CORPUS PUBLISHERS

Current Trends in Engineering Science (CTES)

ISSN: 2833-356X

Volume 3 Issue 3, 2023

Article Information

Received date : April 27, 2023

Published date: May 09, 2023

***Corresponding author**

Juan Sebastian Fernández Ramírez, Department of Chemical and Environmental Engineering, National Universidad Nacional De Colombia, Bogotá, Colombia

DOI: 10.54026/CTES/1030

Keywords

Thermoeconomics; Strategic accounting; Competitive advantages; Exergetic costs

Mini Review

Thermoeconomics as Support for Strategic Accounting

Juan Sebastian Fernández Ramírez*

Department of Chemical and Environmental Engineering, Universidad Nacional De Colombia, Bogotá, Colombia

Abstract

The objective of this reflection article is to demonstrate the applicability of the concept of thermoeconomics as support for strategic management accounting in the chemical industry. The concept of thermoeconomics is described, as well as its applications on energy performance and production process costs. The concept of strategic accounting is also described, and an illustrative example is provided to relate the two concepts and demonstrate that thermoeconomics could be a functional tool in calculating strategic costs for generating competitive advantages in the chemical sector.

Introduction

One of the most important concerns that the chemical industry has in its production processes is how to optimize energy resources for certain unit operations that are part of a process to obtain a product. According to the above, many companies in the sector, along with academia, seek ways to generate high energy efficiency processes that improve productivity and reduce the carbon footprint in their manufacturing processes [1]. Much has been said in the literature about different ways to achieve energy savings in industrial processes, and it is found that, primarily, one of the best ways to achieve energy savings is by changing the technology of a process [2]. However, the adoption of new technologies is not always economically feasible for the industrial sector. That is why tools have been developed to diagnose energy losses in industrial processes, one of which is exergy, which seeks, based on the second law of thermodynamics, sources in the process where energy is not being used correctly.

Exergy can be accounted for through exergetic cost allocation methods for unused energy in the process. This cost allocation to the exergetic streams of the process is what is known as thermoeconomics, and its main objective is to include non-usable energy costs of the process to make improvement decisions for optimizing the energy used in transforming raw materials into value-added products [3]. Considering the information provided by thermoeconomics, it is valid to indicate that there is a relationship between exergetic costs and cost calculations in each chemical industrial process. This relationship is based on the premise that energy consumption can be saved through a thermoeconomic analysis that directly generates a reduction in energy losses and operational costs of the industrial process. Additionally, Silva [3] states that thermoeconomics is an alternative to improve industrial competitiveness. Therefore, it could be indicated that this tool allows the company to generate a competitive advantage in the industrial sector, mainly led by energy-saving strategies and cost leadership. An illustrative example will be shown in section 4 to demonstrate the relationship previously exposed.

Thermoeconomics

The concept of thermoeconomics was first introduced in academia in 1963 by engineers M. Tribus and R. Evans, who were attempting to relate exergy, a property of the second law of thermodynamics, to economics. They stated that thermoeconomics could be identified as the relationship of exergetic cost, obtained through the allocation of costs of an exergetic stream, applied to economic engineering [4]. Later in the 1980s, authors such as Tsatsaronis G. and Szargut J. demonstrated its industrial-scale usefulness in optimizing energy systems. It is important to know the exergetic costs of a process. Lozano & Valero [5] mentioned that to determine these costs, it is necessary to define which streams of the process are product, resource, and residue (P/R/I), since these streams take on an economic meaning in their concept, but instead of monetary amounts, the generation of exergy is measured [6]. The determination of exergetic cost is carried out from a cost balance for each unit of the process. The balance is made considering all flow streams that enter a process (Figure 1) and the resulting expression is seen in equation (1).

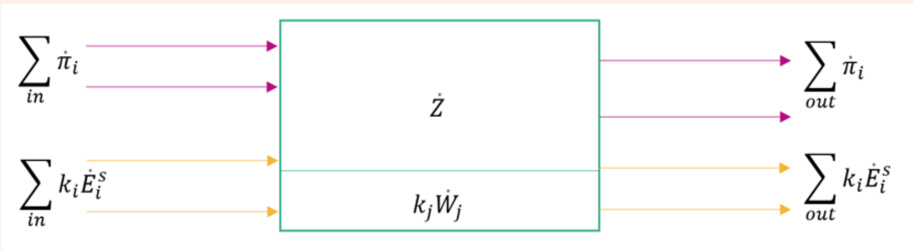

Figure 1: Exergetic and thermoeconomics balance representation.

