

Bánki Donát Faculty of Mechanical Engineering

Institute of Mechanical and System Engineering

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1 Introduction

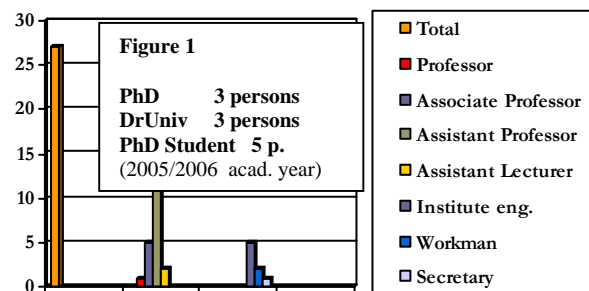
The Institute of Mechanical and System Engineering – its predecessors were the Department of Machine- and Machine Structure (1969-1987), the Institute of Machine and Systems Technology (1987-1990) and the Department of Mechanical and System Engineering (1990-2000) – has been working since the establishment of Bánki Donát Polytechnic.

After 1992 the Institute took care of the Car Technology branch of Mechanical Engineering speciality, and after September 2005, of the Mechatronic Engineering speciality.

The Institute performs its educational and research work in three special groups – in Mathematics and Information Technology, in Mechanical Engineering and in System Engineering special groups. As a consequence of conscious human policy work of the past ten years, with entering young talented colleagues we laid special emphasis on quality improvement. Content of the Institute staff is shown on Figure 1.

Laboratories played a very important role in educational work and research-development activity of the Institute. During the past decade the Institute performed enormous work in this area. Laboratories are located in two groups.

- the **Electrical Laboratory** was established yet in 1969, meeting the demands



of high-level technical schools, and that time it could be regarded as an up-to-date design.

- the **Machine Laboratory** was moved to its present place in 1974, its technical level lags far behind the requirements.

Since then, on these places – according to requirements of present BSc education – information technology, pneumatics, heat, energetic, flow mechanics, technical diagnostic (robot testing), measurement technology, electric machines, mechatronic and robot technology laboratories were established.



Figure 2
Diagnostics in teaching car technology

Finally, a few words about the ‘coach-and-four’ how tradition and innovation, education and research are accomplished in the Institute.

A nice tradition is that our Institute – for a take-leave – welcomes his own students to members of ‘Machine Engineering Company’, and this fact is confirmed by a diploma (this means the end of polytechnic years).

The chair – as a foundation member – since 1994 has been taking part in the work of Polytechnical Control Technique Education Methodology Association (FIOM). This ‘civil’ organisation is intended to promote co-operation of chairs that deal with university and polytechnical control technique by teaching with unique thematics, by issuing of common basic educational lecture notes and by professional agreements. Every year we organise a university and college contest of PLC (Programmable Logic Control), within the frames of which our student teams measure their knowledge, and the winning educational institutes gain the PLCs of companies that sponsor the contest.



Figure 3

Dealing with science creates occasions for learning famous researchers’ results. The Institute, since the establishment of the Budapest Tech – in connection with the programs of Hungarian Science Day – has been organising the International Mechatronics Symposium. On Figure 3 Mr. Dr. Antal Bejczy professor.

2 Education Profile

The predecessor of the Institute until 1994 was the issuing chair for students of the Department of Mechanical and System Engineering, and – according to the curriculum that took effect in 1992 – for students of operator and car technology speciality direction of Mechanical Engineering speciality. The chair has close connections - with these students, teaches most of special subjects organises their professional training, prepares them to state examination, and they perform their dissertations at the chair, they give state exams and defend their dissertations here, proving their knowledge gained at the Polytechnic.



Figure 4

Combustion plant for heat technology exercises

Concerning knowledge of natural sciences, our Institute teaches the following subjects: Mathematics, General Mechanics, Heat and Flow Technology; within the professional base material: Basics of IT, CAD Technology, Basics of Mechatronics, Control Technique, Heat and Flow Technology Machines, Basic Knowledge of Logistics.

The subject of Control Technology deals with systems of pneumatic and hydraulic controls and regulations. (Figure 5)



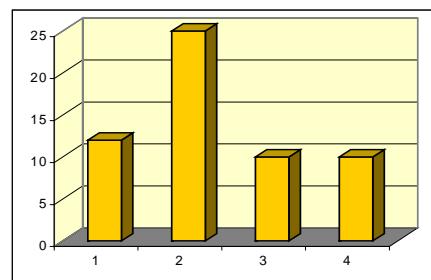
Figure 5

Hydraulic test station

The Institute has undertaken a significant role in working-out of the Mechatronics department (BSc). Figure 6 shows some features of education that gives synergic integration based on mechanical engineering knowledge.

