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BOOK REVIEW

Sanford Klein and Gregory Nellis: Thermodynamics

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Abhishek Saxena

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This book provides a real excellence in a pool of knowledge and intelligence for graduate; post graduated and doctorate level courses in thermodynamics with the basic principles, concepts/fundamentals, tools, and practical examples in the field of engineering and technology. The selection of all the 16 chapters is structured to provide a good introduction to the subject and its importance to its reader. The concepts and techniques used in all major concerns of thermodynamics such as; entropy, enthalpy, power cycles, refrigeration cycles, heat pumps, combustion process, psychometric, and fluid flows are explained well and in an understandable manner. A total of total 82 examples, 415 colored figures, and 54 tables are given in the book (including the figures, and tables of solved examples and appendixes). Figures with their subsections say "a", "b", "c", are counted as one figure. Apart this, a computer programme "Engineering Equation Solver—(EES)", is introduced as a platform for numerical solution of the problems in an approachable manner (as well as eliminating the mathematical complexity involved to solve thermodynamics problems). Besides this, EES has been featured to check the dimensional and unit consistency of the equations. All the illustrations, tables, appendixes, as well as references are provided for better understanding the terms, their meanings, and source of referred literature to its reader.

Chapters 1 and 2 deal with fundamentals of "Thermodynamics," such as: laws of thermodynamics, thermodynamic states, and properties of various fluids used for heat transfer (heating and cooling). Fluid property data of the type, represented by smart figures, and based on the available data (mainly for liquid water and for steam) or sets of data (provided in the Appendix). A basic introduction of EES is given by solving the different problems of heat transfer and energy balances for thermal systems. Operations such as; vacuum by condensation, superheated vapor, thermostatic expansion valve, thermal driven compressor, and fire extinguishing system are explained well in details. Chapter 3 serves a practical theory and relative information on heat transfer and thermal behavior of the open and closed systems under various loads or ideal conditions. The energy balance equations are discussed to determine the thermal behavior of the systems in this section. It has also been stated and discussed that energy is a conserved quantity (in the terms of function of various works) in this chapter. Chapters 4 and 5 have been designed purposely to make comprehensible the concepts of first and second law of thermodynamics and their applications. A general methodology for solving thermodynamics problems that can be summarized as;

1. Carefully review the problem statement and the information.
2. Choose the system.
3. Apply a mass balance on the chosen system.
4. Apply an energy balance on the chosen system.
5. Solve the resulting set of equations.

Besides this, a number of common energy conversion devices such as; turbines, compressors, pumps, nozzles, diffusers, throttles, and heat exchangers are (assumed to operate at steady-state) described with the appropriate simplifications, while their examples are solved by using EES. This chapter focuses on the essence of the second law, and followed by the statements of Kelvin–Planck, Carnot, and Clausius with their practical feasibility.

A. Saxena (✉)
Faculty Department of Mechanical Engineering,
Moradabad Institute of Technology, Moradabad 244001, India
e-mail: culturebeat94@yahoo.com

In chapter 6 “Entropy,” is introduced in order to quantify the quality of energy and explained as a non-conserving candidate in any real process. In addition, “entropy change during phase change,” “Entropy relations for ideal gases,” and “Relations for incompressible substances,” are explained well with good examples. To keep track of the “Entropy changes,” “Generation,” and “Transfers,” occurs during a process, are essential to solve an entropy problem, while the most convenient way is; by using of “Entropy balance”, “Mass balance”, and “Energy balance” methodology as an individual. EES is used to find out the efficiencies of thermodynamic devices such as: turbines, compressors, pumps, nozzles, diffusers, throttles, and heat exchangers. Chapter 7 deals with the thermodynamic concept “Exergy,” and shows that it is useful in several ways such as; it allows the calculation of meaningful process efficiencies. It provides a rational basis for the valuation of “Fuels and resources,” and it allows leveling the processes occurring within a system according to how they contribute to the loss of work producing capability.

In Chapter 8, Power cycles are referred to continue to transform heat in order to power in various thermodynamic systems. These cycles are classified as; closed cycle, open cycle, reciprocating type, steady-flow cycle, and internal-combustion cycles. The Carnot cycle is discussed as an externally powered cycle consisting of four basic reversible processes (“Isothermal expansion, and adiabatic expansion,” and “Isothermal, and adiabatic compression”) while the Rankine cycle is explained as “Ideal and Non-Ideal,” cycle with the effect of temperature (of source and sink) and its modifications (reheat and regeneration). The gas turbine cycle is discussed with its modification and efficiency affecting parameter’s ratios. A number of variants of this cycle (used for propulsion) such as; turbojet, turbofan, and turboprop engines, are explained with their thermodynamic behavior. Reciprocating IC engines (SI and CI engines), and the Stirling engine are explained with their heat transfer mechanism and process cycles. All above this, a natural tradeoff between power and efficiency in the design of a power system has also been discussed. All the power cycles in the chapter, are explained by following suitable examples on “EES.”

