SLOVAK UNIVERSITY OF TECHNOLOGY
FACULTY OF CHEMICAL AND FOOD TECHNOLOGY

DEPARTMENT OF INFORMATION ENGINEERING AND PROCESS CONTROL

ANNUAL REPORT

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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 specialisation 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 optimisation 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 modelling 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.

Doc. Dr. Ing. Miroslav Fikar

II INTRODUCTION

This report summarises 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 during the period 1 January – 31 December 2003.

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 specialisation 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 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 specialisation in various branches of chemical technology or chemical engineering. Approximately 1000 students are currently enrolled in the five-year program leading to the Ing. degree, which is equivalent to the MSc. degree.

III STAFF

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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 Modelling and Simulation
Laboratory of Identification
Laboratory of Optimisation
Laboratory of Neural Networks
Laboratory of Fuzzy Control and Expert Systems
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)

V. EDUCATIONAL ACTIVITIES

V.1 Undergraduate Study

2nd semester (spring)

Informatics	1/0/2	Ondrovičová, Šperka, Vasičkaninová

5th semester (autumn)

Computer Based Data Processing	0/0/2	Jelenčiak, Ondrovičová, Vasičkaninová

6th semester (spring)

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

7th semester (autumn)

Process Control	1/0/2	Bakošová, Karšaiová
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	Fikar
Laboratory Projects	0/0/8	Bakošová, Čirka, Karšaiová, Šperka, Vasičkaninová

8th semester (spring)

Optimisation	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, Mészáros
Modelling and Control		

of Polymerisation Processes	2/0/2	Dvoran, Jelenčiak
Process Dynamics	2/0/0	Bakošová
Laboratory Exercises of Process Dynamics	0/0/1	Bakošová

9th semester (autumn)

Control Theory II	2/0/0	Mikleš
Laboratory Exercises of Control Theory II	0/0/2	Čirka
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	Bakošová, Čirka, Vasičkaninová

10th semester (spring)

Diploma Theses	0/0/27	Bakošová, Čirka, Fikar, Karšaiová, Mészáros, Ondrovičová

V.2 PhD Study

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

V.3 Course contents

V.3.1 Lectures

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

Introduction to automatic control fundamentals. Modelling of special types of processes of chemical technology. Static and dynamic behaviour of controlled systems. Closed loop for control of technological processes. Controllers. Dynamic behaviour 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.

Process Control (1h/week, 7th 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, 7th semester)

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

Operating Systems (1h/week, 7th 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, 7th semester)

Continuous-time controllers, types and their static and dynamic behaviour. Discrete controllers, their dynamic behaviour 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 realisation 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, 7th semester)

MATLAB programming language: internal properties, variables, functions, data analysis, data visualisation, 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 visualisation, special functions. Word - text processor.

Optimisation (2h/week, 8th semester)

Static optimisation, 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 optimisation tasks and their decomposition.

Control Theory I (2h/week, 8th 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 stabilising controllers. BIBO stability. Parameterisation of stabilising controllers. Bezaut equation. Dynamic optimisation. 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 factorisation. 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 generalised algebraic Riccati equations. Connection between LQG and H_2 control.

Experimental identification (2h/week, 8th 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 modelling and control of technological processes.

Modelling and Control of Polymerisation Processes (2h/week, 8th semester)

Principles of modelling of processes of chemical technology. Analytical and experimental approaches to modelling. 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 fibre 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, 9th 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, 9th 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 modelling 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, 9th 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, modelling and control.

Industrial Application of Process Control (2h/week, 9th 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 visualisation. 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, 9th semester)

The course is given for students of specialisation 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.3.2 Laboratory exercises

Informatics (2h/week, 2nd semester)

MS Windows 2000 operating system. MS Excel as a tool for data processing, data processing by tables, data visualisation 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 visualisation by graphs, analytical tools in MS Excel, statistics in MS Excel. Origin as a tool for data visualisation 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 behaviour of processes of chemical technology. Feedback control. PID controllers and their properties in feedback control. Controller synthesis and control of processes of chemical technology.