- 1 Basics of IT
- 2 Basics of Mechanical Engineering
- 3 Basics of Control Technique
- 4 Basics of Electronics

Figure 6



Mathematics, Introduction into Mechatronics, Electronics; in the field of Economics and Human Knowledge: Environment Protection, Logistics.

In the professional base material, the tasks of the Institute include the following subjects: Basics of IT, Analogue and Digital Circuits, Control Technique, and Hydraulics, Maintenance of Heat and Flow Technology Machines.

With the mechatronics testing unit, properties of various electric actuators can be determined. (Figure 7)



Figure 7



Figure 8

For teaching of solutions of complex mechatronic problems a sample system was developed that is suitable for recognition and classification of work pieces that were made of different materials; our students also took part in its designing by their scientific work. On Figure 9 you can see

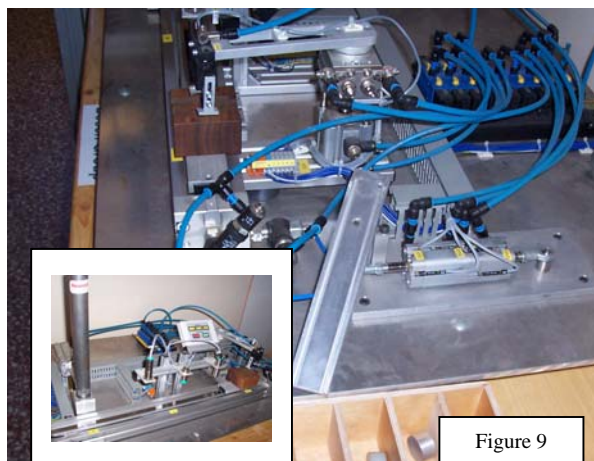


Figure 9

that sorting is performed by a pneumatic manipulator. Detection is performed by

three sensors that work according to different ways of measuring and by their processing unit.

The two developments shown on Figures 8 and 9 give a tool background also for our teachers who wish to perform mechatronics research work in robot technique.

3 Research and Scientific Activity

Beside educational work, predecessors of the Institute performed extended research-development activity. We highlight here some of significant works.

Between 1969 and 1985 the chair continuously performed safety qualification tests on orders of the Construction Quality Control Institute. Acknowledgement for performed works is shown by the fact that after 1975 the chair was charged to perform qualification works not only for individual machines but for fully automated factories, too.



Figure 10

One of most significant research-development area of the chair is hydrostatic and pneumatic energy transfer and control. For this, we mention the work that is directed to further development of the bridge-building crane. Within the frames of a national target program, we have dealt with development of hydraulic test boards for end reception of pressure limiting cartridges, closed valve circuit blocks and directional control valves No. 10. (Figure 10)

On order of Ganz Machine Factory Enterprise, a Diesel-engine driven pneumatic control for mobile oil mining drilling equipment that is suitable for deepening of drilled holes was developed.

On order of Artificial Coal Manufacturing Company we have developed hydraulic power supply units and electric controls for modernisation of hydraulic presses. Since the change of the political system the privatised company has been working under the name of Carbosint Ltd., and on their order we performed service tasks for hydraulic presses that had been developed or reconstructed by us.



Figure 11

For DANUVIA Central Tool and Device Factory we have developed hydraulic measuring testing systems for individual and serial receptions that serve for determination and setting of hydraulic parameters. Members of the family: pressure limiting station, closed-circuit block testing equipment, condition testing and setting system for track changers. In all the equipment a chair's own made volume flow measurement system was built in with analogue-digital display.

For the Újpest Detail Factory a computer-controlled working cylinder test board has been developed and delivered. At the established system the control computer performs also the functions of collection of measurement data, evaluation, calculations, qualification, making statistics, protocols (graphical displaying, printing) connected with the examination of the working cylinder.

Another area of development is designing and construction of complex educational equipment with educational documentation within the frames of the development of a hydraulics and liquid mechanics laboratory for the Yola Technical College in Nigeria. (Figure 11). We successfully put the equipment into operation on the site in 1988.

In the past decade we entered the development of industrial robot technique by resolving diagnostic tasks. The system provides full robot technique testing of PTP- and CP-controlled robots. Advanced measurement of static, dynamic, hydraulic and geometric parameters using computer data processing.



Figure 12

On order of the Ganz Machine Factory Enterprise between 1989-91 we developed mechatronic control for a duplex piston membrane pump. In 1990 this development was given the Ganz Ábrahám prize and the constructor team of the membrane pump won the BNV Grand Award in 1991.

