Thermodynamic Optimization of Finite Time Processes
By R.S. Berry, V.A. Kazakov, S. Sieniutycz, Z. Szwast, and A.M. Tsirlin

Reviewed by Peter Salamon

The book is an impressive monograph treating many of the results in finite-time thermodynamics of the last 25 years. Although the emphasis is perhaps a little heavy on the results of the Russian school, the number of examples treated and the unity achieved is certainly a welcome addition to the literature in the field. The authors begin the book with their stated goal: "to show how the methods of optimal control theory can be used to estimate the limiting possibilities of thermodynamic systems." They carry out this goal to a remarkable extent.

The book begins with a brief review of the basic thermodynamics of closed and open systems. The closing section of Chapter 2 does a particularly elegant job of laying out a framework for the formulation and solution of finite-time thermodynamics problems including the much-needed disclaimers of exactly what the subject can and cannot do.

The book continues in Chapter 3 with a well written treatment of optimization theory which starts where a normal calculus sequence leaves off, and takes the reader through a thorough treatment of finite-dimensional nonlinear programming. Chapter 4 continues their exposition of optimization theory with a good introduction to optimal control. In this chapter, the style changes somewhat interspersing the exposition with numerous examples of finite-time thermodynamics problems that illustrate the theory as it is developed. Their treatment of optimal control theory is novel in that it includes an excellent development of the so-called "average theorems" due to Rozonoer and Tsirlin. These theorems are of vital importance to many results in finite-time thermodynamics but are not part of the normal treatment in any other optimal control theory book. These theorems, along with the assumption of endoreversibility, reduce many finite-time thermodynamics problems to nonlinear programming problems in finite dimensions. One important achievement of the book is to make these results accessible to a wide audience without requiring excessive prior knowledge of optimization theory.

The remaining chapters present a systematic review of problems in finite time thermodynamics. The organization proceeds from simpler systems, in which there are a limited number of heat exchangers and reservoirs, to more complex systems that interact with a number of reservoirs and incorporate mass transfer and chemical reactions. The number of problems presented is impressive and certainly represents a significant synthesis well beyond the reviews of the subject that were available before this monograph.

The book is not without some minor flaws, however. One weakness concerns the authors' use of the English language. English is not the mother tongue of four of the five authors and the book would have benefited from more corrections of an editorial nature. The abuse of the definite and indefinite articles in many of the sections makes for some difficult reading. There are also some unfortunate choices of nomenclature. For

example, the use of NP for the nonlinear programming problem clashes with the usage in combinatorial optimization for NP hard problems. Phrases, such as "poweral efficiency" for an efficiency based on power, are less than judicious.

A second flaw is the limitation in scope resulting from the complete omission of certain topics. Notable among these are (1) the results dealing with the geometry of thermodynamic length and the associated bounds they give on the dissipation in finite-time processes, (2) the results dealing with the thermodynamics of quantum systems, and (3) the results relating to processes driven by solar energy. These areas have all been significantly impacted by the ideas and methods of finite-time thermodynamics and some mention of them in the book would have been desirable. It is true however that inclusion of these topics would have forced the already 500 page book to be significantly longer, and this fact probably played a significant role in the authors' decision to omit these topics.

Finite-time thermodynamics is not a mature field. The present text represents a real step forward in collecting so many results and putting them into a cohesive framework presented at the level of detail that a student willing to put in some effort could follow. The field holds great promise not only for the type of industrial systems, which the authors' analysis treats well, but also for biological systems, quantum systems and for the general understanding of our universe. In summary, the book represents a major contribution to the literature in this area and deserves space on the bookshelf of any worker in this and related fields.