 5th semester)

MATLAB – Simulink as a tool for system simulation, MATLAB – Control toolbox. Filtration of signals, analogue and digital filters, MATLAB – Signal processing toolbox. MS Excel as a tool for data processing. Data processing by tables, data visualization by graphs, analytical tools in MS Excel, statistics in MS Excel. Origin as a tool for data visualization and processing.

Laboratory exercises of Automatic Control Fundamentals (2h/week, 6th semester)

MATLAB/Simulink as a simulation tool for LEACF. Laplace transform as a mathematical tool for LEACF. Input-output description of dynamic systems, transfer functions, poles and zeros. Step responses and impulse responses of dynamic systems. Mathematical models and dynamic behavior of processes of chemical technology. Feedback control. PID controllers and their properties in feedback control. Controller synthesis and control of processes of chemical technology.

V.4.4 Laboratory exercises in Master study

Laboratory exercises of Control Theory I (2h/week, 2nd semester)

Simulation of pole-placement method. State-space approach. State observer design for simple systems. Simulation of state feedback. Simulation of feedback control with a state observer. Design of a set of stabilizing controllers for simple systems. Simulation of MIMO feedback systems by using of stabilizing controllers. Simulation of feedback control by using of a LQ controller for simple serially connected tanks and for a chemical reactor. Synthesis of a PI controller, PI controller design by LQ method. Simulation comparison of a classic and a LQ PI controllers. Simulation of LQ control with deterministic state estimation. LQG state controller. Simulation of feedback control by a state-space LQG controller. LQG input-output controller. Adaptive control. Closed-loop identification. Closed-loop recursive identification. Simulation of adaptive control with recursive identification and with LQ/LQG controller. Adaptive control of serially connected tanks, adaptive control of a chemical reactor.

Laboratory exercises of Process Dynamics (1h/week, 2nd semester)
Simulation of dynamic properties of systems in MATLAB/Simulink. Analysis and simulation of static and dynamic behavior of a system of serially connected tanks with/without interactions. Analysis and simulation of static and dynamic behavior of a tube heat exchanger as a continuously distributed parameter system. Transformation of a system of partial differential equations to a system of ordinary differential equations by discretization. Calculation of a steady-state of a plate distillation column, analysis and simulation of static and dynamic behavior of a plate distillation column as a discretely distributed parameter system. Analysis and simulation of static and dynamic properties of an exothermic continuous-time stirred tank reactor. Calculation of steady state of a chemical reactor, steady-state analysis of a chemical reactor, linearization of nonlinear models.

Laboratory exercises of Control Theory II (2h/week, 3rd semester)
Algebraic theory of linear control. Control of the 2nd order continuous-time system by discrete controller. Self-tuning adaptive control system for the 2nd order linear system, discrete and hybrid approach. Model reference adaptive control (MRAC). Adaptation of static gain. MRAC for the 1st and 2nd order systems. MRAC in the sense of the Ljapunov theory of stability, application on the 1st order system. Predictive control.

VI. CURRENT RESEARCH ACTIVITIES

Research at the Department of Process Control is oriented to advanced control theory as so as to practical applications in control of processes of chemical technology.

VI.1 Main Research Areas

1. Modeling and Simulation (M. Bakošová, A. Mészáros, J. Mikleš, M. Karšaiová, M. Ondrovičová)

Modeling and simulation play an important role in the investigation of static and dynamic properties of chemical processes, units and systems. Most chemical systems are strongly non-linear and their simulation is necessary for the control design as well as for the investigation of the overall control systems. The main aim of the research is to develop program packages for modeling and simulation of various kinds of models. During the last year a package for PC in Simulink and C-language was created.

2. System Identification (J. Mikleš, M. Fikar, Ľ. Čirka, F. Jelenčiak)

System identification deals with problem of the parameter estimation of static or dynamic systems from observed input-output data. Among many topics of system identification, the following areas have been investigated in this project:

a) nonparametric methods, correlation and spectral analysis
b) recursive identification of Z-transform discrete-time models
c) recursive identification of delta models which converge to their continuous-time counterparts
d) identification in closed-loop

A program package IDTOOL has been developed for Simulink. This toolbox implements recursive LS algorithm LDDIF and provides blocks for continuous and discrete time parameter estimation.

