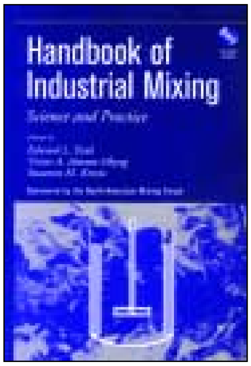
Handbook of Industrial Mixing, Science and Practice

E. L. Paul, V. A. Atiemo-Obeng and S. M. Kresta, Editors, John Wiley & Sons, Hoboken, NJ, 1,377 pp., $160.00, 2003



Sponsored by the North American Mixing Forum (NAMF), the aim of this Handbook is to provide mixing practitioners with a summary of the current state of mixing knowledge, both in terms of fundamentals and from the perspective of industrial practice and experience. It has been written for the practicing engineer who needs to both identify and solve mixing problems. The Handbook comprises a compilation of the experience and findings of industrialists and academics who have, over the last 30 years, been instrumental in the development of mixing as a discipline. As well as describing the state-of-the-art on traditional mixing topics, the Handbook presents methods for recognition of complex mixing problems and alternative mixing designs for critical applications. Particular focus is on the scale-up of processes.

The motivation for the Handbook and for the research efforts that it documents are revealed by the following economic estimates. In 1989, the cost of poor mixing in the U.S. chemical industry was estimated at $1–$10 billion. Costs of poor mixing in the pharmaceutical industry due to low yield, scale-up, process development and lost opportunity amount to $ 0.5–$1 billion/yr. Therefore, time spent improving the understanding of mixing and mixing equipment design is potentially profitable.

The Handbook is designed as a reference work, rather than one that should be read from beginning to end. In order to achieve this, it is well structured with copious cross-referencing and comprehensive references for supporting literature at the close of each chapter. The Handbook is generally well written and easy to read, having been written for the engineer new to mixing, rather than the cognoscenti. Many calculation examples are given.

The Handbook is divided into three broad sections — fundamentals, design and applications. The chapters on fundamental topics should be understood to address difficult mixing problems. Three fundamental chapters cover residence-time-distribution theory and modeling, turbulent mixing theory and laminar mixing theory. Turbulent mixing theory is concerned with the range of length and time scales in the flow and the distribution of energy dissipation. The principal tools used to investigate mixing problems are described in chapters on laboratory mixing experiments and computational fluid dynamics (CFD).

Design of the wide range of mixing equipment now available is described in chapters on traditional stirred tanks (including baffling, impellers, internals and configurations), pipeline mixing (including static mixers), rotor-stator mixers, mechanical aspects of mixing and the role of the mixing equipment vendor. Specialized equipment for powder blending, pulp and paper, petroleum industry and high-viscosity mixing are discussed in the respective applications chapters.

The core mixing design topics of miscible liquid blending, solid/liquid suspension, gas/liquid contacting, liquid/liquid mixing, mixing and chemical reaction, as well as heat transfer and mixing, are each covered in detail in one or more dedicated chapters. Liquid blending (which involves mutually soluble streams) in pipeline systems, stirred tanks and jet mixed tanks is also discussed in detail. The challenging non-Newtonian and laminar blending areas are also covered in-line and in-tank. The solid/liquid suspension chapters include design guidelines for off-bottom suspension, achieving and maintaining uniform solids concentration, mass transfer correlations for solids dissolution, maintaining discharge slurry composition and avoiding nozzle plugging during drainage. The gas/liquid mixing chapter addresses the key objective of maximizing surface area for mass transfer through effective dispersion. Liquid/liquid mixing is arguably the most difficult and least understood mixing problem; its current state-of-art is discussed with important guidelines emerging. The chapters on mixing and chemical reaction discuss in detail the effects of scaling-up mixing-sensitive reactions. Design correlations for stirred-tank heat-transfer coefficients and key heat-transfer concepts are provided in a specific chapter.

The section of the Handbook on industrial applications features chapters on solid/solid mixing fundamentals and practice, mixing of highly viscous fluids, polymers and pastes, mixing in the fine chemicals and pharmaceuticals industries, mixing in the fermentation and cell culture industries, mixing in the petroleum industry, and mixing in the pulp and paper industries. The special requirements of mixing in water, wastewater and food industries are not explicitly described in the Handbook.

The accompanying CD-ROM, Visual Mixing, assists in understanding specific mixing issues by using video clips of lab experiments or CFD simulations. The most informative sections cover circulation in a stirred tank, liquid blending, solids suspension and distribution, and droplet break-up.

In summary, effective mixing is of vital importance in a great many industrial processes. Getting the mixing right impacts the bottom line. This Handbook is the most comprehensive, definitive and up-to-date treatise on industrial mixing available anywhere. It is well written, structured, illustrated and referenced. My colleagues and I at BHR, have already found the Handbook to be our most frequently used mixing reference. It is a "must buy" for all engineers whose work regularly involves mixing or mixing-related problems.

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