Within the frames of the development tender won from National Technical Development Committee (OMFB), in the nineties an MF hydraulic master arm family with 4 degrees of freedom and force back indication was developed. This development appeared at the 'Studentfair '93' exhibition in Vienna, and on the standard prize tender of 'Pneu-hydro '93'

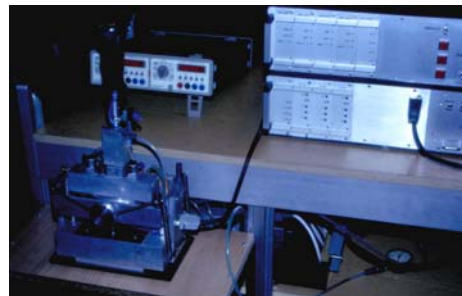


Figure 13

international conference it won the first prize. In connection with the master arm, many scientific publications and lectures have been exposed in our country and abroad, too. (Figure 13)

It was a significant research work and connected to an OMFb tender, we have worked out together with VA Rt. (Control Technique Corp.). The research connected to the modernisation of the quality assurance system that existed at the company, within these frames we have worked out tools and methods that serve for determination of properties of plastic basic materials required for supplier tests.

In the Institute the research work is realised according to comprehensive projects and in teachers' individual research activities.

Mechatronic Fuel Supply – research and simulation of mechatronic fuel supply systems of combustion engines, this has been continuing since 1990.

Its aim is to develop intelligent control technologies connected to mechatronic systems with modernisation of the computing environment and with the expansion of hardware simulation options.

Present results:

The modern car technology fuel supply electronic mechatronic system directly serves for many of subjects taught at the college (mechatronics, electric motorcar equipment, fuel supply, diagnostics), and through their research also for establishment of curriculum for postgraduate studies.

Hungarian and foreign partners:

International co-operation	1	###
Guest researchers' activity at the institute longer than 1 month	1	
Conferences organised together with other institutes (with more than 50 attendants)	7	INES, ICC, RAAD, Science day
Our teachers' participation on conferences	8	
	9	
1999-2005 Hungarian and foreign invited lectures	1	

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Bogazici University Electronics Chair, Kassa Polytechnical University Kibernetics and Artificial Intelligence Chair, Ostfriesland Emden college, Szabadka Technical College Mechanical and Electrical Engineering Institute.

Institute of Mechanical and System Engineering

Hungarian institutes: Mannesmann Rexroth Ltd., Robot Technique and Automation Centre, Technomatic International Engineering Office Ltd., Sandsoft Automation Ltd.

Connecting and supporting researches:

Development of piston membrane pump control and its mechatronic units Technical product, GANZ Engine Works Ltd.

Hardware simulation system for direct electronic control injection for diesel engines Technical product (AMFK), 1997

Research and implementation of new technical diagnostic procedures Technical product (SKF) (continuous co-operation using SKF)

Theoretical researches of mechatronics and their hardware implementation Continuous international and Hungarian (BME) scientific co-operation (FKFP)

Energetic tests and researches connected with the existing combustion plant Industrial orders (topics completed in 1997 and new topics)

R + D projects with researcher's initiative

Environment-friendly modification of diesel motors Ministry of Environment Protection (in co-operation with the RÁBA Corp.)

Hardware simulation system for direct electric control injection for diesel engines / Technical product (AMFK), finished in 1999

Theoretical researches in mechatronics and their implementation / International and domestic (BME) scientific co-operation (FKFP) (continuous co-operation, report on results at Ilmenau science days

Tender for the development of assets in high-level professional training with accredited school system to be financed **from central budget of MPA professional fund** / 2001 (finished tender)

Tender for the development of assets in high-level professional training with accredited school system to be financed **from central budget of MPA professional fund** / 2002 (finished tender)

OMFM (OM) Maecenature tenders – in 1999, 2000, 2001, 2002 won individual mobility tenders (Dr. Attila L. Bencsik)

Regional tender for professional training – 2004, Development of scanning laser interferometer size correctness testing (director of studies: Dr. Tibor Kégl)

TDK works, doctorand training: During the past period, 1 PhD study and 2-3 TDK dissertations per year were connected with this topic.

Control, Testing and Cooperation of Industrial Robots with other Mechanic Systems – Research work since 1987 continuously, after 1996 within OTKA and Tét researches

Director of studies: Dr. Attila L. Bencsik, dr. univ researchers: Dr. Imre J. Rudas DSc; Dr József K. Tar PhD; Dr. Gábor Harkay dr. univ.; István Nagy PhD Student

A special area of mechatronics is the testing of industrial robots, and following this, working-out of possible control strategies. The target of our researches is to work out various direct and indirect control solutions including master-slave force back indication solutions, too. The other line of control strategies is implementation of fixed and mobile systems according to Soft Computing technologies.

