University of Tabriz

Journal of Civil and Environmental Engineering
Volume 51 (2022), Issue 4 (Winter), 23-29

EXTENDED ABSTRACT

Effect of Replacing Current Power Plant in Tabriz Oil Refinery with Combined Heat and Power System (CHP) on Energy Consumption

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Received: 03 September 2019; **Accepted:** 29 September 2020

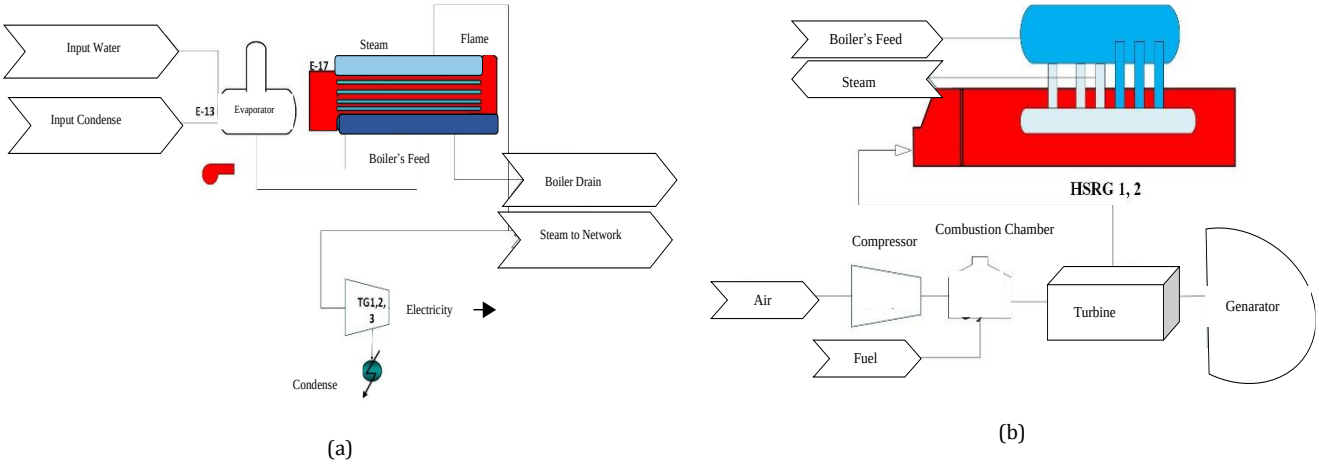
Keywords:
Optimization, Power Plant, Tabriz Oil Refinery, Turbine

1. Introduction

Oil refineries with the aim of converting crude oil to high-value products are one of the most important industries in the world. Refining processes consume large amounts of energy, including electricity and steam. Since most of the energy is generated from non-renewable resources and these resources are exhausted rapidly, energy consumption management and optimization of production in power plants have received great attention in recent years (Eslami et al., 2019; Aryanpur et al., 2019). In this paper, the effect of replacing the current power plant of Tabriz Oil Refinery with a Combined Heat and Power (CHP) system on energy consumption and efficiency of power generation is investigated.

2. Tabriz Oil Refining System

Steam and electricity in Tabriz Oil Refinery are generated through an old Steam Turbine Generator (STG) and a new Gas Turbine Generator (GTG), which is installed due to the low efficiency of the old system. These processes are shown in Fig. 1.



(a) (b)

Fig. 1. STG (a) and GTG (b) in Tabriz Oil Refinery

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Boilers in steam power plants consume liquid fuel and natural gas to produce high-pressure steam which is used in refining processes and also in electricity generation. GTG power plant includes two gas generators with an efficiency of 34%. In the gas stream exiting the generators, a Heat Recovery Steam Generator (HRSG) is installed that produces 25 tons of high-pressure steam per hour. The amount of energy consumed in these two systems can be calculated.

3. proposed Combined Heat and Power System (CHP)

The proposed system for electricity generation includes gas-burning generator with HRSG, and the process is similar to GTG. In this system, natural gas is burned and mechanical energy is transferred to the generator through a shaft, and electricity is generated. Two heat recovery systems in used, the production of warm water from the cooling water of the engine using a heat exchanger and the production of steam or warm water using the heat extracted from hot exhaust gases. This system is shown in Fig. 2.

