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EDITORIAL

Chemical Engineering in Spain

In 1958, as part of the commemoration of the 50th Anniversary of the American Institute of Chemical Engineers, Professor Edgar L. Piret assembled a collection of articles in a book *Chemical Engineering around the World*. Professor Antonio Rius, from the University of Madrid, contributed with a 4-page report, which summarized the achievements of chemical engineering in Spain and the state of the Spanish chemical industry in the first half of the 20th century. Almost fifty years later, this is the first in a series of editorials to be featured in *Chemical Engineering Research and Design* detailing the state of chemical engineering in various countries from around the world.

THE CHEMICAL INDUSTRY IN SPAIN

The chemical industry in Spain took the first significant step in its development in the last decade of the 19th century. The number of chemical companies increased dramatically from roughly 300 to 1500. Most of the companies produced inorganic chemicals (explosives, sulphuric acid, sodium carbonate, etc.). At that time, Spain was primarily an agricultural country, and the situation did not change much in the first third of the 20th century. The Spanish civil war (1936–39) impoverished the country and led to its commercial isolation from the rest of the world. Even after World War II, the situation in Spain was not favourable for industrialization, except in the coal mining and metallurgy sectors.

At the end of the 1960's, the chemical industry in Spain took an important development step, involving the building of refineries and production of petroleum derivatives. Most of the refineries started as public companies, and remained so until the 1980's. In its early development years the chemical industry was not very diverse; most of the technology was purchased from abroad, limiting the impact of domestic chemical engineering. In fact, until recently chemists and industrial engineers had responsibility for most of the work in chemical plants.

The recent history of the Spanish chemical industry is linked to the industrial strategy of the European Union (EU). Many small Spanish companies have been acquired by European or American multi-national companies. Among large Spanish companies, only a refining and petrochemical company (Repsol), remains truly Spanish. Nowadays, the Spanish chemical industry includes more than 3700 companies employing more than 135,000 individuals. Production has increased in the last five years at a rate *ca.* 4% per year, almost one percentage point above the average increase in the EU. Spain is now the seventh largest producer of chemicals in the world.

CHEMICAL ENGINEERING EDUCATION

The evolution of chemistry and chemical engineering in Spanish universities has followed industrial development in the chemical sector. Chemical engineering in Spain traces its roots to 1922 when it was first taught in faculties of chemistry and schools of industrial engineering. However, education was basically oriented towards industrial chemistry. It was not until 1944 when chemical engineering was properly taught at the faculties of chemistry, under the title of 'Technical Chemistry' or 'Doctorate in Industrial Chemistry'. The word 'engineering' was reserved for the schools of industrial engineering, where only industrial chemistry was taught.

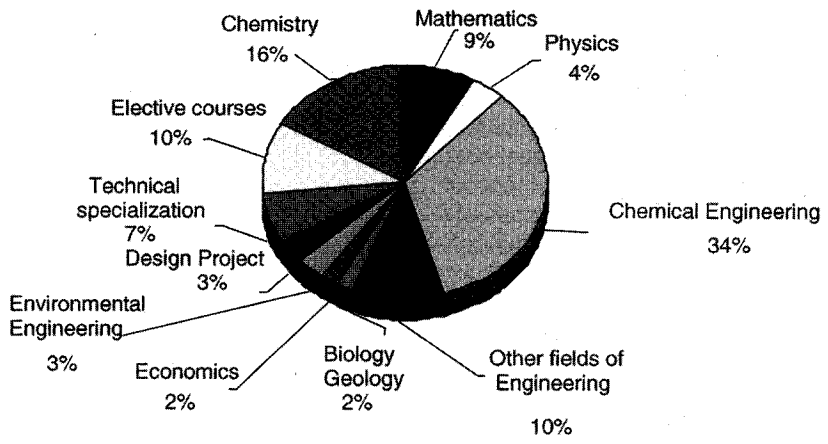

Figure 1. Course distribution in Chemical Engineering in Spain

Chemical engineering is taught in Spain at two levels: Technical Chemical Engineer and Chemical Engineer. The technical degree is a three-year programme offered by schools of industrial technical engineering and provides professional graduates oriented towards chemical plant applications. The chemical engineer degree needs more qualifications, and is granted by faculties of chemistry and schools of industrial engineering.

