Performance Assessment of CHP Cycle in Sugar Industry

Sanjay S. Bhagwat, S. D. Pohekar

Abstract: A huge potential for power generation from waste fuels exists within the sugar cane industry. This paper presents the findings of the energy and exergy analysis of cogeneration i.e. CHP cycle in sugar industry. The study was aimed at assessing the operational performance of the bagasse based cogeneration power plant in sugar industry by evaluating both the energy and exergy efficiency.

Keywords: Energy, Exergy, Entropy, CHP.

I. INTRODUCTION

At the present times, combined-cycle power plants meet the growing energy demand with least fuel consumption. It is, therefore, needed to develop strategies for the optimization of these systems. The efficiency of an energy conversion system is determined according to the first law of the thermodynamics. The second law of the thermodynamics, on the other hand, deals with the quality of energy and determines the maximum amount of work obtainable from an energy resource. Therefore, the application of the exergy analysis in the context of the second law of thermodynamics to the thermodynamic processes has become a necessity.[1] The optimization of power generation systems is one of the most important subjects in the energy engineering field. Owing to the high prices of energy and the decreasing fossil fuel recourses, the optimum application of energy and the energy consumption management methods are very important. Exergy analysis based on the first and second thermodynamic laws is a significant tool to analyze the energy systems. It also reveals the inefficient thermodynamic processes [2]. The prices of the energy sources become expensive in nearly all around of the world. In order to enhance the efficiencies of systems that convert heat energy to mechanical energy, wide range of researches are performed by engineers and investigators [3]. There have been significant changes in the generation of electric power over the last few years, with changes in ownership and dispatch patterns, addition of new generation, and retirement or repowering of older generation. One of the significant trends is the widespread application of combined-cycle technology for new power plants [4]. Exergy is generally not conserved as energy but destructed in the system. 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.

This paper presents the thermal analysis i.e. first law and second law analysis of CHP cycle in sugar industry.

II. COGENERATION IN SUGAR INDUSTRY

The efficiency of cogeneration plants in sugar industries is very high in the range of 75% to 90% because of the low pressure steam coming out of the turbine is not condensed but used for heating and boiling of the juices for treatment & concentration. Even if we do not produce this steam to produce extra power for use somewhere else with same quantity of steam required for process.

A. Technological Options for Cogeneration In Sugar Industry

Cogeneration technologies that have been widely used in sugar industries include two types of steam turbines i.e. back pressure steam turbine and extraction-condensing types (Fig 1). The choice between back pressure turbine and extraction-condensing turbine depends mainly on the quantities of power and heat, quality of heat, and economic factors.

III. ENERGY AND EXERY ANALYSIS

A 16 MW CHP cycle in sugar industry is as shown in Fig.2. The exergy consumption during a process is proportional to the entropy created due to irreversibility's associated with the process. The expression of energy (ή) and exergy (Ψ) efficiencies for the principal types of processes considered in the present study are based on following definitions.

$$\acute{\eta} = \frac{Energy\ out}{Energy\ in}$$

$$\Psi = \frac{Exergy\ out}{Exergy\ in}$$

Revised Version Manuscript Received on February 07, 2017.

Sanjay S. Bhagwat, Department of Mechanical Engineering, Babasaheb Naik College of Engineering, Pusad (Maharashtra) India. **Email:** sanjay_sbhagwat@rediffmail.com

Dr. S. D. Pohekar, Department of Mechanical Engineering, Presidency University, Banglore, India. **Email:** sdpohekar@gmail.com

