EDUCATION OF CHEMICAL ENGINEERING STUDENTS AT THE TECHNICAL UNIVERSITY OF BUDAPEST

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Historical review

Tuition of chemistry at universities, high-schools, the education of chemical engineers and chemists have traditions of old standing in Hungary. Our first chemical department was established in 1763 at the Selmecbánya Mining School, where for the first time in history practical chemical laboratory tuition was given to students. At the time of the French Revolution this system of tuition was adapted by the École Polytechnique in Paris, as recommended in 1794 to the National Convention by the renowned chemist, Fourcroy, referee of the Bill on the foundation of a highschool. [1] In 1769 a common department was founded for chemistry and botany at the University of Nagyszombat, which was resettled in 1777 to Buda, and later to Pest. In 1846 the Department of General and Technical Chemistry was founded at the József Industrial School, the legal predecessor of our Technical University.

At our University the beginning of the education of chemical engineers (up to 1907: chemists) reaches back to the academic year 1863/1864, when engineering students at the József Industrial School were taught already in three groups: engineers, mechanical engineers and chemists. The Chemical Engineering Faculty of the József Technical University, raised to university level by the reorganization of the Industrial School, was founded in 1871, under the name Chemical Section. Further development was indicated by the increase in number of chemical subjects in the curriculum, and later by the organization of new chemical departments at the faculty. Because of academic freedom, introduced on the granting of university level, students could select up to 1882 with relatively great freedom the subjects they wished to attend. However, it soon became evident that in technical higher education an interrelated logical building up of the subjects is indispensable. Thus, in 1892 a compulsory curriculum and time table were introduced. At the chemical section tuition time was 4 years, the weekly number of lessons varying between 30 and 35.

From the foundation of the Faculty up to 1948, the education of chemical engineers was uniform, without specialization, of a duration of 4

years, later 4 ½, and then again 4 years. Following the Tuition Reform in 1948, specialization was introduced. The divisions for inorganic chemical technology, organic chemical technology and agricultural and food chemistry were organized at this time. In the first two years tuition was uniform, and became specialized only in the third and fourth year. The section for inorganic chemical technology ceased at our Faculty in 1952, because its tasks were taken over by the University of Chemical Industry at Veszprém, founded in 1949. Specialization was terminated by the Tuition Reform of 1955, which, correctly, attributed greater importance to fundamental education. This trend was strengthened by the reforms of the sixties, however, at the same time some specialized education was introduced in the following industrial branches: synthetic organic industry, plastics industry, pharmaceutical industry, light industries, biological and food industries [2, 3, 4, 5].

At the end of the sixties two-level engineering training was introduced in Hungary. At the technical and agricultural universities engineers with diploma, who are able to deal with research design and technical development tasks of higher level, and who also are suitable for creative activity, requiring a scientific way of thinking are educated in a five-year tuition. At the high-schools, production engineers obtain their diplomas after a study of three years. This training allows them to perform tasks in connection with daily production and production control, and makes them suitable for solving of detail tasks in the field of design, development and the elaboration of new processes. Exceptions to this are those universities, where two-level education has been introduced [6], and production engineers are also trained in addition to chemical engineers.

The two-level education of chemical engineers was introduced, because, with the exception of the branches mechanical engineering for chemical industry and food industry, there were no higher industrial schools in the field of chemistry in the sixties in Hungary, which could have been converted into technical colleges for the training of production engineers. Three possibilities were then offered for the realization of the education of chemical production engineers: the training of chemical production engineers at new colleges to be organized for this purpose; at college faculties to be established in the institutions for the training of chemical engineers or by the organization of a two-level educational system in these institutions. Considering pedagogic and economic advantages, two-level education of chemical engineers was introduced in September 1969. The main pedagogic advantage seemed to lie in the fact that the level of the education of chemical engineers with diploma can be raised by the organization of two-level education, and the teaching staff, available in the institutions for the training of chemical engineers, seemed to be suitable for the tuition of engineering students at both levels. Moreover, this solution had the economic advantage that a high-standard chemical

production engineer education could be realized at the technical universities at lower expenditure, than the investment cost of a new high-school or high-schools. Thus, the high-level education of graduating students, adjusted to the tasks to be performed, and interlinked tuition concentrated at one place, as the best solution from the aspect of national economy, seemed to be guaranteed at both levels.

In the two-level educational system, after three years of successful learning students obtain their chemical production engineer diploma, and those who meet the prescribed requirements may be granted after a further tuition of 2 years a diploma in chemical engineering. In the beginning an educational model was chosen, according to which the training of students was uniform in the first two years. Following this, chemical engineer candidates studied for further three years, and production engineers for a further year according to different syllabuses. Though this tuition system had several advantages, later we changed over to the uniform 3+2 educational model, built completely upon one another.

At the beginning of the seventies advances in science and technology increased the importance of interdisciplinary subjects, which set new tasks on higher education. During this scientific, technical and economic development several tasks arose, the solving of which required experts well versed in the intertwined interdisciplinary subjects of two or more branches of science, and able to apply this knowledge. To meet this demand, two new interdisciplinary branches were organized: the *system engineering* and the *bioengineering branches*. This does not mean specialization according to industrial branches, but involves interdisciplinary subjects. Tuition in these branches was introduced in the academic year 1974/75, and only students of 2nd level are trained.

