# EDUCATION OF CHEMICAL ENGINEER STUDENTS AT THE TECHNICAL UNIVERSITY OF BUDAPEST

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In a few years the Chemical Engineering Faculty of the Technical University in Budapest will celebrate its first centenary. However, education in chemistry, first and foremost in industrial chemistry, is much older than suggested by this date, and is rooted in a tradition that dates back to much earlier times. Established in 1735, it was the *Selmecbánya Mining School*, that gave its students, for the first time in history, practical chemical laboratory tuition. *Manuel del Rio*, to become a professor of Mexico University and the discoverer of vanadium, *Fausto d'Elhuyar*, later director general of mines in Spanish South America and discoverer of tungsten, *Ferenc Müller* who later, in Erdély (Transylvania), first identified tellurium, had been students at the Selmecbánya School. When the first independent technical university, the Ecole Polytechnique, in Paris,* was founded, the practical laboratory tuition system evolved in Selmecbánya served it as a model and example [1, 2, 3, 4].

No chemists as such were trained yet at our Technical University (Institutum Geometrico-Hydrotechnicum) founded in 1782 and merged, in 1850, into the József Industrial Training School. However, among its departments there was one for General Chemistry [5] and, since 1870, one for Chemical Technology [6].

* When, on the 23rd September of 1794, the French National Convention discussed a proposal in connexion with the Ecole Centrale des Travaux Publics, named Ecole Polytechnique a year later, a distinguished chemist, Fourcroy, as the referee of the Comité de Salut Public, said: "In France hitherto only the theories of physics and of chemistry have been taught."

"The Mining School at Selmecbánya in Hungary is a vivid example of how useful it is to show the students the operations that underlie these sciences."

"There laboratories provided with the necessary equipment and materials are at the disposal of students that they may repeat the experiments themselves and thus see the phenomena as these arise when bodies are compounded".

"The Comité de Salut Public forms the opinion that this is the method that ought to be adopted by the Ecole des Travaux Publics because this promises the twofold advantage that all the senses will be engaged by the process of tuition and that there will be brought to the notice of the students those numerous circumstances which in a lecture stay hidden before students and teacher alike. Students are directed to sit in separate rooms where they work out geometrical constructions they had been taught in the common class-room, similarly, they repeat the main operations of chemistry in separate laboratories to gain experience in the invention of the most suitable methods and best production processes." [23]

A faculty proper for chemistry was organized at the *József Technical University* (established — from József Industrial Training School — in 1871), the legal predecessor of the present Technical University of Budapest, as one besides four other faculties. This Chemical Faculty had two chemical departments, one for *General Chemistry* and one for *Chemical Technology*. Besides these, an important contribution came from the *Department of Zoology, Botany, and Materials Science*, inaugurated in 1864 already, and from the *Department of Mineralogy and Geology*, founded at the same time [6].

The perusal of the curricula of this faculty reveals it as quite up-to-date. Chemical Physics was taught, to cite but one instance, a discipline that was just unfolding in those times [7].

At the beginning of the twentieth century, the progress of Hungarian industry stamped its mark also upon the training of chemical engineers. In 1906, the number of students enrolled for this profession was more than two hundred, while before the turn of the century it never reached as much as fifty.

To meet increasing demands, new departments within this Faculty were founded. 1905 saw the inauguration of the *Department of Electrochemistry*, in 1908 one of *Agricultural Chemical Technology* was created, in 1913 the *Department of Organic Chemistry*, in 1918 that of *Inorganic Chemistry* came into being, while the *Department of Food Chemistry* was founded in 1921. In the same period, the *Department of Chemical Physics* was organized by evolving it, and allowing its autonomy to develop apart, from the *Department of Experimental and Chemical Physics*. The terms of reference for the *Department of Textile Chemistry*, founded in 1939, were significantly broadened in subsequent years to form the present *Department of Organic Chemical Technology*.

