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Coal power development by Electricity Generating Authority of Thailand (EGAT) for clean energy

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Abstract

In this work, KRABI clean coal power plant project is studied and reviewed for the development of coal power in Thailand by Electricity Generating Authority of Thailand (EGAT). This plant will use the state-of-the-practice technology with the high efficiency for emissions control such as (1) Ultra Super-Critical (USC) Boiler for less coal consumption and CO_2 mitigation, (2) Selective Catalytic Reduction (SCR) for NO_x control, (3) Activated Carbon Injection (ACI) for Mercury (Hg) capture, (4) Electrostatic Precipitator (ESP) for Particulate capture, (5) Flue Gas Desulphurization (FGD) for SO2 treatment, and (6) Continuous Emission Monitoring System (CEMS) for near real-time stack detector and on-line monitoring report. In addition to the Birth, Jetty, and Coal Handling System with the underground tunnel are well-designed under the concept of closing and sealing system for dust control. The future of coal power projects (e.g., Thepa site) will be further implemented in the similar or better technology for guaranteed the good air quality in the area. By using Carbon Capture and Storage/Sequestration (CCS) to mitigate global warming and oceanic acidification may be considered to apply for commercial applications in the future.

Keywords: EGAT, Coal-fired power plant, Clean coal technology, Emission control

1. Introduction

Electricity Generating Authority of Thailand (EGAT) generated the electricity by the use of Natural Gas (69.74%), Coal (17.59%), Hydro (9.50%) and Renewable (2.32%) for the year 2015, which was a large distribution of power sources [1]. Regarding to the latest Power Development Plan (PDP 2015), it was proposed to balance this portion to compensate more coal power, improve existing hydro plants and promote new renewable sources, etc [2]. However, the coal-fired power plant will be a major concern due to environment aspects especially on emissions and air pollution control.

In term of coal power perspective, EGAT is under construction 600 MW replacement plant at Mae Moh site. Other plants of 800 MW and 1,100 MW at KRABI and Thepa sites will be developed and implemented the project in the near future, respectively [1-2]. This paper describes on EGAT developments of KRABI Power Plant because this plant is designed by using the most modern technology for the best commercial application. Applications of the USC boiler can be used for better power generation and considering the global warming. ACI for mercury capture will be also applied at the first time.

2. Materials and methods

Figure 1 shows the schematic and block diagram of KRABI Power Plant, which is applied the advanced technology with high efficiency for emissions control after the power generation. The process starts from the ambient air delivered in to USC Boiler for well-mixing with pulverized coal. Internal combustion is inside the boiler with ultra-supercritical once-through steam to drive steam turbine and generate the electricity. The exhaust steams is transferred to the condenser in a liquid form and expanded to the cooling tower for heat treatment before discharging into the environment. Considering the pathway of the hot gas (sometimes called as exhaust gas or emissions) before releasing into the atmosphere, emissions can be controlled through several equipments as (1) Ultra Super-Critical (USC) Boiler for less coal consumption and CO_2 mitigation, (2) Selective Catalytic Reduction (SCR) for NO_x control, (3) Activated Carbon Injection (ACI) for Mercury capture, (4) Electrostatic Precipitator (ESP) for Particulate capture, (5) Flue Gas Desulphurization (FGD) for SO_2 treatment, and (6) Continuous Emission Monitoring System (CEMS) for real-time stack detector and on-line monitor. The detail description of such equipment will be discussed below.

2.1 USC boiler for CO_2 mitigation

Many governmental departments and agencies (e.g., Europe, United States of America, and Japan) have promoted the research and development into the advanced USC plants with the goal of improving a net thermal efficiency on the basis of higher heating value and more CO_2 capture or storage. Nowadays, commercial USC Boiler offers many

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competitive challenges such as durable materials for high-temperature and high-pressure operation, which will be more reliable and economically feasible [3].

USC boiler is one of the key equipment in KRABI Power Plant that can be used to improve the plant efficiency by increasing the steam temperature and pressure of thermal power plants. This was an effective means of reducing the amount of coal consumption and subsequently to CO_2 reduction. Based on the approximation, KRABI Power Plant can achieve CO_2 mitigation (0.7 kg/kwh) compared to other plants in Thailand as shown in Table 1.

2.2 SCR for NO_x control

Using USC boiler with the high temperature can produce more thermal NO_x, which is important to control and to prevent NO_x issues (~70-95%). SCR is the means of converting NO_x with N_2, H_2O, and adding Ammonia (NH_3) onto a catalytic process as the reductive agent [4]. SCR systems will be installed after USC boiler for NO_x control.