Aims and structure of education

Our aims in the education of chemical engineers can be summarized as follows: the students are to acquire profound theoretical knowledge (mathematics, physics, physical chemistry), and shall already be confronted during their studies with all types of tasks, which may be met in the practical works of a chemical engineer. Thus, the student has to acquire laboratory skill, get acquainted with machines and apparatus used in chemical industry, principles needed for their optimal operation, shall get acquainted with a given technology of the chemical, food and light industries in the frame of a few weeks of industrial training, shall carry out technological design, and solve tasks of research character in the preparation of his diploma work.

The engineer must be versed:

in the operative direction of the technology and the personnel of chemical processes on industrial scale;
in the development of the technology and products of industrial chemical processes;
in the technological design of industrial chemical processes;
in the introduction of the application of a chemical product in national economy;
in the elaboration of new chemical processes, operations and technologies.

Great stress was laid on theoretical knowledge, on the developments of calculating ability and also on the foundation of economic concepts.

The structure of our education involves two-level gradual training (production engineer and chemical engineer training), postgraduate training (training of specialist engineers). In gradual training a uniform, non-specialized fundamental training in subjects of natural sciences, technology and social sciences plays an important role. In addition to this, to meet the demands for specialized education, tuition is given both in gradual and postgraduate training in the industrial branches and in the branches mentioned above, representing less specialization.

The aim of the training of *chemical production engineers* is to educate production engineers, who, in possession of knowledge acquired during their training, are able to direct technologies on industrial scale and personnel participating in the realization of the technologies, and are versed in the solving of partial tasks in the field of the technological design and development of chemical processes and of the elaboration of new chemical processes. The training of production engineers includes two industrial practices. Training ends with the working out of a thesis and entering a state examination.

The syllabus of the education of production engineers, besides prescribing in a three-year tuition knowledge to be acquired by production engineers, simultaneously prepares able and voluntary students for participation in the education of chemical engineers by means of the so-called criterion subject system.

Those, non-obligatory subjects are called *criterion subjects,* which are voluntarily registered by the student in the 3rd to 6th term of production engineer tuition, to fullfil by the completion of these lessons one of the necessary conditions of chemical engineer training. (This is one of the criteria for the further studying of the production engineer at the second level.) The syllabus prescribes the taking up a total of 15 hours/week of criterion subjects during these four terms as necessary condition for taking part in the competition for admittance to the chemical engineer tuition level.

The education of production engineers is the tasks of one section called Section of Organic and Biological Chemical Industry, which has the following branches:

Branch of Organic Synthetic Industry,
Branch of Plastics Industry,
Branch of Light Industry,
Branch of Pharmaceutical Industry,
Branch of Biological and Food Industries.

The aim of the education of chemical engineers is a training, based on the education of process engineers, but more comprehensive and deeper, as a result of which graduated chemical engineers become capable of undertaking also at a managing level operational, design, research and application-technical tasks.

At the chemical engineer level tuition is carried out in three sections with the following objects:

At the section of organic and biological chemical industry the aim of the education of chemical engineers in the training of experts, who are able to perform in all the fields of organic and biological chemical industry the engineering tasks mentioned above.

The aim of the education of bioengineers is to train experts on academic level, who are able to solve in the overlapping field of chemical engineering and biological sciences the technical-biological problems, particularly those of environmental protection, water household, medicine, biochemistry, dietetics and nutrition, of the pharmaceutical industry and of other related fields.

The aim of the education of chemical system engineers is the training of experts, who, after appropriate practice, can perform tasks of technological organization in conjuction with the operation, design, regulation, development and overall control of chemical engineering systems.

The section of organic and biological chemical industry includes the following branches:

Branch of Organic Synthetic Industry
Branch of Plastics Industry
Branch of Pharmaceutical Industry
Branch of Chemical Light industry
Branch of Biological and Food Technological Industry.

Branches of the *bioengineer section* are:

Branch of Environmental Protection
Branch of Health Protection.

At the section of *system engineering* there are no branches of tuition.

In all the three sections of the education of chemical engineers one part of the obligatory lesson-hours is allotted to optional obligatory subjects, to meet thereby the individual interest of students. Industrial practice is also included in the training of chemical engineers. At the end of chemical engineering

training students prepare a diploma thesis, defend it and sit for a final examination before a National Board of Examiners.

The main part of the biological subjects of the bioengineer section is taught at the special departments of the Faculty of Natural Sciences at the Loránd Eötvös University, the representants of which sit also in the National Board of Examiners.

Education by evening courses

In addition to the education of day-time students, two-level study by evening courses is also offered at the section of organic and biological chemical industry, the structure of which (5 branches) is essentially similar to that of day-time tuition. Duration of the courses: 4-year process engineer training, and built on it, 6-year chemical engineering training. (There are no bioengineering and system-engineering sections in the evening education.)

This form of education looks back to a past of 35 years. The number of participants in this form of education decreased in the past three decades.

Postgraduate education of engineers

A two-year organized training for engineers doing at the same time their job. This postgraduate training grants after successful learning and state examination a "specialist engineer" diploma. At present, there are the following specialized engineering branches at our Faculty:

Applied radiochemistry
Analytical chemistry
Food chemistry
Pharmaceutical and pesticide chemistry
Chemical technology
Corrosion
Environmental protection
Bioengineering
Plastics technology
Chemistry of fibrous materials
Chemical unit operations.