3. Optimal Control Design (J. Mikleš, M. Fikar)

The main aim of this area is to develop a package of algorithms and program implementation of various known control designs for given plants. The research interests include single input-single output systems as well as multivariable dynamic systems. Control design covers strategies in discrete-time and continuous-time formulation. A program package is created in MATLAB/Simulink environment.

4. Adaptive Controllers (J. Mikleš, M. Bakošová, Ľ. Čirka, M. Fikar)

Most of technological plants exhibit non-linear behavior. To apply a successful control design to practical problems is a substantial effort. It is known that processes are modeled and controlled with serious difficulties caused by their non-linear behavior, high order dynamics, and tendency to instability. Many of industrial processes must be considered as multivariable systems. In a great deal of available control design techniques it is often necessary to carry out the steps of modeling, identification and control design. Theory and implementation of adaptive control in technological systems have been the long-time research topics. The activities in the adaptive control have been concentrated to four main areas as follows:

a) self-tuning control - characterized by repeating parameter estimation and control design
b) model reference adaptive control based on the Lyapunov method
c) decentralized adaptive control
d) adaptive lambda-tracking

5. Neural Networks (A. Mészáros, Ľ. Šperka)

The aim of this research is to investigate two-layer hierarchical control structures for biochemical systems, integrated optimizing algorithms for higher layers of hierarchical control structures, artificial neural-network models obtained by back-propagation for specified biochemical systems, design of a robust long-range constrained predictive control algorithms on the basis of ANN involving a stochastic approximation training algorithm, and development of a control system for our laboratory fermenter.

6. Fuzzy Control and Expert Systems (J. Dvoran, A. Vasičkaninová)

The aim of this research is to investigate fuzzy and neuro-fuzzy controllers. The usefulness of fuzzy control can be considered in two aspects. First, control offers a novel mechanism to implement such control laws that are often knowledge-based or even in linguistic descriptions. Second, fuzzy control provides an alternative methodology to facilitate the design of nonlinear controllers for such controlled plants that art uncertain and very difficult to cope with conventional nonlinear theory.

7. Predictive Control (M. Fikar)

Predictive control has been successful not only in academia but in industrial process applications as well. Its main drawbacks are the stability problems. The aim of this research is to enhance the basic input-output predictive methods. The problem is solved by means of the Youla-Kučera parameterization of all stabilizing controllers. Both finite and infinite horizon formulations are handled. Another approach is to assume that the loop is already controlled by a linear controller and to find the minimum number of control, or tracking error steps that leads to stable closed-loop behavior. In all cases, it can be shown that the minimum number of steps is closely related to the number of unstable poles/zeros of the plant.

8. Dynamic Optimization (M. Fikar, K. Calík, T. Hirmajer)

Increased quality requirements in chemical and petrochemical industries call for more complicated and sophisticated control strategies. Moreover, there is a need to know the achievable limits of performance and speed of transient behavior of processes. Optimal control theory is able to provide responses to these questions. In this research, changeover problems in multicomponent distillation are studied.

9. Robust Control (J. Mikleš, M. Bakošová, D. Puna)

Robustness has been recognized as a key issue in the analysis and design of control systems for the last two decades. Processing of chemical reactors, heat exchangers, distillation columns, etc. is connected with

many different uncertainties. Some of them arise from varying or not exactly known parameters, as e.g. chemical kinetics or reaction activity. In other cases operating points change. The processes are also affecting by various types of perturbations. All these uncertainties can cause poor performance or even instability of closed-loop control system. Application of robust control approach can be one of the possibilities how to overcome all these problems. One of the up to now opened problems is also the problem of a robust static output, which is studied.

10. Process Control

The research of all research groups is focused on control applications for various types of chemical and biochemical processes.

