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SUSTAINABILITY MEASURES FOR INDUSTRIAL PROCESSES: WITH A FOCUS ON ALTERNATIVE ENERGY- BIOMASS

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ABSTRACT

Nowadays, there is a growing awareness worldwide about the use and consumption of energy, which has generated the need to assess and monitor the amount of energy needed to generate products and services. Energy efficiency indicators are an important tool to analyze the interactions between economic and human activity, energy consumption and emissions of carbon dioxide (CO2). This paper deals with a detailed analysis of the factors of energy efficiency at a national level, the differences between energy and exergy addition to proposing the exegetical analysis as an additional index that will identify energy losses (irreversibilities) in a system. From the results of measurement of energy and exergy efficiencies a simulation of a relevant case study was performed in ASPEN HYSYS simulation.

Resumen

Actualmente existe una creciente toma de conciencia a nivel mundial acerca del uso y consumo de la energía, lo que ha generado la necesidad de evaluar y monitorear la cantidad de energía necesaria para generar productos, servicios, así como el abastecimiento de una localidad. Los indicadores de eficiencia energética son una herramienta importante para analizar las interacciones entre la actividad económica y humana, el consumo de energía las emisiones de dióxido de carbono (CO_2). Este trabajo aborda un minucioso análisis de los factores de eficiencia energética que a nivel nacional e internacional no han sido tomados en consideración. Así mismo se estudiaron las diferencias entre energía y exergía además de proponer el análisis exegético como un índice complementario que servirá para identificar las pérdidas de energía (irreversibilidades) en un sistema. A partir de los resultados obtenidos de la medición de la eficiencia energética y exegética, se pudieron poner a prueba los factores seleccionados usando la simulación en ASPEN HYSYS de una planta termoeléctrica abastecida por bagazo de caña.

Palabras Clave

1; Exergy 2; energy efficiency indicators 3; analysis 4; irreversibilities 5; simulation

INTRODUCTION

Energy-based Sustainability indicators are important because they show the amount of energy needed to get a product through an energy saving model, and perform comparisons between amounts of energy required for the production of various materials at local, national and even international standards. However due to the influence of a variety of underlying factors, several information may be required depending analyzed explanatory sector. This info is not always included in basic process energy balances, or is only available for some countries. Therefore, the development of estimates of the sustainable use of energy requires overall level of detailed information for end-use sectors **[1]**.

In consequence, the best way to determine the energy efficiency of a system is through a decomposition method to separate and quantify the individual impacts at each level of activity factors, structure and energy intensity in final consumption energy in every sector and in every country.

Overview of energy efficiency ratings in the world

In 2008, the SENER in collaboration with the International Energy Agency began a project called "Strengthening Indicators of Energy of Mexico" which was aimed at creating energy efficiency indicators in Mexico **[2]**.

In recent years, the European Union has reaffirmed its position in favor of good energy strategies in the Energy Green Paper 'A European Strategy for a secure energy supply, competitive and sustainable, the Action Plan for Energy Efficiency, and the formulation of proposals related to the Climate Action Program in which energy efficiency is combined with climate change. According to the European Commission "Energy efficiency is the most efficient and fastest way to reduce emissions, improve energy security and competitiveness" **[3].**

Table 1: IEA energy efficiency indicators for the industrial sector

INDICATOR	DESCRIPCIÒN	NEEDED INFORMATION
1. Total energy consumption per unit of value added industry	•It measures how much energy is needed to produce a unit of economic output	•Total energy consumption in the industry • Total added value of industry (in currency)
2. Based energy consumption in industrial subsector Added Value Unit	•It indicates the general relationship between energy consumption and economic development	• Energy consumption by industry sub-sector •Corresponding value added (in same currency)
3. Industrial subsector energy consumption based on the Physical Production Unit	•It indicates the relationship between energy and consumption and physical production. Often called specific or energy unit consumption • At a disaggregated level, it can provide better energy efficiency measures a particular production process	•Energy consumption by industry sub-sector •Corresponding physical production unit
4. Total energy consumption by energy source industry	•Vision of the effects of the energy mix of total energy consumption • Overview of trends in CO_2 emissions	•Total energy consumption by energy source
5. Energy consumption in the sub-sectors of industry and by type of energy source	•Explain the role that energy plays mix trends in energy consumption in each sub-sector	•Energy consumption per sub-industry sectors and by type of energy source

