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Research Article

Investigation of gas turbine efficiency Enhancement via HRSG using: lab view software

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Abstract

This paper concerns the study of the UBARI power plant, it consists of four single-cycle gas turbine units with a total capacity of 640 MW. As stated in the specification, the thermal efficiency is low (36.7%), the temperature is high (536°C), and the waste heat loss per MW unit is high (207.94). The aim is to address these issues, meet future electricity demand, and reduce harmful emissions to protect the environment due to the power plant's geographical location. The efficiency of generating high-pressure steam using waste heat in four steam blocks of four steam turbines was investigated. Examining the solution with LabVIEW shows: The capacity of each heat recovery steam generator is 62.16MW, that is, the total capacity of the power plant is about 4×222.16MW, and the total efficiency is (51.35%). In addition to reducing the heat loss of the exhaust gas. A good correlation can be obtained by relating the net capacity and gross efficiency of the combined plant to the operating parameters.

Keywords: *UBARI power plant, combined cycle power, Exhaust temperature, Pressure ratios, Exhaust mass flow*

Introduction

Basic human needs can be met only through industrial growth, which depends to a great extent on the energy supply. Steam is used in nearly every industry, and it is well known that steam generators and heat recovery boilers are vital to power and process plants. It is no wonder that with rising fuel and energy costs, engineers and scientists in these fields to work on innovative methods to generate electricity, improve energy utilization in these plants, recover energy efficiently from various waste gas sources, and simultaneously minimize the impact these processes have on environmental pollution and the emission of harmful gases to the atmosphere.

Heat recovery equipment several technologies are available for power generation such as gas turbine-based combined cycles, nuclear power, wind energy, tidal waves, and fuel cells About 40%of the world's power. Complex multi-pressure, multimodule HRSGs are being engineered and built to maximize energy recovery. Heat sources in industrial processes can be at a very high-temperature range, or very low, on the order of, and applications have been developed to recover as much energy as possible in order to improve overall energy utilization. Heat recovery steam generators form an important part of these systems.

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This is practical if any in certain process plants, energy recovery, and pollution control goes hand in hand with economic and environmental reasons.

Today we can glimpse steam generators and waste heat boilers everywhere in any chemical plant, oil refinery, combined heat and power plant, combined cycle power plant, or conventional power plant, as steam is needed for process and power generation almost everywhere. Electric energy is the main driving force of the modern Renaissance and the main source of all kinds of activities because the development of the country is measured by the consumption of electric energy. Libya has found its way in the field of energy in general and electric energy in particular.

2. Problem statement and descriptions

The Ubari power plant is located in southern Libya, about 1,000 kilometre's south of Tripoli. The plant consists of four gas turbines forming four SGT5-2000E units, in (4) x 160 base load power plants with a final capacity of approximately 640 MW [total], using and to be operated by crude oil as the main fuel primary fuel & LFO. The following table shows the specifications.

Table -1: Rated specifications of the basic design for the gas turbine units (SGT5-2000E)

No.	Property	Value	Unit
1	Power output	160	MW
2	Gross efficiency	37.6	%

3	Exhaust temperature	536	ºC
4	Exhaust mass flow	558	Kg/sec
5	Heat rate	9,863	kJ/kWh
6	Pressure ratio	1:12.8	

Through the analysis of the basic design of the gas turbine unit, the problems existing in the basic design of the station gas turbine unit can be summarized as follows:

- The Exhaust temperature is high and the heat energy loss is large, resulting in an increase in power plant losses and an increase in environmental heat load.
- Lower plant efficiency compared to new international standards for plant efficiency operating for base load, which leads to increased fuel consumption for power generation, thereby increasing the price per unit of electricity production cost.

3. Discussion and results

in order to solve the problems mentioned above in the thermal design of the UBARI power station and to improve the economic benefits of grid-connected power generation, taking into account the geographical location of the power station, we propose in this study: The need to study the effectiveness of using the thermal energy of the exhaust of the gas turbine unit as a secondary source of energy, by updating the gas turbine unit to work with the installed systems that generate electricity.