Present results:

Results of researches could be implemented by involving central support opportunities. In the 90-ies these were the frames of OMFB, AMFK, FEFA, PFP programs. Our researchers have reported their results on many international conferences and we have established a continuous co-operation with universities beyond the border and with European co-institutes.

Foreign partners:

R + D project with international participation	1	###
Guest researchers' activity at the Institute longer than 1 month	1	
Conferences organised together with other institutes (with more than 50 attendants)	8	INES, ICC, RAAD, Science day
Our teachers' participation on conferences	8	
	9	
1999-2001 Hungarian and foreign invited lectures	2	

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University: Karlsruhe Process Control and Robot Institute Machine Tools Production Engineering Chair, Istambul Polytechnical University Mechanical Engineering Institute, Bogazici University Electronics Chair, College: Wilhelmshaven Novi Sad Politechnical University Systems Technology Institute.

Institute of Mechanical and System Engineering

Hungarian institutes: Mannesmann Rexroth Ltd., Robot Technique and Automation Centre, Eurofer Ltd. (previous Csepel Unique Engine Works)

Connecting and supporting researches:

Hardware simulation system for direct Technical product (AMFK), 1997
electronic control injection for diesel engines

Research of master-slave manipulation systems International research co-operation (chair research)

Development of testing methods and tools of plastic basic materials and parts Research-development + technical product (Control Technique Parts Manufacturing Corp.) 1997-98

Theoretical researches of mechatronics and their hardware implementation International and Hungarian (BME) scientific co-operation (FKFP)

Results:

OMFB R+D Development of master arms with force back indication
Research-development + technical product Reference system at the college.
Eurofer Ltd. 1992-1993 (finished)

OMFB R+D Development of testing methods and tools for plastic basic materials and parts, research-development + technical product (Control Technique Parts Manufacturing Corp.) 1999 (finished)

Theoretical researches in mechatronics and their implementation /
International and domestic (BME) scientific co-operation (FKFP) (continuous co-operation, report on results at Ilmenau science days

Tender for the development of assets in high-level professional training with accredited school system to be financed **from central budget of MPA professional fund / 2001** (finished tender)

Tender for the development of assets in high-level professional training with accredited school system to be financed **from central budget of MPA professional fund / 2002** (won tender)

OMFM (OM) Maecenature tenders – in 1999, 2000, 2001, 2002 won individual mobility tenders (Dr. Attila L. Bencsik, István Nagy)

Regional tender for professional training, Bosch-Rexroth, 2003, 3D Descartes robot development (director of studies: Dr. Attila L. Bencsik)

Bosch-Rexroth, 2004 – Mechatronic sample system, material sort detection and sorting, development (director of studies: Dr. Attila L. Bencsik)

Bosch-Rexroth, 2005 – Industrial robot (EC drive and proportional pneumatics) development (director of studies: Dr. Attila L. Bencsik)

TDK works, doctorand training

During the past period, 1 PhD study and 3-4 TDK dissertations per year were connected with this topic.

Teachers' researches:

Research of Possibilities of Application of Conditional Maintenance in Military Engineering with Special Regard to Vibration Diagnostic and Thermograph Tests (József Szabó, PhD research)

The aim of the research is to discover the military tools that have not used vibration diagnostic or conditional maintenance. The target is outlined – research of maintenance strategies of NATO, or application of vibration diagnostics, its analysis for Hungarian Army, working-out of corresponding methods.

A further target is to work out a vibration measurement and diagnostic method and technology that would work based on a computer for the researched military tools and for other suitable rotating machines found in the Hungarian Army, which – in case of equipment of similar type – would serve as a sample and will make the operation of this equipment more reliable in the practice, too.

Stability Test for Tractor-Driven Trailer-Coaches (Tamás Szakács PhD – research)

Aim of research: establishment of a simulation model system that is built up of full dynamics models of agricultural transporting vehicle train systems that are constructed from a combination of various agricultural tractors and trailers, and using the model, development of a drive control system that will provide primarily the safe operation of the vehicle train, and secondarily it minimizes energy losses that emerge in case of multiaxial driving.

Research and Development of Bioethanol Processing for Fuel Cells (BIOETHANOL) – research co-operation (EU) (Tamás Szakács)

Prof. Dr. István Farkas

Szent István University, Physics and Process Control Chair
The main target of the program is to perform the tasks of research and development of bioethanol processing for fuel cells topic.