11. Control Engineering Education (M. Fikar, Ľ. Čirka, M. Bakošová)

The research in control engineering education has been oriented on use of new information technologies in control engineering education, interactive on-line courses and automatic generation of test problems. The task of personification of a web page for students and teachers is solved recently.

12. Information Technologies (M. Fikar, Ľ. Čirka, T. Hirmajer, D. Puna)

The research in information technologies has been oriented on

a) use of information technologies for data manipulation, retrieval, and visualization,
b) development of static and dynamic web pages not only for use in control and measurement, but also for general information and data management.

Technologies are based on open-source projects like Apache, MySQL, PHP, etc.

VI.2 Research Projects in Slovak Republic

1. VEGA Project No 1/1046/04: Progressive methods of adaptive and intelligent control applied to processes of chemical/biochemical technologies (A. Mészáros)

The main goals of the project can be listed as follows:

- Design of a new adaptive, intelligent control strategy on basis of ANN, using hybrid modeling approach. Testing through simulation experiments for non-linear biotechnological process.
- Design of an original, inverse plant model based robust neural controller with bias neuron weights adaptation. Testing through

simulation experiments for both, linear and non-linear system in presence of noise.

- Analysis of performance and parameter tuning of the proposed adaptive, intelligent control strategy on basis of ANN, using hybrid modeling approach.
- Analysis of performance and parameter tuning of the inverse plant model based robust neural controller with bias neuron weights adaptation.
- Design of a new intelligent feedback control strategy on basis of neuro-fuzzy concept, testing through simulation experiments for linear and non-linear systems, with and without control constraints.
- Implementation of control algorithms introduced using ANN to computer control of laboratory fermenter LF-3, testing performance in real physical circumstances.
- Design of a new adaptive lambda-tracking policy for linear SISO and MIMO systems with relative degree greater than 1, with constraints imposed on control variables.
- Verification and testing of proposed adaptive lambda-tracking algorithms on non-linear chemical process models, especially distillation columns.
- Implementation of control algorithms derived on basis of lambda-tracking policy to direct computer control of laboratory distillation column.
- Selection of the most „successive“ algorithm from the methods proposed and its transformation into software module, suitable for industrial control application (in collaboration with partner companies)

Original results obtained in the frame of the project are:

- inverse plant model based robust neural controller with bias neuron weights adaptation
- continuous-time and discrete-time adaptive lambda-tracker for control of SISO or MIMO nonlinear chemical processes,
- ANN-based control system for data acquisition and control of a laboratory fermenter.

2. VEGA Project No 1/0135/03 Development of optimal and supervisory control methods for mass transfer processes (M. Fikar)

The main goals of the project can be formulated in the following items:

- Modeling and verification of a detailed distillation column model for binary mixture of ethanol-water and methanol-water and modeling of packed columns.

- Modeling and simulation of the activated sludge processes (ASP) in waste-water treatment plants (WWTP). Construction of a detailed model and its reduction to low order models suitable for controller design and feedback control.
- Connection of laboratory processes to the control systems dSPACE and Siemens Simatic S7 300 for the purpose of application of theoretical results.
- Experimental identification of laboratory processes using closed-loop identification and physical parameters identification.
- Modeling and simulation of hybrid (mixed continuous/discrete) systems.
- Analysis and design of hybrid systems control.
- Dynamic optimization of a continuous and hybrid processes systems and with special attention to mass transfer processes.
- Implementation of a software package for simulation and dynamic optimization of hybrid systems.
- Control design of ASP processes modeled by detailed and reduced models. Comparison and analysis of the results, recommendations for practical implementation of WWTP plants control.
- Implementation of the software package for dynamic optimization of hybrid systems.
- Intranet connection of the laboratory processes controlled by the dSPACE and Siemens Simatic S7 300 systems with the possibility of remote control.
- Application of theoretical results in control and optimization on the laboratory processes.
- Transfer of the theoretical and experimental results into industrial conditions and demonstration of the advantages of the modern control methods in Slovak chemical and food industries.