Laboratory exercises of Control Theory I (2h/week, 8th 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 stabilising controllers for simple systems. Simulation of MIMO feedback systems by using of stabilising 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, 8th semester)

Simulation of dynamic properties of systems in MATLAB/Simulink. Analysis and simulation of static and dynamic properties of a system of serially connected tanks with/without interactions. Analysis and simulation of static and dynamic

properties of a tube heat exchanger as a system with continuously distributed parameters. Modelling of a system with continuously distributed parameters, transformation of a system of partial differential equations to a system of ordinary differential equations by discretisation. Calculation of a steady-state of a plate distillation column, analysis and simulation of static and dynamic properties of a plate distillation column as a system with discretely distributed parameters. 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, linearisation of nonlinear models.

Laboratory exercises of Control Theory II (2h/week, 9th 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. Modelling and Simulation (M. Bakošová, A. Mészáros, J. Mikleš, M. Karšaiová, M. Ondrovičová)

Modelling 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 modelling 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 behaviour. To apply a successful control design to practical problems is a substantial effort. It is known that processes are modelled and controlled with serious difficulties caused by their non-linear behaviour, 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 modelling, 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 - characterised by repeating parameter estimation and control design
b) model reference adaptive control based on the Lyapunov method
c) decentralised adaptive control
d) adaptive lambda-tracking

5. Neural Networks (A. Mészáros)

The aim of this research is to investigate two-layer hierarchical control structures for biochemical systems, integrated optimising 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 parameterisation of all stabilising 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 behaviour. 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 Optimisation (M. Fikar)

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 behaviour of processes. Optimal control theory is able to provide responses to these questions. In this research, changeover problems in multicomponent distillation are studied.

9. Process Control

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

10. 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.

11. Information Technologies (M. Fikar, Ľ. Čirka, T. Hirmajer)

The research in information technologies has been oriented on

a) use of information technologies for data manipulation, retrieval, and visualisation,
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

2. VEGA Project No 1/8108/01: Adaptive and Intelligent Control Strategies for Processes of Chemical/Biochemical Technology (Alojz Mészáros)

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

- Design of a new predictive, intelligent control strategy on basis of ANN, (the PID-ANN-P algorithm), and its simulation for linear and non-linear systems.
- Design of a new robust, intelligent control strategy on basis of ANN (the PID-ANN-R algorithm), and its simulation for linear and non-linear systems; without as well as in presence of noise and disturbances; without as well as with constraints on control.
- Testing the PID-ANN-R procedure on non-linear models of chemical processes.
- Design of adaptive λ-tracking control and its verification for non-linear SISO and MIMO systems.
- Implementation of control algorithms introduced using ANN (the PID-ANN, PID-ANN-P and PID-ANN-R algorithms) to computer control of laboratory fermenter LF-3; testing performance for real physical circumstances
- Implementation of control algorithms derived on basis of λ-tracking policy to direct computer control of laboratory distillation column.

- Computer control of laboratory distillation column using adaptive predictive approaches involving low order concentration gradient models.
- Selection of the most „successive“ algorithm from the methods proposed and its transformation into software module, suitable for industrial control application.

Original results obtained in the frame of the project are:

- adaptive intelligent PID controller using artificial neural networks (PID-ANN algorithm),
- robust intelligent controller using artificial neural networks (PID-ANN-R algorithm),
- 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 (Miroslav Fikar)

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

- Modelling and verification of a detailed distillation column model for binary mixture of ethanol-water and methanol-water and modelling of packed columns.
- Modelling 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.
- Modelling and simulation of hybrid (mixed continuous/discrete) systems.
- Analysis and design of hybrid systems control.
- Dynamic optimisation of a continuous and hybrid processes systems and with special attention to mass transfer processes.
- Implementation of a software package for simulation and dynamic optimisation of hybrid systems.

- Control design of ASP processes modelled 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 optimisation 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 optimisation 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 Programmes

1. Project of Slovak – Czech Scientific Cooperation No. 112/189

Advanced Control Methods for Processes of Chemical and Food Technologies

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.

Coordinator at the FCT STU: J. Mikleš

Participants: Department of Process Control, Faculty of Chemical Technology, Slovak University of Technology, Bratislava, Slovakia; Department of Process Control and Computer Techniques, University of Pardubice, Pardubice, Czech Republic

Period: January 2002 – December 2003

VI.4 International Educational Programmes

1. LEONARDO No. RO/00/B/F/PP141028

Eurocompetencies Transfer in Vocational Guidance for Young Specialists in Bioscience Field

The aim of the project is organising of training courses in various biochemical and biotechnological branches for students, graduate students, young scientists and young specialists from praxis.

