Versatility of Chemical Engineers

By Ir. Ts. Shum Keng Yan

Did you know that a chemical engineer can be found in almost every industry? When I was flipping through Shreve's "Chemical Process Industries" in my undergraduate years, I was surprised at the breath and scale of the industries covered. In fact, the chemical engineer has branched into even more industries today.

Let us look at what makes chemical engineers so versatile. Let's begin with the chemical engineering programme.

The chemical engineering programme is not well understood by the general public. I recall when I was contemplating which engineering programme to pursue, my career counsellor advised me that since I wanted to be an engineer and I enjoyed chemistry, I should pursue a chemical engineering degree! Over 25 years later, some of the chemical engineering undergraduates I met still share the same story with me. One common surprise that we found out was it was more than just chemistry!

Creating Versatility

So, what is chemical engineering? What does the programme prepare us for?

Chemistry and the understanding of the physical laws provide the fundamentals that define a process. In addition to the chemistry of things, the chemical engineering programme prepares the future engineer to:

1. Understand what needs to be produced;
2. Design the optimal process that considers cost, efficiency, quality, environmental, health, safety, sustainability and social impacts;
3. Determine the best choice and quantity of raw materials;
4. Select the necessary equipment;
5. Maximise the use of resources (energy, water, utilities) during the manufacturing process;

Chemical engineers can apply skills in various industries

6. Work with almost all the other branches of engineering, as well as finance, regulators, IT and the list goes on....to put everything together;
7. Engage various stakeholders to "sell" the process; and
8. Manage the project to make all the above a reality!

It is a remarkable balancing act and it requires understanding of the various branches of engineering.

Thus, a chemical engineer brings forth certain skill sets in:

1. Process design;
2. Process integration;
3. Process control;
4. Equipment selection;
5. Technical problem solving;
6. Analytical problem solving;
7. Environmental, Health, Safety and Sustainability;
8. Optimisation; and
9. Value creation.

Professor Ir. Dr Abdul Aziz, the Deputy Vice Chancellor (Student Affairs) of Universiti Malaya

and former Chairman of the Institution of Chemical Engineers Malaysia, shared his views on how the chemical engineer is able to work in multiple industries as we are trained to apply the fundamentals and solve problems in a very systematic way.

Professor Ir. Dr Abdul Aziz explained, "We are process driven and value adding. What we study are fundamentals that can be applied in various industries. The core syllabus does not change. We add in enablers such as the application of software and new technologies."

He added an analogy in how producing undergraduates is similar to the chemical engineering processes: *The students are raw materials in a chemical reactor (university). We will have a residence time (the time spent in the programme) and the right pressure (assignments, projects), volume (breadth of syllabus) and temperature (the author still recalls the heat of deadlines and exams...) to produce the final product (a graduate). There is even a relief valve for the pressure in social activities!*

Chemical Engineers are Everywhere

Along my own career, I have encountered chemical engineers in these ponds:

1. Manufacturing and Production;
2. Research and Development;
3. Engineering Consultancy, Design and Services;
4. Contracting;
5. Risk Management;
6. Environmental Sustainability and Green Technology;
7. Health and Safety;
8. Education;
9. Digital technology; and
10. Regulatory services.

Ts Tania Jessica Lai, a chemical engineering graduate of Curtin University, shared, "We can experience major career shifts and yet still be in chemical engineering. It is so diverse and flexible that you can be in process engineering or environmental engineering or even engineering flavours for the kitchen!"

Ts. Tania's career started in Quality Assurance and eventually moved into Environmental, Health and Safety. She reflected, "I have worked in industries such as feed production, insulator technology and building solutions. I am still able to touch these industries by solving problems in the chemical engineering way. This is what I call versatile." Today, Ts. Tania is an Industry Advisory Panel member in Taylor's University School of Computer Science and Engineering.

Bringing Versatility to Industry

I tapped Ir. Dr Yeoh Hak Koon, an Engineering Manager and a former lecturer in chemical engineering for his insights into the needs of academia and industry.

"I think the syllabus varies between universities. Some allow a wider latitude while others are more focused. Mass and energy balance, equipment design and selection, plant design, control loop development, are the core courses that enhance such versatility. Beyond these, computer programming, strength of materials, corrosion, introduction to civil and structural engineering, biotechnology, design codes, laws, finance, human factors, the arts of communication complement the wider reach," he elaborated.