VI.3 International Scientific Programs

1. Project of Slovak – Czech Scientific Cooperation No 041

Advanced Control Methods for Processes of Chemical and Food Technologies (J. Mikleš)

The aim of the project is to develop new methods of adaptive, robust and intelligent control and to implement obtained control algorithms for processes of chemical and food technologies.

Participants: Department of Information Engineering and Process Control, FCFT STU, Bratislava, Slovakia; Department of Process Control and

Computer Techniques, FCT, University of Pardubice, Pardubice, Czech Republic

Period: January 2004 – December 2005

2. Project of Norwegian – Slovak Scientific Cooperation No 2032040

Norwegian competencies transfer into new curricula of environmental engineering education at the Slovak University of Technology in Bratislava (A. Mészáros)

The aim of the project is to transfer Norwegian competencies into new curricula of environmental engineering education at the Slovak University of Technology in Bratislava.

Participants: Department of Information Engineering and Process Control, Department of Chemical and Biochemical Engineering, Department of Environmental Engineering, FCFT STU, Bratislava, Slovakia; Norwegian University of Science and Technology, Norway.

Period: January 2004 – December 2005

3. Project of Slovak – French Scientific Cooperation Štefánik No 07921RE

The aim of the project is to investigate and develop new methods of dynamic and global process optimization.

Participants: Department of Information Engineering and Process Control, FCFT STU, Bratislava, Slovakia; LSGC-CNRS, Ecole Nationale Superieure des Industries Chimiques (ENSIC), Nancy, France, France

Period: January 2004 – December 2005

VI.4 International Educational Programs

1. SOCRATES No 2004/5 (M. Fikar)

The aim of the project is to develop a MATLAB package for dynamic optimisation based on orthogonal collocation on finite elements.

Period: October 2004 – March 2005

VII. COOPERATION

VII.1 Cooperation in Slovakia

Department of Automatic Control Systems, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Bratislava

Department of Automation and Control, Faculty of Electrical Engineering and Information Technology, Slovak University of Technology, Bratislava

Department of Automation and Measurement, Faculty of Mechanical Engineering, Slovak University of Technology, Bratislava

Institute of Informatics, Slovak Academy of Sciences, Bratislava

Department of Cybernetics and Artificial Intelligence, Faculty of Electrical Engineering and Informatics, Technical University of Košice, Košice

Department of Management and Control Engineering, BERG Faculty, Technical University of Košice, Košice

Siemens, Inc., Bratislava

ProCS, Ltd., Šaľa

VII.2 International Cooperation

Department of Process Control and Computer Techniques, Faculty of Chemical Technology, University of Pardubice, Pardubice, Czech Republic

- Control system design
- Modeling and control of distillation columns

Department of Computing and Control Engineering, Institute of Chemical Technology, Prague, Czech Republic

- Control of biochemical reactors

Institute of Information Technologies, Tomas Bata University, Zlín, Czech Republic

- Adaptive control
- Robust control
- Decentralized control

Institute of Information Theory and Automation of the Academy of Sciences of the Czech Republic, Prague, Czech Republic

- Adaptive control
- Predictive control

Faculty of Electrical Engineering, Czech Technical University, Prague, Czech Republic

- Polynomial synthesis
- Predictive control

LSGC-CNRS, Ecole Nationale Superieure des Industries Chimiques (ENSIC), Nancy, France

- Dynamic optimization of distillation columns
- Waste-water treatment plants

Ecole Nationale Superieure des Ingenieurs de Genie Chimique-Chemin de la Loge (ENSIGC), Toulouse, France

- Neural networks
- Predictive control

Ruhr University, Bochum, Germany

- Closed-loop identification
- Predictive control
- E-learning in control

Technical University of Budapest, Budapest, Hungary

- Modeling of chemical processes

VII.3 Membership in Domestic Organizations and Societies

Slovak Society for Cybernetics and Informatics, Bratislava (J. Dvoran, A. Mészáros, J. Mikleš)

Slovak Society of Chemical Engineering (M. Bakošová, J. Dvoran., A. Mészáros, J. Mikleš)