2.3 ACI for Mercury capture

As clearly seen on Figure 2, ACI shows the potentials for Hg capture under the performance of the activated carbon, which is related to the physical and chemical characteristics of surface area and size distribution.

Pore size distribution is a major factor to the ability of Hg and other sorbent to penetrate particles, in which pores of the activated carbon sorbent should be as large as possible to provide free access to the internal surface area. While particle sizes decrease, the access to the internal surface area may increase along with the adsorption rates [5]. At this state, Bottom Ash and Hg capture will be collected by ESP.

At this end to ensure the amount of the total mercury reduction, mercury detection system with sampling and probing will be installed at the stack and monitored with CEMS in parallel with other emissions, which will be discussed later.

2.4 ESP for particulate capture

ESP is a filtration and collective equipment that can remove both coarse and fine particles, (i.e., dust) from an exhaust gas by using electrostatic charge through the multi-parallel plate against gases flow (~95-99%) [6]. Bottom ash will be delivered through the ash conveyor to nearby landfill with the sufficient capacity of the plant lifetime. Fly ash will be collected for use in construction industry to enhance cement product.

2.5 FGD for SO_2 treatment

Wet type FGD will be used for SO_2 treatment due to its high effective to capture SO_2 (~92-99%). FGD utilized calcium carbonate ($CaCO_3$) as an absorbent agent and chemically reacted to obtain gypsum ($CaSO_4$ and $2H_2O$) [6]. Unfortunately, it was unable to apply gypsum for industrial application at this stage. Thus, this process was for SO_2 treatment only and gypsum as by products.

2.6 CEMS for real-time stack monitor

Like other modern power plants, CEMS was widely used as a tool or an instrument to monitor exhaust gas at the stack tip before releasing out to the atmosphere (e.g., criteria and toxic pollutants of SO_2, NO_x, PM (via flue gas opacity), Hg, O_2, and Moisture etc). CEMS also provided the historical real-time information in the form of collective emission database, which will be compared to the emission standard or determined the peak incident [7]. This could be simply connected to the national monitoring network of governmental departments such as Department of Industrial Work (DIW) and Pollution Control Department (PCD) for safety and security purpose.

3. Results and discussion

Table 2 shows the estimated emissions from KRABI Coal-fired Power Plant under the block diagram as mentioned above. These values are not for the comparison purpose but for the standard reference line that emissions level shall not exceed. The results also provide the general overview of emissions goal, which is clearly seen a great differentiation when evaluated to those of Thailand standard for conventional coal power. For NO_x, SO_2, and PM, emissions can be subjected to 3-4 times smaller while Hg contribution can be negligible.