At the end of World War II, the siege of Budapest imposed heavy losses upon our University. Several Departments were ruined completely, and none escaped damage. Without laboratories and with little equipment, yet studies were commenced in the spring of 1945. The re-building of premises was finished by 1948. With the Three-Year National Plan the modernization of syllabuses, studies, and equipment began [7, 8]. Training reforms were put under way to arrive at yet more high levels and up-to-date forms of the training of chemical engineers. The demands stemming from these reforms brought new departments into being, that of *Plastics and Rubber*, in 1953, that of *Unit Operations* in 1954, that of *Mechanical Engineering for Chemical Industry* in 1966, in this year also one for *Applied Chemistry* was organized, mainly to teach general chemistry and physical chemistry to students of the Mechanical Engineering Faculty and to those of the Electrical Engineering Faculty.

In 1948, the training of chemical engineers in Hungary was subdivided into several divisions; within the Chemical Engineering Faculty there were organized those for inorganic chemical technology, organic chemical technology, and agricultural and food chemistry.

In 1949, at Veszprém, the Faculty of Heavy Chemical Industries of the Technical University in Budapest was established; this Faculty was made an independent technical university in the autumn of 1951. Gradually, this establishment extended its activities so that at present it functions as the University of Chemical Industry at Veszprém, with 12 departments.

Since 1952 the *Chemical Engineering Faculty of the Technical University of Budapest* trains chemical engineers mainly for the organic chemical, the food processing, and the light industries; the *University of Chemical Industry at Veszprém* caters for the inorganic chemical, the petroleum and coal processing, and the silicate industries. Accordingly, the Chemical Engineering Faculty of the Technical University in Budapest comprises *a*) a branch for the synthetic organic chemical industry, *b*) one for the plastics industry, *c*) one for the pharmaceutical industry, *d*) one for the light industries, and *e*) one for the biological industries. The University of Chemical Industry at Veszprém has a branch each for *a*) inorganic chemical technology, *b*) petrochemical industry, *c*) silicate industry, and *d*) radiation chemistry.

Characteristic of the expansion of the Chemical Engineering Faculty at Budapest is the fact that on the 1st of January, 1967, 721 students were listed as its regulars, 448 as students of the evening courses, and 201 as members of the professional specialist courses.

Due to the special circumstances that obtain in Hungary, education of chemical engineers differs from that offered by specialized technical high schools in the U.S.S.R. and some countries in Eastern Europe, and it differs also from the general educational systems in the Western Countries.

It might be noted that apart from the training of chemical engineers at the Chemical Engineering Faculty of the Technical University of Budapest, and at the University of Chemical Industry at Veszprém, chemists are trained at the science faculties of three universities of arts and sciences, namely at the *Loránd Eötvös University at Budapest*, the *Lajos Kossuth University at Debrecen*, and the *Attila József University at Szeged*.

Quite a great interest is shown in chemical industry in Hungary, therefore the selection of students from among the great number of candidates is by entrance examination. This covers mathematics and physics, and consists of a written and an oral part, and only the best are accepted for matriculation.

## Education of chemical engineer students, and aims of the branches of the Faculty

The aim of the Chemical Engineering Faculty of the Technical University of Budapest is to train, according to the needs of national economy, chemical engineers who are equipped with adequate theoretical and practical knowledge mainly in the fields of organic chemical industry and biochemical industry.

In accordance with the tasks the Faculty has set itself, the duties of a chemical engineer comprise participation in, and direction of, the work of plant and laboratory, notably:

— design of technological processes, setting up of material- and energy-balances,

— selection of a suitable type of apparatus, determination of their main dimensions as a function of physical, chemical, and operational parameters, but no constructional design and stress analysis of such apparatus,

— co-operation on the basis of his knowledge of instrumentation and automation with specialists in these fields,

— experimental establishment in the course of laboratory or pilot-plant research work, or by calculations where possible, of parameters which must be known for the introduction of a novel process,

— finally, development and design work towards the realization of targets set by the national economy in the field of chemical and allied industries (pervasion of other industries by chemical porducts and processes), with practicability and economical advantages in mind.

