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Book review

RULES OF THUMB IN ENGINEERING PRACTICE

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WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, Germany
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The book ***Rules of Thumb in Engineering Practice*** is a synthesis of data from the author's experience which can help the engineers solve problems concerning process design, improvement, operation and maintenance.

The author Donald R. Woods, who is Professor Emeritus of Chemical Engineering at McMaster University, conducted research in the field of process design, cost estimation, surface phenomena, problem-based learning, assessment, improvng student learning and developing skills in problem solving, group and teamwork, self-assessment, change management and life-long learning.

The book is structured in ten parts and appendices which include: units and conversion of units, dimensionless groups, vapor pressures, very detailed capital cost guidelines for different types of operations and equipment.

The book is thought out based on several rules of thumb (which are given a definition in the preface) devoted to guide engineers to make decisions, set goals, check results and help answer questions such as:

- When might something be used?
- How could an approximate answer be obtained?
- How might an approximate estimation of the cost be obtained?
- What is a reasonable operating know-how?
- What should be done when something goes wrong?

The author stresses the uniqueness of the book structure and highlights and gives some reasons which justify this feature:

- the consistency in terminology and units
- the consistency and its extensive cross-referencing
- the range of process equipment
- the depth and breadth of coverage for each piece of equipment
- the fact that it attempts to code the source of the rule of thumb
- the synthesis of the information
- the ability to consider issues not usually considered in books about rules of thumb

Chapter 1, *Rules of Thumb,* describes the concept and highlights the importance of rules of thumb for process design and engineering practice, including:

- the chemical process equipment
- the working conditions of certain equipment (materials, corrosion, process control, operation options: i.e. batch versus continuous, economics)
- the process conception considering the engineer's design and practice skills (referring to: problem solving, goal setting, decision making, thermal pinch, process design, process improvement, troubleshooting and health-safety-environment issues)
- inter-personal communication and teamwork as a part of process engineering
- the context in which engineers can perform (leadership, intrepreneurship, entrepreneurship, e-business)

It is emphasized the focus is on rules of thumb about process equipment for selecting, rough sizing, costing, operating and troubleshooting. Section 1.1 details the organization of these rules of thumb, while Sections 1.2 - 1.7 provide rules of thumb for selecting equipment considering the properties of materials, corrosion, process control, batch versus continuous and economics. Rules of thumb for process synthesis, based on the engineer's design and practice skills are given in Sections 1.8 – 1.16. A summary of the rules of thumb for the people, part of engineering (communication, listening, inter-personal skills and teamwork) is given in Sections

1.17 – 1.20. Sections 1.21 – 1.26 describe the context in which engineers work (performance review, leadership, intrepreneurship, entrepreneurship, e-business and self-management).

Chapter 2, *Transportation,* starts with some considerations on fundamentals of fluid movement. Sections 2.1 – 2.2 include aspects on gas moving, discriminating between pressure service and vacuum service. The discussion dredges in the depth and breadth of coverage, including five dimensions important for the practicing engineer:

- the area of application
- guidelines for sizing
- capital cost guidelines
- principles of good practice
- approaches for troubleshooting

In a similar manner is approached the problem of liquid transportations in Section 2.3, as well as for gas-liquid (two phase flow) in Section 2.4. Section 2.5 refers to liquid-solid systems – pumping slurries, while Section 2.6 to solids. Duct and pipes are discussed in Section 2.7.

Chapter 3, *Energy Exchange,* deals with heat transfer equations, coefficients and equipment. Section 3.1 considers mechanical drives. Sections 3.2 – 3.5 see about furnaces and exchangers, condensers and reboilers, fluidized beds with coil in the bed, static mixers. The following sections (3.6 – 3.10) consider direct contact systems for heat transfer: liquid-liquid, gas-liquid cooling towers, gas-liquid quenchers, gas-liquid condensers, gas-gas thermal wheels. Heat loss to the atmosphere is described in Section 3.11, while sections 3.12 – 3.14 deal with refrigeration, steam generation and high-temperature heat transfer fluids. Section 3.15 highlights the main aspects of tempered heat exchange. All this equipment is analyzed considering the five dimensions important for the practicing engineer, presented within the review of Chapter 2.

