e-Portfolio of Elementary Principles of Chemical Processes

LECTURER: Dr. Aznizam bin Abu Bakar

SECTION: 08

LECTURE TIME: Lecture 8.00 am - 10.00 am

Lecture 8.00 am - 9.00 am

Tutorial 9.00 am - 10.00 am

This course introduces student to the chemical engineering profession and the fundamental operations of chemical process equipment. It also provide students with the basic principles of chemical engineering material balances as well as calculation technique to solve material balance problems for chemical process system and equipment. It also provide students with the basic principles of the First Law of thermodynamics and its application.

WEEK 1

1.Introduction to engineering calculation
1.1units and dimensions
1.2conversion of units
1.3system of units
2.Process and process variables
2.1Mass and volume
2.2Flow rate
2.3Chemical composition
2.4Process and process equipment in chemical industry

We have learn how to convert one set of units in a function or equation into another equivalent set, other than that we also learn to calculate the composition in term of mole fractions and vice versa when the composition of a mixture is given in term of mass fractions. Determine the average the average molecular weight of a mixture from the mass or molar composition of the mixture.

WEEK 2
3. Fundamentals of material balances
3.1Process classification
3.2Balances
3.3Material Balance calculation

We define a system and draw the system boundaries for which material balance is to be made.An open and closed system we learn to differentiate them.

WEEK 3
3. Fundamentals of material balances
3.4General procedures for single unit.

We wrote a set of independent material balance equations for a process. We also solve some set of linear equations, and solve one or two simultaneous nonlinear equations.

WEEK 4
3. Fundamentals of material balances
3.5Balances on multiple unit processes

To solve question in this chapter, we have been taught to solve problem by apply the 10 step strategy without chemical reactions.

WEEK 5
3. Fundamentals of material balances
3.6Balances on single or multiple unit process with recycle and bypass

We learn how to draw a flow diagram for problems involving recycle, bypass and purge. We can apply the strategy to solve steady state problems with and without chemical reaction involving recycle, and/or bypass, and/or purge streams.

WEEK 6
4. Material Balances on reactive processes
4.1Chemical reactions stoichiometry
4.2Limiting and excess reactants, fractional conversion, extent of reaction and chemical equilibrium
4.3Multiple reactions, yield and selectivity

Learned to write and do a balance chemical reaction equation and identify excess reactant, limiting reactant, conversion, degree of completion, selectivity and yield in a reaction.

WEEK 7
4. Material Balances on reactive processes

4.4 Balances on reactive system using the atomic, molecular and extent of reaction approach

Applied the material balance equation when chemical reactions occur and the strategy to solve problems involving chemical reactions.

WEEK 8
4. Material Balances on reactive processes
4.5Balances on reactive system involving recycle
4.6Balances on reactive system involving purging
4.7Balances on combustion reactions

Defined flue gas, stack gas, Orsat analysis, dry basis, wet basis, theoretical air (oxygen), required air (oxygen) and excess air (oxygen) also applied the strategy to solve problems involving combustion reactions.

WEEK 9
5.Single phase system
5.1Liquid and solid densities
5.2Ideal gases
5.3Standard Temperature and pressure
5.4Ideal gas mixture
5.5Equation of states for non ideal gases (EOS)
5.6Compressibility factor equations of states
5.7Compressibility factor equations of states for non ideal gases.

Wrote down the ideal gas law, defined and manipulated all its variables and parameters and their associated dimensions. Calculated the values and units of the ideal gas law constant R in any set of units from the standard conditions, also the reduced temperature, reduce pressure and reduced volume for real gas law and use any two of these parameters to obtain the compressibility factor, z, from the compressibility charts. Compressibility factors used and appropriate charts to predict the p-V-T behavior of a gas, or given the required data to find compressibility factors.Calculated the vapor pressure of a substances from an equation that relates the vapor pressure to the temperature, such as Antoine equation and look up the vapor pressure in reference books.

