A REVIEW ON ADVANCES IN ULTRA LOW EMISSION CONTROLTECHNOLOGIES FOR COAL FIRED POWER PLANT

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Abstract
Coal power plant control systems have progressively evolved to meet the growing demand for efficient and flexible power generation whilst maintaining low emissions. In particular, optimization of the combustion process has required increased use of online monitoring technologies and the replacement of standard control loops with more advanced algorithms capable of handling multivariable systems. Improved stoichiometric control can be achieved with coal and air flow sensors or imaging and spectral analysis of the flame itself, whilst in situ laser absorption spectroscopy provides a means of mapping CO and O_2 distribution in hot regions of the furnace. Modern plant control systems are able to draw on a range of computational techniques to determine the appropriate control response, including artificial intelligence which mimics the actions of expert operators and uses complex empirical models built from operational data. New sensor technologies are also being researched to further improve control and to withstand the high temperature and corrosive environments of advanced coal plant and gasifiers. Increased use of optical technologies is of particular interest, with sensors based on optical fibres able to perform low noise, highly sensitive, and distributed measurements at high temperatures. Microelectronic fabrication techniques and newly developed high temperature materials are also being combined to develop miniaturised devices which provide a robust and low cost solution for in situ monitoring of gases and other parameters.

Keywords: C_O, O_2, Coal Power plant , Modern plant & New sensor technologies.

Introduction

Coal is one of the most abundant energy sources in the world. Advanced emission control technologies are needed to cleanly use coal for electricity generation. Environmental regulations of coal-fired power plants in Asia cover a broad range of requirements. Depending on the area within Asia and the type of coal to be burned, different combinations of technologies are needed to meet local regulations. There are a multitude of advanced emissions control technologies available to address the most common targeted pollutants such as sulphur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM), as well as other pollutants which are increasingly becoming targeted worldwide, such as mercury, sulphur trioxide (SO_3), condensable PM, and other trace metals. This paper examines state-of-the-art emissions control systems that are available to meet the multipollutant requirements for coal-fired power plants. These technologies include selective catalytic reduction (SCR), electrostatic precipitators (ESP), fabric filters, flue gas desulfurization (FGD), wet ESP, dry sorbent injection, and mercury control methods.

Literature

A.L.Moretti et al.,[1] One of the most plentiful energy sources in the planet is coalin order to use coal for the gene ration of energy cleanly, advanced to generate power using coal cleanly, advanced emission control systems are required. Different fusions of technology are required to satisfy local requirements depending on the region of Asia and the type of coal to be burned control technologies. The modern emissions control technologies that are available to coal-fired power stations to meet their most frequently targeted pollutants, such as sulphur dioxide (SO_2), nitrogen oxides (NOx), and particulate matter (PM), as well as other pollutants that are increasingly being targeted globally, like mercury, sulphur trioxide (SO_3).

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Toby Lockwood et.al.,[2] say's Coal power plant management systems have changed over time to satisfy the increasing demand for efficient and flexible electricity output while reducing emissions. Optimization of the combustion process, in particular, has necessitated growing use of online monitoring. technology, as well as the replacement of traditional control loops with more complex algorithms capable of dealing with multivariable systems. Improved stoichiometric control can be obtained by the use of coal and air flow sensors, as well as imaging and spectral analysis of the flame itself, while in situ laser absorption spectroscopy can map CO and O_2 distribution in hot sections of the furnace.

Raghav Pachouriet.al.,[3] discussed Many countries, including India, are concerned about air pollution. particulate matter (pm), SOx, NOx, mercury, and other pollutants pollute the air. industries, thermal power plants, construction and demolition work, etc. India has nine of the world's ten most polluted cities in terms of pm2.5 levels. Kanpur, Faridabad, Gaya, Delhi, Gurugram, Varanasi, Agra, Lucknow, and Patna are among the Indian cities on the list. ambient air pollution is commonly acknowledged to have serious detrimental effects on human health. SOx, NOx, and mercury undergo chemical reactions when they are released into the atmosphere

Shahzad Baig et.al.,[4] say's Most of the people in this world are concerned about the environmental impacts of coal based power plants. Coalfired power plants are one of the sources of SO_x, NO_x and mercury emissions. These emissions have serious impact on the health of neigh boring people such as increased rates of premature death, to the exacerbation of chronic respiratory diseases. The objectives of this review article are: [1] To identify the issues of air pollution and the environmental impact of coal fired power plants. [2] To discuss techniques and equipment that can contribute to improve the environmental sustainability .