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

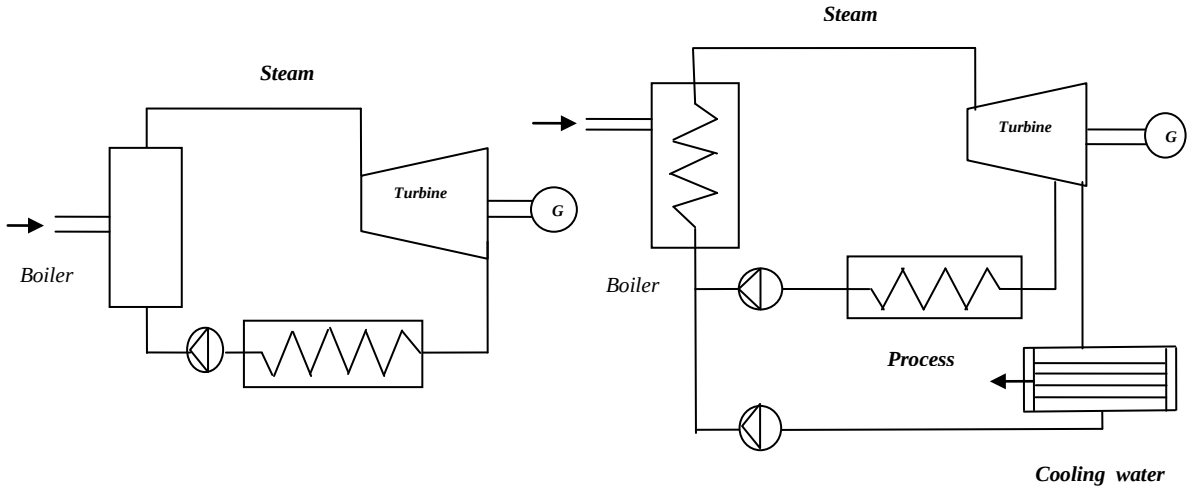

Fig 1(a) Back Pressure Turbine **Fig 1(b) Extraction–Condensing Turbine**

Figure 1: Various Configurations of Cogeneration Systems

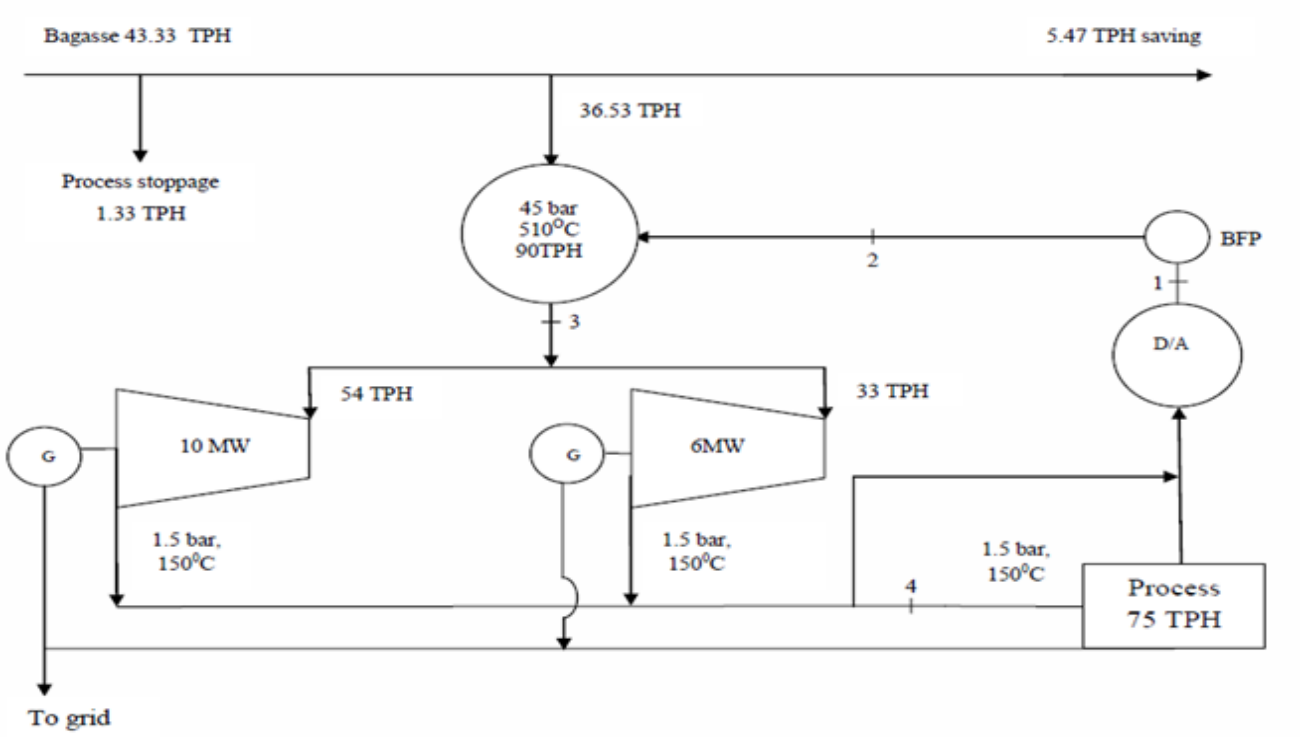

Fig.2 16MW CHP Cycle in Sugar Industry

TABLE 1 : Energy And Exergy Analysis of 16 MW Cogeneration Power Plant in Sugar Industry

Cogeneration Power Plant	16MW
Boiler Pressure P (bar)	45
Temperature T (^{O}C)	510
Temperature of Feed Water T_{fd} (^{O}C)	90
Reference Temperature, T_o (^{O}C)	30
Mass Flow Rate of Bagasse, kg/sec	10.14
Calorific Value of Bagasse, kJ/kg	9500
Chemical Exergy of Bagasse ψ_0,kJ/kg	9660.71
Power Generated, W_{cg}, kW_e	14400
Process Heat Energy Q_{cg}, kW_{th}	57751
Cogeneration Power Plant	16MW
Process Heat Exergy, E_Q , kW_{ex}	13646
Energy Efficiency EUF %	74.83
Exergy Efficiency, η_{ex} %	28.63

IV. RESULT AND DISCUSSION

The analysis performed in this paper showed that the energy efficiency of the CHP cycle is higher than its exergy efficiency. Thus, from the analysis it can be concluded that exergy analysis gives qualitative performance of the system for the available energy.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.

REFERENCES

1. A.Cihan, O.Hacıhafızoglu, & K. Kahveci,, "Energy–exergy analysis and modernization suggestions for a combined-cycle power plant" International Journal of Energy Research, 30(2), 2006,pp.115-126.
2. M.Ameri, P. Ahmadi & A.Hamidi, "Energy, exergy and exergoeconomic analysis of a steam power plant: A case study", International Journal of Energy Research, 33(5), 2009, pp. 499-512.
3. O.Can, N. Celik and I. Dagtekin, "Energetic–exergetic-economic analyses of a cogeneration thermic power plant in Turkey", International Communications in Heat and Mass Transfer, 36(10),2009, pp. 1044-1049.
4. F.Jurado, O. Can., & J. Carpio, " Modelling of combined cycle power plants using biomass",. Renewable Energy, 28(5), 2003, pp. 743-753.

Sanjay S. Bhagwat is working as associate Professor in Mechanical Engineering Department, Babasaheb Naik College of Engineering, Pusad, His area of work in thermal engineering, renewable energy, etc.

Dr. S. D. Pohekar is working as Professor Mechanical Engineering Department, Presidency University, Banglore. His area of work in thermal engineering, renewable energy, heat transfer etc.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication Pvt. Ltd.