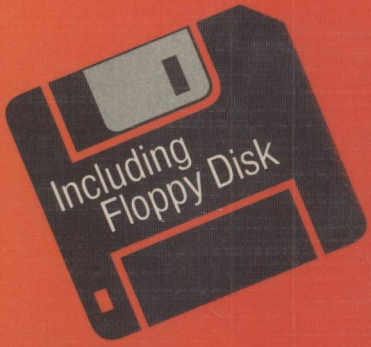
D. P. Tassios

Applied Chemical Engineering Thermodynamics



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To my students,

Past, Present, and Future

The Hazards of Literary Life

"The hardships endured by authors are typified by a letter bound inside the flyleaf of a volume in exhibition of annotated rare books on view at the Smithsonian Institution. .....

The book in question is "History and Progress of the Steam Engine", published in London in 1837. It was written by civil engineer Elijah Galloway, who addressed the letter inside to Charles Manby, a prominent English engineer. It reads:
'Dear Sir:

I am just on the eve of completing a new work on "The Mechanic Powers and Their Application to Machinery". But literary work is only paid for when the Manuscript is completed and what with ill health and the all absorbing nature of this kind of labor I am in the awful predicament of ***wanting a bit of bread!***

I have by me an only copy of my well known "History of the Steam Engine", which Mrs Galloway will herewith hand you. Will you in charity purchase it of her? This is the only legitimate source by which I can avert the horror of hunger and cold for we have neither food, fire, nor a penny in the world!

I am, Dear Sir, Your ever Obliged E. Galloway.'"

(Chem. & Eng. News, Nov. 10, 1986, p.40.)

This is by way of expressing my appreciation to NJIT for granting me a Sabbatical leave for the 1985-1986 academic year, during which most of this book was written.

Preface

There are many excellent books on Chemical Engineering Thermodynamics, but their use in teaching the subject in the classroom leads to two serious difficulties:

First, most books tend to concentrate either on undergraduate or graduate level material only. This creates problems in the review of undergraduate material, which I have found essential for an effective graduate course.

Second, their presentation of the subject is too extensive for the number of credits allocated to it (about six semester hours in the undergraduate level and three in the graduate one). As a result, Chapters - or Sections of them - must be skipped, making the subject - that is by its very nature complex - still more difficult for the students to comprehend. Thus, not only learning suffers, but a fear of Thermodynamics is embedded into the student's mind, which hinders his or her future learning and use of the subject. (This fear is apparent to anyone teaching the graduate level course; and felt by many practicing engineers and chemists, leading a well known thermodynamicist to state a few years ago: "The most underutilized subject in the chemical and petroleum industries is Thermodynamics.")

These problems are, hopefully, avoided with this book for the material included in it **covers both levels and can be presented in the aforementioned semester hours.**

Obviously, less material is thus presented, but the book does provide the undergraduate and graduate student with the material needed in industrial practice and for future study; in addition, through the extensive list of pertinent references, it provides for:

* a more in depth study of the different subjects;
* practical applications;
* the development of awareness of data sources, and
* making the student appreciate the importance of using the literature in problem solving.

The emphasis is, of course, placed on covering the undergraduate level material, while that for the graduate one is presented in Sections of Chapters 3,5,7, 8, and 12, with the Problems numbered over 50 assigned to it; and in Chapters 10, 16 and 17. The presentation is made in such a fashion, however, that minimizes any loss of continuity in the undergraduate material, while the latter's review in the graduate course is facili-

tated with the assignment of some of the aforementioned Problems (51, 52...).

The short length of the book should also make it useful to the practicing engineer and chemist that needs a relatively quick review of the subject, as well as references for a more detailed study of items of his/her interest.

The development of the subject is based on the Laws of Thermodynamics, i.e. it follows the *historical* approach, which seems easier for most students to understand than the *postulatory* one. (The latter is based on a small number of postulates, that cannot be proved but only disproved by showing that consequences resulting from them are in disagreement with experimental evidence, and from which the laws of thermodynamics can be derived.)

We start the presentation of Chemical Engineering Thermodynamics by taking a Glimpse at the Subject and proceed with a discussion of its Laws, followed by a brief Historical Account of its development. (A Nation cannot exist without a sense of its history, why should a field of Science and Technology?)

We continue with a discussion of Efficient Energy Utilisation - a subject of immense importance that became, unfortunately, apparent only after the energy crisis of the early 1970's - followed by a brief presentation of the Broader Implications of the Second Law. (We are educating the technological leaders of tomorrow, not just technologists.)

We proceed with a limited discussion of Intermolecular Forces, which will help in understanding the Physical and Thermodynamic Properties of Pure Fluids which are considered next and, of course, the rest of the subject matter.

Cubic Equations of State are then considered for they have become a major tool in describing quantitatively the properties of Pure Fluids, as well as those of Mixtures, which are discussed next.

We continue with a discussion of Equilibrium and Stability, that prepares the ground for the ensuing presentation of the two topics of paramount importance to chemical engineers: Phase and Chemical Reaction Equilibria.

We close with a brief discussion of Statistical Mechanics that should prepare the student for further study in this area, which is becoming progressively more and more important in applied thermodynamics.

The inclusion of computer Programs in the enclosed diskette should help the students in developing familiarity with the determination of fluid properties and phase equilibria calculations.

The presentation of the material has been influenced by the excellent books of Professors K. Denbigh (*The Principles of Chemical Equilibrium*, 4th Ed., Cambridge University Press, 1981), J.M. Prausnitz (with R.N.

Lichtenthaler and E.G. de Azevedo, *Molecular Thermodynamics of Fluid Phase Equilibria*, 2nd Ed., Prentice Hall, 1986) and H.C. Van Ness (with J.M. Smith, *Introduction to Chemical Engineering Thermodynamics*, 4th Ed., McGraw-Hill, 1987), that are often mentioned in the book. The philosophy of presentation, however, has been shaped by many students, who always want to know the why and the relevance of what they are taught, and to whom this book is dedicated; and from my own conviction, that we should strive to make the topic more attractive to students by exposing them to the broader world of Thermodynamics. If they like this book, the effort will have been more than worthwhile.

In closing I would like to gratefully acknowledge: Professor D. Cardwell for permitting the use of material from his book: *From Watt to Clausius*; Professor H. Van Ness for providing the program that generates the Steam Tables; and Academic Press for permitting the use of material from W. Kenney's book *Energy Conservation in the Process Industries*; and, of course, to express my appreciation to NJIT for granting me a Sabbatical leave for the 1985-1986 academic year, during which most of this book was written.

Dimitrios P. Tassios
Athens, 1992

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