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ULTRA SUPERCRITICAL COAL FIRED POWER PLANT

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ABSTRACT

Ultra Supercritical (USC) coal fired power plants are a type of coal-fired power plant used in more modern designs. It differs from traditional coal power plants because the water running through it works as a supercritical fluid, meaning it is neither a liquid nor a gas. This occurs when water reaches its critical point under high pressures and temperatures, specifically at 220 bar and 600°C (Bright Hub, 2015). As a liquid approaches its critical point, its latent heat of vaporization begins to decrease until it reaches zero at the critical point (Bright Hub, 2015). This means that the amount of energy needed to change the water into steam becomes less and less, and eventually the water's vaporization phase change is instant. This reduces the amount of heat transfer to the water that is normally needed in a conventional coal fired plant, therefore, less coal is used to heat the same amount of water. This increases the plant's thermal efficiency by a considerable amount (Bright Hub, 2015). These plants are the standard for new coal power plants, as their efficiencies can reach around 47.5%, compared to older coal power plants that operate around 33%. Improved efficiency corresponds to fewer greenhouse gas emissions, as well as pollutants like NOx, SOx, and particulate matter which all cause adverse health effects. An ultra supercritical coal plant (as opposed to a traditional coal plant) will decrease waste heat produced by 25% and cut pollution and CO2 by roughly the same amount (World Coal, 2015).

KEYWORD

Ultra Supercritical, coal fired, power plant, vaporization, heat transfer.

INTRODUCTION

Tanjung Bin Energy (TBE) Power Plant is a 1×1000MW Ultra Supercritical Pulverized Coal Fired Thermal Plant that located at Tanjung Bin, Pontian, Johor Darul Takzim. The Power Plant is owned and operate by Malakoff Corporation Berhad. The location of the power plant is as shown in Figure 1. The plant achieved Commercial Operation on 21 March 2016. TBE has a 25 year Power Purchase Agreement (PPA) with the off taker – Tenaga Nasional Berhad (TNB).

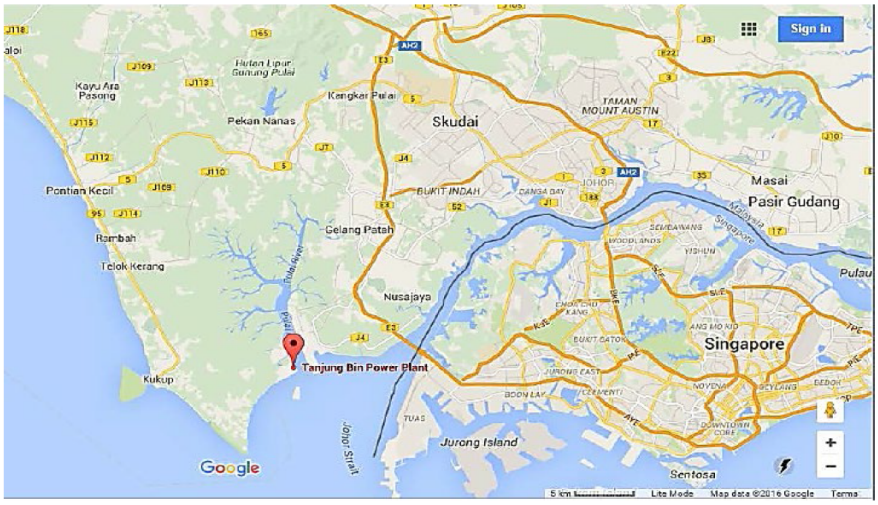

Figure 1: TBE Power Plant Location.

The Primary Fuel is Sub-Bituminous Coal. However, Light Fuel Oil (Diesel) is used for Start-up and Shut-down process. Under the PPA and Coal Supply Transportation Agreement(CSTA), coal supply is obtained mainly from Indonesia, Australia and South Afrika through TNB Fuel Services Sdn. Bhd.

POWER PLANT DESCRIPTION

The main equipment of the power block comprises the following: -

- One Steam Turbine supplied by GE (Alstom) – model STF 100 with four- modules type single reheat steam turbine (1 High Pressure(HP), 1 Intermediate Pressure(IP) and 2 double flow Low Pressure(LP)) with a nominal capacity of 1076MW.
- One GE(Alstom) GIGATOP 2-pole generator (model 50WT25E-158) with a rating of 1270.6 MVA.
- One 2-pass Ultra Supercritical Reheat Boiler with evaporation rate of 3,226 ton/hour at a superheater outlet pressure of 282.4 bar gauge and temperature of 600 °C manufactured by GE(Alstom).
- Three Single Phase Generator Step-up Transformers 270/360/450 MVA 27/500kV supplied by GE (Alstom) Power Systems, stepping up the generator output power for connection to the TNB's Transmission Network.

