A Review Paper on

Cooling System for a Coal Power Plant

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ABSTRACT

Coal power plants traditionally have required huge volumes of water to condense steam from the turbine exhaust. The complex interdependency between water and energy poses new challenges for policy makers to achieve a safe, secure and sustainable supply of water and energy in the future. Cooling systems are the most water-intensive part of the thermoelectric generation process, presenting significant opportunities to reduce the withdrawal and consumptive use of fresh water. Reuse of superheated steam by condensing it to saturated steam for cooling can reduce freshwater withdrawal and decrease water contamination and withdrawal-related impacts on aquatic life and the environment. Preheating of saturated steam can give better efficiency. Here we focus on challenges and opportunities for improving water efficiency in the cooling systems of Coal power plants. First, we present the types of cooling systems in a Coal power plant. Then, we illustrate the key criteria for feed water appropriate design and operation guidelines for cooling systems. In order to facilitate the use of saturated steam in coal power plants, we suggest the key technical issues and available water technologies for brackish water desalination.

Keywords

Water consumption Water withdrawal Energy-efficient technology Zero liquid discharge Fit-for-purpose use.

INTRODUCTION

In general, condensers and cooling towers have not received the attention they deserve. However, in today's competitive electric power market more attention is now being given to improving their operating efficiency. Although the basic design of cooling towers and condensers has not fundamentally changed over the years, the manufacturers have not been idle. Two major changes in recent years have been the introduction of new cooling tower fills and the use of thinner wall titanium and stainless-steel tubing in condensers. The cooling systems reduced the heat generated in the power plant and thus protecting the equipment's of the plant from wear and tear due to heat generated in the plant. By increasing the efficiency of the plant also reduces the emission of excess CO2 in to the atmosphere.

LITERATURE SURVEY

Diana Siqueira, Renata Vitor Francisco, Rogério J Silva, Genésio J. Menon: In this article, the authors discussed about the cooling of coal power plant in Brazil. The operation of coal and natural gas with combined cycle power plant utilizes water for steam production and cooling system. The operation of coal and natural gas with combined cycle power plant utilizes water for steam production and cooling system. The once-through system is more efficient than the closed system because the cooling water that returns to the system with a temperature higher than the ambient water temperature. Besides, the water consumption of the once-through system is lower than the one of the closed system, with an evaporation rate by 0.5% to 2% (EPRI, 2013). The closed system is classified as wet (cooling pound, mechanical or natural cooling towers) or dry (air-cooled condenser or dry cooling tower). Once through system and wet cooling tower are the most popular cooling system in EUA (DOE, 2014). The huge amount of water used by thermal power plants using once-through cooling system is one of the main incentives to convert it the system for closed system. Cooling towers are classified in natural or mechanical, and these can be classified in forced or induced. The towers are more efficient in heat transfer than the cooling ponds or dry cooling system. Besides, they have a lower withdrawal rate (about 97% lower than once through system) (Harvey, 2008), but they have a higher water consumption (about 83% of total water consumption of the power plant) (Elcok, 2011). Besides, the closed system affects the power plant operation, causing a reduction in overall efficiency by 2% to 5% (World Nuclear Association, 2017). [1]

Richard J. Campbell: In this article, the authors discussed about the Increasing the Efficiency of Existing Coal Fired Power Plants. The overall efficiency of a power plant encompasses the efficiency of the various components of a generating unit. Minimizing heat losses is the greatest factor affecting the loss of CFPP efficiency, and there are many areas of potential heat losses in a power plant. Efficiency of older CFPPs becomes degraded over time, and lower power plant efficiency results in more CO_2 being emitted per unit of electricity generated. By improving the efficiency of the parts of a coal power plant the emission of CO_2 can be reduced. The mechanical parts loose efficiency due to high heat generation resulting in the wear and tear of the mechanical parts. The options most often considered for increasing the efficiency of CFPPs include equipment refurbishment, plant upgrades, and improved O&M schedules. [2]