WEEK 10
6.MULTI PHASE SYSTEM
6.1Single component phase equilibrium
6.2The Gibbs phase rule
6.3Gas-liquid systems: One condensable component
6.4Multi component Gas-liquid system

Applied Raoult's Law for a single condensable species, other than that explained the meaning of ideal solution and the applicability of Henry's Law and Raoult's Law.Diagram used to determine the Bubble and Dew point temperatures and pressure, compositions and relative amounts of each phase in a two phase mixture and the effects of varying temperature and pressure on Bubble point, Dew point and phase amount and compositions.

WEEK 11
6.Multi phase system
6.1Single component phase equilibrium
6.2The Gibbs phase rule
6.3Gas-liquid systems: One condensable component
6.4Multi component Gas-liquid system

Applied Raoult's Law for a single condensable species, other than that explained the meaning of ideal solution and the applicability of Henry's Law and Raoult's Law.Diagram used to determine the Bubble and Dew point temperatures and pressure, compositions and relative amounts of each phase in a two phase mixture and the effects of varying temperature and pressure on Bubble point, Dew point and phase amount and compositions.

WEEK 12-WEEK 14
7. Energy balance for closed and open system
7.1The concept of the conservation of energy
7.2Energy balances for closed system
7.3Energy balances for open system
7.4A general procedure for energy balance
7.5Thermodynamics property tables

Stated energy balances in words and wrote the balance in mathematical symbols for closed system, simplified the energy balance equation in conformity with the problem statement and other information,enthalphy was calculated and internal changes from tables given the initial anf final states of the materials.

Prior to the following discussion on the fulfillment of this subject on the requirement of program specifications for bachelor in Chemical Engineering all eleven programme learning outcomes would be tabulated as follows:

Programme learning outcomes (PO)	Explanations/ descriptions
PO1: apply general fundamental scientific and chemical engineering knowledge	Utilize the suitable theories and principles (such as **thermodynamics, mass balance, energy balance, fluid mechanics, mechanics of materials, materials science**) in solving the design problems in the field of chemical engineering.
PO2: identify, formulate and solve engineering problems critically and creatively.	Relate the learnt theories and knowledge with the contemporary developments in the related fields and generate useful ideas to solve the problems in these fields; creativity and innovation are required to be incorporated in problem solving.
PO3: Plan, design and conduct experiments, analyze and interpret data, and apply the skills to chemical engineering practices	Plan and design experiments to collect related data for verification of certain problems found in the literature research, solving uncertainties regarding physical data in chemical processes, etc.
PO4: Select and design a system or process to meet the desired engineering, economic, health, safety and environmental requirements towards sustainable development.	Identify the requirements of sustainable developments in chemical processes (steps to control pollution, reduce cost, recycle and reuse unused materials to achieve material usage optimization, etc.), increase product quality, ensure safety and health requirements, etc.
PO5: Utilize computational techniques and skills (with appropriate tools) to solve problems in chemical engineering practices.	Solve or simplify problem solving procedures using computational techniques e.g. write C++ program to solve logical problems, create Excel spreadsheet to calculate the molar flow rate of product given certain conditions, etc.
PO6: Communicate effectively in both written and oral forms	Able to communicate effectively with course-mates and lecturers in the lectures, discussions, or when leading and conducting group assignment, experiments (lab), etc.

PO7: Function effectively as an individual or in a group	Able to work independently and with other individuals for project or assignment completion.
PO8: Lead a team by setting direction, providing motivation, delegating tasks and integrating contributions	Able to be an effective leader of a group to assign tasks, motivate and connect to team members, provide guidance and directives, and integrate contributions from members to form complete version of the task result.
PO9: Practice professional ethics, integrity and social responsibility.	Demonstrate ethics in professional practice (for example in environmental and social issues related to chemical engineering).
PO10: Display life-long learning skills	Possess ability and passion to seek for contemporary developments in chemical processes and equipments, pollution control technologies, etc; able to generate learning issues and find information through literature research based on reliable sources (with firm credentials)
PO11: Apply entrepreneurship knowledge in decision making	Able to relate business thinking in design of chemical processes, equipments or problem-solving.

It was found that not all program learning outcomes listed above were fulfilled by this subject; for instance, the generic skills such as leadership, communication skills, and team-working were mostly overlooked in conduction of teaching and learning of PCP 1.