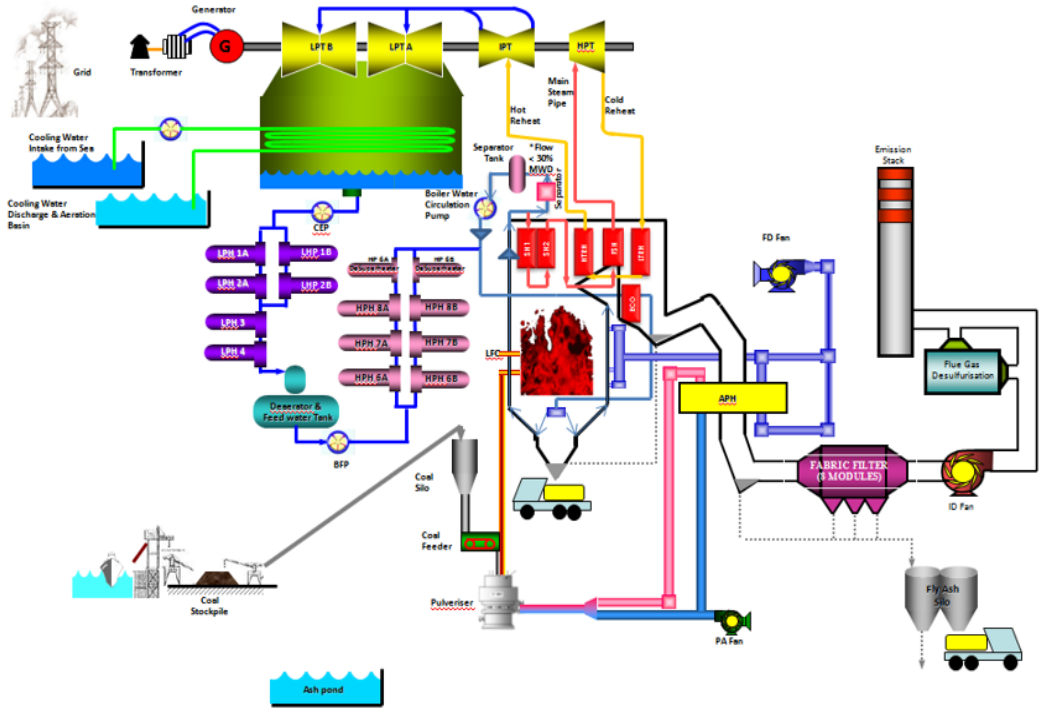

Figure 2: TBE Overall Process Schematic

The overall process for TBE is as shown in Figure 2. The electricity generation unit includes a high-pressure (HP) turbine, an intermediate pressure (IP), two double-flow low pressure (LP) turbines and the electric generator. Superheated steam enters the HP turbine and expands. The cold reheat steam is brought into the boiler reheat section and enters the IP turbine. In the IP turbine, steam expands and is eventually brought to the LP turbines where it will expand further. The exhaust steam from the LP Turbines is sent to the sea water cooled condenser to convert the steam back into condensate for reuse in the boiler again.

DISCUSSION AND WAY FORWARD

Operating a USC Coal-Fired Power Plant like TBE are having more advantages than conventional coal-fired power plant. The advantages are as below:

- Provide even greater thermal performance and efficiency improvements. The combination of utilizing supercritical throttle pressures along with an increase in throttle temperatures results in cost reductions in fuel usage and handling, flue gas treatment and ash disposal.
- Have the ability to respond and adjust to changes in electricity load demand while maintaining tight control of steam temperatures. Hence, reducing the thermal stress on the Steam Turbine Components.
- Less fuel consumption, less emission of gases and higher efficiency. Thus, align and supports Malakoff's Environmental, Social, & Governance (ESG) goals.
- Improved reliability and increased boiler tube life management

However, there are challenges in operating a USC Coal-Fired Power Plant like TBE. The challenges are such as below:

- Stringent water chemistry requirements due to High Water Pressure and temperature. Higher potential of causing the boiler tubes failure.
- The high pressure and temperature of supercritical boiler restricts use of boiler tubes due to availability of material and difficulties experienced in the turbine and condenser operation due to large volumes.
- Unstable global coal price due to Russian invasion of Ukraine
- Causing a big drop in national grid frequency when the 1000MW power plant is tripped.

CONCLUSION

In conclusion, Ultra Supercritical Power Plant such as TBE is consider the only solution to generate electricity in thermal power plants in the most efficient way with minimum pollution to the environment thus comply with Environment(E), Social(S) and Governance(G) goals.

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