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BRIEF SUMMARY OF THE RESEARCH ACTIVITY ON THE OCCASION OF THE DEPARTMENT OF ELECTRICAL MACHINES' CENTENARY

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The first Department of Electrical Engineering at this University was founded in 1893. Károly Zipernowsky, one of the inventors of the closed-core transformer and former director of the Ganz Electric Works, was its first head and lectured at Budapest Technical University for 32 years. In 1925, Prof. Imre Pöschl became Head of the Department which was renamed as Department of Electrical Machines and Measurements. In 1942, Prof. József Liska succeeded him and he became the first Dean of the Faculty of Electrical Engineering, which had been established in 1949. In 1961, Prof. Ottó Benedikt became Head of this Department, which had taken over the two previously independent departments, namely the Department of the Theory of the Operation of Electrical Machines and the Department of Special Electrical Machines.

Between 1966 and 1988, Prof. Gyula Retter, former deputy of Profs. Liska and Benedikt, was the Head of Department, followed by Prof. Sándor Halász and in 1991 by Prof. Peregrin László Timár. Other staff members in earlier years included Professors Géza Á. Pattantyús, Béla Karsa, Károly Simonyi, János Urbanek, László Schnell, Andor Frigyes, Róbert Tuschák and Tibor Kelemen.

In the Department, four groups operate and carry out research continuously.

The research activity of the ELECTRIC MACHINES Group is primarily connected to the design, optimization and expertise of rotating electric machines. Computer design programs have been prepared for both conventional and special electric machines. In the case of the traditional conventional rotating electric machines, research is focused mainly on some special topics; e.g., the parameter identification of large asynchronous machines with starting disc or the investigation of the rotor losses of inverter-fed squirrel cage motors. The finite element method is broadly used for the determination of the magnetic field display, e.g., to clear some design

problems of d.c. machines with laminated stator, of permanent magnet synchronous machines, and of switched reluctance motors. The group's work in the Department has a decisive importance in the Hungarian electric machine industry; computer programs designed by the group are widely in use, and a large series of machines were manufactured according to its design for demanding customers (such as IBM, BOSCH, SIEMENS).

The group is playing a significant expert role in the field of testing automotive-electric machines. The industry highly appreciates that equipment, which has been developed and designed at the Department for controlled driving and loading purposes for testing generators and starter motors used in vehicles. The same can be said about that computer-assisted measuring system, which was developed for the measurement of thermic and electric parameters of these machines.

One interesting research topic is the investigation of the steady state and transient mode of operation of asynchronous motors having a solid, ferromagnetic rotor, taking into consideration the iron saturation as well as the investigation of the asynchronous starting of solid iron-rotor synchronous motors operating from the network.

The group is hallmarked by numerous patents (e.g. low vibration small asynchronous motors) and by books published as, e.g., Matrix and Space-Phasor Theory of Electrical Machines and Noise and Vibration of Electrical Machines.

The ELECTRIC DRIVES Group took part in state-of-the art research of semiconductor-controlled a.c. drives at an early stage and carried out internationally recognized and appreciated pioneer research.

The Park-vector method, which can be used for both calculation and measuring purposes, has since spread out and is applied world-wide in papers and publications. The Park-vector method and its calculation and measuring applications were developed by the group under the leadership of Prof. István Rácz and were first applied for semiconductor fed a.c. drives.

In 1969, the group designed the first subsynchronous static converter cascade in Hungary operating under industrial conditions for the Water Utility Company (Budapest). The development of the semiconductor-controlled drive for the Diesel test bed of the Kama Car Factory (in USSR) and the manufacturing of the sample drive was another outstanding task of the group.

In 1971, the Electric Drive Group developed a torque-measuring instrument for three-phase machines which works on electrical principles. At the time this was considered world-wide as a technical development and was published in international papers and received a patent license. This instrument has undergone technical updating and has been developed into a microprocessor-controlled instrument for industrial use. In the years 1978-

80 the group prepared a study of four volumes (and experimental drives) for the Ganz Electric Works titled 'Inverter fed traction drives' which formed the basis of the factory developed inverter fed asynchronous motor driven multiple unit train.

