

Preface

This book deals with heat and mass transfer intensification in thermal, fluidic and reactive components and energy systems by multidisciplinary actions. The shape optimization through a multi-scale approach is an important and original issue of intensification which I try to illustrate in this book.

The Process Intensification (PI) concept was initially proposed as “increased productivity of a process with reduced occupied space (equipment, system, factory, etc.)”. However, after almost 20 years of development, the notion of PI covers much more than that, thanks to numerous and often diverse contributions made by individuals and research teams. Various definitions, intensive discussions, and incisive viewpoints on PI have appeared in the literature, and its core value has been summarized in a more fashionable manner as: “*produce more with less*”. Moreover, the recent trends in chemical engineering put forward the necessity of a new paradigm¹ and the PI is considered as an essential theme.

As a practitioner on PI, either consciously or unconsciously during my whole research career, I believe that it is worth publishing a book on this concept. Owing to the kind invitation of Springer in 2009, especially the encouragement of Anthony Doyle, senior editor of engineering, the book is finally written three years later. It is regarded not only as a milestone that builds on my previous research work, but also as a stimulator of ideas which may be interesting, original, and of importance for the future. It is not simply a synthesis of the published literature, but rather a deepening of personal reflexions and thoughts that may bring contributions to this rapidly evolving notion.

The book begins by raising the issues of “*what is intensification?*” and “*where might intensification occur?*” and the introductory chapter portrays theoretical reflexions based both on the literature and on a personal analysis. For the first question, a personal definition is proposed based on both the basic equations of heat and mass transfer, and the notion of “interface”. The main objectives of PI

¹ The first paradigm—Unit Operations, 1923; the second paradigm—Transport Phenomena, 1960; the third paradigm—?

have been categorized into five aspects, namely: *productivity intensification*; *compactness intensification*; *energy intensification*; *temporal intensification* and *functionality intensification*. As for the second question, my personal contribution may be the identification of the important role of a multi-scale approach for PI. To improve the global performance (productivity) of a process, intensification should necessarily be implemented at three scales: *local scale*, *component scale* and *system scale*. Intensification on local scale aims at augmenting the density of fluxes transferred through interfaces; intensification on component scale calls for novel designs of fluidic, thermal, and reactive components; intensification on system scale expects the integration of multiple functionalities and seeks for the synergetic effects because the global optimum of a system is usually not the simple accumulation of individual optima of each component or each step.

Chapters 2–6 are devoted to “*how to achieve intensification*” in different contexts. The readers are invited on a journey through detailed research topics that I have developed with my coworkers: gas adsorption processes in porous media (Chap. 2); fluid flow distributors based on meshed circuits or arborescent geometry (Chap. 3); compact heat exchangers for maximization of the heat transfer performance with constraints of pressure drop (Chap. 4); micro-structured mixer/reactors for single- or two-phase application (Chap. 5) and evolutionary CA-based (Cellular Automaton) algorithm for the shape optimization of flow paths (Chap. 6). These chapters cover different topics, but share the central role of intensification.

In these chapters, special emphasis has been placed on the role of *shape optimization* in PI. This aspect has been largely overlooked by classic PI techniques but has been deeply explored in this book. Shape optimization (especially the shape of *interfaces*) implies intensification. The minimization of dissipation at transfer interface is an important criterion for local scale intensification. The distribution of the dissipations at different spatial or temporal scales is also a key issue for performance optimization of a system (or a component). There is a real problematic of multi-scale shape optimization with the establishment of scaling laws where one must distinguish from the optima of design and the optima of operation.

The book logically concludes with prospects and proposes a redefinition of intensification, as being the *optimization of the productivity*, with the constraints of *quality* and *efficiency*. This redefinition somehow extends the PI concept: for global productivity augmentation, PI should be implemented at all three scales (local, component, system) and the internal links between these scales should be carefully examined (should we call this “scale intensification”?).

It should be noted that PI is always an important subject in the course of my research life. Apart from the pursuit of intensification, the interest of this book also lies in the merging of scientific cultures and disciplines, realized with my initial experience as a thermal engineer, my academic culture of process engineering, and also with new domains of thermodynamics, energy conversion, material science, chemical reaction, fluid mechanics, numerical tools, characterization methods, optimization methodologies, and microfabrication. The coverage is broad and diverse, and may be of benefit to academic and industrial researchers, to practicing

energy and process engineers, and to industrial energy users and producers. It may also serve as a reference book for undergraduate or postgraduate students during their course work as well as completion of their thesis.

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