Since chemistry is pre-eminently an experimental science, acquisition of a proper attitude to, and of a certain flair for, experimental approaches must figure as an essential feature during training. Therefore, the training of chemical engineers must ensure that students, besides becoming well versed in theoretical and experimental knowledge, will acquire a proper attitude also to production problems: this necessitates their participation in pilot-plant experiments and their doing part-time work in a plant.

## The five branches of the Faculty are the following

a) *Synthetic organic industrial chemistry*

Students are trained mainly for engineering tasks in the field of dye-, intermediary- (also those made from basic petrochemicals) and finished products manufacture.

b) *Production of plastics*

The task of training in this branch is to provide students with knowledge needed in the manufacture and processing of plastics and rubber.

c) *Pharmaceutical industrial chemistry*

This branch trains chemical engineers who will possess the necessary knowledge enabling them to manufacture synthetic pharmaceutical substances.

d) *Light industries*

The main task of training in this branch is to equip students with chemical engineering knowledge applicable in the textile, dyeing, finishing, cellulose, paper, leather, and furriery industries.

e) *Biological industries*

Students are trained for chemical engineering tasks that occur in sugar-, starch-, vegetable oil-, canning and meat preserving-, milk processing-, baking-, and confectionery production or industries, and also in connection with industrial fermentation processes and with production and isolation of natural organic substances of plant and animal origin.

## Institutions of the Chemical Engineering Faculty

At present, the following departments provide tuition for chemical engineering students (the Departments are listed in alphabetical sequence according to their designation in Hungarian).

*Department of Applied Chemistry*

Provides courses in Measuring Techniques for students of the Chemical Engineering Faculty, and courses of Chemistry for students of the Mechanical Engineering, and for those of the Electrical Engineering Faculties. Further courses offered are in Physical Chemistry for the vacuum and semi-conductor techniques branches of the telecommunication section of the Electrical Engineering Faculty. Also held are courses on chemistry (Chemistry II) for students of component parts manufacture in the instrument and telecommunication technology branch of the Electrical Engineering Faculty, and instruction is given in the Fundamentals of Continuous Technologies to students of the measurement and control branch of the section for instrumentation and regulation techniques.

*Department of General and Analytical Chemistry*

Its task is the training of chemical engineering students in classical chemical analysis, organic chemical analysis, and instrumental analysis, and the management of special (postgraduate) courses in instrumental analysis.

*Department of Food Chemistry*

This department is responsible for courses in Biochemistry, and for those in Food Chemistry and Technology, the latter for students of the biological industrial branch. Chemical technology of food production is taught to students of the Mechanical Engineering Faculty. This Department participates also in the teaching of specialized engineering (postgraduate) disciplines within these fields.

*Department of Physical Chemistry*

The task of this Department is the teaching of Physics, Physical Chemistry, Electrotechnics and Electronics, further, in part, that of Radiation Chemistry and Isotope Techniques. It participates in the training of nuclear engineering.

*Department of Chemical Technology*

Its task is to provide courses in General Chemical Technology, and on Chemical Manufacturing Plant, for students of chemical engineering, further in Hydrocarbon Techology for students of the synthetic chemical industries branch, and for those of the plastics industries branch. It co-operates in the courses held on Radiation Chemistry and Isotope Techniques. For students of the Mechanical Engineering Faculty lectures are held by this Department on Chemical Technology; chemical industrial technology and silicate industrial technology is taught by it to students of the chemico-mechanical engineering section; on motor fuels and lubricants lectures are held for stundents of the automotiv engineering branch. The training of nuclear chemical specialists within the Chemical Engineering Faculty is directed by this Department, and a postgraduate course of lubrication is also organized.

*Department of Mathematics*

Provides lectures on, and tuition in, mathematics for the students of the Chemical Faculty.

*Department of Agricultural Chemical Technology*

Its task is to provide courses in Biochemical Engineering, in Technical Microscopy, in Industrial Microbiology, Agricultural Industries, and plant design for students of the biological industries branch, then in biology for students of the pharmaceutical industries branch, further in biologically based light industries for students of the light industries branch. It participates in the

training in Radiation Chemistry and Isotope Techniques, also on that of specialized postgraduate courses.