In industry, he reminded, "Although, we cannot do all the engineering calculations, we are more keenly aware of the needs and constraints posed by other dimensions of engineering. In short, systems thinking, and multi-disciplinary exposure makes chemical engineers versatile."

Ir. Dr Yeoh did caution that we should guard against over-reaching and end up being jacks of all trade and experts of none. The core competency of mass and energy balance, control loop development, equipment design and selection must remain the chemical engineering specialty.

His comments struck a chord, as I reflected my days running projects — chemical engineers need to understand for example: foundations but not enough to design a plinth; area classification but not enough to design electrical systems; piping and instrumentation diagrams (P&ID) but not enough to design the instruments; etc.

Preparing Future Chemical Engineers

Professor Ir. Dr Abdul Aziz's comment: "We add in enablers such as application of software and new technologies" echoed in my mind. How do we enable chemical engineers for the future?

I decided to seek further inputs from Dr Mah Shee Keat, Head of the Department of Chemical Engineering, Universiti Tunku Abdul Rahman (UTAR). He reasoned: *As educators, we have to constantly remind ourselves that the industries in the 21st century no longer only demand chemical engineers with technical expertise, but also with the abilities to communicate, to collaborate, to be creative and think critically in solving complex problems and continuously advancing personal knowledge. It is no longer adequate to revise the curriculum every time to suit current needs because whatever skills which are crucial in the current scenario may be obsolete in four to five years' time except fundamental knowledge. This is the reason in which it is more important to inculcate the versatility and problem-solving skills to graduates while they are learning the specific skills that are crucial for their chemical engineering profession. We have to shift the focus of the curricula from knowledge to capabilities and character building. They have to learn to see things in a bigger picture, and we have to put the knowledge into context – the holistic view, showing the connectedness between knowledge and real-world phenomena, and the consequences of their actions. The learning is then to be converted into solutions to solve real-life problems with real-life implications.*

Thus, UTAR implemented open-ended laboratory assessments where undergraduates are now encouraged to devise their own solutions to solve a given problem which may be multi-disciplinary in nature instead of merely following a given set of procedures as done in the past. The aim is for students to seek and decipher the relevant information swiftly and leverage them efficiently to achieve their goals.

Professor Dr Ezzat Chan from the Department of Chemical and Environmental Engineering, Malaysia-Japan International Institute of Technology, Universiti Teknologi Malaysia (MJIIT) had the same views with regards to the soft skills being key. Soft skills can be viewed as "Human Skills" or *Ningen Ryoku* which is incorporated into the MJIIT programme. Professor Dr Ezzat Chan shared that MJIIT offers a unique learning experience where the undergraduates are provided with immersive Japanese culture as they further their studies through learning the Japanese language with many opportunities to be in Japan. In addition, the academic staff includes professors from renowned Japanese universities. These mechanisms provide the platform for the undergraduates to be exposed in Japan for a semester for credit transfer, or to fulfil their industrial training; through the Sakura Exchange programme, Global Mobility Programme and many more.

I further consulted Dr Ramuna binti Mohamed, a Deputy Director in a department within the Ministry of Human Resources. She explained, "Chemical engineering is about converting the less valuable to more valuable in the most economical and efficient way possible. Chemical engineers do not only take care of the processes in industries but also design it and the equipment involved in the process. The job of chemical engineers is not restricted to only the process equipment but also the utilities required to run that equipment.

"It is inter-disciplinary in nature. Chemical engineering is found in a wide variety of aspects. From the use of micro-organisms as in fermentation to electronic devices as in control systems, from solid state crystallisers to plasma reactors," she added.

Dr Ramuna envisaged that future chemical engineers need to look into emerging areas such as:

1. Industry 4.0 and its nine pillars;
2. Advance process control;
3. Nanotechnology;
4. Safety and health especially in chemical plants or chemical manufacturing processes;
5. Failure analysis in chemical plants or chemical manufacturing processes;
6. Energy regeneration;
7. Green Technologies; and
8. Insulation materials for heat transfer or heat generation equipment.

The general agreement is the ability to collaborate across different engineering fields and balance the dynamics of different stakeholders to bring efficient processes to reality.

The future chemical engineer must continue to be adaptive in the new highly disruptive world by tapping into lifelong learning and having a solid foundation of the process fundamentals.

The career of a chemical engineer is certainly far reaching, evolving and versatile! ■

Note: The interviewees' roles are correct at the time of writing (November 2020).