Chapter 4, *Homogeneous Separation,* considers the separation of species contained in the homogeneous phase, such as a liquid or a gas. The separation is based on exploiting a fundamental difference which exists between the species. Sections 4.1 – 4.2 discuss separation methods which exploit differences in vapor pressures (evaporation, distillation). Methods which exploit differences in freezing temperature and solubility, melt crystallization, zone refining are analyzed in sections 4.3 – 4.5 while methods exploiting solubility (solution crystallization, precipitation, absorption and desorption) in Sections 4.6 – 4.9. Solvent extraction which exploits differences in partition coefficient is described in Section 4.10. Other separation methods from homogeneous systems are also presented: methods based on exchange equilibrium and molecular geometry (adsorption of species from a gas, Section 4.11, and from a liquid, respectively, Section 4.12. Ion exchange, foam fractionation, are described in Sections 4.13, 4.14, considering the method of separation.

Separation using membranes, gas permeation, dialysis, electrodialysis, are presented in Sections 4.15 – 4.18.

Other methods to separate species in liquids are given in Sections 4.19 - 4.24, such as: pervaporation, reverse osmosis, nanofiltration, ultrafiltration, microfiltration, chromatographic separation. An overall guideline is provided and the five dimensions important for the practicing engineer are used to present each set of separation methods.

Chapter 5, *Heterogeneous Separations,* starts with general guidelines to specific options, classified based on the type of phases to be separated, which refers to:

- considerations on shifting from heterogeneous phase separation to homogeneous phase separation
- analysis of the possibility to separate the gaseous phase first, then the liquid and then solid-solid.
- consisderations on using dense media separation to preconcentrate before grinding to final liberation size
- using the feed assay and liberation size as criteria to guide selection of options
- the possibility to try froth flotation as a first option

Sections 5.1 – 5.4 address the separation of gas from liquid , gas from solid, liquid from liquid and gas liquid liquid, while Section 5.5 gives an overview of options to separate liquids from solids with details in the Sections 5.6 – 5.17.

Section 5.18 is an overview of the options applied to separate solids from solids with some details given in Sections 5.19 – 5.30.

Chapter 6, *Reactions,* starts with criteria for the selection of a reactor configuration. The general factors which affect the selection of the reactor are completed with general guidelines given in Section 6.2. Section 6.3 considers details fro defferent types of reactions which affect the size of the reactor. Data are given for sizing reactors. Then details are given for over 30 reactor configurations. Section 6.4 discusses burners, while Sections 6.5 – 6.26 consider plug flow tubular reactors.

Stirred tank reactors, STR, are analyzed in Sections 6.27 – 6.33, while Sections 6.34 – 6.37 explore combining reactors with other unit operations.

Chapter 7, *Mixing*, is an analysis of mixing of gases, liquids, mixtures and solids based on the same five dimensions important for the practicing engineer, highlighted in the review of Chapter 1.

The fundamentals for the mixing of liquids are described in Section 7.1, the mixing of immiscible liquids in Section 7.2, the mixing of liquids and solids in Section 7.3 and dry solids in Section 7.4.

Chapter 8, *Size reduction,* takes into account some options for creating drops and bubbles. Size reduction operations, such as foams, sprayers, emulsification, crushing, grinding and cell disintegration are discussed.

Chapter 9, *Size Enlargement,* summarizes key information about equipment to increase or change the size of the drops, bubbles and particles (demisters, coalescers, flocculators, spray dryers, fluidized beds, agglomeration, pelletizing, extrusion, flakers, prilling, coating).

The fundamentals of these operations based on surface phenomena are considered. Surface properties, such as surface energies, contact angles wetting, are found to be important in size enlargement operations.

Chapter 10, *Process Vessels and Facilities,* considers process and storage vessels, bins and hoppers and bagging machines.

A detailed Index of subjects allows for a quick and reliable possibility to locate certain equipment, the keywords and solution for a matter.

The book can be considered a very useful tool for all the specialists involved in process synthesis analysis, operation and maintenance, which need such rules of thumb to guide decisions, set goals, check results and answer important questions about the most appropriate moment to use a piece of equipment, the way to obtain an appropriate answer, how to obtain an approximate estimate of the cost, the most reasonable know-how and what to do if something goes wrong.

This is the first analysis of its kind that has been presented in the open literature, based on a rich experience gained by the author in over 50 years.

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