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**Book review**

# Industrial separation processes: fundamentals

**André B. de Haan and Hans Bosch**
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Separation processes constitute an integral part of the chemical, oil, food and material processing industries. Nowadays, when the need for more purified chemical products becomes even more imperative, proper selection of a suitable separation technique and profound understanding of its operation principles are very important and critical.

The book contains 372 pages and is structured into 12 distinct chapters, each one describing a specific separation method. Chapter 1 serves as a general introduction to industrial separation technologies by providing a clear definition and classification of the separation methods, as well as, some important characteristics of their industrial applications. In particular, different separation mechanisms and, thereby, techniques are selected and applied for each mixture given its uniformity level and phase equilibrium behavior. Equilibrium-based and rate controlled processes are commonly employed for homogeneous feed – which will be described in chapters 2–5 and 6–8, respectively – whereas for heterogeneous mixtures mechanical separation processes are mainly preferred – which will be covered in chapters 9–11.

Chapter 2 deals with the evaporation method whose operational principle is based on the different volatilities of the compounds comprising the liquid mixture. Apart from the presentation of some characteristic thermodynamic factors of the vapor-liquid equilibrium, the chapter also elaborates on some fundamental design and operating parameters of both single-stage and multistage distillation columns. In the case of a multistage distillation column, the determination of the required number of stages for a desired separation can be achieved either graphically by the McCabe-Thiele method, or analytically by the Fenske-Underwood equations.

Chapter 3 describes the principles of gas absorption and the design procedure of an absorption and desorption column. More specifically, this method takes advantage of the different solubility of a certain compound or compounds of a gas mixture in a given liquid solvent with the view to achieving either a purified gas or an enhanced product recovery. In terms of the absorber/desorber design approach, the steps for calculating the operating lines and the minimum required stages of the columns are comprehensively provided for both the graphical McCabe-Thiele method and the analytical Kremser equation. At the end of the chapter, an overview of the available industrial absorbers and their function is presented.

The focus of chapter 4 is mainly oriented towards the development of a proper model that enables the estimation of the minimum column diameter and height for a desired separation. By analyzing the mass transfer kinetics of a gas/liquid contractor and considering some important column design parameters that are discussed in the previous chapters, the appropriate equations are derived for the evaluation of minimum column dimension and pressure drop under different liquid/vapor flow rates.

Chapter 5 is devoted to the liquid-liquid extraction method which mechanism is based on the relative solubility of the mixture components in two different immiscible solvents. The equilibrium behavior of a liquid-liquid mixture is fairly discussed while stressing the importance of selecting the appropriate solvent for an effective extraction. Essential design parameters, like extract, raffinate, minimum solvent mass flow rates and required number of stages of a countercurrent extraction for a totally immiscible system are provided based on the same graphical and analytical methods discussed previously, whereas for partially immiscible mixtures a different graphical approach is considered for the estimation of the same design criteria. In the last section of this chapter various configurations of available industrial liquid-liquid extraction systems, as well as, a selection scheme for a suitable extractor given the desired separation are exhibited.

Chapter 6 focuses on the adsorption and the ion exchange processes in which gas or liquid compounds are attracted on a solid surface, called absorbent. The selectivity and the capacity of an absorbent material are determinant of the separation efficiency and are dependent on the value of the specific surface area of the absorbent. Among the widely proposed adsorption isotherms, the most applied is the Langmuir isotherm which is studied thoroughly in this chapter. Moreover, fundamental

principles and characteristics of ion exchange method are also discussed at the last section of the chapter.

In chapter 7, the separation process of drying is introduced which actually entails the removal of any liquid solvent from a solid by evaporation. The definitions of certain factors associated with the humidity of the carrier gas and the moisture captured in the solid are given and their influence on the drying process efficiency is explained to an extent.

Chapter 8 deals with the crystallization method which separates the desired solvent in a solid form. Some important characteristics of the crystallization process are the morphology, the size distribution of the generated crystals and the employed supersaturation technique. Some critical parameters that should be taken into consideration when modeling and designing a crystallizer are the degree of supersaturation, the nucleation mechanism and the crystal growth.

In chapter 9 the sedimentation process is presented in which the settling of suspended solids out of a liquid mixture takes place under the effect of either gravity or centrifugal force. Sedimentation induced by gravity is closely associated with certain mechanisms, such as dilute sedimentation, hindered settling etc., that determine the settling rate and concentration of the suspended solid particles. Moreover, various types of industrial-scale centrifuges are described in terms of their capability and other related inherent operational characteristics, like the capacity and capability of disc and bowl centrifuges, respectively.

Chapter 10 focuses on the fundamentals of filtration process which are commonly used in the separation of solid compounds from a liquid or gas stream. Apart from providing the necessary terminology to evaluate the performance of cake filtration, intense interest has been also placed on the interceptive filtration and the techniques that employ the particular mechanism.

Chapter 11 argues the function and principles of membrane filtration which is a continuation of the previous chapter with the only difference being the membrane which is used as the studied filtration medium. Microfiltration, ultrafiltration and nanofiltration are some categories of membrane filtration based on the size of the treated solid particles.

Last but not least, the aim of chapter 12 is to provide a guideline for the selection of the appropriate separation method based on the characteristics of a given mixture. Significant role in the aforementioned decision-making procedure play the product economics, the operational scale, the feasibility and the reliability of the selected separation method/process.

The book aims at undergraduate and graduate chemists and chemical engineers who are interested in getting familiar with the available laboratory and industrial separation techniques, as well as, the fundamentals and mechanisms that govern each technique in a comprehensive and methodical way. The book is well-written and follows a certain structure that facilitates the profound reading and comprehension of basic concepts and terminology. It provides a clear theoretical framework of the separation process design principles and also illustrative examples of industrial-scale separators making, thereby, the knowledge transfer more effective and efficient.

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