In addition to these branches, the Technical University of Budapest offers possibility to our chemical engineers to obtain a diploma in engineering economics by attending 2-year postgraduate courses besides working, and provides also within the frame of this training for the acquiring of knowledge on the economics of chemical industry.

At certain specialized engineering sections and within the frame of economist-engineer training, postgraduate training proceeds within the scope of branches or specialized directions, e.g. in the section of environmental protection the following branches are organized: air pollution control, water pollution control, noise abatement, regional protection and planning. The education of specialized engineers is directed by the faculties. Moreover, important possibilities of postgraduate training are offered by the *Institute of Postgraduate Studies for Engineers,* cooperating with the faculties in the organization and managing of the postgraduate courses.

Scientific extension training for the degree of Doctor of Engineering is also of great importance at our Faculty. Candidates prepare their thesis, which are related to research work at the departments, or in certain cases with research work at their working place, and obtain their degree of Doctor of Engineering from our University.

Several research fellows are doing their work for the scientific degree of Candidate or Doctor of Chemical Sciences at the departments of our Faculty. The qualification of these and the granting of the scientific degrees is the task of the Scientific Qualificatory Commission of the Hungarian Academy of Sciences.

Syllabuses

Syllabuses valid for the bicentennial academic year are shown in Tables 1–4. Table 5 shows the syllabus of the specialized engineering branch Chemical Unit Operations, organized within the frame of postgraduate training. We wish to emphasize that these syllabuses give only an orientative information on our tuition, as only partial conclusions can be drawn from the names of the subjects on their true content. Indeed, certain larger themes are taught at certain universities in the form of concentrated subjects, while at other places the single chapters of larger themes form separate subjects. In addition to the subjects contained in the syllabuses, criterion subjects and optional obligatory subjects (the latter are not listed) form an organic part of our tuition.

Criterion subjects are shown in Table 6. Criterion subjects were divided into 5 groups: mathematics, physics and physical chemistry, chemistry, chemical unit operations and biology, and the were marked with letters. Students have to choose according to prescription. If, e.g. somebody wants to continue his studies at the second level in the bioengineering section, he can choose 1 subject from group "A" and 4 from group "E", while candidates for the section Organic and biological chemical industry choose 1 subject from each of the groups, A, B, C and D, while the fifth subject can be chosen from any of the A–E groups.

Table 1

Education of Production Engineers

Subjects	No. of lessons per week (Theoretical + practical + laboratory), e = examination, r = recapitulative examination, p = practical mark, s = signature					
	1.	2.	3.	4.	5.	6.
	Terms					
Political economics			1+1+0e	1+1+0s	1+1+0r	
Philosophy	1+1+0s	1+1+0e				
Scientific socialism					1+1+0s	1+1+0s
History of labour movement						1+1+0e
Mathematics	4+5+0pe	2+3+0pe				
Computer mathematics	2+0+0s	0+0+2p				
Physics		3+2+0pe	3+0+3pe			
Physical chemistry			3+2+0pe	3+2+3pe		
General and inorg. chemistry	4+2+0pe	2+0+0e				
Chemical lab. practices	0+0+8p	0+0+7p				
Organic chemistry		4+2+0e	2+0+8pe			
Chemical analysis				3+0+0s	0+0+7pe	
Biochemistry				2+0+0e		
Macromolecular chemistry				2+0+0e		
Machines elements, mechanics	3+0+2pe	1+0+4p				
Electronics and instrumentation					2+0+0s	2+0+3pe
Unit process						2+1+0p
General chemical technology			3+0+0e	0+0+3p		
Unit operations				3+2+0pe	3+0+4pe	
Org. chem. ind. process					2+0+4pe	
Biochemical operations					2+0+0e	0+0+4p
Ind. economics and systematics						2+2+0e
Work safety				2+0+0e		
Specialization subjects				2+0+0e	2+0+0s	14pe
Russian language	0+3+0p	0+3+0p	0+3+0e			
Chosen language				0+3+0p		
Physical training. Sports.	0+0+2s	0+0+2s	0+0+2s	0+0+2s		
Home defence knowledge	0+0+2s		0+0+1s		0+0+1s	
Thesis work						0+0+3s

No. of hours per week Criterion subjects or Obligatory facultative subjects	14+11+14=39	13+11+15=39	12+6+14=32 max 9	18+8+8=34 min 3 max 6	13+2+16=31 min 3 max 9	37 max 3
No of examinations	3	5	6	6	4+1	5
Plant visit		+	+	+	+	

Industrial training: 3 weeks after 2nd, 4 weeks after 4 th term

	4.	5.	6.
		Terms	
Specialization subjects			
I. Organic chemical industrial branch			
Technology of hydrocarbons	2+0+0e		0+0+5p
Organic chem. technology		2+0+0s	2+0+5pe
Raw materials			1+1+0p
II. Plastic ind. branch			
Structure of polymers	2+0+0e		
Polymer production		2+0+0s	2+0+0s
Application technology			2+0+0e
Polymer lab. practices			0+0+10p
III. Pharmaceutical ind. branch			
Pharmaceut. chem. processes	2+0+0e		
Pharm. chem. technology		2+0+0s	2+0+6sp
Chemistry of natural substances			2+0+0e
Biology and biotechnology			2+0+2sp
IV. Light ind. branch			
Chem. and techn. of fibrous materials I.	2+0+0e	2+0+0s	
Chem. and techn. of fibrous materials II.			6+0+8sp
V. Biolog. and food ind. branch			
Food chemistry	2+0+0e		
Ind. microbiology		2+0+0s	0+0+4pe
Food and biol. technology			4+0+6sp