Table 2: Indicators related to the energy issue in Mexico

INDICATOR	DESCRIPTION	UNITES
1. Energy intensity per unit physical production	Relation between energy units consumed by physical production	GJ/tonness produced
2. Thermal efficiency plants by kind of gas	Amount of electricity generated in relation to the amount of fuel used in the process	TJ Generated / TJ consumed

- *Energy and Exergy*

Energy intensity is defined as the amount of energy consumed by activity or production delivered by sub-sector and end use. Generally the energy intensity is calculated as the energy consumed divided by an economic indicator; for example, Gross Domestic Product (GDP) or added value per sector. Energy intensity is determined by several factors, not just for energy efficiency. Such factors may include economic structure, industry base rate, the exchange rate, and the cost of energy services, the size of the country, climate and behavior. The impact of efficiency may be masked due to variations in these factors unrelated to energy, thus, a methodology that uses energy intensity as an approach to energy efficiency can lead to erroneous results **[4].**

Exergy is a measure of the usefulness or value or quality of an energy form. Technically, exergy is defined using thermodynamics principles as the maximum amount of work which can be produced by a system or a flow of matter or energy as it comes to equilibrium with a reference environment **[5].**

Energy efficiency"Energy efficiency is to obtain the same energy goods and services , but with much less energy with the same or better quality of life, less pollution, less than the current price , extending the life of resources and less conflict." **[6].**

Table 3: Difference between energy and exergy [7].

Energy	Exergy
1. Depend of properties of only a matter or energy flow, and independent of environment properties	Dependent on properties of both a matter of energy flow and the environment
2. Has values different from zero when in equilibrium with the environment (including being equal to mc in accordance with Einstein's equation)	Equal to zero when in the dead state by virtue of being in complete equilibrium with the environment
3. Conserved for all processes, based on the First Lay of Thermodynamic	Conserved for reversible process and not conserved for real processes (when it is partly or completely destroyed due to irreversibilities), based on the Second Law of Thermodynamic
4. Can be neither destroyed nor produced	Can be neither destroyed nor produced in a reversible process, but is always destroyed (consumed) in an irreversible process
5. Appears in many forms (for example kinetic energy, potential energy, work and heat) and is measured in that form	Appear in many forms (for example kinetic, exergy, potential exergy, work and thermal exergy), and is measured on the basis of work or ability to produce work
6. A measure of quantity only	A measure of both quantity and quality

MATERIALS AND METHODS

In order to obtain a critical analysis, energy and exegetical efficiency were calculated from the simulation of a thermoelectrical plant. It is assumed supplied 3.7 MT/h of bagasse of cane and 17% excess air, the operation was set up at steady. It is subjected to hot air to reach 160 ° C for further supply to a reactor in equilibrium as bagasse, with the gases produced by combustion and ash. The combustion gases are passed through a heat exchanger to make the most of the load. Finally, the steam enters the high pressure turbine with 4 bar and 448 °C. for later go to a heater and into the

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low pressure turbine to 2 bar and 444 °C. The remaining vapor will condensate and will be made to recirculate through the heat exchanger.

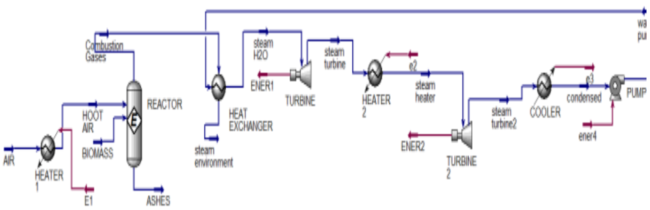

IMAGE 1: Case study simulation

The corresponding equations are applied following the first and second laws of thermodynamics to obtain exergy efficiencies of each component **[8].**