*Department of Plastics and Rubber Industries*

This Department provides a course on Macromolecular Chemistry for the whole grade, then on plastics production, testing and processing, further it provides practical courses on plastics technological design and plastics technologies, for the students of the plastics industries branch. On the Mechanical Engineering Faculty too, this Department provides lectures in the field of the Processing and Application of Plastics, and fulfils an important role also in specialized training.

*Department of Organic Chemistry*

The task of this Department is to provide the very extended tuition in organic chemistry for the students of the Chemical Faculty, besides giving the lectures on Natural Organic Substances to students of the pharmaceutical industries branch.

*Department of Organic Chemical Technology*

The task of this Department comprises studies in the field of the Basic Processes of the Organic Chemical Industry. Organic chemical technology courses are presented to, and practical courses are held on this subject for students of the organic synthetic industries branch. Pharmaceutical Chemistry and Technology, Basic Process in Pharmaceutical Chemistry and Pharmaceutical Technological Design are taught to students of the pharmaceutical industries branch; Chemistry of Fibrous Materials, Man-made Fibres, Textile- and Paper-technology are taught to, and practical courses in design in the field of chemical light industries are held for, students of the chemical light industries branch. This Department organizes the lectures on work safety. Organic chemical technology courses are presented to students of the chemical apparatus and machinery branch of the Mechanical Engineering Faculty. Also this Department co-operates in the training of specialized chemical engineers, in the postgraduate training of Textile-, of Pharmaceutical Technology and of Pharmaceutical Research.

The reorganisation of the Department of Organic Chemical Technology into *Institute of Organic Chemical Technology* containing three chairs (departments): the *Department of Organic Synthetic Chemical Industry*, *Department of Pharmaceutical Chemistry and Technology* and *Department of Textile Chemistry and Technology* is in progress for the time being.

*Department of Inorganic Chemistry*

This Department provides courses on general and inorganic chemistry and directs laboratory work, and chemical calculation exercises, in conjunction with this subject. It also directs the postgraduate course for corrosion engineering.

*Department of Mechanical Engineering for Chemical Industry*

It provides courses, both theoretical and practical, on machine part design and mechanical drawing, on mechanics; it also directs laboratory and industrial practice in conjunction with these subjects.

*Department of Chemical Unit Operations*

By lectures, laboratory experiments, and pilot plant work, this Department provides tuition in Unit Operations and Process Control.

## Program of tuition of the Chemical Engineering Faculty

The curricula adopted at present have been evolved during the last 15 to 20 years in accord with the demands and possibilities of national economy [9, 10, 11, 12, 13]. One of the most difficult problems to be resolved was the determination of the proper ratio between primary, fundamental, and branch subjects. In the course of its deliberations the managerial body of the Faculty laid great stress upon the groundwork that rests on the natural sciences, but found it feasible, at the same time, to provide for instruction in special chemical technologies that are the most important for the successful performance of the chemical engineering tasks presented by the several branches of industry. In the fixing of this ratio the principle was kept in mind that a strong grounding is essential, whereas in connection with technologies, which do in part change as they progress, only laws, or principles, and subject matter needed most should be taught. A Table presents the syllabuses of the Faculty.

In connection with it we may mention that students have to pass examinations, so-called colloquia, at the end of a term. There are two terms in a scholastic year. Laboratory, calculation, drawing, and design practice work must be presented for marking.

