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Book review

Bejan, A., Lorente, S., The Constructal Law (La Loi Constructale), L'Harmatan, Paris, ISBN 2-7475-8417-8. pp. 109

Improving systems configuration for achieving better performances is the major goal in engineering. In the past, the scientific and technical knowledge combined with practice and intuition have guided engineers in the design of man-made systems for specific purposes. Soon after, the advent of the computational tools has permitted to simulate and evaluate flow architectures with many degrees of freedom. However, while system performance was analyzed and evaluated on a scientific basis, system design was kept at the level of art.

The Constructal Law states that *for a finite-size flow system to persist in time (to live), it must evolve in such a way that it provides easier access to the imposed (global) currents that flow through it*. This is a major step toward making system design a science. This law states that if a system is free to morph under global constraints, the better flow architecture is the one that minimizes the global flow resistances, or maximizes the global flow access. A basic outcome of the Constructal Law is that system shape and internal flow architecture do not develop by chance, but result from the permanent struggle for better performance and therefore must evolve in time. As in engineered systems, in nature the competition is permanent (e.g., river basins, global circulations, trees and animals morph and improve in time under changing constraints).

This theoretical advance is reviewed in a new book in French by Bejan and Lorente, which includes also recent developments of design of dendritic flow structures and multiple scale design. Chapter 1 is devoted to presenting an analytical formulation of the Constructal Law. While classical thermodynamics defines the states of a system in equilibrium as relationships between state variables, the Constructal Law determines the equilibrium flow structures (i.e., structures for which the performance is the highest) in terms of geometric variables of flow (non-equilibrium) systems. Every flow system has a global objective (e.g., minimization of global resistance) and global constraints (e.g., overall size and total duct volume). The infinity of possible flow structures occupies a region of "global performance versus freedom to morph". This region of non-equilibrium flow structures is bounded by an envelope representing the best flow structures that are possible when the freedom to morph is limited.

Chapter 2 reports two new advances on constructal design. The first is the generation of dendritic (tree-shaped) networks that distribute a stream optimally from one source to a disc-shaped area for which the source is in the center. The second advance is that the overall thermal resistance of the tree decreases as the size and complexity of the flow architecture increase. Complexity, like the rest of the flow architecture, is a constructal result. It is optimized, not maximized.

In Chapter 3 the authors summarize their experience with developing a new course on the generation of system configuration (geometry, architecture and drawing) while performance is optimized. They show how resistances (imperfections) can be balanced and distributed through the available volume and how system architecture emerges from this process. The approach is evolutionary, from the simple to the complex and some examples illustrate the method.

The new concepts presented in this book, which follows other recent books published by the authors, have already triggered investigations about structure and configuration of flow systems in fields ranging from engineering to economics, and from geophysics to biology and physiology. A growing number of papers reporting advances in these fields based on the Constructal Law have been published in the last years. In the next future we can envisage that new developments will appear because the field of application of the Constructal Law extends flow system to every (living or inanimate).

This book is highly recommended for design engineers, physicists, biologists and researchers working in fluid flow and heat transfer, and to all people interested in the occurrence of self-organization and self-optimization in nature.

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