**PS1-Study Report**

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**THERMAL POWER PLANTS**

**Theory :**

Thermal power plants use heat energy obtained by combustion of fuel, to generate high pressure steam which is then used to rotate steam turbines connected to the shaft of a generator(alternator). The rotating shaft of the generator produces electricity and as a result, we see conversion of heat to electrical energy with a drop in pressure and temperature of the steam that is expelled from the steam turbines.

The resulting low pressure steam is again rerouted to the steam boiler through a condenser and low pressure water heater, thus forming a cycle of heat exchange.

**Process Overview :**

In a steam boiler, the water is heated up by burning the fuel in the air in the furnace, and the function of the boiler is to give dry superheated steam at the required temperature. The steam so produced is used in driving thesteam turbines. This turbine is coupled to a synchronous generator (usually three-phase synchronous alternator), which generates electrical energy. The exhaust steam from the turbine is allowed to condense into water in the steam condenser of the turbine, which creates suction at very low pressure and allows the expansion of the steam in the turbine to very low pressure. The principal advantages of the condensing operation are the increased amount of energy extracted per kg of steam and thereby increasing efficiency, and the condensate which is fed into the boiler again reduces the amount of fresh feed water.

The condensate along with some fresh makeup feed water is again fed into the boiler by a pump (called the boiler feed pump). In the condenser, the steam is condensed by cooling water. Cooling water recycles through the cooling tower. This constitutes a cooling water circuit.

**Performance and efficiency of TPP :**

Overall efficiency of a thermal power plant is calculated as the ratio of heat equivalent of electric power and heat produced due to fuel combustion in the furnace.



Although many factors affect the heat transfer cycle and efficiency, the major ones are :

###### **Boiler Efficiency :**

Depends on the heat content of the outlet steam and the heat provided by combustion of fuel. Incomplete combustion can lead to excess impurities and decreased efficiency. A typical steam boiler has an efficiency of 85%

###### **Cycle Efficiency :**

The overall thermodynamic cycle also affects the efficiency. Since the thermal power plants use a Rankine cycle with steam/water as the working fluid, loss of heat content which is expelled from the steam turbine affects the efficiency significantly.

###### **Turbine Efficiency :**

This is the efficiency of a turbine to convert heat energy carried by steam from boiler into useful mechanical energy.

###### **Generator Efficiency :**

Generator efficiency is calculated using the mechanical energy input from the steam turbine and the actual energy output generated. A typical generator has an efficiency of 96-99

A typical Thermal Power Plant efficiency is quite low. Generally, it ranges between 25 to 30%, and in extremely rare cases it is 40%.

A thermal power plant operation resembles a Rankine cycle, hence increasing the temperature of steam from the boiler or decreasing the temperature of cooling liquid in the condenser increases the overall efficiency of the plant

Industries usually take steps to implement this, few of which are:

1. Energy output generated by the generator has a high dependence on the pressure and temperature of steam entering the turbine chamber. Higher the temperature and pressure more is the power generated. This is the main reason why steam from the boiler is superheated before it is sent to the steam turbine.
2. Exhaust steam from the turbine is sent back to the boiler through the BFP, but pressurizing steam is an expensive and difficult task. Hence it is first passed through a condenser where it is converted to low pressure water. This water has much less volume (nearly 1/17th times the original volume of steam) and is also easier to pressurize

**LATEST TECHNOLOGY TO IMPROVE THERMAL POWER PLANT PERFORMANCE**

New technologies and studies to improve thermal power plant performance include :

1. Continuous combustion tuning with artificial intelligence
2. Optimizing turbine operations in real time using machine learning
3. Predictive maintenance to avoid unplanned downtime using machine learning
4. Remote monitoring to detect unexpected operational variations

Oxyfuels are also being tested to provide lower emissions and increased power output.

The oxygen-fired pulverised coal power plant technology assists in removing completely (reported: 90% CO2 removal efficiency) the CO2 generated in the combustion process with very little air pollutant.

**ADVANCED PROCESS CONTROL (APC)**

**WHAT IS APC?**

Basic process control (or process automation) is the technology enabled automation of complex industrial processes. It is implemented within the control systems of an industrial process, which in case of power plants may include DCS. A single process control typically operates independent of other control systems, hence any variation in one process control will require the operator to manually change operational parameters of another process control to maintain the same level of performance.

Basic control loops such as those for flowrate, temperature, level, and pressure are controlled by systems such as a distributed control system (DCS), and the operator adjusts the setpoints manually to achieve targets such as that of energy conservation. Accordingly, the performance varies significantly, so a large allowance is required against the operational limit in case unexpected changes occur during operation.

An Advanced Process Control is added on top of an existing set of control systems that helps to stabilize and optimize plants

In control theory, Advanced process control (APC) refers to a broad range of techniques and technologies implemented within industrial process control systems. They are usually deployed optionally and in addition to basic process controls. Advanced process controls are typically added subsequently, often over the course of many years, to address particular performance or economic improvement opportunities in the process.

APC is typically implemented using function blocks or custom programming capabilities at the DCS level. In some cases, APC resides at the supervisory control computer level.

**NEED FOR APC**

Traditional power plants are operating in uncertain times. These plants are competing against new sources of energy generation such as solar and hydro power plants which have significant advantages in terms of efficiency, performance and overall process control. To remain competent in the market, traditional power plants are required to improve profits and power generation efficiency, without compromising plant equipment and safety parameters.

Power plants today are subject to stresses that exceed their original design criteria. This leads to increased equipment wear and higher maintenance costs.

To stay competent in the market thermal power plants need to run at full capacity, while also optimizing performance to eliminate unplanned downtime, meet regulatory burdens, increase power output and offer significant improvements in profitability.

Advanced Process Control (APC) is a proven control and optimization technology delivering measurable and sustainable improvements in production yield, coupled with the added value of energy savings. APC has become a standard solution for realizing stable control processes.

**ADVANTAGES OF APC**

With today’s APC solutions steam plant operators can optimize thermal efficiency, reduce emissions and decrease thermal stresses or accelerating maintenance intervals.

For example, APC allows boilers to maintain low nitrogen oxides (NOx) emission

conditions and high carbon burnout, both of which are critical for plant emission performance and efficiency.

APC systems help keep expenses under control by ensuring the plant always operates within certain limits.

Power plants are large users of electricity, which is used to drive a whole range of auxiliary systems, such as pumps, fans, compressors, drives, etc. Depending on how they are configured, APC systems can also manage steam temperatures and pressures

throughout the steam cycle, allowing the best achievable efficiency while minimizing mechanical stresses. Optimizing coordinated boiler/turbine control for grid frequency support also can be achieved. System parameter collection and performance data analysis helps in scheduling predictive and prescriptive maintenance activities, lowering maintenance costs significantly.

APC solutions can be used to control gas turbines. Modern turbines are limited due to material capability hence efficiency improvement is instead done by improving load response (e.g., startup and ramping) as well as low-load capability.