S A. Nihalani et.al.,[5] discussed Coal thermal power plants are one of the primary sources of artificial air emissions, particularly in a country like India. Ministry of Environment and Forests has proposed draft regulation for emission standards in coal-fired power plants. This includes significant reduction in sulphur dioxide, oxides of nitrogen, particulate matter and mercury emissions. The first step is to evaluate the technologies which represent the best selection for each power plant based on its configuration, fuel properties, performance requirements, and other site-specific factors. This paper will describe various technology options including: Flue Gas Desulfurization System, Spray Dryer Absorber, Circulating Dry Scrubber, Limestone-based Wet FGD, Low NOx burners, Selective Non Catalytic Reduction.

Zainal Arifin et.al.,[6] say's The utilization of co-firing (coal-biomass) in existing coal-fired power plants (CFPPs) is the fastest and most effective way to increase the renewable energy mix, which has been dominated by pulverized coal (PC) boilers, particularly in the Indonesian context. This study aims to investigate the technical and economic aspects of co-firing by conducting a pilot project of three PC boiler plants and capturing several preliminary figures before being implemented for the entire plants in Indonesia.

Yin-Biao Chen et.al.,[7] proposed China's energy mix is changing more quickly as a result of pressure from the environment, climate change, economic costs, and energy security. consequently, efficient and environmentally friendly use of coal-generated powerplays a bigger part in China's efforts to address its energy and environmental issues. Shenhua Guohua Sanhe was one of the first coal-fired power plants to implement a number of ultra-low. emission and energy-efficient technologies, following the current trend and aiming to lead the industry in innovation, profitability, and environmental protection.

Bandi Dayasagar et.al.,[8] discussed Energy is the most important requirement for the growth and development of a nation since it is the basic necessity for every sector. The most common form of energy used is electricity. Electricity is the form of energy that is used both commercially and non-commercially. Thus, generation of electricity is the most significant requirement. Thermal electric power generation is one of the major methods for generation of electricity. But generation of electricity is it enough. It has to be done in the most effective and efficient manner.

S. Rubin et.al.,[9] proposed This study looks at historical successes in reducing Sulphur dioxide (SO_2) and nitrogen oxide (NOx) emissions from coal-fired power facilities. Focusing in particular on the experiences of the US and other countries with two major. Environmental control technologies include selective catalytic reduction (SCR) systems for NOx control and flue gas desulphurization (FGD) systems for SO_2 control. We use these data to develop quantitative "experience curves" that describe the rates of cost reduction as a function of the total installed capacity of each technology. We quantitatively characterize historical trends in the deployment and costs of these technologies over the past 30 years.

Xinxin et.al.,[10] say’s The globe now faces a number of challenges and issues as a result of the over use of fossil fuels, including the natural environment and climate change. As a crucial component of the system for supplying energy, clean energy encourages the energy supply to become diversifying, clean, eco-friendly, and low-carbon. New power technologies like wind, hydro, solar, and other forms of renewable energy are a sign that nations all over the world are starting to hasten the switch to clean energy. Currently, clean energy power generation has produced ground-breaking outcomes.

Pramit Verma et.al., [11] proposed Poland is a prime example of an energy transition economy, with its goal of converting from a fossil fuel foundation to renewable energy sources. The difficulties and possibilities for local resilience were noted in this evaluation, which was followed by a thorough examination of Low Carbon Economy Plans in Poland's ten major cities. The methodology involved applying K-means clustering to the chosen Polish cities and doing bibliometric analysis of the peer-reviewed research published from 2010 to 2022.