Table 2

Education of Chemical Engineers

Subjects	No. of hours per week (theoretical + practical + laboratory), e = examination, p = practical mark, r = recapitulative examination, s = signature			
	7.	8.	9.	10.
	Terms			
Political economics		1 + 1 + 0e		
Philosophy	1 + 1 + 0p			
Scientific socialism			1 + 1 + 0p	
Physical chemistry	2 + 0 + 5pe			
Colloidics	2 + 0 + 0e			
Quantum chemistry			2 + 0 + 0e	
Cristallography			2 + 0 + 1e	
Organic chemistry	2 + 0 + 0s	2 + 0 + 7pe		
Chemical analysis	2 + 0 + 0s	0 + 0 + 6pe		
Measuring technics and process control			3 + 0 + 2pe	
Chemical technological cybernetics	2 + 0 + 2pe			
Unit operations	3 + 1 + 3pe			
Radiochemistry		2 + 0 + 2pe		
Specialisation subjects			10pe	
Planning practice			0 + 0 + 4p	
Industrial economics and systematics		0 + 2 + 0p		
Industrial organization		2 + 2 + 0e		
Optional language	0 + 6 + 0p	0 + 6 + 0e		
Home defence knowledge	0 + 0 + 1s		0 + 0 + 1s	
Thesis work			0 + 0 + 4s	0 + 0 + 32s
No. of hours per week	14 + 8 + 11 = 33	7 + 11 + 15 = 33	31	0 + 0 + 32
Obligatory facultative subjects	+ 6	+ 6	+ 6	+ 4
No. of examinations	4(+2)	6(+2)	4(+2)	(+2)

Industrial training: 4 weeks after 8th term.

Specialization subjects	9. term
I. Organic synthetic industry branch	
Organic chemical technology	3+0+3pe
Corrosion protection	2+0+2pe
II. Plastics industry branch	
Polymer physics	2+0+4pe
Petrolchemistry	2+0+2p
III. Pharmaceutical ind. branch	
Synthesis of biological active substances	2+0+5pe
Pharmaceutical chemistry	3+0+0e
IV. Light industry branch	
Chemistry of fibrous substances	3+0+3sp
Physics of fibrous substances	2+0+0pe
V. Biological and food ind. branch	
Food industry	2+0+3pe
Biological ind. operations	2+1+2pe

Table 3

Education of Biological Engineers

Subjects	No. of hours per week (theoretical + practical + laboratory), e = examination, p = practical mark, r = recapitulative examination, s = signature			
	7.	8.	9.	10.
	Terms			
Political economics		1+1+0e		
Philosophy	1+1+0p			
Scientific socialism			1+1+0p	
Biochemistry and molecular biology	5+0+6pe			
Bioengineering operations			2+0+6pe	
Biological experimental techniques	2+0+0e	0+0+4p		
Oecology and environmental protection	4+0+0e			
Microbiology	2+0+0e	0+3p		
Radiochemistry	2+0+2sp			
Population biology		3+0+0e		
Specialization subjects		9ep	16ep	
Planning practice			0+0+4p	
Ind. economics and systematics		0+2+0p		
Ind. organization		2+2+0e		
Optional language	0+6+0p	0+6+0e		
Home defence knowledge	0+0+2s			
Thesis work			0+0+4s	0+0+32s
No. of hours per week	16+7+10=33	33	34	0+0+32
Obligatory facultative subjects	+6	+6	+3	+4
No. of examinations	4(+2)	5(+2)	4(+1)	(+2)

Industrial training, 4 weeks after 8th terms

	8.	9. terms	10.
Specialization subjects			
I. Environmental protection branch			
Air and water protection		3+0+4ep	
Environmental analysis	2+0+7ep		
Hydrobiology		2+0+3ep	
Oecology		4+0+0e	
II. Health protection branch			
Immunology, serum production		2+0+4ep	
Food chemistry, alimentation	2+0+0s	0+0+2ep	
Microbiological genetics	2+0+3ep		
Food and feed production	2+0+0s		
Applied microbiology		2+0+2ep	
Clinical biochemistry		0+0+4p	

Table 4

Education of Organization Chemical Engineers

Subjects	No. of hours per week (theoretical + practical + laboratory), e = examination, p = practical mark, r = recapitulative examination, s = signature			
	7.	8.	9.	10.
	Terms			
Political economics		1 + 1 + 0e		
Philosophy	1 + 1 + 0p			
Scientific socialism			1 + 1 + 0p	
Physical chemistry	2 + 0 + 3pe			
Unit operations	3 + 0 + 0e	0 + 0 + 3p		
Chem. ind. systematics	2 + 0 + 1p	5 + 0 + 1e		
Ind. economics and systematics	5 + 2 + 0e	1 + 2 + 0p		
Theory and practice of organization		3 + 2 + 0pe		
Decision models			4 + 0 + 3e	
Planning of plants			0 + 0 + 4p	
Chem. ind. optimalization			2 + 0 + 2pe	
Math. programation	2 + 0 + 4pe			
Math. statistics	2 + 0 + 1e			
Process control		3 + 0 + 3pe		
Measuring theory and instrumentation			2 + 0 + 1e	
Chem. technological systems	2 + 0 + 1e	2 + 0 + 2pe		
Specialization subjects			4 + 0 + 3pe	
Knowledge of laws				2 + 0 + 0e
Labour psychology				2 + 0 + 0e
Optional language	0 + 6 + 0p	0 + 6 + 0e		
Home defence knowledge			0 + 0 + 2s	
Thesis work			0 + 0 + 4s	0 + 0 + 32s