Slovak Society of Industrial Chemistry (M. Bakošová, Ľ. Čirka, J. Danko, L. Dermíšek, J. Dvoran, M. Fikar, F. Jelenčiak, M. Karšaiová, A. Mészáros, J. Mikleš, M. Ondrovičová, Ľ. Šperka, A. Vasičkaninová)

Scientific Grant Agency VEGA MŠSR a SAV - Commission for Elektrotechnics and Informatics (J. Mikleš)

Commission for defense of dissertations (DSc) at science 28-30-9 Chemical Engineering and Process Control (J. Mikleš)

Commission for defense of dissertations (DSc) at science 38-01-9 Automation and Control (J. Mikleš - chairman)

Common branch commission for PhD study at science 28-30-9 Chemical Engineering and Process Control (J. Mikleš – vice-chairman, M. Bakošová, J. Danko, J. Dvoran, M. Fikar, A. Mészáros)

Common branch commission for PhD study at science 38-01-9 Automation and Control (J. Mikleš)

Editorial board of AT&P Journal (J. Dvoran, A. Mészáros, J. Mikleš)

Editorial board of Cybernetics and Informatics (J. Mikleš)

VII.4 Membership in International Organizations and Societies

International Federation of Automatic Control, Technical Committee on Control Design (J. Mikleš)

International Federation of Automatic Control (IFAC), Slovak National Member Organization (Slovak NMO) (J. Mikleš)

European Federation of Biotechnology (A. Mészáros)
The New York Academy of Sciences (A. Mészáros)
Public Board of the Hungarian Academy of Sciences (A. Mészáros)
Czech Society of Chemical Engineering (M. Bakošová)
Czech Society of Chemical Engineering (A. Mészáros)

VIII. THESES AND DISSERTATIONS

VIII.1 Graduate Theses (Bc Degree) for state examinations after three years of study (supervisors are written in brackets)

Halas, M.:	PID controller tuning for setpoint response of a neutralization process. (J. Mikleš)
Herceg, M.:	Control of a fan heater. (M. Fikar)
Starigazda, P.:	PID controller tuning for load disturbance response of a neutralization process. (J. Mikleš)
Uhnavá, X.:	Control of a system of tanks for liquid storage. (J. Danko)
Vaneková, K.:	Industrial control system SIMATIC. (M. Ondrovičová)
Pardupa, R.:	Data verification in the e-learning module Laboratory exercises of automatic control fundamentals. (Ľ. Čirka)
Petruš, P.:	Industrial control system GENIE. (M. Ondrovičová)
Szücsová, A.:	Controller design for a plate distillation column. (M. Bakošová)
Zábojníková, K.:	Web page design for the course Process Dynamics. (M. Bakošová)

VIII.2 Graduate Theses (MS Degree) for state examinations after five years of study (supervisors are written in brackets)

Blach, P.	Software design for control of tanks for gas storage by control computer SIEMENS. (J. Danko)
Gomboš, D.	Robust control of a continuous-time stirred tank reactor. (M. Bakošová)
Krajmer, M.	Mathematical model of a chemical reactor and nonlinear state estimation. (J. Mikleš)
Lipničanová, T.	Animations in process control using MATLAB. (M. Fikar)
Lehocký, M.	Design of an information system for publications. (Ľ. Čirka)

Puna, D.	Design of an information system for Department of Process Control and Information Engineering. (Ľ. Čirka)
Vöröš, J.	Intelligent control using PLC Simatic S7 with MATLAB support. (J. Mikleš)

IX. PUBLICATIONS

IX.1 Books

[1] Mikleš, J., Fikar, M.: Modelovanie, identifikácia a riadenie procesov II. Process modeling, identification and control II (in Slovak). STU Press, Bratislava. 260 s. (2004). ISBN 80-227-2132-8.

[2] Mikleš, J., Fikar, M.: Process modeling, identification and control II. STU Press, Bratislava. 260 s. (2004). ISBN 80-227-2134-4.