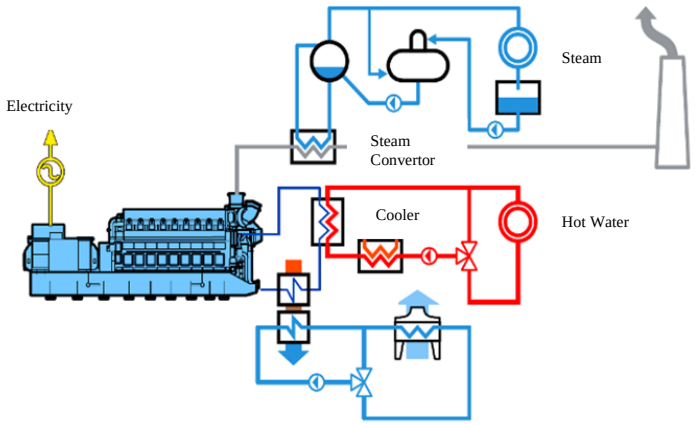

Fig. 2. Proposed system for electricity generation in Tabriz Oil Refinery

4. Results and discussion

4.1. Energy consumption in STG and GTG

Tables 1 and 2 indicate the amount of energy consumed and wasted and the system efficiency for STG and GTG, respectively. The results showed that about 11% of the energy in the old power plants is wasted through smokestack and boiler walls, and in total, 50% of energy is wasted. Calculations for GTG showed 16% efficiency, which is lower than the 46% design efficiency. The results for the proposed system are shown in Table 3.

Table 1. Fuel consumption and energy generation for STG

STG & BOILERS	
Boiler gas fuel consumption (kg/yr)	120257280
Boiler liquid fuel consumption (kg/yr)	7264562
(kcal/kg) Heating value of gas fuel	11615
(kcal/kg Heating value of liquid fuel	9845
Percent energy wasted from boiler	11
Steam sent to the generator (ton/yr)	414716
Electricity generated from generator (MW/yr)	75403
Medium pressure steam generated from generator (ton/yr)	163965
Percent energy wasted in generator	50
Total energy wasted in old power plant	55

Table 2. Fuel consumption and energy generation for GTG

GTG & HRSG	
Gas fuel consumption of GTG (kg/yr)	44781120
Heating value of natural gas (kcal/kg)	11297
Electricity generated (MW/yr)	92238
Percent energy wasted from GTG	84
High-pressure steam generated from HRSG (kg/yr)	142246650
Percent energy wasted in HRSG	77
Total energy wasted in new power plant	65

Based on similar calculations for the designed CHP system with the capacity of at least 6 MW, total efficiency (electrical + thermal) of 85-87% was obtained. Therefore the use of a CHP system with the capacity of 7.5 MW which is able to produce 6 MW electricity, is recommended.

4.2. Cost of electricity from STG, GTG and CHP

Comparing the amount of fuel consumption in three power plants, the total price of electricity generated per hour from STG, GTG, and CHP was found to be 3266777, 300000 and 195000 Rials, respectively. Therefore the cost of electricity from the CHP system is much lower than that for the other two systems.

Table 3. Fuel consumption and energy generation for CHP

CHP	
Gas fuel consumption (kg/yr)	913
Electricity generated (MW/yr)	52560
Percent energy wasted in CHP	52
Steam generated from HRSG (ton/yr)	4380
Percent energy wasted in HRSG	29
Total percent of energy wasted in CHP	15

In terms of the annual cost of electricity based on the amount of fuel consumed, it was found that the electricity generation using the proposed CHP system, even without the HRSG unit, is economically feasible.

5. Conclusions

In this study, current systems of electricity generation in Tabriz Oil Refinery were investigated, and their efficiency was compared with a new combined heat and power system. The results indicated that the efficiency of the proposed power plant is 48% which is higher than the efficiency of two other systems. In fact the amount of fuel consumed for electricity generation and the total cost of electricity generation in the proposed system is lower than the other two systems, and installation of the new power plant could save energy and offer economic incentives for oil refining industries.

6. References

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