For about 15 years, theoretical and experimental research has been carried out in the field of optimum pulse width modulation of transistor voltage source inverters. Along with this research several microprocessor-controlled inverter fed drives were developed.

The group realized in 1978-79 the flux controlled firing system for converter fed synchronous motors which was a revolutionary development compared with the shaft control applied until then. Based upon this research, in 1984-85 a microprocessor-controlled converter fed synchronous motor drive was developed for industry.

The research staff of the Department contributed numerous details to the development of the theory of field-oriented control, with results published in international conference papers.

In recent years a tremendous effort has been put into research carried out in the field of economically operated energy saving electric machines, electric drives and controls. The impedance (and admittance, respectively) control developed for asynchronous motor drives can be regarded as a significant achievement in this field. The latest fields of research of the group include: PWM controlled current source inverters, network friendly PWM controlled converters.

The Group of ELECTRIC MACHINE MEASUREMENTS pays much attention to the computer-aided evaluation of electric machine measurements, the automation of such measurements and also to the problems of parameter identification. This activity is in strong correlation with some theoretical problems of electric machines and in many aspects has contributed to the improvement of the theory.

Important results were reached by the group in the field of warming up of electrical machines. The two-dimensional heat model of the windings, the warming-up calculation method of asynchronous motors having a closed cooling system without internal circulation as well as asynchronous motors with surface cooling were developed. A procedure and a measuring instrument has been worked out for the measurement of the heat transfer coefficient. Most of the results of this research have been put into application by industry.

At the experimental investigation of the commutation of d.c. machines, it was aimed to qualify the process of commutation on an objective, measurement data supported basis. The effect of rippled current and dissymmetries in commutator geometry were investigated as well. Results of the research were realized in much of the microprocessor-controlled,

computer-aided equipment which were ordered by industry. The group dealt with the computer-aided analysis of the sudden three-phase short circuit phenomenon of synchronous machines based on special sampling technics. A further research project of the group is the calculation of the running up torque of asynchronous machines from the sampled measuring data of two line voltages and two line currents. With the help of the computer modelling of the asynchronous motor being switched on non-simultaneously, such a switching circuit has been designed which eliminates the slowly damping d.c. component, thus ensuring optimum switching-on conditions. A process for the parameter identification of d.c. machines was worked out which takes the magnetic nonlinearity into account and makes the precalculation of characteristics possible. A further process, which was worked out by the group, makes the optimum choice concerning the slot number combinations of asynchronous motors possible from the point of view of electromagnetic noise and vibration.

The group is working now on the development of an automated, computer-aided measuring system which is suitable for the investigation and qualification of asynchronous motors, a monitoring oriented noise and vibration measuring method, and on the theoretical and operational investigation of inverter fed polyphase asynchronous motors.

The SERVO AND ROBOTICS DRIVE Group is the newest of all the groups, starting its work in January 1992, although its roots reach back to 1967 when plans of the first Hungarian step motor were prepared by the Department. This followed the design of some other step motors and special servomotors and the preparation of a computer program for the design of step motors. From 1985 onwards lecturers dealt continuously with both the educational and research aspects of special electric machines and special controlled drives of robotics, machine tools, computers and consumer electronics.

At the moment, the build-up of such a robotics and servo drive laboratory is under progress; it offers the possibility of carrying out both educational and research activities in the given field. The laboratory equipment is partly designed by the Department and made up of elements available in industry and partly industrial drives that have been turned into laboratory equipment.

The research of the group is now focused on the following topics:

- Current vector control of permanent magnet synchronous servo drives having square and sinusoidal magnetic fields and their being matched to the given motor types.
- Matching of the construction and power supply of the switched reluctance motors which take into account the servo requirements.

- Speed and position control rendering overshooting free setting with sliding mode control.
- Position control in multimachine systems.

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