Organic chemistry, physical chemistry, and political economy are subjects for which the Program of Tuition prescribes a comprehensive and recapit-

**Syllabuses of the Chemical Engineering Faculty**

*I. General education*

| Subjects | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Mathematics | 300 | 150 | — | 150 | — | — |
| Physics | 210 | 120 | — | 60 | 30 | — |
| Physical Chemistry | 255 | 195 | | 60 | — | — |
| Experimental Physical Chemistry | 135 | — | — | — | 135 | — |
| Technical Microscopy | 15 | — | — | — | 15 | — |
| General and Inorganic Chemistry | 165 | 135 | — | 30 | — | — |
| Experimental Chemistry | 285 | — | — | — | 285 | — |
| Chemical Analysis | 365 | 75 | — | — | 290 | — |
| Organic Chemistry | 465 | 165 | — | 15 | 285 | — |
| Biochemistry | 30 | 30 | — | — | — | — |
| Crystallography | 30 | 15 | — | 15 | — | — |
| Machine Elements, Mechanical Drawing | 150 | 45 | — | 105 | — | — |
| Electrotechnics, Electronics | 75 | 45 | — | 15 | 15 | — |
| Engineering Mechanics | 75 | 60 | — | 15 | — | — |
| Unit Operations | 320 | 170 | — | 75 | 75 | — |
| General Chemical Technology | 150 | 75 | — | — | 75 | — |
| Radiation Chemistry and Isotope Techniques | 60 | 30 | — | — | 30 | — |
| Measuring Techniques | 30 | 30 | — | — | — | — |
| Process Control | 105 | 60 | — | — | 45 | — |
| Macromolecular Chemistry | 60 | 60 | — | — | — | — |
| Fundamental Processes in Organic Chemical Ind. | 180 | 60 | — | — | 120 | — |
| Biochemical Engineering | 120 | 40 | — | — | 80 | — |
| Chemical Plant | 30 | 30 | — | — | — | — |
| Political Economics | 135 | 75 | — | 60 | — | — |
| Philosophy | 90 | 45 | — | 45 | — | — |
| Scientific Socialism | 90 | 45 | — | 45 | — | — |
| Industrial Economics | 40 | 30 | 10 | — | — | — |
| Industrial Plant Economics | 75 | 45 | — | 30 | — | — |
| Work Safety | 20 | 20 | — | — | — | — |
| Russian | 120 | — | — | 120 | — | — |
| Facultative Language | 95 | — | — | 95 | — | — |
| Facultative Sociology Subject | 30 | 30 | — | — | — | — |
| Physical Training, Sports | 60 | — | 60 | — | — | — |
| *II. Specialized Education* | | | | | | |
| *Branch of Organic syntheses industry* | | | | | | |
| Chemical Technology of Hydrocarbons | 75 | 30 | — | — | 45 | — |

| Subjects | 1. | 2. | 3. | 4. | 5. | 6. |
|---|---|---|---|---|---|---|
| Organic Chemical Technology | 60 | 60 | — | — | — | — |
| Organic Chemical Technology, Experimental | 180 | — | — | — | 180 | — |
| Organic Synthese, Technological Design | 60 | — | — | — | — | 60 |
| Facultative Special Subject | 60 | 60 | — | — | — | — |
| Diploma Thesis | 480 | — | — | — | 480 | — |
| *Branch of Plastics industry* | | | | | | |
| Chemical Technology of Hydrocarbons | 75 | 30 | — | — | 45 | — |
| Plastics Production | 45 | 45 | — | — | — | — |
| Testing of Plastics | 45 | 15 | — | — | 30 | — |
| Processing of Plastics | 30 | 30 | — | — | — | — |
| Plastics Technology, Experimental | 150 | — | — | — | 150 | — |
| Plastics Technological Design | 60 | — | — | — | — | 60 |
| Facultative Special Subject | 30 | 30 | — | — | — | — |
| Diploma Thesis | 480 | — | — | — | 480 | — |
| *Branch of Pharmaceutical industry* | | | | | | |
| Chemistry of Natural Organic Substances | 45 | 45 | — | — | — | — |
| Biology | 60 | 30 | — | — | 30 | — |
| Pharmaceutical Chemistry and Technology | 60 | 60 | — | — | — | — |
| Basic Process in Pharmaceutical Chem. | 30 | 30 | — | — | — | — |
| Pharmaceutical Chemistry and Technology, Exper. | 150 | — | — | — | 150 | — |
| Pharmaceutical Technological Design | 60 | 30 | — | — | — | 30 |
| Facultative Special Subject | 30 | 30 | — | — | — | — |
| Diploma Thesis | 480 | — | — | — | 480 | — |
| *Branch of Chemical light industry* | | | | | | |
| Chemistry of Fibrous Materials | 45 | 45 | — | — | — | — |
| Man-made Fibres | 30 | 30 | — | — | — | — |
| Biological Light Industries | 60 | 30 | — | — | 30 | — |
| Textile- and Paper Technologies | 75 | 75 | — | — | — | — |
| Chemical Light Industries, Experimental | 135 | — | — | — | 135 | — |
| Chemical Light Industrial Design | 60 | — | — | — | — | 60 |
| Facultative Special Subject | 30 | 30 | — | — | — | — |
| Diploma Thesis | 480 | — | — | — | 480 | — |
| *Branch of Biological industries* | | | | | | |
| Food Chemistry and Technology | 180 | 60 | — | — | 120 | — |
| Industrial Microbiology | 90 | 45 | — | — | 45 | — |
| Agricultural Industries | 60 | 30 | — | — | 30 | — |
| Plant Design Exercises | 75 | — | — | — | — | 75 |
| Facultative Special Subject | 30 | 30 | — | — | — | — |
| Diploma Thesis | 480 | — | — | — | 480 | — |

