Chemical Engineering for Non-Chemical Engineers

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In a career that has spanned almost 50 years, four organizations, and teaching publicly for the past 15 years, I have to ask myself, "How did all this happen?" An excellent education from Carnegie Mellon University was the start. The opportunities, both technical and managerial, at Dow Chemical, the National Center for Manufacturing Sciences, Ansell Edmont, and Cabot were all important. My accidental introduction to Inventive Problem Solving ("TRIZ") was another. The opportunities to teach "Essentials of Chemical Engineering for Non-Chemical Engineers" for the American Institute of Chemical Engineers and to serve in leadership positions in its Management Division and on its national Board of Directors were the final experiences. But what was the common factor? You cannot move a family multiple times and pursue these opportunities without the support and glue that keeps things together and supports your dreams and ambitions. Sincere thanks to my wife, our four daughters, and our wonderful grandchildren for years of love, dedication, and unyielding love and support.

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Preface

Prior to 1908, individuals in the United States who practiced chemistry on an industrial and commercial scale were members of the American Chemical Society. As you might imagine, and as we will discuss in significant detail, the practice of chemistry on a laboratory scale is quite different and offers significantly different challenges than that same chemistry practiced on an industrial scale. In 1908, in Pittsburgh, Pennsylvania, a group of these individuals held the first meeting of the American Institute of Chemical Engineers, an organization I have been proud to be a member of since 1967, upon my graduation from Carnegie Mellon University.

Today what we know as chemical engineering is practiced in every country around the world. Chemical engineers are employed by nearly every Fortune 500 company in the United States and every large industrial organization in the world. Chemical engineers are employed in the global oil, gas, and petrochemical industries, enabling our entire transportation system. The roads we drive on are manufactured from petroleum products or high-temperature chemical processing of sand and aggregate. In government, chemical engineers serve as employees of the Environmental Protection Agency, the Chemical Safety Board, the Department of Homeland Security, and agencies involved with the oversight of the shipment and processing of chemicals and materials by land, sea, and air. Chemical engineers, in the industrial world, work for energy, food, and consumer companies who produce the energy that heats our homes, powers our cars, and provides the myriad of products we use every day (and take for granted) including simple things as toilet paper and food wrap materials used in packaging and protecting goods; construction materials used in our homes, buildings, and roads; and products that protect our homes and food products from pests and spoilage. They develop products and systems used in photography systems, security systems, and sensor systems. They have developed processes to separate air into its individual components, such as nitrogen and oxygen, allowing the prevention of fire hazards, emergency breathing equipment, and frozen foods. There is virtually nothing that we use or interact with in our daily lives that has not been developed, commercialized, and enhanced by chemical engineers and the knowledge base of chemical engineering.

This book is not intended to be an academic textbook in chemical engineering with detailed equations and complicated mathematical models (there are many excellent ones already available), but to be a layperson's text on what chemical engineering is, its basic principles, and provide simple examples of how these principles can be used to estimate and do rough calculations for industrial equipment and applications. This book is an outgrowth of my teaching a course for the American Institute of Chemical Engineers for the past 15 years entitled "Essentials of Chemical Engineering for Non-Chemical Engineers" (http://www.aiche.org/academy/courses/ch710/essentials-chemical-engineering-non-chemical-engineers). This course has been taken by chemical plant technicians and operators, chemists, biologists, EPA lawyers and interviewing accident psychologists, and Department of Homeland Security inspectors, as well as mechanical and other types of engineers who interact with chemical engineers on a daily basis but may not have a fundamental understanding of the data they are asking for and why, how this information is used, or why they may be asked to perform certain functions in a given way or in a specific order. It is also designed for managers of departments in large organizations, small start-ups, and in organizations who supply equipment and assistance to the chemical industry, but who are not personally chemical engineers. It is also directed at those who are responsible for chemical engineering activities but need a more thorough understanding of what they are managing or directing. A final interested group may be students now entering chemical engineering graduate programs coming in from outside the traditional chemical engineering undergraduate curricula and may find a basic overview helpful in their transition. To all of these potential readers, I hope this book provides some basic understanding and value.

The book is divided into chapters, each focused on a particular aspect or unit operation in chemical engineering and an appendix with the following structure:

1) A discussion and review of the topic basics, using illustrations of equipment where possible
2) A list of general discussion questions for your use within your organization
3) A set of multiple-choice questions on the materials in the chapter, with answers and explanations in the appendix to the book

As we walk through the basics of chemical engineering, the brewing of coffee will be used as an everyday example of the application of many of the principles to an operation that most of us do every day without thinking about the technical principles involved. We will also discuss, at the beginning and end of the book, how chemical engineering principles are used in the manufacture of beer.

Additional materials in the appendix include references and links for MSDS and safety-related material as well as commentary on future challenges for chemical engineering.

At the end of each chapter, a list of additional resources, primarily from AIChE's flagship publication, *Chemical Engineering Progress*, is included. The AIChE website is at www.aiche.org.

Appendix I contains commentary regarding future challenges for chemical engineering. Appendix II contains a list of on line sources of information related to each chapter. Appendix III contains the answers to the multiple-choice questions.

Acknowledgments

For the past 15 years, it has been my personal and professional pleasure to have taught a course for the American Institute of Chemical Engineers entitled "Essentials of Chemical Engineering for Non-Chemical Engineers." AIChE allowed me to teach the basics of a profession that has been the core of my professional life to a variety of people that I could never have imagined. These have included chemists, laboratory and process technicians and operators, other types of engineers, managers of chemical engineers with a different background or training, business managers, safety and health professionals from the government and private sector, patent attorneys, equipment vendors, and psychologists. They have often taught me as much as I knew from their hands on experience in particular areas. I also gratefully acknowledge all my professional colleagues at Dow, the National Center for Manufacturing Sciences, Ansell Edmont, and Cabot—all of whom have advanced my knowledge of chemical engineering and its application in a myriad of applications.

AIChE's flagship publication, *Chemical Engineering Progress*, has been a continuing source of ideas, illustrations, and examples, and this publication will be used and cited throughout this book. Other web-based resources are also used for equipment illustrations and these will be cited at the appropriate time.