IX.2 Chapters in Books

[1] Mikleš, J.: Automation and control in process industries. In: Encyclopedia of Life Support Systems (EOLSS), Part 6.43: Control Systems, Robotics and Automation (Editors: N. G. Basov and others), EOLSS Publishers, Oxford, 29 s. (2004).

[2] Dvoran, J., Fikar, M.: Informačné technológie v pedagogickom procese. Information technologies in education (in Slovak). In: Nové trendy v chémii. Vydavateľstvo STU , Bratislava, 17-22 (2004). ISBN 80-227-2026-0

IX.3 Journals (registered in Current Contents)*

[1]* Andrášik, A., Mészáros, A., de Azevedo, S.: On-line tuning of neural PID controller using hybrid plant model. Comp. Chem. Engng. 28, 1499-1509 (2004).

[2]* Mészáros, A., Andrášik, A., Mizsey, P., Fonyó, Z., Illeová, V.: Computer control of pH and DO in a laboratory fermenter using a neural network technique. Bioprocess Biosyst. Eng. 26, 331-340 (2004).

[3]* Dostál, P., Bakošová, M., Bobál, V.: An approach to adaptive control of a CSTR. Chemical Papers 58 (3), 184-190 (2004).

[4] Danko, J., Ondrovičová, M., Veselý, V.: Robust controller design to control of warm air-drying chamber. Journal of Electrical Engineering 55 (7-8), 207-211 (2004).

[5] Bakošová, M., Kostendová, M., Karšaiová, M., Ondrovičová, M.: Adaptive lambda-tracking of a laboratory fan heater. Selected Topics in Modeling and Control 4, 142-147 (2004).
[6] Fikar, M., Chachuat, B., Latifi, M. A.: Dynamic optimization of the aeration time in a small-size alternating activated sludge process. Selected Topics in Modeling and Control 4, 136-141 (2004).
[7] Fikar, M., Unbehauen, H., Mikleš, J.: Design of a predictive controller based on pole-placement. Selected Topics in Modeling and Control 4, 131-135 (2004).
[8] Mészáros, A., Andrášik, A., Šperka,Ľ.: New approaches to neural control. Selected Topics in Modeling and Control 4, 172-180 (2004).
[9] Mikleš, J., Čirka, Ľ., Fikar, M.: Self-tuning LQ control of a chemical reactor. Selected Topics in Modeling and Control 4, 125-130 (2004).
[10] Ondrovičová, M., Bakošová, M., Čáran, M., Karšaiová, M.: Riadenie rektifikačnej kolóny riadiacim systémom SIMATIC S7-300. Control of a distillation column using control system SIMATIC S7-300 (in Slovak). AT&P Journal 11 (1), 44-45 (2004).

IX.4 Conferences (International conferences, Le Lectures, Po Posters)*

[1]* Mikleš, J., Čirka, Ľ., Fikar, M.: Youla-Kučera parameterization in self-tuning LQ control of a chemical reactor. In: Proc. 7. IFAC Int. Symp. Advanced Control of Chemical Processes. Hong Kong (China), January 11-14, 2004. HKSAR, CD ROM 154 (2004). (Le)
[2]* Fikar, M., Chachuat, B., Latifi, M. A.: Dynamic optimization of the aeration time in a small-size alternating activated sludge process. In: 9. IFAC Symp. Computer Applications in Biotechnology. Nancy (France), March 28-31, 2004. IFAC/EFB, CDROM p104 (2004). (Po)
[3]* Mikleš, J., Čirka, Ľ., Fikar, M.: Closed-loop identification of a chemical reactor. In: Proc. IASTED Int. Conf. Applied Simulation and Modeling. Rhodes (Greece), June 28-30, 2004. ACTA Press, pp. 201-206 (2004). (Le)
[4]* Bakošová, M., Vasičkaninová, A., Karšaiová, M., Ondrovičová, M.: PID controller tuning for cascade control of a chemical reactor. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R119 (2004). ISBN 80-7194-662-1. (Po)
[5]* Čirka, Ľ., Fikar, M., Hirmajer, T., Bakošová, M.: On new trends in control engineering education at FCFT STU. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R015 (2004). ISBN 80-7194-662-1. (Le)

