# IMPROVE THE EFFICIENCY OF COMBINED CYCLE POWER PLANT

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**Abstract -** *Electricity production, and energy in general, play a pivotal role in every modern society, as electricity is required for filling almost all basic needs, food, water, transportation, shelter, and security. Modern world requires still more and more energy due to the increase in consumption. Especially it is electrical energy that is being requested. There is of course an effort (and due to strict emission standards a necessity) to raise the efficiency as much as possible and to optimize these sources of power from the economic point of view.*

***Key Words***: HRSG (Heat Recovery Steam Turbine), GT (Gas Turbine), ST (Steam Turbine), CCPP (Combined Cycle Power Plant).

## 1. INTRODUCTION

A predominant portion of electrical energy is generated by steam turbines. If we consider classic thermal (fossil, biomass) power plants, it is not possible to attain as high efficiency as in a combination of two thermal cycles. This fact is successfully used in combined cycle power plants (CCPP) which combine gas turbine and steam turbine cycles. From the energetic point of view it is not reasonable to release hot exhaust gas from the gas turbine directly to the stack. This exhaust gas can be further utilized since it has appropriate parameters for steam generation in a heat recovery steam generator (HRSG). The heat is brought in the cycle at a very high temperature and taken out at a very low temperature (in comparison to a single cycle configuration).There are many ways to improve the efficiency. From the point of view of thermal efficiency it can be: raising inlet parameters of live steam (temperature and pressure), implementing regeneration and reheating, reducing backpressure, etc. Optimizing the flow path improves thermodynamic efficiency of the turbine. Mechanical efficiency can be improved for example by reducing the friction in bearings or by using electromagnetic bearings (in the future).

## 1.1 RECENT RESEARCH

Many researchers focus on improve the modeling of CCGT power plant system utilizing the Brayton Cycle gas turbine and Rankine Cycle steam turbine with air (gases) and water (steam) as working fluids achieve efficient, reliable, and economic power generation. Current commercially available generation CCGT power plants achieve total thermal efficiency typically in the 50- 60% Lower Heating Value range.

On 30th April 2018, the combined cycle gas and steam power plant, with one of the highest net efficiency rates worldwide, went into operation in Pakistan. The plant's owner/operator installed H-class gas turbines for the first time in Pakistan. The power plant is located in Haveli Bahadur Shah Punjab, Pakistan and features one of the highest net efficiency rates ever recorded: 62.4 %.

## 1.3. OBJECTIVES

1. To get higher thermal efficiency of the plant.
2. To get high reliability operation.
3. To utilize the fuel consumption properly.
4. To reduce electricity cost by providing more production of electricity.

## 2. COMBINED CYCLE POWER PLANT

A typhical combined-cycle power plant (CCPP) consists of a gas turbine (GT), a steam turbine (ST), a heat-recovery steam generator (HRSG), and a generator mounted in tandem on a single shaft. The GT of a typical CCPP is equipped with inlet guide vanes (IGVs) that adjust the airflow to maintain a high exhaust temperature.

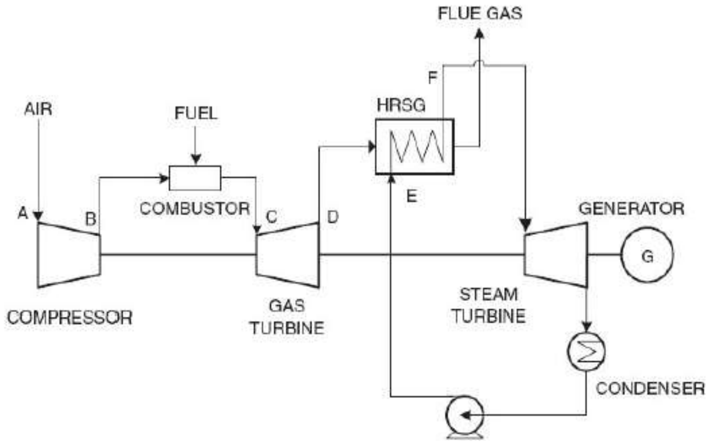


**Figure 1: Schematic arrangement of CCPP**

This is how a combined-cycle plant works to produce electricity and captures waste heat from the gas turbine to increase efficiency and electrical output.

1. Gas turbine burns fuel.
    - The gas turbine compresses air and mixes it with fuel that is heated to a very high temperature. The hot air-fuel mixture moves through the gas turbine blades, making them spin.
    - The fast-spinning turbine drives a generator that converts a portion of the spinning energy into electricity.