$$\sum_{in} k_i \dot{E}_i^{s} - \sum_{out} k_i \dot{E}_i^{s} + k_j \dot{W}_j = 0 \qquad (1)$$

Where k_i is defined as the unit exergetic cost of stream i and k_j will be the unit exergetic cost of the required or produced work of equipment j. $\dot{E}_i^S$ is the total exergy flow and $\dot{W}_j$ is the work or energy that equipment requires or produces, both in energy units (kJ/s). This dimensionless unit exergetic cost represents a factor that compares the exergy required to produce an exergy stream in the process [5] and is defined as shown in equation (2).

$$k_i = \frac{\dot{E}_i^*}{\dot{E}_i^S} \quad (2)$$

Where $\dot{E}_i^*$ is the exergetic cost (kJ/s). Additionally, it is possible to obtain thermoeconomic costs that do have a monetary value. Similarly, to the previous section, Figure 1 is reviewed to determine the thermoeconomic costs, π_i, as an elementary economic balance is performed, which expresses the total costs of inputs plus fixed costs of depreciation, maintenance, operation, and general expenses of a plant, represented by Z [6].

$$\sum_{in} \dot{\pi}_i + \dot{Z} = \sum_{out} \dot{\pi}_i \quad (3)$$

The equations (1) to (3) allow for a thermoeconomic analysis of a given process. This analysis provides a physical explanation for the costs of a real process [5], as well as minimizing the costs incurred by energy waste and the costs of the input and output flows of the process [7].

Strategic Accounting

The first to speak about strategic accounting was Simmonds [8], who mentioned the importance of knowing information about the competition for the development and follow-up of business strategy. Later, Bromwich [9] would present a study that would relate two economic theories to provide theoretical support for strategic accounting. Bromwich mentioned that attribute analysis, based on the calculation of costs by product characteristics, was related to Porter's differentiation strategy, while contestable markets theory, based on internal cost structure and competitor costs, was related to Porter's cost leadership strategy.

Due to the aforementioned, it can be said that strategic accounting is a contribution of science to companies, making them increasingly competitive, since the different techniques of strategic accounting, presented by Cadez & Guilding [10], allow for analysis of competitors' strategies, markets, and technologies, and based on this, the company must make the best decision, based on internal and external information, to change competitive strategies [11]. Previously mentioned were techniques of strategic accounting. Cadez & Guildin [10] classified 16 techniques into 5 groups: cost calculation, planning, performance control and measurement, strategic decision making, competition accounting, and customer accounting. This classification of techniques is applied to management accounting, but they exhibit a strategic orientation, therefore, they enter as support for strategic accounting.

Illustrative Example

A basic scheme of a chemical transformation process is presented, (Figure 2) in which flow streams A and B enter at certain operating conditions. Additionally, energy is required for the transformation to take place. Flow streams C and D leave at certain temperature, flow, and pressure conditions, and an example of a non-utilizable energy stream in the process, i.e., a stream of energy losses, is also illustrated. Stream C is the desired product and D represents waste.

Analyzing the figure 2, it can be inferred that each process stream has an exergetic flow stream, an exergetic cost, an exergetic unit cost, and a thermoeconomic cost, as seen in Table 1. To determine these values, it is necessary to use the equations and concepts presented in (1) to (3). The procedure for determining each one can be carried out according to the methodology of Lozano & Valero [5] or more recent methods presented by Montes, García, and Querol [6].

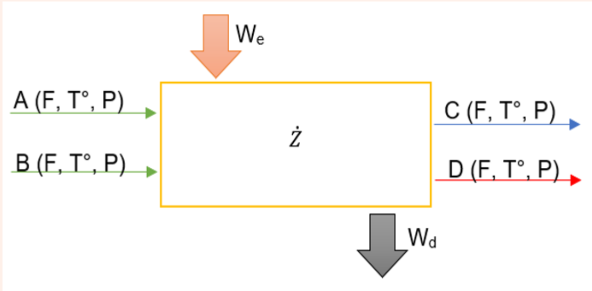

Figure 2: Basic representation of a chemical industry process.

Table 1: Exergetic and thermoeconomics streams.