A national university decree issued in 1976 allowed more flexibility in university curricula and chemical engineering was taught, a few years later, as a two-year specialization in chemistry. The new university law of 1983 and a decree in 1992 established the degree of Chemical Engineer and major changes have occurred in chemical engineering education since then. The duration of the current undergraduate chemical engineering programmes in Spain is five years. Teaching activities comprise approximately 3400 hours (lectures, problem discussion sessions, and laboratory classes). The distribution and components of curricula may vary from one university to another, but the basic curricula are distributed approximately as shown in Figure 1.

Almost every chemical engineering department in Spain has a specialization option in the fifth year. The most common options are Process Engineering, Bioprocesses, and Environmental Engineering. In each specialization, students are required to take five specific course modules and they must work on a design project in their area of specialization. A common feature of chemical engineering undergraduate education in Spain is a strong chemistry background and extensive laboratory experience.

There are presently 70 universities in Spain (50 public and 20 private) with 34 departments offering a chemical engineering degree. In the past ten years, the number of students accepted by each department has been of the order of 100. However, enrolments have declined in the last two years, perhaps because of the large number of graduates (more than 2000 per year) and the scarcity of jobs for most university graduates. In fact, many of the students participating in Erasmus/Socrates programmes decide to pursue their careers in the country where they studied as exchange students.

GRADUATE PROGRAMMES

After the five-year program, students may proceed to graduate studies in chemical engineering. The programme consists of nine courses (300 hours of lectures), which should be completed during the first two years, and a thesis project. After the first two years of courses and research, the graduate student has to present in front of a faculty committee the preliminary results of the research, as well as objectives and plans for subsequent research work leading to a PhD thesis. The PhD thesis is defended in front of a committee of five members (two of whom are usually from the candidate's department, but the thesis director does not serve on the committee). The graduate programmes have attracted many students from South American countries, as they find them to be a good educational experience with the advantage of a common language that facilitates programme completion.

CHALLENGES FOR THE FUTURE

Chemical Engineering is well established in Spain and teaching and research have progressed substantially in the past two decades. Faculty members are very productive in terms of publications, relative to some high-ranked peer institutions abroad. International courses are offered in some universities, with wide participation by foreign students. However, there are many challenges that should be faced in the future:

- *Bologna agreement.* The Bologna agreement (June 19, 1999) must be implemented by year 2010, with the goal of promoting a more uniform European system of higher education. Chemical engineering in Spain is already oriented towards the Anglo-American model, but a new framework must be designed to accommodate both Technical Chemical Engineers and Chemical Engineers, because both types of professionals are needed.
- *Mobility of professors.* The 1983 university law changed the system for access to professorial positions leading to frequent inbreeding of faculty, with little mobility. The absence of mobility is a problem that must be addressed to promote innovation and transfer of ideas for improvement of research and teaching programmes
- *Employment of chemical engineers.* The job market for chemical engineers in Spain is currently depressed. Industry must promote more research and design activity to compete in the international marketplace. Continued progress by the chemical industry in Spain will require close relations with the educational system, academic research programs, and extensive interaction with the research institutions, both private and governmental. Furthermore, universities will have to consider their graduate output, which far exceeds the needs of the country.
- *Infrastructure needs.* In the past decade resources for research have improved substantially, but the laboratory facilities for teaching have not improved to the same extent. If the EU wants to promote mobility of students and high educational standards, Spanish universities will have to upgrade their teaching laboratories, in order to continue providing chemical engineers with the education necessary to be productive contributors for both their employers and society at large.

Professor José Coca
University of Oviedo, Spain
Subject Editor – Separation Processes