No. of hours per week Obligatory facultative subjects	19+9+10=38	15+11+9=35 +3	13+1+19=33 +3	4+0+32
No. of examination	6	6(+)	4(+)	2

Industrial training 4 weeks after 4th term

Optional branch technologies	9. term
1) Light industrial technology	4+0+3pe
2) Food and biol. ind. technology	4+0+3pe
3) Plastics technology	4+0+3pe
4) Pharmaceutical technology	4+0+3pe

Table 5

Education of Chemical Unit Operations Engineers

Subjects	No. of hours per week (theoretical + practical + laboratory), e = examination, p = practical mark, r = recapitulative examination, s = signature			
	7.	8.	9.	10.
	Terms			
Mathematical programing	2+0e	2+0e		
Computers	2+2s			
Planning and evaluation of experimentation		3+1pe		
Chemical unit operations	4+0e	3+0e	2+0e	
Chemical system technique			2+1e	
Chem. ind. process control		2+0e	2+0e	0+2p
Chem. ind. optimalization			2+0e	
Chem. ind. planning		0+1s	0+3s	0+2p
Computer processing				2+0e
Chem. ind. energetics	2+0e			
Chem. ind. general planning				2+0e
Chem. ind. environmental protection				2+0e
Biol. ind. operations				2+0e
No. of examinations	4	3	4	4

Subjects of final state examination: 1. Chem. unit operations
2. Chem. ind. process control
3. optional
   a) Math. programing
   b) Planning and eval. of exper.

Table 6

Criterion subjects

Group of subjects	A Mathematics	B Physics, Physical chem.	C Chemistry	D Operations	E Biology
Term 3	Techn. evaluation of differential equations	–	Selected chapters from org. chem.	Material preparation and transport	Cytology
Term 4	Techn. evaluation of differential equations Lin. algebra	Transport processes Phys. chem. of surfaces	Heterocyclic compounds	Fluid mechanics	Botanics, Zoology
Term 5	Pract. calculation methods	Reaction kinetics Thermodynamics	Org. chem. analysis	Momentum, heat- and mass transfer	Zoobiology Plant biology Genetics Enzimology
Term 6	Calc. of probabilities	Solid state physics	Modern synthetic methods	Chem. ind. energetics	Biophysics and biocolloidics

Departments of the Faculty of Chemical Engineering and their Activity

At present there are 13 departments at the Faculty of Chemical Engineering, the tuition and research work of which can be summarized as follows:

Department of Agricultural Chemical Technology (founded in 1908): Its tuition work is the teaching of bioengineering fundamentals, technologies of the spirit, sugar, brewing, vegetable oil and starch industries and pertinent knowledge. The field of tuition includes also the fundamentals and industrial realization of fermentation, and within the scope of the branch of light industries, lectures on Tanning industrial technology.

The Department teaches both at the production engineering and chemical engineering levels as main course the subjects Bioengineering unit operations and processes, and Bioengineering unit operations, resp. For students of specialized branches it provides courses on Industrial microbiology, and holds lectures on several optional obligatory subjects (e.g. Fermentation industries, Microbiological genetics, Agricultural chemistry, etc.).

The Department organizes both in gradual and postgradual education the Biologist-engineering section, and the spezialized engineering training of the Sugar industry branch of the Food chemistry section, and participates in the tuition of the specialized engineering section Environmental protection.

The Department is engaged in *research work* in the field of biotechnology, aimed at the biotechnical development of agricultural industries, food industries, pharmaceutical and other industries.

The main fields of research are the following:

Bioengineering research on fermentation: elaboration of the manufacturing technology of SCP and tryptophane on methanol basis in automatic fermentation equipment connected to a mass spectrometer and linked with a computer.

Enzyme engineering research: preparation and reaction-kinetic investigation of immobilized enzymes (glucoseisomerase, glucamylase), determination of active center and the changing of products spectrum, fermentation of cellulase enzyme and its application for the utilization of agricultural wastes. Utilization of biostatic immobilized cells as enzyme sources for the preparation of bioactive compounds.

Microbiological research: isolation of lysine producing microbes and their genetic modification, lysine production on various substrates, anaerobic wet conservation of agricultural products and by-products, investigation of the microbiological role of lipids.

Bio-operational research: investigation of biological waste water purification and denitrification, optimization of biogas production, investigation of the aeration of biological systems, recovery of active substances of plant origin (sterines, dyes) and of protein, operational development of emulsification, extrusion and spraying.

Department of Applied Chemistry (founded in 1965): Its tuition task at the Faculty of Chemical Engineering is Radiochemistry. Among its facultative subjects one can find Applied Radiochemistry, Isotope Indication, Physical Chemistry of Interfaces, Organic Electrochemical Synthesis and Chemistry of Environmental Materials. At the Faculty of Chemical Engineering the Department has the care of the postgraduate course for engineers: Applied Chemistry.

