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Optimization of Thermal Systems, From Small Heat Sinks to Big Buildings: Which Way?

Gerardo Maria Mauro
Università degli Studi del Sannio, Department of Engineering, Piazza Roma 21, 82100 Benevento (Italy),
germauro@unisannio.it

Abstract

Optimization is the key for evolution and transition to a better and more sustainable World. Thermal systems are everywhere to be found in most industrial, transport and civil applications. Thus, optimizing the design and operation of thermal systems is essential for everyone, from industrial stakeholders, to governments, to single individuals, with different objective functions, e.g., minimizing cost, carbon footprint, energy consumption, or maximizing profit, comfort, performance. This is a hard task because there is a plethora of thermal systems, deeply different from each other, from small heat sinks for electronic cooling, to big buildings/districts and their thermal devices. There is a plethora of optimization approaches, deeply different from each other, form single- to multi-objective, from deterministic to heuristic, from calculus to search methods. There is plethora of possible objective functions, as mentioned, and design variables to define the system design and/or operation. So, which way to optimize thermal systems? Definity, it depends on different factors, such as system typology, size, complexity and governing physics/equations. However, the ultimate goal is always the same, that is maximizing the degree of freedom to achieve the best performance in a feasible way (say computational effort). This presentation shows some examples to address such a challenge for two extreme case studies, i.e., small heat sinks and big buildings. Such systems are deeply different, thereby needing different optimization methods. Topology optimization, i.e., a calculus method optimizing material distribution within a design space for a given objective function, is applied to the thermal design of heat sinks to minimize the average temperature, i.e., the entropy generation. It can be seen as an application of evolutionary design, which is advancing in several engineering fields, as predicted years ago by the constructal law: "For a finite-size system to live, it must evolve in such a way that it provides easier access to its currents". A multi-objective genetic algorithm, i.e., a heuristic population-based search method, is applied to the design of buildings to minimize energy consumption, global costs and thermal discomfort. Then, a final focus is proposed. Big systems are made or smaller sub-systems, such as a building is made of envelope components. Thus, in order to achieve a comprehensive optimization, different methods should be integrated in a multi-scale holistic optimization approach.

The aim is to provide food for thought to "optimize" the "optimization" of thermal systems.