Unit		*Above T_0*
Heat exchange	Source	$\left(\dot{E}^{T}_{H,in} - \dot{E}^{T}_{H,out}\right) + \left(\dot{E}^{p}_{H,in} - \dot{E}^{p}_{H,out}\right)$
	Sink	$\left(\dot{E}^{T}_{C,out} - \dot{E}^{T}_{C,in}\right) - \left(\dot{E}^{p}_{C,in} - \dot{E}^{p}_{C,out}\right)$
Compression (pumps and compressors)	Source	$\dot{W}$
	Sink	$\dot{E}^{TM}_{out} - \dot{E}^{TM}_{in}$
Expansion (expander)	Source	$\dot{E}^{TM}_{in} - \dot{E}^{TM}_{out}$
	Sink	$\dot{W}$
Expansion (valve)	Source	$\dot{E}^{TM}_{in} - \dot{E}^{TM}_{out}$
	Sink	Dissipative losses

$$\in = \frac{Ex_{recuperada}}{Ex_{suministrada}}$$

IMAGE 2: Equations for calculating the efficiency exergy

RESULTS

Table 5: Factors that are not taken into account in the calculations of energy-based sustainability indicators

Factor has not been considered	Index with which relates
1.Quality of input resources	Energy intensity per unit of physical production, Energy consumption of industrial subsector based on unit value, Total energy consumption per unit added value of the industry, Total energy consumption in the industry by source energy, Energy consumption in the subsectors of the industry and by type of energy source
2. Material quality produce	Energy intensity per unit of physical production, Energy consumption of industrial subsector based on unit value, Total energy consumption per unit added value of the industry, Total energy consumption in the industry by source energy, Energy consumption in the subsectors of the industry and by type of energy source
3. Changes in gross domestic product	Total energy consumption per unit of added value in the industry
4. Industrial subsector energy consumption based on unit value	Total energy consumption per unit of added value in the industry
5. Pollutant emissions during processing	Thermal efficiency of power stations by fuel type, Total energy consumption by energy source industry, Energy consumption in the subsectors of the industry and by type of energy source
6. Factors or specific average emissions from industry or country	Thermal efficiency of power stations by fuel type, Total energy consumption in the industry by energy source, Energy consumption in the subsectors of the industry and by type of energy source
7. Infrastructure place where production takes place	Energy intensity per unit of physical output, thermal efficiency of the power stations by fuel type, Energy consumption of industrial subsector based on unit value, Total energy consumption per unit added value of the industry, Total energy consumption in industry by energy source, Energy consumption in the subsectors of the industry and by type of energy source
8. Methodology production processes	Energy intensity per unit of physical output, thermal efficiency of power stations by fuel type, Energy consumption of industrial subsector based on unit value, Total energy consumption per unit of value added industry, Total energy consumption in industry by energy source, Energy consumption in the subsectors of the industry and by type of energy

9. Mixtures of fuels used during the process	Energy intensity per unit of physical output, thermal efficiency of power stations by fuel type, Energy consumption of industrial subsector based on unit value, Total energy consumption per unit of value added industry, Total energy consumption in industry by energy source, Energy consumption in the subsectors of the industry and by type of energy source
10. Technology used to carry out the process	Energy intensity per unit of physical output, thermal efficiency of the power stations by fuel type, Energy consumption of industrial subsector based on unit value, Total energy consumption per unit added value of the industry, Total energy consumption in the industry by source energy, Energy consumption in industry subsectors and by type of energy source
11. Using direct and alternative energy	Energy intensity per unit of physical production, Energy consumption industrial subsector based on unit value, Total energy consumption per unit added value of the industry, Total energy consumption in industry by energy source, Energy consumption in the subsectors of the industry and by type of energy source

From the simulation a generation of 14.114 MW turbines high and low pressure as well as a exergy efficiency of 0.90% was obtained. Compared with the already previously reported in the thesis energy efficiency in the use of biomass for power generation: energy optimization and exergy in which there was a generation of 7.9 MW from waste wood and exegetical efficiency 0.73%.

CONCLUSIONS

Current energy efficiency ratings do not take into account aspects that are able to modify the results obtained thus applying an exegetical analysis to supplement the percentage of energy lost is obtained and therefore can propose improvements to the system in order to minimize energy losses.

The power generated starting from the combustion of bagasse was good, however, a great quantity of kg per hour is required.

The exegetic efficiency obtained from the simulation indicates that there is an energy loss of 0.10% the greater amount of energy lost is in reactor in which takes place combustion of biomass.

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