Key. 1. = sum total of hours allowed, therefrom
2. = lectures on theory „ „
3. = class-room exercises „ „
4. = exercise in study-groups „ „
5. = laboratory work „ „
6. = design work in study-groups „ „

ulative examination to be passed. At the end of their studies candidates have to present a diploma thesis and argue it before a National Board of Examiners, they also have to sit for a final examination in three subjects of which one, chemical unit operations, is obligatory for every student of the Faculty, the two other being selected according to the branch of industry the student had opted for.

The main purpose of the Tuition Reform implemented between 1960 and 1965 was the strengthening of the engineering aspect in the curricula, the better adjustment of the ratio of theoretical to practical studies, the fostering of general engineering knowledge at the expense of specialization, and, together with this, the determination of adequate proportions for the several branches of study, finally, the setting of a proper time for practical work in factories. Equally, great stress was put upon the modernization of the subject matter presented, and account was taken of the burden devolving upon students and of how this burden might be lightened or adjusted [9]. (In this period significant reforms along the same lines were realized also by the University at Veszprém [14, 15)].

In an appreciation of the kind, and volume, of primary subjects of study the institutions of higher education of the world seem to differ. There happens to be a university where chemical engineering students attend lectures on astronomy, in contrast, mainly at strongly specialized technological institutes only a rather narrow domain of natural sciences is covered. We feel that chemical engineering training requires a strong fundament of mathematics, and physics, beside general, inorganic, organic, and physical chemistry.

However, great importance should be attributed also to engineering fundamentals. At the time of the Reform mentioned, the matter taught in the field of mechanics and unit operations has been extended and greater emphasis was put on measuring and control techniques than before, in conjunction of which students learn the essentials about computers. The sequence of these subjects is carefully adjusted. In the first year machinery part and mechanical drawing, in the second mechanics, in the third and fourth unit operations are taught, the eighth and tenth terms (semesters) bring measuring and control techniques.

The Table of syllabuses shows that in the reformed program of studies 3355 hours or 64 per cent, from a total of 5280, are allotted to fundamental subjects. 345 hours are devoted to lectures on social sciences, and 3010 hours are distributed as follows.

| | | |
|---|---|---|
| General and Inorganic Chemistry | 450 | hours |
| Physical Chemistry | 390 | ,, |
| Chemical Analysis | 365 | ,, |
| Organic Chemistry | 465 | ,, |
| Biochemistry | 30 | ,, |
| Chemical fundamentals | 1700 | hours |

| | | |
|---|---|---|
| Mathematics | 300 | hours |
| Physics | 210 | ,, |
| Electrotechnics. Electronics | 75 | ,, |
| Machine Elements. Mechanical Drawing | 150 | ,, |
| Mechanics | 75 | ,, |
| Crystallography | 30 | ,, |
| Technical Microscopy | 15 | ,, |
| Unit Operations | 320 | ,, |
| Measuring Techniques | 30 | ,, |
| Process Control | 105 | ,, |
| Mathematics, physics, and technical fundamentals .. | 1310 | hours |

Thus in education of chemical engineer students, 56.5 per cent of the professional fundamental subjects presented is of some aspect of chemistry, and 43.5 per cent comprise mathematics, physics, and disciplines in the domain of mechanics.

