THESIS DEFENSE IN MECHANICAL ENGINEERING

GRADUATE PROGRAM IN MECHANICAL ENGINEERING

Universidade Federal do Espírito Santo

RODRIGO GUEDES DOS SANTOS
LATTES: http://lattes.cnpq.br/1710594961530586

https://engenhariamecanica.ufes.br/

pos.engenhariamecanica@ufes.br

https://www.instagram.com/ppgem_ufes/

Title: Flows and systems disaggregation for thermoeconomic modeling in thermal system analysis.

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Advisor:

Prof. Dr. José Joaquim C. S. Santos (UFES, BR)

Co-advisors:

Prof. Dr. Atílio Barbosa Lourenço (UFES, BR)
Prof. Dr. Luis M. Serra de Renobales (UNIZAR, ES)
Prof. Dr. Miguel A Lozano Serrano (UNIZAR, ES)

Composition of the examination board:

Prof. Dr. Julio Augusto Mendes da Silva

Federal University of Bahia (UFBA, BR)

Prof. Dr. Reynaldo Palacios Bereche

Federal University of ABC (UFABC, BR)

Prof. Dr. Eduardo Antonio Pina

Federal Polytechnic School of Lausanne (EPFL, CH)

Prof. Dr. Marcio Ferreira Martins

Federal University of Espírito Santo (UFES, BR)

ABSTRACT

Thermoeconomics is an interdisciplinary field that integrates concepts from thermodynamics and economics, providing insights that extend beyond traditional energy and economic analyses. A critical aspect of thermoeconomic modeling is the determination of the productive structure. Exergy serves as an appropriate thermodynamic parameter for cost allocation, incorporating the first and second laws of thermodynamics, assessing the quality of energy flows, and identifying subsystem irreversibilities. However, specific applications require the disaggregation of exergy. As the field evolves, the study of complex thermal systems reveals a growing number of plants with diverse equipment and challenges related to the isolation of dissipative equipment, waste cost allocation, and environmental considerations. Various thermoeconomic methodologies focused on the disaggregation of physical exergy have emerged; however, none have successfully addressed the simultaneous isolation of dissipative equipment and waste cost allocation while maintaining low model complexity. Consequently, these issues remain subjects for further exploration. This study presents ideas related to the disaggregation of flows and systems as approaches to address the identified problems. The A&F Model introduces a novel methodology for disaggregating physical exergy into two components: Helmholtz energy and flow work. Furthermore, the study explores a new approach to system disaggregation, in which a thermal system is divided into smaller subsystems that, when recombined, recreate the original system. The research conducts thermodynamic and thermoeconomic analyses to present and validate the A&F Model, assessing the model's ability to manage dissipative equipment, allocate waste costs, and maintain low complexity across various thermal systems. Concurrently, the investigation of system disaggregation examines the decomposition of the steam cycle of a sugarcane cogeneration plant into subcycles, revealing significant advantages. Integrating energy billing optimization and thermoeconomic analysis in this context determines the plant's optimal operational mode while elucidating the cost formation processes of internal products, such as refinery heat, process heat, and electricity consumption. In conclusion, the ideas presented in this thesis introduce innovative approaches within thermoeconomics, primarily through disaggregation methods for flows and systems. These contributions enhance the understanding of thermal systems' cost formation processes, facilitate dissipative equipment isolation, address waste cost allocation, and maintain low modeling complexity. Furthermore, this research significantly contributes to the application of thermoeconomics in analyzing variations in market prices within cogeneration, thereby broadening the perspective on cost allocation in thermoeconomic analyses.

Keywords: thermoeconomics, systems disaggregation, flows disaggregation, dissipative equipment, waste cost allocation, model complexity