Exergy Flows (kJ/s)		Exergetic Cost (kJ/s)		Exergetic Unit Cost		Thermoeconomics Cost ($/s)	
$\dot{E}^s_A$	$\dot{E}^s_C$	$\dot{E}^*_A$	$\dot{E}^*_C$	k_A	k_C	$\dot{\pi}_A$	$\dot{\pi}_C$
$\dot{E}^s_B$	$\dot{E}^s_D$	$\dot{E}^*_B$	$\dot{E}^*_D$	k_B	k_D	$\dot{\pi}_B$	$\dot{\pi}_D$

Once the costs have been obtained, the corresponding thermoeconomic analysis can be performed. We see in table 1 the values of each component of equations (1) to (3). It has been mentioned that the allocation of costs to each flow stream offers a monetary value represented in the thermoeconomic costs, and these costs represent the thermodynamic inefficiencies accounted for that provide information on, first, how much energy is lost during the process (economically) and how energy-efficient the process is (thermodynamically). Second, it provides information on possible optimization processes or manufacturing routes in which costs can be reduced and energy efficiency increased. For example, how the exergetic and thermoeconomic cost of stream C and D would be reduced, since as mentioned the product of interest is C, but on the other hand, there is waste that needs to be reduced.

Now, the direct support that thermoeconomics can provide to strategic accounting is based on a study conducted by Gaggioli & Wepfer [12] where they assert that the key to cost accounting in an industrial process lies in accounting for the energy of exergetic costs since it is through them that the utility of the system can be costed, optimal processes can be designed, and economic feasibility studies can be conducted in a preliminary process design. They call this "exergy accounting" and give it the classification of a thermoeconomic technique that supports decision-making to understand if a process or process unit should be completely changed or improved. This type of analysis generates alternatives for the industry to be more competitive because, as Silva [3] says, energy saving in the chemical industry sector is of great importance to have more economically sustainable processes. This is like what Bromwich [9] mentions when he says that companies must become more competitive if they want to survive and they must look for strategic ways to do so. Therefore, it is found that strategic accounting allows the organization to become more competitive with the use of different techniques that focus on differentiation or cost leadership. On the other hand, the contribution of thermoeconomics to strategic accounting would focus as a tool within the classification of strategic decision-making for techniques such as strategic costing and pricing.

Conclusion

The applicability of thermodynamics as a tool to support strategic accounting had been suggested, and through an illustrative example, direct relationships were identified, such as the accounting of exergetic costs, which serve as analysis for decision-making on efficiency and savings in an industrial energy system. Additionally, the use of thermoeconomics was in one of the groups of techniques mentioned by Cadez and Guilding; being a clear support for strategic costing and pricing in chemical industries.

Different authors in the field have expressed the interdisciplinary nature of the concept of strategic accounting, meaning that it is not only managed by the accounting area, but there is interaction from different areas of a company. Therefore, thermoeconomics, as a defined concept used by engineers from different areas, allows itself to be included in that interdisciplinary nature of strategic accounting, providing a solid contribution to the costing of energy systems that allows for a reduction in costs related to energy efficiency from fixed costs.

As a recommendation for future research, studies dedicated to cost optimization from the perspective of strategic accounting by applying thermoeconomics to industrial energy systems could be included. It would be a deeper expansion of the applicability of strategic accounting in the chemical sector that would contribute to the evolutionary development of the field.

References

1. López DO (2018) Energy efficiency in industry: an effective solution to save energy. Letters Con Ciencia TecnoLógica p. 31-38.
2. Donoso CI (2017) Chemical energy in industrial processes. FIMAQ Research and Teaching p. 1-41.
3. Silva JR (2014) Thermoeconomics as an alternative to improve industrial competitiveness. free judgment 12(21): 97-116.
4. Tribus M, Evans R (1963) Thermo-economics of sea-water conversion. Industrial Engineer Chemistry 4(2): 195-206.
5. Lozano MA, Valero A (1993) Theory of the exergetic cost. Energy 18(9): 939-960.
6. Montes JM, García T, Querol E (2009) Thermoeconomics and energy optimization. Gomez Pardo Foundation.
7. Kim DJ (2010) A new thermoeconomic methodology for energy systems. Energy 35: 410-422.
8. Simmonds K (1981) Strategic management accounting. Management Accounting 59(4): 26-29.
9. Bromwich M (1990) The case for strategic management accounting: the role of accounting information for strategy in competitive markets. Accounting Organizations and Society 15(1-2): 27-46.
10. Cadez S, Guilding C (2008) An exploratory investigation of an integrated contingency model of strategic management accounting. Accounting Organizations and Society 33: 836- 863.
11. Brouthers KD, Roozen FA (1999) Is it time to start thinking about strategic accounting. Long Range Planning 32(3): 311-322.
12. Gaggioli RA (1980) Exergy-economics: I. Cost accounting applications. Energy 5(8-9): 823-837.