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Book Review

Advanced Engineering Thermodynamics, third ed., A. Bejan. Wiley, Hoboken, NJ (2006). ISBN: 978-0-471-67763-5

A new edition of Bejan's *Advanced Engineering Thermodynamics* has arrived for the benefit of the thermal sciences and engineering community. It redoubles the author's long standing successful project of putting together the theory and practice of applied thermodynamics with heat transfer and fluids engineering, in a comprehensive, integrative framework for the fundamental and definitive understanding of these disciplines.

The third edition of *Advanced Engineering Thermodynamics* reinforces the central role of this treatise among the dozen-and-a-half textbooks and titles in the thermal sciences, written by Adrian Bejan (not to mention the more than 450 original papers published in prestigious journals). Well-provided with clarifying examples, comments and recreating historical notes, the book presents the fundamentals of thermodynamics using a rigorous scientific language but sufficiently clear and elegant that the reader can get a full understanding of this science, sometimes considered as impenetrable. The laws of thermodynamics are introduced right at the beginning to properly construct the theoretical framework of this science in a modern, contemporary description of energy and matter transformations. It makes full use of concepts such as entropy generation and exergy destruction without loosing formality and yet, putting them in a clear and appealing pathway for the reader. These topics are covered in Chapters 1–3, about one-fifth of the 880 pages of the entire book.

In Chapters 4, 6 and 7, a full treatment of single- and multiple-phase systems as well as chemically reacting systems is presented. A complete coverage is provided for important topics such as equilibrium conditions, the relations between thermodynamic properties, gas mixtures, the minimum principia for various thermodynamic energy properties, stability conditions, chemical equilibrium, irreversible reactions, and combustion, including chemical exergy and maximum work output of fuels. Chapter 5 extends the method of exergy analysis to nonflow and flow systems, so valuable for analyzing many energy intensive industrial processes.

Chapters 8, 9 and 10 are devoted to power generation, solar power and refrigeration, respectively. They cover the most important aspects and applications of thermodynamic processes, engines and integrated systems, according to the advanced technologies in use today, highlighting the entropy generation and the optimal use of energy and materials.

The final part of the book composed by Chapters 11, 12 and 13, is spent on the topical irreversible thermodynamics, and on the two contemporary, innovative subjects – Entropy Generation Minimization and Constructal Theory.

Many of the last two decades contributions by Adrian Bejan are centered in these two essential matters. The method of Entropy Generation Minimization (also known in engineering where it was developed, as thermodynamic optimization, and as finite time thermodynamics in the Physics literature) is introduced in Chapter 3 of this book, but it was first reviewed in book form by the author in 1982. It consists of modeling and optimizing real life devices and systems that get their thermodynamic imperfection from heat transfer, mass transfer and fluid flow, among other transport processes. The method combines the basic principles of thermodynamics, heat transfer, and fluid mechanics, emphasizing the minimization of the calculated entropy generation rate for a given process or design, an aspect that distinguishes the method from exergy analyses and makes insufficient the classical thermodynamics considerations.

The truly innovative Constructal Theory developed by the author, utilizes results from optimally engineered assemblies to discover a primary principle for the design (geometric formation and operation) of natural systems. The Constructal Law states that "for a finite-size flow system to persist in time (to survive) its configuration must evolve such that it provides greater and greater access to the currents that flow through it". The Constructal Theory is thus established explaining how certain basic elements, individually and collectively optimized to form an arrangement, are employed to construct more complex natural and engineering systems, within the specific constrains imposed by the physics in every case.

For instance, by globally optimizing a flow system, the thermal and fluid flow resistances are minimized together—not individually, that is, a balance of them is obtained such that their sum is minimum. This means that flow geometry, i.e., configuration for flow systems (called non-equilibrium systems in thermodynamics) is being generated through this optimizing process. This is, in words of the author, "a universally present phenomenon which did not previously have an underlying principle... The phenomenon of generation of flow configuration is responsible for the morphology of natural flow systems and engineered

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systems... That principle is a law of physics—the constructal law—...".

It is a predictive theory of the geometry and rhythm of nature, and the principle according to which they can be deduced, is the optimized shape and structure obtained from engineering analysis. The core analysis and synthesis methods of this theory are totally based on the author's own research experience during many years, previously published in specialized journals and books, and supported by many observed facts and results, fully documented in the open literature.

The newest Constructal Theory predictions reported in this book are the scaling laws of all animal locomotion (running, flying, swimming), the distribution of the sizes of human settlements, the Hortonian scaling laws of river basins, the shape of all Egyptian pyramids, vegetation, and the evolution of science and civilization.

The book contains many illustrative examples, exercises at the end of each chapter and is plenty of up-to-date references in every matter that it presents. Many creative drawings and diagrams that Adrian Bejan likes to compose in all his explanations are incorporated in the text. Reading the book is a delightful experience that encourages the reader to further deepen his understanding of thermodynamics and the thermal sciences.

The book can be used as textbook or as a supporting, superior reference book, for both graduate and undergraduate in standard courses. It can also be used by practicing engineers and is highly recommended for researchers or any one interested in the thermal sciences.

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