2. Heat recovery system captures exhaust.
    - A Heat Recovery Steam Generator (HRSG) captures exhaust heat from the gas turbine that would otherwise escape through the exhaust stack.
    - The HRSG creates steam from the gas turbine exhaust heat and delivers it to the steam turbine.
3. Steam turbine delivers additional electricity.
    - The steam turbine sends its energy to the generator drive shaft, where it is converted into additional electricity.

## 3. PROPOSED SYSTEM

In modern plants these loses are reduced by generation of steam at several stages of pressure. However number of steam generation stages is limited as each stage requires separate system of evaporation and lowering tubes, water and water-steam drums, pump. This complicates the plant so in modern most sophisticates combined cycle power plants number of stages of steam generation is limited to three. If processes of heat transfer from gas to wet steam will not be used and heat will be transferred only from gas to liquid and from gas to saturated or superheated steam, then losses, related to irreversibility of heat transfer may be reduced. Steam will be generated in the multi-stage throttling of liquid from super-critical pressure and near-critical temperature to the pressure, slightly above condensation pressure. Since throttling of liquid and separation of wet steam on saturated liquid and steam do not require complicated technical devices, number of steam generation stages may be more than in conventional combined cycle power plant. Such increasing of number of steam generation stages will not complicate the plant.

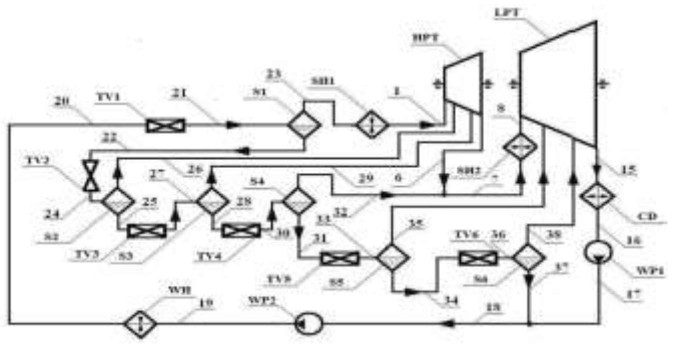


**Figure 2 : Scheme of steam part of combined cycle power plant with multi-stage throttling of working substance. HPT, LTP – high and low pressure turbines; SH1, SH2 – steam overheaters; CD– condenser; WP1, WP2 – feed water pumps; WH – water heater; TV1…TV6 – throttling valves; S1…S6 – separators of wet steam**

## 4. METHODOLOGY/APPROACH

Efficiency of combined cycle power plant may be improved by reducing internal irreversibility of processes in the thermodynamic cycle of the power plant. It is necessary to transfer between working substances of gas and steam cycles considerable part of the heat, supplied in the gas cycle. This imposes restrictions on the shape and parameters of the steam cycle. As a consequence thermal efficiency of the steam cycle in combined cycle power plant is substantially lower than in the ordinary steam power plant – 36% and 53% respectively for the same values of maximum steam temperature. The following points are to be considered;

1) Increase the turbine inlet temperature provided the turbine materials can stand the temperature or one has access to replacement parts that can withstand the temperatures.
2) Increase the pressure ratio. There is a limit to the efficiency increase depending upon the turbine inlet temperature. One can concievably increase the pressure ratio to a point that the increased work is never recovered because the expansion across the turbine is inadequate to recover the work. Also, this would likely require a new compressor although some work was done in the past involving "supercharging" the compressor with a blower.
3) Power augmentation through steam injection.
4) On turbines with HP and LP turbine separated, apply reheat.

## 5. RESULTS AND DISCUSSIONS

New methods of increasing efficiency of steam, gas and combined cycle power plants are being proposed. Calculations shows increase of net efficiency 22.1% for steam turbine power plant, 12.9% for gas turbine power plant and 4.2% for steam part of combined cycle power plant.

The main aspect of this case study is to improve the efficiency of the combined cycle power plant. In the single cycle power plant we release the exhaust gas to the environment which pollutes our environment but in the combined cycle power plant we can rotate another turbine (steam turbine) by using the exhaust gas that is left after rotating the first turbine which helps to reduce environment pollution. The way to improve the power output of the power plant was to replace the single pressure condenser by the double-pressure one. Two possible limit options were calculated: with preserved heat exchange surface and with preserved terminal temperature difference in relation to the original condenser.

## 6. CONCLUSION

As global energy demand continues to grow, combined cycle power plants are becoming more relevant. So the efficiency of plant plays a vital role in modern power generation system .The higher the efficiency, the higher the electricity is produced. For this reason electricity cost of generation will be reduced .The more people are getting the electricity facility by improving combine cycle power plant efficiency.

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