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THERMAL ANALYSIS OF SUGAR INDUSTRY BOILER

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ABSTRACT: This paper presents performance of the Bagasse fired boiler by evaluating the efficiency of both energy and exergy basis. Energy efficiency improvement as well as energy savings is the major concern in most of the development countries all over the world. In this study, the useful concept of energy and exergy utilization is analyzed to investigate the energy and exergy efficiency.

Keywords: [Energy Efficiency, ExergyEfficiency, Availability, Irrversibility, Sustainable Development].

1. INTRODUCTION

The general energy supply and environmental situation requires an improved utilization of energy sources. Therefore, the complexity of power-generating units has increased considerably. Plant owners are increasingly demanding a strictly guaranteed performance. This requires thermodynamic calculations of high accuracy. As a result, the expenditure for thermodynamic calculation during design and optimization has grown tremendously [1]. The most commonly-used method for evaluating the efficiency of an energy-conversion process is the first-law analysis. However, there is increasing interest in the combined utilization of the first and second laws of thermodynamics, using such concepts as exergy (availability, available energy), entropy generation and irreversibility (exergy destruction) in order to evaluate the efficiency with which the available energy is consumed. Exegetic analysis allows thermodynamic evaluation of energy conservation, because it provides the tool for a clear distinction between energy losses to the environment and internal irreversibilities in the process. Exergy is defined as the maximum Theoretical useful work (or maximum reversible work) obtained as a system interacts with an equilibrium state [6]. Exergy is generally not conserved as energy but destructed in the system. Exergy destruction is the measure of irreversibility that is the source of performance loss. Therefore, an exergy analysis assessing the magnitude of exergy destruction identifies the location, the magnitude and the source of thermodynamic inefficiencies in a thermal system. Boiler efficiency therefore has a great influence on heating- related energy savings. It is therefore important to maximize the heat transfer to the water and minimize the heat losses in the boiler. Heat can be lost from boilers by a variety of methods, including hot flue gas losses, radiation losses and, in the case of steam boilers, blow-down losses [7]. This indicates that there are huge savings potentials of a boiler energy savings by minimizing its losses. Wide range of steam inlet parameters are used in the sugar industries and vary between 21–110 bar (a) in pressure and 300–540^{0}C in temperature [6-8].This work aims to identify and assess methods for increasing efficiencies of steam power plants, to provide options for improving their economic and environmental performance.

2. ENERGY ANALYSIS

The concept of energy was first introduced in mechanics by Newton when he hypothesized about kinetic and potential energies. However, the emergence of energy as a unifying concept in physics was not adopted until the middle of the 19th century and was considered one of the major scientific achievements in that century.The concept of energy analysis is based on the first law of thermodynamics.

First law efficiency of Boiler,

$$\eta_{b1} = \frac{m_s \times (h_3 - h_2)}{m_b \times C.V.}$$

where, h_3 = enthalpy of steam steam

h_2 = enthalpy of feed water

3. EXERGY ANALYSIS

The concept of exergy based on the second law of thermodynamics. It is used to calculate the amount of energy present in a matter that is feasible to be turned into useful work. This means that exergy is a measure of energy quality as well as quantity. Exergy also differs from energy in the way that it can be destroyed or consumed, which is not the case for energy. Energy is, as stated in the first law of thermodynamics, conserved in the same way as mass.

The environment is considered as a large reservoir which is not influenced by the considered system, as shown in Fig 1.

Second law efficiency or exergy efficiency of boiler,

$$\eta_{b2} = \frac{m_s(\psi_3 - \psi_2)}{m_b \times \psi_f}$$

where, ψ_3 = exergy of steam steam

ψ_2 = exergy of feed water

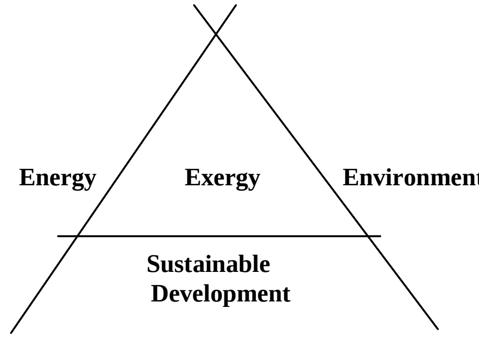

Figure 1- Interdisciplinary Triangle Covered by Exergy Analysis

Boiler Pressure P bar	Energy Efficiency, η_{b1}		Exergy Efficiency, η_{b2}	
	90 TPH	100 TPH	90 TPH	100 TPH
45	77.53	77.53	32.78	32.78
67	84.39	84.39	37.06	37.06

Table 1- Energy and Exergy Efficiency of Bagasse Fired Boilers

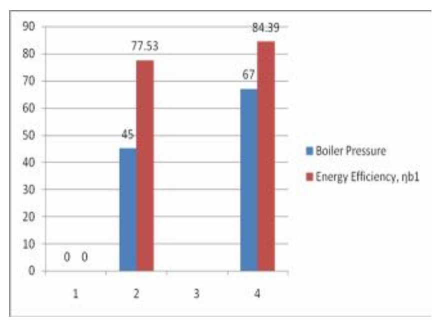

Figure 1- Energy Efficiency of Boilers (90 TPH and 100 TPH)

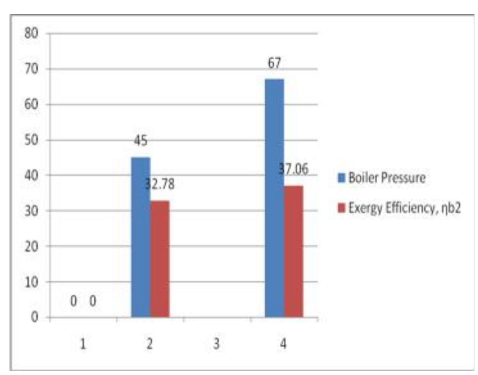

Figure 2- Exergy Efficiency of Boilers (90 TPH and 100 TPH)

4. RESULTS AND DISCUSSION

The energy and exergy efficiencies of 45 bar pressure boiler are 77.53% and 32.78 % for 45 bar boiler respectively. The energy and exergy efficiencies of 67 bar pressure boiler are 84.39% and 37.06 % for 67 bar boiler respectively. The exergy is efficiency is low due to irreversibility of the system.

The steam generation capacity does not affect the energy and exergy efficiency of the boiler.

CONCLUSION

Today the Sugar Industry is facing a problem of Sugarcane shortage which otherwise could go for the Co-generation. This problem can be overcome by replacing boilers with higher pressure ratings so that considerable improvement in both energy and exergy efficiency results in fuel saving will be possible. This saving in fuel bagasse is useful for surplus power generation in sugar industry.

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