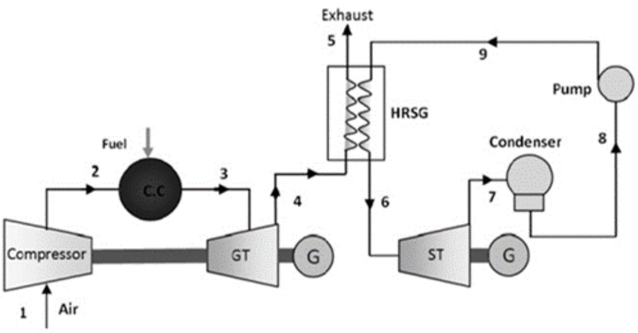

Fig.1: proposed a design for the combined Cycle

The heat transferred from the exhaust gasses is:

$$q_{ex} = m_{ext} \times C_{pg}[T_4 - T_{cri}]$$

Find m $_{vapor}$ Applying heat balance at the boiler heat lst by exhaust gases heat current by water coming low the GT to carry the steam:

$$m_{ext} \times C_p \times [T_4 - T_{cri}] = m_{vap} \times [h_5 - h_{\mathrm{d}}] \succ \quad (1)$$

Where

h_{st} = Enthalpy of generated steam after the boiler or before the HP turbine.
h_d = Enthalpy of the feed water pump.
T_{cri} = Temperature of exhaust gases output from the boiler (nearly 150 ºC).

The net power (steam) can be calculated using the following equation:

$$W_{Net\ power\ Steam} = m_{vap} \times \left[W_{work\ done\ \ steam} - W_{\text{work done pump}}\right] \succ \quad (2)$$

Therefore, we need to find enthalpies for the Brayton cycle well i.e., air-standard analysis:

$$W_{Net\ power\ Steam} = m_{vap} \times [(h_6 - h_7) - (h_9 - h_8)] \succ \quad (3)$$

The heat gain (Q_{add}) of fuel combustion in the combustor can be calculated by the following equation:

$$Q_{add} = m_f \times C_v \times \xi_{cc} \succ \quad (4)$$

The thermal efficiency of the steam turbine device can be calculated by the following equation:

$$\xi_{steam} = \frac{Net\ power\ Steam}{The\ heat\ added} \succ \quad (5)$$

The total thermal efficiency of the combined cycle:

$$\xi_{Total} = \xi_{Net,gas} + \xi_{Net.steam} \succ \quad (6)$$

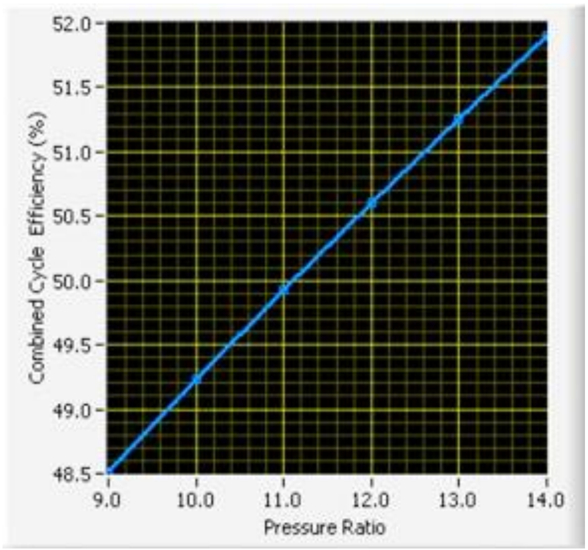

Chart -1: The relation between the pressure ratio and the combined cycle thermal efficiency

Ratios as well as isentropic efficiencies are strongly affected by the overall thermal efficiency of a combined cycle gas turbine power plant. It is explained that (as the pressure ratio increases, the thermal efficiency of the combined cycle increases)

Conclusions

After studying, we conclude some results that indicate that the specifications of the station were relied upon in calculating efficiency and various standards. It is a calculation that shows a decrease in the amount of exhaust heat, thus reducing the effects of emissions. The increased compression ratio has been improving the combined-cycle gas-turbine performance. The results show that the overall efficiency increases with the increase of the peak compression ratio. The total power output increases with the increase of the peak compression ratio. Using a heat recovery steam generator with a steam turbine, the overall efficiency reached 51.35%.

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