This latter figure is worth notig as it allows our students to be trained for technical leadership in an up-to-date chemical industry that utilizes the progress in mechanics and in automation in an ever increasing degree.

Several industrialists complained about the difficulties young chemical engineers experienced in the face of *technological design* problems that happened to crop up in manufacturing practice. Therefore, owing to the initiative of the Department of Agricultural Chemical Technology [16, 17, 18], the reforms established practical lessons of design in all the branches, further, utilizing the experience gained at the University of Chemical Industry at Veszprém, a new course, designated as the Chemical Plant, has been introduced. Therein essentials of building technology are taught besides those referring to the establishment and operation of chemical plant. At the pharmaceutical industries branch design studies include those on scale up methods.

There is no doubt that *production exercise* is beneficial from the point of view of training chemical engineers. Also this new type of tuition serves more emphatically to present the engineering aspects to, and to enhance the workshop attitude of, the trainees [19, 20, 21]. Following the first year, a four week spell of maintenance work in a mechanical shop of a chemical plant is allotted; following the second year, experimental work mainly in hydrodynamics in a university laboratory is performed, and 10 weeks during the eighth term are consecrated to practical professional jobs. In the tenth term some final test work is done in a chemical plant.

The so-called "*long*", *i.e. ten-week production exercise* demands great efforts from our teaching staff and, based upon overall experience, seems to have worked well in the Chemical Engineering Faculty, primarily thanks to the relatively smaller number of students and the careful direction under which they worked. The aim of this type of probationary practical work is to acquaint students with circumstances that obtain in plants, and to make them see the operational and mechanical aspects of production technologies. During this

apprenticeship students have to try and solve some technical problem. Students with good marks may be sent abroad for this production exercise period.

In what we have discussed up to now we emphasized what the Faculty did for the strengthening of the engineering side of training. The data we have adduced prove the extension of the volume of subjects that relate to physics and mechanics. At the same time, the importance of the *chemical subjects* should not be underestimated. No doubt, an up-to-date chemical engineer should possess a well founded and thorough knowledge in chemistry; when the significance of technical subjects is stressed it must be borne in mind always that it is chemical engineers we want to train.

As a shortcoming of the present program of studies of the Chemical Engineering Faculty in Budapest the fact must be pointed out that the subjects are too many and thus the risk of fragmentation is real. Partly due to this, the hours prescribed for technical laboratory exercises are reduced, for upper grade students. Formerly, 15 to 20 years ago, technical laboratory work had to be done for 15 or 20, even 30 hours weekly to cover one set task, thus sufficient time was available for more elaborate study.

However, the character of tuition in the *technological laboratories* did much progress and is quite modern. Several Departments (those of organic chemical technology, agricultural chemical technology, chemical technology, plastics and rubber, unit operations) have pilot plant facilities for the training of their students.

Finally, we might mention that parallel with engineering subjects due stress is put upon *economics* in the formation of chemical engineering attitude.

An important item is the work in the tenth term on a *diploma thesis*, mainly done in one of the technology departments. Since in the course of their plant exercise work students got acquainted with conditions and problems of manufacture and in the course of their studies had been confronted also with technological design tasks, further, since the solution of a chemical problem must be attempted first in a laboratory in most of the cases, the work on a diploma thesis too consists of research work in a laboratory.

Characteristic of the program of studies, and of the *intensity of education*, is the fact that out of the 5280 hours only 2030 (38.5 per cent) are allotted to lectures, 70 hours (1.3 per cent) to class-room exercises, 920 hours (17.4 per cent) to study-group work, 60 hours (1.1 per cent) to design work, and 2200 hours (41.7 per cent) for work in the laboratory.