Coordinator at the FCFT STU: V. Báleš

Coordinator of the project: University Politehnica, Bucharest, Romania;

Participants: Ost European Centrum, University Hohenheim, Germany; Romanian Society of Biotechnology and Bioengineering, Bucharest, Romania; Research Institute for Chemistry, Bucharest, Romania; University Politehnica, Bucharest, Romania; Pluri Consultants SRL, Bucharest, Romania; University of Agronomic Sciences and Veterinary Medicine, Bucharest, Romania; CERA Foundation, Bucharest, Romania; Department of Chemical and Biochemical Engineering, Faculty of Chemical and Food Technology, Slovak University of Technology, Bratislava, Slovakia; Department of Information Engineering and Process Control, Faculty of Chemical and Food Technology, Slovak University of Technology, Bratislava, Slovakia; Natural Resources Institute, University of Greenwich, Greenwich, Great Britain;

Period: November 2000 – November 2003

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 - Processing of graphical displays for RS Centum CS 3000.

VII.2 International Cooperation

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

- Control system design
- Modelling and control of distillation columns

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

- Control of biochemical reactors

Department of Control Theory, 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

Trnka Laboratory for Automatic Control, Faculty of Electrical Engineering, Czech Technical University, Prague, Czech Republic

- Polynomial syntehsis
- Predictive control

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

- Dynamic optimisation 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

- Modelling of chemical processes

Technical University of Vienna, Vienna, Austria,

- Optimisation of combustion processes

VII.3 Membership in Domestic Organisations and Societies

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

Slovak Society of Chemical Engineering (M. Bakošová, 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 - Comission for Elektrotechnics and Informatics (J. Mikleš)

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

VII.4 Membership in International Organisations and Societies

International Federation of Automatic Control, Technical Committee on Control Design (J. Mikleš)
International Federation of Automatic Control (IFAC), Slovak National Member Organisation (Slovak NMO) (J. Mikleš)
European Federation of Biotechnology (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)

Borkovič, P.: Robust control of a time-delay system. (A. Vasičkaninová)
Burian, P.: Control design for a concentration system. (A. Vasičkaninová)
Cebuľa, M.: Design of an adaptive lambda-tracker for control of a distillation column. (M. Bakošová)
Hudec, P.: Development of an publication information systems for the department. (Ľ. Čirka)
Klačko, M.: Internet simulation of dynamic systems using MATLAB. (Ľ. Čirka)
Palacka, O.: Computer control of a laboratory distillation column. (M. Bakošová)
Pastoreková, L.: Control of pressure tanks. (J. Danko)
Prček, T.: Design of an adaptive lambda-tracker for control of a chemical reactor. (M. Bakošová)
Rybárová, K.: Testing of an optimisation method in MATLAB. (J. Dvoran)

Škultéty, M.: Identification fo physical parameters of a chemical reactor. (M. Ondrovičová)

Valo, R.: New methods for PID controllers tuning for control of chemical technological processes. (M. Bakošová)

Závacká, J.: Internet processing of measured data using MATLAB. (Ľ. Čirka)

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

Čáran, M.: Using of control system SIMATIC for control of a distillation column. (M. Ondrovičová)

Čokinová, A.: Mathematical model of a process of mixture homogenisation. (M. Bakošová)

Hirmajer, T.: Design of a library information system for the DEEPC. (M. Fikar)

Chalupová, K.: Control design for a distillation column for separation of methanol-water mixture. (M. Ondrovičová)

Jančovič, P.: Design of an information system for the PROCESS CONTROL conference. (Ľ. Čirka)

Kostendová, M.: Application of adaptive lambda-tracking method for control of technological processes. (M. Bakošová)

Murínová, M.: Design of a control stucture for a technological process. (M. Karšaiová)

Oláh, A.: Methodology design for an application of visualisation systems. (A. Mészáros)

Smetana, S.: Hybrid modelling of a biotechnological process. (A. Mészáros)

VIII.3 Dissertations (PhD.)