Chapter 9 approached to justify the thermodynamics of refrigeration and heat pump cycles (vapor compression, absorption, recuperative cryogenic cooling, reverse Brayton, Joule–Thomson, and liquefaction cycles). A review of refrigerants has also provided from a thermodynamic perspective. The vapor compression cycle is explained with some of the good examples on TS diagrams and with properties of refrigerants. Moreover, it is discussed that by modifying the flow direction; the same hardware (as used for VCC) can be used for space heating and starts acting as a heat pump. Various performances affecting parameters are discussed (by using EES) such as: efficiency, COP, heating system performance factor, effectiveness, pressure loss, heat transfer and mass flow rate, power required and produced, and refrigeration loads with a neat schematic diagram. In Chapter 10, the determination of properties for fluids which do not obey the ideal gas law has been explained. Equations of state for pressure, volume, and temperature are discussed with quality features of EES. The characteristics of the equation of state which must have been limiting ideal gas behavior, the Boyle isotherm, and critical point behavior are fine explained. Fundamental property relations are discussed with a few practical approaches and applications, while complete equations of a particular state are used to solve the problems of different properties (enthalpy, temperature, pressure, entropy, volume, etc.) of a thermodynamic system are expressed by using EES. All of this, a thermodynamic property “Fugacity” is introduced in this chapter, which is useful for the multicomponent phase and chemical equilibrium calculations.

In Chapter 11, P–v–T relationship of ideal gas mixtures and multicomponent phase equilibrium are discussed. The properties of ideal gas mixtures and mixtures in which the components do not obey the ideal gas law are also examined with two-phase liquid–vapor mixtures. In the, “Psychrometrics”—(the study of air–water vapor mixtures), is discussed for moist gas mixtures and its functions. The study of “Building air-conditioning system”, “Building heating/ humidification system” (desiccant systems also), and “Psychrometric processes for comfort conditioning” is explained by using psychrometric chart and EES. Thermal behavior of cooling towers is discussed in this section by considering it as an evaporative cooler. In Chapter 13, “Combustion” is explained as the major source of useful energy for transportation, electrical generation, space conditioning, water heating, and industrial processes. Besides this, the author is also shown the consumption of fuels (to produce energy) in US with generation of Carbon dioxide and global warming at present. The use of air as an oxidizer, and methods for quantifying excess air are explained well with balanced equations for complete combustion and Psychrometric issues. The application of the first law for systems involving combustion reactions such as; enthalpy of formation, heating values of fuels, enthalpy and internal energy as a function of temperature are discussed with process and practical issues. Using of EES for determining properties (and functions) is explained purposely in the chapter, while entropy considerations are adopted to provide an approximate solution of the problems.

Chapter 14 presents methods for determining the equilibrium state of a system that can chemically react in one or more ways. In this section, the concept of a reaction coordinates is introduced that simplifies balances in chemical reacting systems. Besides this, the necessity to identify the relation between Gibbs free energy and composition in order to determine the equilibrium composition of a system is explained. Some approachable methods are also given to determine an equilibrium state for a chemically reactive system. In case of determining the equilibrium temperature and composition for an adiabatic reaction, the energy balance equations and the chemical equilibrium conditions are marked for essence.

In Chapter 15, “Statistical Thermodynamics (an explanation of how matter behaves)”, the goal of this chapter is to present a simple treatment of statistical thermodynamics applied to monatomic ideal gases in order to provide clear understanding of the concept of properties and the origin of the Second law. A brief review of Quantum theory is given, with numbers of attempts to explain electromagnetic radiation. All the thermodynamic properties (internal energy, entropy, pressure, and temperature) are determined using the partition function by taking the case of “Monatomic Ideal Gas”. In Chapter 16, “Compressible Flow,” this chapter provides amore detailed analysis of nozzle behavior, which are used in gas and steam turbine engines to allow the conversion of a high pressure gas into a high kinetic energy flow stream that can then be converted into mechanical power by the blades of a turbine. Nozzles are used directly to provide thrust in jet engines and rockets. In addition, the unique behavior of nozzles makes them very useful for flow rate measurement. A set of problems of very high velocities (sometimes exceed the speed of sound) for a particular designed nozzle, is presented.

Overall this book is beneficial to its reader purposely for science and technology. Besides this “EES” is good software to find the optimum solution of different problems of thermodynamics for practical applications as well as for industrial applications. It is an excellent book.

Reviewed by

Abhishek Saxena
Faculty Department of Mechanical Engineering
Moradabad Institute of Technology-244001, India
e-mail: culturebeat94@yahoo.com
+91-591-2450391