In this subject, however, independent learning skills and life-long learning skills are very crucial in order to achieve thorough understanding of the topics covered in this subject. The term ‘thorough’ refers to the ability to relate the knowledge (albeit not sufficiently deep and comprehensive for such purpose) with the real chemical engineering industries and real applications, accompanied by the attempt to seek for contemporary issues and developments in this field. For instance, the chemical engineering students (in my opinion) should realize that exam-oriented learning style would not contribute to their future to achieve or perform as successful engineers in the future.

There are several individuals who had shared their views regarding the importance of critical learning skills (not bound by the syllabi); First of all is the PhD student in Chemical Engineering currently studying the microwave drying of substances under the high temperature thermal processing (N32 is the code of the building for this studies and related laboratory) named Ng Pang Soon. According to Ng, for academic purpose, the problems posed in the examinations, assignments, lectures and tutorials are not practical with idealizations of conditions and assumptions that help simplify the problem solving. For instance, in the elementary principles of chemical processes 1, the mass balance problems come with the equations and parameters required (such as mass composition, molar composition, equipments, and mass or molar flow rates/ mass or number of moles of the components of the process stream) but in real industry, the system would be very complex with an array of piping systems and different arrangements of equipments; and the quantities stated above as well as the state variables (such as pressures and temperatures) are unknown unless the chemical engineers are well-versed with the measurement of these parameters using appropriate tools (barometer, flow-meter, thermocouple), and dealing with the unsteady-state measurement errors.

Second individual sharing the common idea is an Engineering Mathematics 2 lecturer of section 63 namely Associate Professor Dr Ong Chee Tiong. He mentioned that the students should have engineering outlook from the very beginning since the course enrolment, that is, they should attempt to seek and investigate the potential fields to be explored and developed (related to the chemical engineering) such as development and invention of composite materials with desired properties and commercial benefits; and get involved in related researches with the researchers (most probably the lecturers).

Hence the students should plan their engineering outlook as early as possible to enable to seek for appropriate opportunity in the field of engineering studied;

Planning:

Integrated chemical processing- field of specialization

Goal: design chemical process to generate product.

In my case, since I am involved in the investigation of microwave drying and collection of data regarding the conditions of (pressure, temperature (influenced by heating mode) and dimension of samples i.e. thickness) drying process and how different conditions would contribute to different product outcomes in terms of appearance, microstructure, rehydration ability and moisture recovery, structure rebuilding during rehydration, nutrition loss, etc., my goal would be on design plant to mass produce dried food sample (dried jackfruit).

Requirement:

- Acquire technical knowledge in plant design (involve all core subjects in this four-year course).
- Collect data regarding the drying conditions and outcomes.
- Research on the contemporary drying techniques and compare them to deduce suitability to be applied or incorporated in the process.

Steps to be taken:

- Be lab assistant of related researcher (in microwave drying process) and conduct relevant experiments to get results (improvising and reorganizing data for compilation for future usage)
- Study and excel in chemical engineering core subjects i.e. **elementary principles of chemical processes 1 (basic mass balances and introductory energy balances)**, **fluid mechanics, chemical engineering computation, chemical engineering thermodynamics, transport processes, separation process, chemical reaction engineering, pollution control, analytical chemistry for engineering, physical chemistry for engineering, environmental engineering and sustainability, process control and instrumentation, plant design, engineering economics and project management, safety and health in chemical industry, biotechnology for engineers.**
- Be aware and seek for information related to the contemporary development in the chemical processes, instrumental tools, analytical techniques, discoveries, etc. through literature research and life-long learning. (**conference journal**, related materials by IEM, American Engineer Society, Icheme, etc., **seminars or talks** (such as talk regarding the **integrated Process Design**), etc.)

Assessment based on PO1:

The curriculum offered in the subject of Elementary Processes of Chemical Processes fulfills the first program learning outcome (which is based on the technical knowledge instilment of the learners).

The textbook of PCP 1 consists of extensive information regarding the chemical processes. In this subject, the learners could acquire the basic skills to deal with the mass balance of non-reactive and reactive processes involved in the single process unit system or multiple unit system (with and without recycle and purge streams).