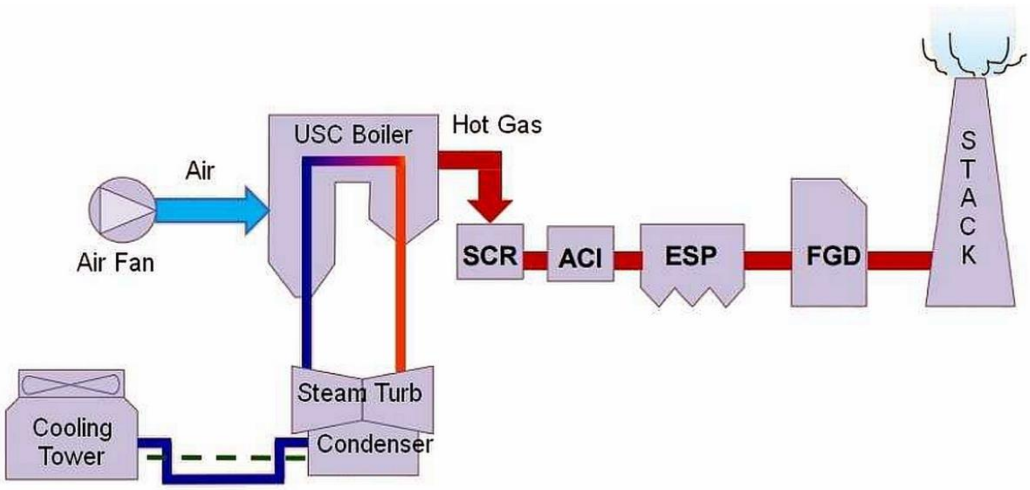

Figure 1 Schematic Diagram of KRABI Coal-fired Power Plant

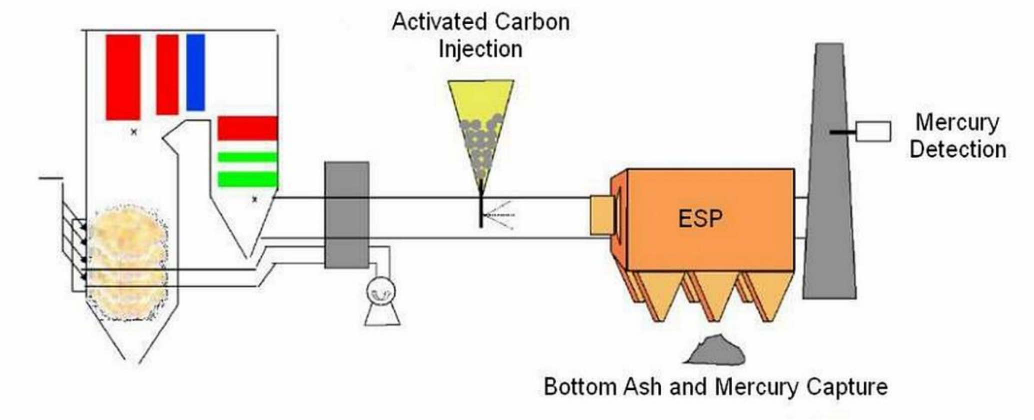

Figure 2 Activated Carbon Injection (ACI), Bottom Ash and Mercury Capture, and Mercury Detection

The coal quality is an external factor to be discussed. Due to the difficulty to exactly identify the coal properties at this moment; thus, KRABI Power Plant proposed to use import coal in sub-bituminous type (i.e., from Indonesia or Australia) with the standard quality of high heating value and low ash and sulfur content. The coal transport can carried through a small gross ton ship (8,000 ton per time per day) through its Birth and Jetty. To ensure dust control from coal handling system, the underground tunnel is designed with closing and sealing conveyor system to be proposed.

Table 1 Comparison of CO_2 Emissions for Coal-fired Power Plants in Thailand

Power Plant	CO_2 [kg/kwh]
KRABI	0.700
MMRP 4-13	0.930
BLCP	0.923
GECGO 1	1.101

Table 2 Estimated Emissions from KRABI Coal-fired Power Plant

Emissions	Conventional[1]	KRABI[2]
NO_x (ppm)	200	50
SO_2 (ppm)	180	50
PM (mg/m^3)	80	30
Hg (mg/m^3)	2.4	0.000051

[1]Thailand Emissions standard from Environmental Protection Committee regulated by PCD and EGAT.
[2]Reference state at 1 atm., 25 degree Celsius with 7% O_2 excess dry.

4. Conclusion

This paper presents the trends of clean coal power by EGAT to improve emissions and maintain air quality. The project development of KRABI coal-fired power plant is reviewed and discussed, especially on emissions control and monitor (e.g., USC Boiler for CO_2, SCR for NO_x, ACI for Hg, ESP for PM, FGD for SO_2, and CEMS for emissions monitoring). Emissions estimate are also presented to evaluate those of national emissions standard and found acceptable level much lower than baseline, particularly Hg. The future development may propose the clean technology for Carbon Capture Storage / Sequestration (CCS) to mitigate global warming and its related issues.

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6. References

[1] Electricity Generating Authority of Thailand (In Thai). EGAT Annual Report 2015. Nonthaburi: Electricity Generating Authority of Thailand; 2015.
[2] Energy Policy and Planning Office, Ministry of energy [Internet]. Thailand Power Development Plan 2015 (PDP2015) from 2015 – 2036 (in Thai) [cited 2016 Mar 3]. Available from: www.eppo.go.th/ power/PDP2015/PDP2015 .pdf
[3] Wakabayashi Y, Maruta T, Hokano M, Kitagawa Y, Suganuma H, Fujimura K. Reduction of CO2 emissions in conventional boilers. Mitsubishi heavy industries technical review 2009;46(2):13-17.
[4] Wikipedia [Internet]. Selective catalytic reduction. [cited 2016 Mar 3]. Available from: https://en.wikipedia.org/wiki/Selective_catalytic_reduction
[5] U.S. Environmental Protection Agency [Internet]. Control of mercury emissions from coal-fired electric utility boilers. North Carolina: Research Triangle Park [cited 2016 Mar 3]. Available from: https://www3. epa.gov /airtoxics/utility/hgwhitepaperfinal.pdf
[6] Cooper CD, Alley FC. Air Pollution Control: A Design Approach. 4th ed. Illinois: Waveland Press, Inc; 2011.
[7] Jahnke JA. Continuous Emissions Monitoring. 2nd ed. New Jersey: John Wiley & Sons; 2000.