Anne M Carpenter: In this article, the author discussed about the ways of saving water in bottom ash handling, pollution control, and cooling systems. Recovering the moisture from the coal could provide water for internal use and minimizing the fresh water usage. Pre-drying lignite before it enters the mill (preferably using low-grade heat) offers the potential to recover the evaporated moisture from the dryer exhaust. Otherwise, the water vapour could be recovered from the mill exhaust. By using evaporative processes and non-evaporative dewatering processes we can minimize the water usage this way of minimizing the water is named as water recovery from coal. A new technology being developed in China is the Getting Water from Lignite (GWFL) system is used for Water recovery from mill exhaust. [3]

Mirjana Lakovic, Milos Banjac: In this article, the authors discussed about the evaporative cooling system of a coal fired power plant and the analysis of it. The paper presents a theoretical analysis of the cooling system of a 110 MW coal-fired power plant located in central Serbia, where eight evaporative towers cool down the plant. In the paper they described about the working of open-cycle and closed-cycle cooling systems and the calculations that need to satisfy the conditions to produce the cooling effects based the principle of Rankin's. [4]

Arthur H.A. Melani, Carlos A. Murad, Adherbal Caminada Netto, Gilberto F.M. Souza, Silvio I. Nabeta: In this article, the authors discussed about Maintenance Strategy Optimization of a Coal-Fired Power Plant Cooling Tower through Generalized Stochastic Petri Nets (GSPN). Improving the performance of coal power plant by maintenance and optimization of the plant by using effective cooling method will significantly increase the performance of the plant and also reduces the environmental impacts. To achieve this, GSNP is the process used to optimize the plant by maintenance. GSNP is the graphical representation of PN employs the following notations: Places (described by circles), Transitions (described by boxes or bars), Arcs (described by arrows that connect Places to Transitions and vice versa), and Tokens (described by a black dot). The tokens located in a place are referred to as the marking of a place; the initial marking represents the initial condition or state of the PN Predictive maintenance is one of three types of maintenance tasks that can be applied to a particular type of equipment, which are: Corrective maintenance, Preventive maintenance, Predictive maintenance. The GSPN method proved to be a very effective modelling tool for describing and analysing the dynamic behaviour of the system under scrutiny. [5]

Staffan Qvist, Paweł Gładysz, Łukasz Bartela, Anna Sowizdzał: In this article, the authors discussed about Retrofit Decarbonization of Coal Power Plants. It is a case study for Poland. In this the authors are saying that adding carbon capture, fuel conversion, and the replacement of coal boilers with new low-carbon energy sources, in each case re-using as much of the existing equipment as economically practicable while reducing or eliminating emissions. The life span of a coal power plant, adding carbon capture, Converting to Biomass Feedstock, Converting to Natural Gas and Carbon Capture, Switching Out Coal Boilers for Nuclear Reactors, Coal Plant Decommissioning Costs and Salvage Value, condering these factors and improving them would allow the site to maintain or even increase existing capacity and annual generation. [6]

M V J J Suresh, K S Reddy, A K Kola: The objective of this study is to analyse and compare the thermodynamic performance of a small capacity conventional Rankine cycle power plant using pulverized coal firing (PF) repowered with Pulverised coal power plant (PPCP) in terms of energy and exergy. Though PPCC is in an early stage of development, this study is carried out to evaluate the possible performance of PPCC power plant in Indian climatic condition (design cooling water temperature 33C) using HA Indian coal. [7]

Moti L. Mittal Chhemendra Sharma and Richa Singh: In this article, the authors discussed about the Emissions from Coal Fired Thermal Power Plants in India. The emission estimates are based on a model in which the mass emission factors are theoretically calculated using the basic principles of combustion and operating conditions. CO2 emissions are estimated based on the carbon content as obtained from the elemental analysis of the coal and the excess air used at the power plants. A small percentage of the carbon in the coal remains un-burnt due to factors, such as reactivity of the coal particles, milling, air to fuel ratio, flame turbulence, fuel residence time etc. A small portion of the un-burnt carbon goes with the fly ash (FA) and the remaining un-burnt carbon goes in the bottom ash (BA). Exact portion of un-burnt carbon can only be determined by experimental measurements. ions and hence it is relatively cumbersome to develop plant specific emission factors by measurements. There is a wide diversity between plants for coal usage (kg/kWh), coal quality, and the operating conditions. Hence there are large differences in emission factors (g/kWh) of CO2, SO2, and NO as shown earlier. [8]