[6]* Danko, J., Veselý, V., Ondrovičová, M.: Robust controller design by small gain theory. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R256 (2004). ISBN 80-7194-662-1. (Po)

[7]* Dermíšek, L., Mikleš, J., Vöröš, J.: Intelligent control by Simatic S7 300 PLC with Matlab support. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R290 (2004). ISBN 80-7194-662-1. (Po)

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[9]* Karšaiová, M., Bakošová, M., Ondrovičová, M.: Control system based on simplified mathematical model. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R212 (2004). ISBN 80-7194-662-1. (Po)

[10]* Mészáros A.: New approaches to neural control. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R274 (2004). ISBN 80-7194-662-1. (Le)

[11]* Mikleš, J., Čirka, Ľ., Fikar, M.: Self-tuning LQ control of a chemical reactor. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R257 (2004). ISBN 80-7194-662-1. (Le)

[12]* Ondrovičová, M., Bakošová, M., Karšaiová, M.: Industry control systems in education. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R235 (2004). ISBN 80-7194-662-1. (Po)

[13]* Šperka, Ľ., Mészáros, A.: Fuzzy tuning of PID-like inverse neural controller. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R157 (2004). ISBN 80-7194-662-1. (Po)

[14]* Vasičkaninová, A., Bakošová, M.: Control design of distillation column. In: Proc. 6. International Scientific-Technical Conf. Process Control 2004. Kouty nad Desnou (Czech Republic), June 8-11, 2004. University of Pardubice, CD ROM R288 (2004). ISBN 80-7194-662-1. (Po)

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[17]* Mészáros, A., Mizsey, P., Horváth, M., Fonyó, Z.: Dynamic analysis and control of recycle processes. In: Proc. 31. Int. Conf. SSCHE. Tatranské Matliare (Slovakia), May 24-28, 2004. SSCHE Bratislava, CD ROM 116 (2004), ISBN 80-227-2052-6. (Le)

[18]* Šperka, Ľ., Mészáros, A., Bakošová, M.: Control of bioprocess using fuzzy-neural controller. In: Proc. 31. Int. Conf. SSCHE. Tatranské Matliare (Slovakia), May 24-28, 2004. SSCHE Bratislava, CD ROM 119 (2004), ISBN 80-227-2052-6. (Po)

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[20]* Ondrovičová, M., Bakošová, M., Karšaiová, M., Čáran, M., Dermíšek, L.: Application of Simatic 300 to distillation column control. In: Proc. 16. Int. Congress of Chemical and Process Engineering CHISA 2004. Praha (Czech Republik), Aug. 22-26, 2004. Orgit Ltd., Praha, CD ROM P5.1 (2004), ISBN 80-86059-40-5. (Po)

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[23] Bakošová, M., Fikar, M., Čirka, Ľ.: Nové prístupy k vyučovaniu základov automatizácie a riadenia procesov. New trends in process control education (in Slovak). In: Zb. konf. Workshop 2004. Slovenská chémia v 3. tisícročí. Bratislava (Slovakia), Febr. 11 – 13 2004. STU Bratislava, 7-8 (2004). ISBN 80-227-2023-2. (Le)

[24] Ondrovičová, M., Bakošová, M., Karšaiová, M.: Laboratórium riadenia procesov. Process control laboratory (in Slovak). In: Zb. medzin. konf.

Automatizácia a informatizácia strojov a procesov. Bratislava (Slovakia), Sept. 6-8, 2004. STU Bratislava, CDROM 018 (2004). ISBN 80-227-2106-9. (Po)

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[26] Horváth, M., Mészáros, A., Szanyi, Á. Mizsey, P.: Recirkulációt tartalmazó rendszerek szabályozhatóságának vizsgálata. Investigation of controllability of systems with recycle (in Hungarian). In: Műszaki Kémiai Napok. Veszprém (Hungary), April 20-22, 2004. Műszaki Kémiai Kutatóintézet Veszprém, 253-257 (2004). ISBN 963-9495-37-9. (Po)