Chemical Reaction Engineering 2 (Heterogeneous Reactors) - Video course

COURSE OUTLINE

In simple terms, Chemical Engineering deals with the production of a variety of chemicals on large scale. Large scale production is associated with the engineering problems such as fluid flow, heat and mass transfer, mixing and all types of unit operations. These chemicals are produced through chemical reactions in a vessel called “Chemical Reactor”. Chemical Reactor is known as the heart of any chemical plant since the new chemicals are produced only in this vessel and the economics of the entire plant depends on the design of reactor. Chemical Reaction Engineering (CRE) deals with the design of Chemical Reactors to produce chemicals. The design of Chemical Reactors is based on a few simple and useful concepts. Though the concepts are simple, it is not easy for the students to develop a feeling for these concepts unless the teacher explains by giving different day to day examples with which the students are familiar with.

This is what I tried to do in these courses, one on homogeneous reactions (some call this as Chemical Reaction Engineering I) and heterogeneous reactions (some call this is as Chemical Reaction Engineering II).

After understanding the concepts, if we look at the subject of Chemical Reaction Engineering, it will be full of simple to complex mathematics. But, without understanding the concepts, the subject appears to be meaningless mathematical exercise and the student does not have “a feel for the design of the reactor”.

My experience at IIT Madras for the last 30+ years, unfortunately, is that, even most of the PG students who come for their Master’s and Doctorate degrees also do not have “the feel for the design of the reactor”. I find that this is due to lack of conceptual understanding of fundamentals of Chemical Reaction Engineering.

With this in mind, I tried to spend more time in explaining the concepts and physical understanding of the problems in CRE in terms of simple and familiar examples rather than spending a lot of time in solving a differential equation in the class. My belief is that once the student understands the concepts thoroughly, he/she develops a passion for the subject. Once the student is passionate about any subject, using mathematics or any tool to solve the problems is part of that unstoppable passion.

NP-TEL

NPTEL

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Chemical Engineering

Additional Reading:

1. Fogler, H.S., 1999, *Elements of Chemical Reaction Engineering*, 3rd Ed., Prentice-Hall, Englewood Cliffs.
2. Froment, G.B., and K.B. Bischoff, 1990, *Chemical Reactor Analysis and Design*, 2nd Ed., Wiley, New York.
3. C.G. Hill Jr., 1977, *An Introduction to Chemical Engineering Kinetics and Reactor Design*, John Wiley & Sons, New York.
4. Carberry, J.J., 1976, *Chemical and Catalytic Reaction Engineering*, McGraw-Hill, New York.
5. Smith, J.M., 1981, *Chemical Engineering Kinetics*, 3rd Ed., McGraw-Hill, New York.
6. Kunii, D & Levenspiel, O, *Fluidization Engineering*, 2nd Edn.

As all of us know, it is impossible to cover all aspects of CRE even in these two courses and hence I tried to address some important general aspects, where these general aspects can be extended to specific cases. For example in heterogeneous reactions, gas-liquid reactions will be part of gas-liquid-solid reactions (slurry reactor) in simple analysis. I could not spend time on gas-liquid and liquid-liquid reactions, but the methodology used to analyze other reactions e.g. gas-solid reactions, can be easily extended to these reactions.

To try put the students on the right track for learning, I was telling in the lectures some morals, some anecdotes, stories etc., whenever there is an opportunity. These may please be taken in the right spirit since my intention was to make the students learn as much as possible. I think that I have given enough introductions to these courses and it is time for you to explore. I always enjoyed teaching/explaining CRE and I hope that you enjoy listening to CRE!!.

COURSE DETAIL

Lecture Number	Lecture Topic
1	Introduction to Kinetics (Gas solid non-catalytic reaction)
2	Intro to Kinetics contd. for catalytic reactions in different reactors
3	Heterogeneous rate of reactions and different types of kinetic models for non-catalytic reactions
4	Basics of Kinetics of type A & B reactions (Shrinking core model & Porous particle homogeneous model)
5	Shrinking Core Model Contd.
6	Contd.
7	Contd. & Proof of Pseudo steady state assumption
8	Shrinking core model contd. for type D reactions
9	Contd.
10	Homogeneous reaction model & Design of non-catalytic gas solid reactors

Engineering, 2nd Edn. B&H, Boston.

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11	Design of non-catalytic gas solid reactors Contd.
12	Contd.
13	Design equation for MF of solids, uniform gas composition, const. single particle size, Shrinking core model.
14	Design equation for MF of solids, mixture of particles for different sizes but unchanging size, uniform gas composition, SCM
15	Design equation for MF of solids with elutriation, mixture of particles of different size, uniform gas composition, SCM
16	General Performance equation for non-catalytic gas solid reactions
17	Catalytic reactions (LHHW Kinetic model)
18	LHHW Kinetic model contd. Part I
19	LHHW Kinetic model contd. Part II
20	Industrially important catalytic reaction models
21	Inter and Intraphase effectiveness fator
22	Interface effectiveness factor & Generalized nonisothermal effectiveness factor for external mass transfer step…
23	Generalized nonisothermal effectiveness factor for external mass transfer step contd.
24	Mass transfer correlations for various reactors
25	Isothermal intraphase effectiveness factor Part I
26	Isothermal intraphase effectiveness factor Part II

27	Non-isothermal intraphase effectiveness factor
28	Inter & Intraphase effectiveness factor contd.
29	Inter & Intraphase Mass transfer
30	Packed (fixed) bed catalytic reactor design
31	Graphical design of Fixed bed reactors
32	Packed Bed Design Contd.
33	Design equations for Packed bed reactor design
34	Conservative Equations for Packed bed Reactor design
35	Problem solving session
36	Fluidized Bed Reactor Design Part I
37	Fluidized Bed Reactor Design Part II
38	Fluidized Bed Reactor Design Part III
39	Fluidized Bed Reactor Design Part IV
40	Contd. (Fluidized bed reactor Models)
41	Contd. (Davidson Harrison model and Kunii Levenspiel model)
42	Contd. (Kunii Levenspiel Model)
43	Slurry Reactor Design

References:

O. Levenspiel, Chemical Reaction Engineering, 3rd Edn, Wiley & Sons (1999).