Čirka, Ľ.**:** Adaptive LQ control. Youla-Kučera parametrisation of controllers and process models. (J. Mikleš)

Rusnák, A.: Intelligent control of biotechnological processes. (A. Mészáros)

IX. PUBLICATIONS

IX.1 Books

[1] Bakošová, M., Fikar, M., Čirka, Ľ.: Základy automatizácie. Laboratórne cvičenia zo základov automatizácie. Automatic Control Fundamentals. Laboratory Exercises of Automatic Control Fundamentals (in Slovak). Vydavateľstvo STU, Bratislava, 153s. (2003). ISBN 80-227-1831-9.

[2] Báleš, V., Mészáros, A., Munteam, O., Polakovič, M., Štefuca, V.: Biochemické technológie. Biochemical technologies (in Slovak). AB-ART, Bratislava. 128 s. (2003). ISBN 80-89006-75-2.

[3] Fikar, M.: Decoupling control. In: Encyclopedia of Life Support Systems (EOLSS), Part 6.43: Control Systems, Robotics and Automation. (Editors: N. G. Basov and others), EOLSS Publishers, Oxford, 28s. (2003).

IX.2 Journals (registered in Current Contents)*

[1] Kožka, Š., Mikleš, J., Fikar, M.: An iterative identification based on the Youla-Kucera parameterisation without model reduction. Archives of Control Sciences 13 (1), 5-17 (2003).

[2]* Kožka, Š., Zemanovičová, A., Bachmann, G., Hofbauer, H.: An application of identification and control design to the experimental calorimeter. Chemical Papers 57 (4), 229-236 (2003).

[3]* Kožka, Š., Mikleš, J.: An iterative identification and control design of a chemical reactor. Chemical Papers 57 (5), 335-341 (2003).

[4] Andrášik, A., Mészáros, A., Šperka, Ľ.: Adaptívny neurónový regulátor založený na hybridnom modelovaní. Adaptive neural controller based on hybrid modelling (in Slovak). AT&P Journal, 10 (4), 69-72 (2003).

[5] Mészáros, A., Andrášik, A., Illeová, V., Šperka, Ľ.: Riadenie laboratórneho fermentora pomocou neurónového regulátora. Control of a laboratory fermenter using neural controller (in Slovak). AT&P Journal, 10 (4), 66-68 (2003).

[6] Bakošová, M., Ondrovičová, M., Karšaiová, M.: Riadenie mnohorozmerových chemickotechnologických procesov metódou adaptívneho lambda-sledovania. Control of MIMO processes in chemical technology using adaptive lambda-tracking (in Slovak). AT&P Journal, 10 (4), 73-75 (2003).

[7] Bakošová, M., Fikar, M., Čirka, Ľ.: Nové prístupy k vyučovaniu základov automatizácie a riadenia procesov. New trends in teaching process control fundamentals (in Slovak). AT&P Journal, 10 (11), 17-19 (2003).

[8] Mikleš, J., Čirka, Ľ., Fikar, M.: H2 optimálne riadenie chemického reaktora. H2 optimal control of a chemical reactor (in Slovak). AT&P Journal, 10 (11), 92-94 (2003).

IX.3 Conferences (International conferences, Le Lectures, Po Posters)*

[1]* Fikar, M., Unbehauen, H., Mikleš, J.: Using controller knowledge in predictive control. In: Proc. 2. IFAC Conference CSD 2003. Bratislava (Slovakia), Sept. 7-10 2003. Ed. STU Bratislava, CDROM 054-31-34 (2003). (Le)

[2]* Fikar, M., Chachuat, B., Latifi, M. A.: Dynamic optimisation of alternating activated sludge processes. In: Proc. ECC 2003. Cambridge (UK), Sept. 1-4 2003. University of Cambridge, CDROM 536 (2003). (Po)

[3]* Mikleš, J., Čirka, Ľ., Fikar, M.: H2 Optimal Control of a Chemical Reactor. In: Proc. 11. Mediterranean Conference on Control and Automation. Rhodos (Greece), June 18-20 2003. NTU Athens, CD ROM IV05-01 (2003). ISBN 960-87706-0-2. (Le)

[4]* Andrášik, A. Mészáros, A., Azevedo, F. S.: Hybrid modeling based adaptive neural controller. In: Proc. 11. Mediterranean Conference on Control and Automation. Rhodos (Greece), June 18-20 2003. NTU Athens, CD ROM T3-030 (2003). ISBN 960-87706-0-2. (Le)