Its further important task is to teach students of other faculties chemistry and physical chemistry. Technical Chemistry is taught to first-year students of the faculties of mechanical and traffic engineering in collaboration with the Department of Chemical Technology. At the Faculty of Mechanical Engineering Chemistry for mathematical-engineering students and Physical Chemistry for students of the branch of Mechanical Engineering for Chemical Industry are taught as well. The Department participates in teaching of knowledge of materials to students of the Faculty of Architecture and Building and Faculty of Civil Engineering. At the Faculty of Electrical Engineering, Chemistry is taught in the first year for all students, Chemical Technology at the Microelectronics Section, and Physical Chemistry for students of the branch of Technical Physics of the Telecommunication Section, Chemistry of Semiconductors for students of the Instrument and Telecommunication Technology Section. It participates in the tuition of the process control laboratory as well.

Within the frame of research work since a long time the Department has been engaged in the complex qualification of biological and environmental matrixes, and in the determination of their trace contaminants by destructive and non-destructive neutron activation, X-ray fluorescence, atomic absorption and fluorescence analyses. Thermoluminescent substances, internationally recognized and successfully applied in environmental protection and space dosimetry, have been prepared. Important fundamental and applied research has been carried out to prepare and qualify various laboratorial and industrial sorbents. The Department has been employed since years in the chemical and electrochemical synthesis of bioactive basic materials and intermediates for the pharmaceutical, cosmetic and household-chemical industries. As a result of this work, several processes have been adapted on industrial scale.

Department of Biochemistry and Food Technology (founded in 1921) teaches the subject Biochemistry for all the students of the Chemical

Engineering faculty, and in the branch Biology and food technology within the frame of the education of production engineers the subjects Food chemistry and Biological and food technology. This latter branch provides in the training of chemical engineers for the courses Selected chapters of Biochemistry, Selected chapters of food chemistry and Selected chapters of food technology, and teaches for students of the biological engineering section the subjects Biochemistry and molecular biology, Food chemistry and dietetics, and Food and feed production. The Department provides courses in Food technology and microbiology for students of the Mechanical Engineering Faculty of our University. The Department organizes within the frame of postgraduate training at the specialized engineering section Food chemistry the branches Food qualification, Food technology and Meat technology. (The latter in collaboration with the Faculty of Mosonmagyaróvár of the Agricultural University of Keszthely), and participates also in the tuition work at the branch Sugar technology of the specialized engineering section Food chemistry.

The research work of the Department concerns fundamental and applied research in the field of food sciences, product and process development in food technology, research on new protein sources, biological evaluation of proteins and optimal protein utilization, elucidation of relationships between cereal protein structure and flour quality, investigation of the biological changes of industrial plants, research on bioactive substances (enzymes, vitamins, micotoxins, pesticides, thionines, biogenic amines, etc.), elaboration and development of modern food testing methods, investigation of packing materials for the food industry.

The *Department of Chemical Technology* (founded in 1870) teaches students of the Chemical Engineering, Mechanical Engineering and Transport Engineering Faculties. At the Chemical Engineering Faculty it provides courses in General and inorganic chemical technology at production engineering level for all the students, and at the section of General and Organic chemical engineering it teaches the subjects Hydrocarbon technology and Raw materials of the chemical industry. At the chemical engineer level Cybernetics in chemical technology is taught for all of the students, Petrolchemistry at the branch of Plastics industry, and Corrosion controll at the branch of Organic syntheses industry. At the production and chemical engineer levels courses are provided in obligatory facultative subjects, among others on Catalytic processes of petroleum industry, Water chemistry and technology, Chemization of national economy, Preparation and application of isotopes, Electrochemistry, Coal chemistry and technology, Simulation of chemical engineering systems, etc. The Department teaches at the Biological engineering section the subject Air and water protection, and at the section Organization for chemical

engineering the subject Chemical engineering systems and their management. Stress is laid also on the tuition of the application of computers.

As mentioned already, together with Department of Applied Chemistry, Technical chemistry is tought to students of the Mechanical Engineering and Transport Engineering Faculties.

The Department organizes the specialized training courses Environmental protection, Lubricating technology and Cybernetics of chemical engineering.

The research work of the Department concerns mainly energy sources, petroleum processing and petrolchemistry, chemical unit processes, environmental protection, silicate chemistry, technical electrochemistry, application of computing technics in chemical engineering, corrosion control and isotope technics.

Scientific works of main importance: Conversion of hydrocarbons in the plasma; Catalytic cracking and catalytic gasoline reforming; Mathematical modelling of ethane pyrolysis; Application possibilities of active carbon for industrial waste water purification; Nitrogen oxide removal from the tail gases of nitric acid manufacture with molecular sieves; Investigation of the micro-impurities of environmental samples with special regard to the determination of polyaromatic hydrocarbons and polychlorinated biphenyls; Development of separation-technical methods and their combined application for the separation of complex mixtures; Group separation and characterization of heavy petroleum products and coal products; Steady state flowsheeting; Investigation of microstructure systems containing silicates.

