What is Chemical Engineering ?

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As was noted in the editorial of the second issue of Zede, the chemical engineering field has already experienced lack of people in the profession. There is only one Ethiopian chemical engineer in the major established chemical process industries: sugar and cement mills and petroleum refinery. A paper mill which is to be integrated with a pulp mill at a later stage is under construction. Expansions or vertical and horizontal integration of these or similar industries and the establishment of new ones may be expected in the not too distant future. If something concrete is not done now the dependency of the country on expatriate chemical engineers will be more and more acute. The objective of this article is, therefore, mainly to inform students at high school and college levels what chemical engineering is and what it has in store for them and the country.

Chemical engineering is not easy to define. In its broad sense it is a field which deals with chemicals and process industries. A quotation from an article in Chemical Engineering Progress (June 1964) commenting on a motion picture prepared to interest American teenagers in chemical engineering may perhaps put some light on this definition. The article states that "chemical engineering starts with general concepts, enlarges upon them through theoretical calculations, proves them out in pilot plant developments and economically brings them to fruition in commercial sized plants".

From the above quotation one can visualize that some steps are involved in developing a laboratory chemical product. The first step is mainly the domain of a chemist. In his laboratory a research chemist discovers or makes by either synthesis or decomposition a chemical substance and determines its chemical and physical properties. If and when he proves that some of the chemical's particular properties qualify it for some profitable end use, the chemical engineer comes into the picture. It is up to him to develop a process or technique for large economical scale of production. This he accomplishes by stages which are at times time consuming and may involve a lot of expense.

The first stage is mainly paper work. It consists of accumulating technical data from existing literature (if available), selecting the most suitable process and making theoretical calculations of inputs and outputs (material, energy etc. balances). These together with his knowledge of the chemical and physical properties of materials enable him to design a pilot plant, a small experimental plant made up of replica equipment to simulate the desired ultimate full scale process. (The pilot plant is nowadays being replaced by a micropilot which is multipurpose, safer, more flexible and cheaper.) This is done through the help of flow sheet or chart which is a co-ordinated sequence of unit processes and unit operations to be defined later. It is through the pilot plant that the most suitable conditions for the manufacture of the product in question are determined. Erection and operation of the pilot plant is the next stage. During operation the chemical engineer together with the chemist learns and solves both expected and unexpected difficulties, difficulties such as chemical reactions, yields, corrosion and defects in materials of construction. The desired end result at this stage is to definitely establish the feasibility of economic production of the chemical and thereby show the order of magnitude of the profit that may be expected from a large scale plant.

Based on the final results of the pilot plant, designing of the large scale plant is done by what is known as the scale-up technique. Erection and then operation of the plant follow. Because of process trials to strike equilibrium throughout the process, start-up and attaining production at rated capacity takes a considerable time especially if the process is conducted for the first time.

The stages enumerated above are but a brief outline of a general nature, usually followed in developing a new process or venture. Some of the steps, especially the pilot plant idea, may be dispensed with when dealing with processes and operations that have been done before on a large scale for the same or similar product or process.

Another way of looking at chemical engineering is through its unit operations and unit processes. The former are physical operations for industrial handling of chemical and allied products, such as, evaporation, extraction, filtration, drying, crystallization and conveying which are common to a number of individual processes or industries. The latter are chemical reactions involving chemical changes. Neutralization, nitration, halogenation, esterification, polymerization and pyrolisis are examples of unit processes. Both unit operations and unit processes, the very tools of the chemical engineer, may be applied independently or simultaneously, as the case may be, and are the features common to the wide and diversified nature of manufacturing procedures of chemical and allied products.

A different approach to the understanding of the meaning of chemical engineering could be the identification of the major subjects that a student of chemical engineering is supposed to follow. Attempts have been made by the Committee on Chemical Engineering Education of the American Institute of Chemical Engineers to evaluate the relative importance or weighting of the major subjects in chemical engineering. The results of the said attempts are shown hereunder:

Chemistry ...	28	Physics ...	8
Cultural	15	Mechanics	6
Other engineering	14	Elective ...	3
Mathematics ...	12	Other sciences	2
Chemical Eng.	12	Total ...	100

As may be expected chemistry takes the lead. The relative weighting of chemical engineering is however surprisingly small compared to, say, cultural or other engineering. It consists mainly of the unit operations and unit processes already mentioned. Metallurgical, mechanical and electrical engineering and geology are the main subjects included under other engineering. A broad background or understanding in such related fields is essential for all the steps involved in commercialization of an idea conceived in a laboratory.

Commercialization of an idea means production and delivery of a product at the lowest possible cost to another industry or the consuming public. This statement implies the important role that economics, practical or engineering economics in particular, may be expected to play in chemical engineering. Although not explicitly shown as such in the weightings it is an essential tool for the chemical engineer. According to the American Institute of Chemical Engineers "chemistry, physics and mathematics are the underlying sciences of chemical engineering, and economics its guide in practice".

An alternative way of acquainting oneself with chemical engineering is through its coverage in terms of commodities. Reference to the revised Standard International Trade Classification of the United Nations is probably the best approach to this. Section 5 of this classification groups the 100,000 odd chemicals into the following nine general divisions:

51. Chemical elements and compounds;
52. Mineral tar and crude chemicals from coal, petroleum and natural gas;
53. Dyeing, tanning and colouring materials;
54. Medicinal and pharmaceutical products;
55. Essential oils and perfume materials, toilet, polishing and cleansing preparations;
56. Fertilizers, manufactured;
57. Explosives and pyrotechnic products;
58. Plastic materials, regenerated cellulose and artificial resins;
59. Chemical materials and products, not elsewhere specified.

It should be noted here that the above classification is strictly for the so called chemical commodities. The expression chemical and process (allied) industries encompasses a much wider and diversified field The production of ceramics, glasses, cements, oils, fats, sugar, dairy products, starch, yeast, malt, spirits, leather, pulp and paper, petroleum products and metals and their alloys, for instance, all involve unit operations and unit processes, characteristics of the chemical industry. Whether they are classified under building materials industry, food processing, petroleum refining. metallurgy etc. the important role of the chemical engineer in their manufacture or processing is obvious.

To summarize, chemical engineering deals in practical research on new and old products and their applications; development and evaluation of new and improvement on known processes and designs taking into account alternative raw material and technological routes for the same end-product; design, installation, start-up, operation, improvement and management of manufacturing units and marketing of products. If one were to observe the possible permutations and combinations of these general fields of specialization with, say, a few hundred of the thousands of odd products of the chemical industry, the most dynamic and the fastest growing industrial sector in the world, one can see that the chemical process industry is unsurpassed in diversification, scope, challenge, excitement and opportunities it can offer to those who would make it their field of choice or profession.

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