Paul Feron1, Ramesh Thiruvenkatachari, Ashleigh Cousins: By using liquid absorbent-based CO2 capture and desalination process water is produced. I t uses forward osmosis process replacing the trim cooler in the capture process. Process simulation studies indicate that the specific cooling duty will increase in line with the reduction of the power plant efficiency. Liquid absorbent-based processes are currently the commercially dominant technology for both CO2 capture at low pressure (flue gases) and high pressure (synthesis gas, natural gas). The liquid absorbents used are alkaline solutions often based on amine (monoethanolamide, methyl diethanolamine, piperazine, etc.) or carbonates. In an absorption-based CO2 capture process implemented on a coal-fired power station, the flue gas is first cooled down and/or pre-treated to get to a temperature level beneficial for the chemical absorption process and to remove components, for example, SO2, that might impact negatively on the CO2 capture process. By using some of these process like forward osmosis the water is produced and used. [9]

Włodzimierz Wróblewski, Sławomir Dykas, Sebastian Rulik: In this article, the authors discussed about the Selection of the cooling system configuration for an ultra-critical coal-fired power plant. The computation algorithm applied for the calculations of the condenser basic operating parameters is based on American design guidelines using the HEI model. The mentioned about the parallel cooling system configuration and serial cooling system configuration and impact of the exhaust loss. Based on the results obtained from the above results analysis of economic efficiency has been obtained. In this paper the authors analysed and defined the basic parameters of a cooling system for a 900 MW ultra-supercritical coal-fired power plant. [10]

SUMMARY

The rising complexities in advanced technological units have increased the importance of reliability, availability and maintainability. This is mainly true in process industries, characterized by expensive specialized equipment's and rigorous environmental conditions. From the literature review, it is found that no rigid system for maintenance can be applied universally to process industries to control every situation. The high temperature surroundings reduce the efficiency of the Coal power plant and thus releasing excess amount of CO2, resulting environmental contamination. Therefore, a proper maintenance procedure must be designed and develop to suit the requirements of a particular process industry.

CONCLUSION

The excess heat released from the power plants can be reduced by introducing effective cooling systems. The reuse of superheated steam by converting it in to saturated steam will not reduce the heat in the surroundings but also increases the quality of the steam produced in the boiler. Using this steam increases efficiency and as efficiency increases the CO2 emission is reduced thus making less air contamination.

References

[1] R. V. F. R. J. S. G. J. M. Diana Siqueira, "Analysis Of Thermal Power Plants Cooling System In Climate Changes Regards," in *24th ABCM International Congress of Mechanical Engineering*, January 2017.

[2] R. J. Campbell, Congressional Research Service, December 20, 2013 .

[3] A. M. Carpenter, "Water conservation in coal-fired," IEA Clean Coal Centre, February 2017.

[4] S. L. M. B. Mirjana Lakovic, "Analysis of the evaporative towers cooling system of a coal-fired power plant," pp. 375-385, September 12, 2012.

[5] C. A. M. A. C. N. G. F. S. a. S. I. N. Arthur H.A. Melani, "Maintenance Strategy Optimization of a Coal-Fired," p. 28, : 21 May 2019.

[6] P. G. Ł. B. a. A. S. z. Staffan Qvist, "Retrofit Decarbonization of Coal Power Plants—A Case Study," p. 37, 28 December 2020.

[7] K. S. R. a. A. K. K. M V J J Suresh, "Thermodynamic analysis of a coal-fired power plant repowered with pressurized pulverized coal combustion," p. 12, 8 July 2011.

[8] M. L. C. S. a. R. S. Mittal, "Estimates of Emissions from Coal Fired Thermal Power Plants in India," Florida, USA.

[9] R. T. 2. &. A. C. Paul Feron, "Water production through CO2 capture in coal-fired power," 18 October 2017.

[10] S. D. S. R. Włodzimierz Wróblewski, "Selection of the cooling system configuration for an ultra-critical coal-fired power plant," *www.elsevier.com/locate/enconman,* December 2013.