The *Department of Chemical Unit Operations* (founded in 1952) is dealing with the tuition of two basic engineering subjects: Chemical Unit Operations and Chemical Process Control, both of them obligatory for all students but the Biologist-engineer section. Moreover, the Department plays an important role in the tuition of the Organizing Engineer section (courses in Mathematical modeling, Chemical system engineering and Chemical process optimization). The Department also provides courses on several obligatory facultative and criterion subjects of general interest (e.g. Multicomponent distillation, Extraction, Chemical plant energetics, Design of experiments). In postgradual training the Department organizes the specialized engineering section of Chemical Unit Operations.

Research activities at the Department of Chemical Unit Operations comprise a wide range of mass transfer operations, equipment and relating problems, such as mixing, energetics, system engineering, process dynamics and control. Among these, distillation and extraction is investigated in the widest sense: beginning with the physical-chemical fundamentals and resulting finally in the design of industrial apparatus. Within this scope binary and multicomponent phase equilibria are measured, treated by statistical methods

and predicted using suitable models. Contribution has been done to develop improved methods for computer simulation of multicomponent distillation. Investigation of the hydraulics and mass transfer characteristics of tray columns led to a new tray device patented and used in several countries.

The Department participated in the design and experimental evaluation of new extractor-types, and contributed to the more efficient extraction of effective pharmaceutical substances. New design correlations were established for mixing equipment.

Distillation energetics, optimization, process dynamics and control of extraction and distillation equipment were concerned using systems concept. We participated in the elaboration of a more efficient power plant water treatment system. Computer program systems have been developed for multiproduct processes scheduling optimizing the utilization of production capacity.

The main task of the *Department of General and Analytical Chemistry* (founded in 1846) is the training of chemical engineering students in classical, instrumental and organic chemical analysis. The theoretical fundamentals of analytical chemistry are provided by the courses on Analytical chemistry, Organic chemical analysis and Automatic analysis. For the deepening of their knowledge the students solve complex analytical tasks in laboratory practices.

The Department organizes and manages specialized engineering training on Instrumental analysis, and in collaboration with other departments plays an important role in the tuition of other specialized engineering branches.

The scientific activity of the Department is composed of the work of the scientific research groups of the Department, namely the electroanalytical, organic analytical, atomic spectroscopic, thermoanalytical, technical analytical, radioanalytical and chemometric research groups. The main objectives of scientific research work are the development of new analytical methods, search for possible new applications and the elaboration of methods for solving analytical problems for the industry.

The most important fields of research are, e.g., analytical research of flow systems, recognized also internationally, research on ion-selective electrodes, atomic spectroscopic research, structure elucidation of bioactive substances, research on separation methods, thermoanalytical and chemometric research, etc.

Department of Inorganic Chemistry (founded in 1921). Its tuition work provides for lectures and pertinent laboratory and calculation practice on the subject General and inorganic chemistry for first-year students of the Chemical Engineering Faculty, laying thereby the groundwork of chemical knowledge and forming their proper chemical attitude. In the tuition of general chemistry and inorganic chemistry the mode of discussion based on the knowledge of structure of materials is thought to be important. For a more

detailed and deeper understanding of atomic and molecular structure the subject Quantumchemistry is taught to students of the chemical engineer grade.

Lectures are also given on the following criterion and optional obligatory subjects: Selected chapters of inorganic chemistry, Organometallic chemistry, Inorganic polymers, Fundamentals of inorganic theoretical chemistry. In the field of postgraduate training, the Department organizes the postgraduate course for corrosion engineering.

The research work of the Department is connected with the following scope of themes:

Preparation of organosilicon compounds, spectroscopic investigation of the compounds and determination of their bond and molecular structures. For the latter, semi-empirical quantumchemical calculations on the compounds are of great help. In the field of structural investigations dielectrometric investigations, determination of the dipole moment, play an outstanding role.

One of the important research aims is the finding of new fields of application for organosilicon compounds (medical practice, telecommunication, protection of monuments and industrial practice).

Of importance are electrochemical investigations and research on corrosion control, which made possible the solving of several industrial corrosion problems, further the field of thermoanalytical research for the studying of coordination compounds and for the investigation of the thermal behaviour of plastics.

Department of the Mathematics (founded in 1948, as independent department of the Faculty): Its tuition activity involves lecturing, study group exercises and consultations. The Department teaches at the Chemical Engineering Faculty the subjects Mathematics and Computer mathematics, as branch subject Mathematical programming, as criterion subjects Differential equations, Practical calculation methods and Linear algebra, and as optional obligatory subjects Mathematical analysis and Probability calculation.

Scientific work of theoretical and practical character is carried out at the Department. True to its traditions, the Department is engaged in research work on the convergence, summation and approximation problems of orthogonal series. Moreover, some special and topical problems of modern functional analysis, the so-called spectral theory are studied. Some fields of modern algebra, important also from the point of view of application, form also a part of scientific research (linear algebra and its applications in mathematic programming).

The parts of approximation theory dealing with the application of spline-functions, which are closely connected with chemical engineering problems, can be considered as of practical character. Intensive research is carried out in the field of operational research and its industrial applications.

Department of Mechanical Engineering for Chemical Industry (founded in 1965): Within the frame of its tuition activity basic knowledge in mechanical engineering-mechanical drawing, machine elements, strength of materials, conveying machines, fluid mechanics, machines for fluid technics, operation of machines, material handling and preparation in the chemical industry, indispensable for chemical engineers, are taught. Machines are discussed from the aspect of operation and energetics. Ability to read machine drawing is acquired in an active way, by making sketches and by designing pencil drawings. The concentrated three-week machine laboratory practice deals with the measuring of machines and the evaluation of the measurements. The Department teaches in addition to criterion subjects first year students. The Department considers the shaping of the engineer's way of thinking and of the technical-economical approach one of its important tasks.