Moreover, the techniques on doing basic energy balances on closed and open systems are also acquired as part of the learning outcomes. For further consolidation of knowledge in the field of chemical engineering, the learners are also provided with the CD-room uploaded with all useful information related to the equipments and tools common in a chemical plant such as **boiler, distillation column, absorber, scrubber, settler, decanter, flash column, compressor, piping, throttle, diffuser, nozzle, mixing tank, chemical reactor (batch or CSTR), evaporator, crystallizer, etc.**

Assessment based on PO2:

Creative problems are incorporated in the textbook to motivate the students to include innovation and creativity in problem solving. For instance, there are problems that require the students to state as many as possible the methods to measure air pressure or concentration of a solution.

However, this actually requires the students' own effort to attempt these problems independently and look for information through different resources since the lecturers usually would not emphasize on this aspect. Learning process using these problems would enhance the students' ability to think, plan and solve the problems innovatively.

In this context, the lecturer of this subject for section 05 had also demonstrated the teaching method using analogy to explain the principles of chemical processes; by relating the problems with the daily application would enable the learners to visualize the theories and enhance their creative thinking regarding the possible applications of the theories learnt in their daily life processes.

Assessment based on PO3

Due to the lack of laboratory session in this semester, the learners do not have the opportunity to acquire the skills to design, plan and conduct experiments to seek for required data for certain problem solving.

This would be fulfilled in the following semesters seeing the presence of fluid mechanics laboratory, process separation laboratory, pollution control laboratory, etc.

Assessment based on PO4

This learning outcome is only theoretically fulfilled. Elementary Principles of Chemical Processes has introduced the students to the economic design of chemical process through incorporation of recycle stream (which optimizes the overall process conversion) and purge stream to prevent the accumulation of inert components (that will lead to unsteady state and fluctuating operational state variables (pressure and temperature)); the cost for higher pressure and lower temperature during the operation (which lead to higher yield of product theoretically but not practical for real industrial operation due to requirement of extra thick piping and long period required for the attainment of chemical equilibrium at low temperature) is also included in the text.

The actual picture for this aspect would be more thoroughly covered in the **plant design, engineering economics and project management, and safety and health in chemical industry**.

Assessment based on PO5

There are plenty of computer problems in the text of Elementary Principles of Chemical Processes that require the students to write programming or spreadsheets for calculations. By working out such problems, the students would be able to acquire the skills of utilizing basic computational tools to solve the basic engineering calculation problems.

Assessment based on PO6, PO7 and PO8

The subject does not fulfill these three programme learning outcomes that are based on the learners' generic skills. The assignments given were not completed in group but only individually. Group project was not included as part of the teaching and learning processes unlike in the first semester (introduction to chemical engineering). However, this was understood to be the effect of heavier content of the subject matter compared to the last semester. The lecturers could only focus on the completion of the syllabus teaching and making sure that the students could understand the underlying concepts to be applied in problem solving (which is actually more on the technical side).

The lecturer of section 5 (Associate Professor Dr Ramli Mat) attempted to introduce English language-based interaction in his lecture but the response from students was not prominent.

Suggestion for overcoming this problem is by assigning group project (such as on designing a chemical process or calculation of mass flow rates in a chemical process plant) and makes this a part of the overall assessment of this project.

Assessment based on PO9

Ethics such as prevention from plagiarism and cheating during the examination were practiced by the students of this subject. The lecturer had also emphasized on the actions that would be taken to penalize those conducting such unethical acts, such as expelling from the course or loss of qualification to further take the core subjects in the coming semesters.

Assessment based on PO10

The instilment of the passion and sense of need of life-long learning through this subject can only occur if the students have the independent attempt to self-improve though independent learning process using the tools provided by the material, text and CD-room, as well as other resources available online or through literature research.

In the text, the learners are always encouraged to refer to the Perry's Handbook for Chemical Engineers to look for physical data such as boiling points, densities, specific volumes, specific enthalpies and specific internal energies for certain substances under given condition (combination of pressure and temperature).

Assessment based on PO11

The instilment of entrepreneurship and business thinking through such technical subject is actually difficult if it is taught without being accompanied by the case studies of the economic aspects of the chemical plant or process design and control. This would be dealt with in the final-year subject that is **engineering economics and project management**.