[5]* Svetíková, M., Annus, J., Čirka, Ľ., Fikar, M.: Real time control of a laboratory fan heater using dSPACE tools. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 211 (2003). ISBN 80-227-1902-1. (Po)

[6]* Mikleš, J., Čirka, Ľ., Fikar, M.: Youla-Kučera parametrisation in self-tuning LQ control of a chemical reactor. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 217 (2003). ISBN 80-227-1902-1. (Po)

[7]* Karšaiová, M., Bakošová, M., Ondrovičová, M.: Optimal control based on simplified mathematical model**.** In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 218 (2003). ISBN 80-227-1902-1. (Po)

[8]* Bakošová, M., Kostendová, M., Karšaiová, M., Ondrovičová, M.: Adaptive lambda-tracking of a laboaratory fan heater. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 219 (2003). ISBN 80-227-1902-1. (Po)

[9]* Ondrovičová, M., Bakošová, M., Karšaiová, M., Čáran, M., Dermíšek, L.: Distillation column control by SIMATIC 300. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia),

June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 225 (2003). ISBN 80-227-1902-1. (Po)

[10]* Danko, J., Veselý, V., Ondrovičová, M.: PID controller design for uncertain affine SISO systems**.** In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 224 (2003). ISBN 80-227-1902-1. (Po)

[11]* Dermíšek, L., Jelenčiak, F., Mikleš J.: Dynamic model and optimal control of a reactor. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 216 (2003). ISBN 80-227-1902-1. (Le)

[12]* Andrášik, A., Mészáros, A., Šperka, Ľ.: Neural control of a continuous yeast fermenter. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 220 (2003). ISBN 80-227-1902-1. (Po)

[13]* Šperka, Ľ., Andrášik, A., Mészáros, A., Smetana, S.: Identification od a fermentation process – hybrid modelling vs. recursive LSM. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 221 (2003). ISBN 80-227-1902-1. (Po)

[14]* Vasičkaninová, A., Zemanovičová, A.: Control design of a multi-kilogram capacity calorimeter. In: Proc. 14. Int. Conference Process Control'03. Štrbské Pleso, High Tatras (Slovakia), June 8-11, 2003. KIRP FCHPT STU Bratislava, Slovakia, CD ROM 213 (2003). ISBN 80-227-1902-1.

[15]* Andrášik, A., Mészáros, A., Bakošová, M., Šperka Ľ: DO concentration control in a laboratory fermenter using neural networks. In: Proc. 30. Int. Conf. SSCHE. Tatranské Matliare (Slovakia), May 26– 30 2003. SSCHE Bratislava, CD ROM P239 (2003), ISBN 80-227-1889-0. (Po)

[16]* Bakošová M., Mészáros A.: Control of nonlinear chemical processes by an adaptive lambda-tracker with variable sampling rate. In: Proc. 30. Int. Conf. SSCHE. Tatranské Matliare (Slovakia), May 26– 30 2003. SSCHE Bratislava, CD ROM P142 (2003), ISBN 80-227-1889-0. (Po)

[17]* Dermíšek, L., Jelenčiak, F., Mikleš J.: Dynamic model of a reactor. In: Proc. 30. Int. Conf. SSCHE. Tatranské Matliare (Slovakia), May 26– 30 2003. SSCHE Bratislava, CD ROM P115 (2003), ISBN 80-227-1889-0. (Po)

[18]* Fikar, M., Bakošová, M., Čirka, Ľ., Dvoran, J.: Multimediálne štúdium na Fakulte chemickej a potravinárskej technológie STU. Multimedia study at the Faculty of chemical and food technology STU (in Slovak). In: Zb. konf. Principia Cybernetica '03. Liberec (Czech Republic), Sept. 3 – 5 2003. TU Liberec, 206-210. ISBN 80-7083-733-0. (Le)

[19] Latifi, M. A., Fikar, M. Chachuat, M.: DYNO : un code d'optimisation dynamique des procedes. 9eme Congres Francais de Genie des Procedes, Saint-Nazaire (France), Sept. 9-11 2003. (Po)
[20] Latifi, M. A., Fikar, M., Chachuat, B., Roche, N.: Regles simples pour la mise en oeuvre en boucle fermee de l'optimisation dynamique des stations d'epuration de petite taille. 9eme Congres Francais de Genie des Procedes, Saint-Nazaire (France), Sept. 9-11 2003. (Po)