Research work of the Department is connected with two spheres of themes:

In the field of fluid flow mechanics research concerns the pumping of viscous and non-Newtonian fluids, the development of methods of injector calculations, and the reduction of flow losses attainable by the addition of polymers with long molecular chains.
In the field of two-phase flow research concerns pneumatic material conveying, storage of adhesive materials in silos, and jet aerator equipment.

Department of Organic Chemistry (founded in 1913): Teaching profile: on production engineer level the Department is responsible for teaching the basic subject Organic chemistry, leads the complete respective laboratory exercises, provides courses in the criterion subjects Heterocyclic compounds and Modern synthesis methods of organic chemistry, and for students of the branch of pharmaceutical industry as optional obligatory subjects Chemistry of natural organic substances, Organic chemical practice, Organic stereochemistry and Special chapters of organic chemistry. The Department plays an important role in the education of students specializing in pharmaceutical industries.

Research at the Department is carried out in three research groups:

synthesis of alkaloids, prostanoids, insect hormones and pheromons,
chemistry and photochemistry of nitrogen-containing heterocyclic compounds,
synthesis of natural oxygen-containing heterocyclic compounds and of their glycosides.

The teaching and research staffs of the Department achieved important international results in the field of pharmaceutical technology.

Department of Organic Chemical Technology (founded in 1938). Its tuition task is to provide for lecture and laboratory courses on Unit processes of the organic chemical industry, a subject obligatory to all the students of the Chemical Engineering Faculty, and to lecture on Work Safety.

The Department organizes tuition in chemistry and chemical technology of pharmaceutical and light industries, and provides for most of the relevant educational tasks. Courses are related to the theory and practice of pharmaceutical chemistry and technology, chemistry and technology in the textile and paper and pulp industries, as well as to the chemistry of plant protection. Together with the Department of Chemical Technology it organizes and gives specialized lectures at the branches of Chemical Industry, dealing with organic syntheses. The educational staff of the Department announces yearly in the field of obligatory and optional obligatory subjects 37 courses. These are dealing with chemical processes in the industries of bioactive organic compounds, and fibre.forming polymers, as well as with processing and application of catalysts.

They organize specialized engineering training in their field of science.

A course is given by the Department in Organic chemical technology for students of the Mechanical Engineering Faculty.

The scientific activity of the teaching and research staff of the Department concerns mainly four special fields:

Synthesis and application of bioactive compounds,
application and modification of fibre forming polymers,
investigation and preparation of catalysts, and their application in heterogeneous catalytic processes,
preparation and application of surfactants and phase transfer systems.

Department of Physical Chemistry (founded in 1926): Its tuition work is to provide for students of chemical engineering courses and laboratory exercises in the following obligatory subjects: Physical chemistry, Electronics and measuring technics for chemical industry, Colloid sciences and rheology, and Measuring theory. Moreover, it is the educational task of the Department to teach criterion subjects Reaction kinetics I and Thermodynamics II, and among optional obligatory subjects Chemical application of quantum mechanics, Thermodynamics of transport processes, Computer-oriented measuring technics, Fundamentals and application of statistical mechanics and Fourier-NMR spectroscopy.

The Department takes part in postgradual education, managing the branch Structural research of the Specialized engineering section for analysis.

The main research activity of the Department concerns three fields:

— Structural research. Quantumchemical calculation of excited electron states, determination of geometry and conformation with quantumchemical

methods, quantumchemical calculation of vibrational force fields, theoretical spectroscopic research, determination of the composition of multicomponent systems by computerized method on the basis of spectroscopic data.

— Colloid chemistry, Stability problems of colloid suspensions and emulsions, research on parameters regulating two-phase flow, stability conditions of flow, problems of surface viscosity.

— Measuring technics. Development of detecting methods in gas chromatography, experimental and theoretical study of continuous counter-current gas chromatography, instrumental development of square-wave polarographic and voltammetric measuring technics.

— In addition to these main field of research, theoretical thermodynamical research and the experimental investigation of the equilibrium of multicomponent multiphase systems are carried out at the Department.

The fundamental tuition task of the *Department of Plastics and Rubber Industries* (founded in 1952) is on the one hand to make acquainted students of chemical engineering with the fundamentals of macromolecular chemistry, and on the other hand to train within the frame of branched education experts, able at a high level for the solving of tasks arising in the industrial manufacture and processing of polymers and in the application of plastics in various field of national economy

The Department organizes lectures in postgradual training, and courses of specialized engineering training. In the specialized engineering courses Processing and application of plastics and Rubber and varnish technology systematic extension training is offered to experts working in industry.

The research work of the Department involves partial fields of polymer chemistry and physics, and of the processing technology and application technology of plastics. Research concerns partly plastics produced in large quantities in Hungary (polyolefins, PVC), and partly the preparation and technical application of new polymers with special properties (plastics of high thermal resistance, polymer gels, modified resins).

Processing technological research at the Department is centered on injection moulding and extrusion processes. These are organically complemented by fundamental research on rheology and material structure, and by the investigation of the decomposition and stabilization of polymers, and studies on the crystallization and melting of polymers.

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