Hungarian participation is connected primarily with a partial task named Production of hydrogen from bioethanol that was described in the WPI working program.

Non-Classical Tasks for Theories of Plastic Flow (Endre Ruzinkó PhD)

Research topics: influence of sudden temperature changes on plastic flow strain
Influence of preliminary mechanic-temperature processing on plastic flow, speed of steady crawling as a function of preliminary plastic strain, testing the effect of the preliminary plastic strain on the kinetics of non-stationary plastic flow, and

kinetics of the load surface under mechanic-temperature processing and the next plastic flow. An important area is influence of ultrasound on plastic strain and flow. Influence of preliminary ultrasound radiation on plastic flow, forming of microhollows under plastic flow.

A practical aspect of the research is determination of stresses and strains in turbine disks during plastic strain and flow, influence of preliminary mechanical-temperature and ultrasound processing on plastic strain and flow of the disks.

Transformation of Knowledge Bases (Ágnes Bérces-Novák PhD)

The research is connected with artificial intelligence and applied logics sciences, and based on present results it was examined with what conditions can two knowledge bases – specified in a logic representation – be connected together in a consistent way.

Fellow-researchers: András Benczúr, full professor at ELTE, Peter Revesz full professor at the University of Lincoln, USA.

Geometric Databases and Questions of their Complexity (Ágnes Bérces-Novák PhD)

Within the frames of this research we have specified such graph representations in the PLA spatial model that will result in significant acceleration of graph theory algorithms. We have dealt with a search of Euler paths, circles and Hamilton circles in case of special, centrally coherent graphs with the help of this model and have given a fast algorithm for this. The newest application is modification of the model to store special graph classes using the principle of Halin graphs.

We have expanded the PLA model into a spatiotemporal model and established the possibility for using it as a fuzzy model, too.

An important partial area of this research topic is interoperability, in which connection we have overviewed practically the essential models. Fellow-researchers: Márton Bérces and Zoltán Ludányi PhD students, Dept. of Measurement Technology, BUTE, Zsolt Tuza full professor, Informatics Faculty, Veszprém University and SZTAKI.

Mobile Robots with Navigation System (István Nagy PhD – research)

The aim of research is to design a path for going along, which has a minimal measurement error, for a given working area, based on the precision of measurement, especially of laser camera measuring head and according to measurement accuracy. An additional condition for the path to be go along is that it must be free of extreme accelerations. This can be achieved using splines. Error fields calculated for the given working area and the track designing algorithms will be modelled in MATLAB environment.

The present research is establishment of a simulation system (in MATLAB environment) that makes the error field for a given working area on a multi-agent platform with given measuring equipment.

Modelling of Instable Processes by Fuzzy Differential Equations (Barnabás Bede PhD)

The aim of the research is one of the first practical application of the general fuzzy differential – a new mathematic modelling of friction using *fuzzy differential equations*. As the classical mathematical model leads to non-linear differential equations, yet linearization of them by classical methods is not possible, a problem emerges: what mathematical model can correctly model the processes under friction. Therefore a new friction member was introduced that transfers the classical non-linear differential equation into a fuzzy differential equation and linearizes it.

Fellow-researchers: János Fodor DSc, József K. Tar PhD Dr. Attila L. Bencsik

Comparison of the German and Hungarian Education of IT (Gábor Kiss PhD) Research)

The research is directed to finding a solution, how the German and Hungarian education of IT can be compared. In Germany in 16 provinces, school system and education of IT are different. In certain provinces of Germany IT in secondary schools is obligatory, elsewhere it is facultative. In Hungary it is regulated by the national basic schedule (NAT), so there are no big differences. The comparison discovers not only differences in school-work between the two countries but after working-out of a series of questions and answering them in both countries, effectiveness of education in either countries can be evaluated and any possible differences can be measured.

Measurement Technology of Parachromatism (Ingrid Langer PhD) Research)

Parachromatism is a deficiency that concerns 8% of men, and this excludes applicants from choosing of more than 100 professions. At the Dept. of Mechatronics, Optics and Device Technology, BUTE, research work directed to optical correction of parachromatism has been performing for almost 20 years. As a result of this, eye-glasses for correction of colour vision were developed, and these provide an effective assistance for approximately 70% of people suffering from parachromatism. The aim of further research is to work out a new, more exact measurement procedure for diagnosing of parachromatism and for exact measuring of colour vision.

Publications (2005):

In Hungarian: 12 books, ed. lecture notes, 8 papers in professional journals, 22 papers at conferences

In English and German: 1 book (chapter), 12 papers in professional journals, 42 papers at conferences