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Book review

Richard E. Sonntag and Claus Borgnakke:
Introduction to Engineering Thermodynamics, John Wiley & Sons, Inc. 2001

The textbook by Richard E. Sonntag and Claus Borgnakke is well written and easy to read, which is a great advantage for students learning thermodynamics, a subject traditionally complicated and hard to understand.

The humble title of 'Introduction to Engineering Thermodynamics' reflects only one aspect of the book. This introduction is namely developed based firmly on the properties and functionality of devices widely used in engineering thermal fluid sciences. The first chapter (Some Introductory Comments) explains the basics of the processes that occur in a steam power plant, a gas turbine, a chemical rocket engine, different types of refrigerators, an air separation plant and other commonly used equipments.

The aim of this introduction is obvious; the operational concepts of these equipments are almost impossible to understand without the knowledge of thermodynamics, while the classical development of thermodynamics is associated with the properties of heat engines, refrigerators and other related equipment. The authors thus combine the two subjects teaching process control and thermodynamics at the same time. I find their version of this approach rather successful and to my knowledge unprecedented.

Many engineering students are not really motivated by subjects that are developed on an abstract mathematical basis, but most of them are interested in up-to-date applications. The authors of this book offer an enjoyable blend of application and abstract concepts.

A usual failure of the traditional introduction of thermodynamics (in contrast to the statistical or postulatory treatments) is the lack of a solid logical and exact quantitative basis of thermodynamic quantities, such as internal energy, entropy or temperature. In this respect, this book is carefully written. If the students really learn the basic functions of the devices described in the introduction, they will be able to understand thermodynamic concepts in an exact and quantitative way.

One can also raise the question about the potential readers of the textbook. As explained above, the text is ideal for a first course in thermodynamics for all the students who are interested in engineering thermal fluid sciences and should learn it sooner or later during their studies. It is a wide range of students from mechanical engineering to chemical engineering. However, the virtues of the book for engineering students are actually disadvantages for most of the science students, including physics, chemistry and biology, as they

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are not really interested in learning so much details about heat engines, refrigerators and other related devices.

A necessary decision in writing any 'introductions' to thermodynamics is what to include in the text. In this book it is automatically decided by the dual-purpose structure of the development of thermodynamics described above. Everything essential to understand the basics of equipment design is included, but nothing which is not relevant or important from this point of view. The concept of a thermodynamic system is also approached from the practical point of view: 'a thermodynamic system comprises a device or combination of devices containing a quantity of matter being studied'. The concept of 'control volume' is used for (stationary) systems with entering and leaving mass flows, while 'control mass' is used if the system is closed for mass flow.

There is a clear distinction of energy content and energy transfer, state functions (called point functions or properties in the text) and path functions. Special care is taken also to distinguish between heat and work in such cases when exact knowledge of the system boundaries is necessary to make the distinction. The explicit inclusion of kinetic and potential energy (if necessary) in the energy balance also follows from the practical point of view related to various engineering equipments. Besides the classical description of equilibrium states and other steady state systems, the book also contains elementary description of transient processes and the thermodynamic characterisation of the corresponding rate equations.

Though the formal statement of the second law is based on experimental conclusions about the performance of practical devices, the next section is entirely dedicated to the description of the properties of entropy, and there is an extensive use of this function in the subsequent treatment of different practical processes and devices. The distinction between reversible and irreversible processes is also supported by the concept of the entropy.

After completing the development of the basics of thermodynamics, the equipments described in the introduction are reconsidered, but this time with the full potential of the thermodynamic background.

The book contains a large number of examples, which help the student to deeply understand not only additional applications but also the 'theoretical' concepts developed in the main text. The end-of-chapter problems are also numerous and give a convenient possibility to develop a good skill in solving practical problems. In connection with the problems, the extensive thermodynamic tables printed as annexes in the book (and easily accessible on the diskette attached) should also be mentioned. The reviewer remembers a young engineer who has found working fluids that could be used to construct heat engines, which outperformed a Carnot engine operating with heat reservoirs of the same temperature. He has showed the same possibility of higher efficiency than that of the Carnot engine using steam tables, especially near the critical point. A closer examination of the tables used showed that mechanical and caloric data were not interpolated in a matching way, thus giving a possibility to violate the second law. Thoroughly checking the data available on the diskette, we could not find any incompatibilities of interpolation within the precision provided by the database.

It is a delicate issue to decide what should be considered as an introductory material and included in the textbook. The authors emphasize at several instances that the reader

should bear in mind the incompleteness of the treatment of thermodynamics in the text. However, we think that one important point might have been explained in the text; namely, that the principles of thermodynamics have a much wider foundation than the actual treatment on the basis of the performance of heat engines. The ambitious young engineer mentioned above would not have been hunting for a cycle of higher efficiency than that of the Carnot engine if he knew that the validity of laws of thermodynamics are not only a question of being able to find a better performing engine. When he realized it, he was wondering why he had not been informed about the general validity of thermodynamic laws in nature during his engineering thermodynamics studies.

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