It was not an easy task to define *the volume of specialized education*, to select fundamental and basic subjects so that without their being broken up into special sections they should adequately serve the requirements of special training within the limits set by the plan. The fundamental subjects had to form the basis for both the synthetic and the biological directions in specialization, too.

Some controversy had emerged around the question of the depth of specialized training for the several branches. Part of the industrialists that participated in the discussions of reform maintained that young engineers should know much more about technologies and chemical industry. They failed to appreciate that technical university training ought to convey knowledge that is well founded and of lasting value since most that a specialist will need to know may be learnt by experience and extansion training, while to acquire fundamental knowledge after a diplome had been granted is hardly possible or very difficult indeed.

In the deliberations over specialization the conditions obtaining in our country were kept in mind. We did not forget that ours is a small country, that though we have progressed and still want to progress further and the progress of our chemical industry and its application in other industries is especially fostered the demand for chemical engineers does not justify extensive specialization. At the same time, the ratio between the progress rates of the several branches of our industry is not amenable to rigorous planning and this also demands that chemical engineers should be trained who will be useful and happy in a diversity of chemical engineering jobs.

In accord with the interest evidenced by our students we have devised, as did the other Faculties, a system of facultative subjects to be taken up (in 30 hours). Thus students can go deeper into some special subjects, and also the scope of studies offered by the Faculty is extended.

*At the Chemical Engineering Faculty 4 years are consecrated to general training, and out of the total of 5 provided only the last one is dedicated to branch specialization.* If the time occupied by the working-out of the diploma thesis is not counted in, the divergence between the branches appears in one term only, i.e. in 80 per cent of one term time, calculated in hours. There are 540 hours on the average in one term, the sum total of hours, without those of diploma work, allotted to special subjects is 435.

## Education of chemical engineer students by evening courses

Evening courses are organized mainly for those already engaged in work in the chemical industry, to enable them to get a diploma of chemical engineering. By our Faculty a 6 year program of study by evening courses is offered, the same branches contributing as in regular tuition. Evening courses amount to 12 obligatory and 4 facultative lectures each week over 6 years, while regular studies involve 36 hours of study each week. On the average, 15 week make one term, or semester.

The program of studies of the evening courses for chemical engineering, 2820 hours in contrast to the 5280 of regular courses, does not reduce equally

the time allotted to the several subjects. This program puts relatively greater emphasis upon training in fundamentals; the ratio of this is 75.5 per cent in evening courses, and some subjects e.g. languages, physical training, etc. are not included.

## Specialized postgraduate engineering education, and scientific extension training

In the preceding we tried to impress how great an emphasis is being put on a strong training in fundamentals and that in specialist training only the most important technologies are dealt with. However, industry needs specialists, therefore, over and above the five year regular training of students, to chemical engineers with adequate experience a two-year specialized engineering training is made available. During this time engineers are doing their job proceeding with their studies at the same time [22]. Up to now, plastics processing, corrosion, pharmaceutical research, textile chemistry, pharmaceutical manufacturing technology, rubber technology, food processing technology, instrumental chemical analysis, and nuclear chemistry are the branches for which, according to the demand of industry, specialized training has been made possible. Within the system of these courses training in engineering economics is also provided for. Also this form of training involves examination in each subject, and a state-examination at the end.

After research work, the acceptance of a thesis that embodies some original scientific result, and the passing of the doctoral examination, our University will grant the candidate the degree of Doctor of Engineering.

There are several Departments in our Faculty where research fellows are doing their work for the scientific degree of Candidate of the Chemical Sciences granted by the Scientific Qualificatory Commission of the Hungarian Academy of Sciences.

## Summary

An outline of the evolution of chemical engineering education in Hungary is given. Details of the study program of the Chemical Engineering Faculty of the Technical University of Budapest, and the principles of its training system are discussed. In a somewhat closer scrutiny the results of the educational reforms implemented between 1960 and 1965 are dealt with and, finally, forms of extension study and of the granting of scientific degrees are presented.

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