Christian Hasse et.al., [12] discussed Several nations made commitments to phase out coal generation as soon as feasible after the 2021 United Nations Climate Change Conference which resulted in the deactivation of hundreds of power facilities in the near future. These plants can produce power without the emission of CO_2 by converting them to burn iron. H_2 can be used to collect the iron oxides created during the process and convert them back to metallic iron in a circular process, turning it into an energy carrier.

M V J J Suresh et.al., [13] say’s Fossil fuels, coal, and natural gas, contribute a major share of electricity generated in India as well as the world and will continue to do so well into the future. With the justified concern of their rapid depletion and the environmental impacts associated with their large-scale use, there is a quest for advanced coal-fired power generation technologies which are energy efficient and environmental friendly.

Tathagata Mukherjee et.al.[14] discussed “Real-time coal classification in thermal power plants” Continuous variations in coal quality have a strong influence on operation of thermal power plants. However, in absence of real-time measurements of quality, the operators remain partially blind to the actual coal being consumed, leading to sub-optimal operation. A two-stage solution is proposed for real-time soft sensing of coal type.

Zhiyong Zhou et.al. [15] proposed “Review on occurrence, speciation, transition and fate of sulfur in typical ultra-low emission coal-fired power plants” Sulfuric pollutants (SO_2, SO_3/sulfuric acid mist, sulfate, etc.) generated in coal-fired power plants (CFPPs) have been receiving more and more attention due to their adverse effects on the operation of power plant and environment.

Fangqi Liu et.al .[16] proposed “effects of ultra-low emission air pollution control devices on the evolution of pm and its associated water-soluble ions in a 1000 mw coal-fired plant” PM (Particulate matter) is a major air pollutant from CFPPs (coal-fired power plants). APCDs (Air pollutant control devices) work in concert to achieve ultra-low emission requirements. Large-scale and higher parameters CFPPs have become a future trend. This work investigated the PM evolution of the APCDs in a 1000 MW ultra-low emission CFPP.

Kuixu Chen et.al. [17] say’s “integrated technology for dust removal and denitration of high-temperature flue gas in coal-fired power plants” A new integrated technology of high-temperature dust removal and denitration, which solves the catalyst problems of wear, blockage, and poisoning caused by the operation of selective catalytic reduction (SCR) denitration systems in coal-fired power plants

under high concentrations of particulate matter, is developed. A pilot plant was established for the integrated technical performance test research based on the actual engineering flue gas..
Yuxin Han et.al [18] discussed "Effects of coal blending on arsenic and fine particles emission during coal combustion" the blending coal technology was proposed to control arsenic emission during coal combustion. The experimental results demonstrated that the blending coal could suppress the fine particles formation during coal combustion. Meanwhile, it was also found that arsenic mass size distribution was not consistent with particulate matter mass size distribution.
Guicai Liu et.al.[19] say's "Simultaneous removal of N_O and volatile organic compounds by doping-modified selective catalytic reduction catalysts in denitrification zone of coal-fired gas" A series of Ce/Mo doping-modified V-W/Ti type catalysts were prepared by one-step impregnation method, in an attempt to realize collaborative removal of NO and volatile organic compounds (VOCs) in selective catalytic reduction (SCR) reaction zone (the temperature scope of 260–420 °C). Benzene and Toluene were used as model compounds of VOCs. A self-built experimental platform was conducted to simulate the coal-fired flue gas denitrification zone with a flue gas of 750 mL/min.
Waitrons-Motyka et.al. [20] proposed "NOx control for high-ash coal-fired power plants in India" Many countries have strict emission limits for nitrogen oxides (NO_x); thus NO_x control systems are widely deployed. India has recently introduced NO_x emission limits, which require that pollution control technologies must be installed on most coal-fired plants. However, operational experience with NO_x control systems in India is limited to primary measures only. Additionally, Indian coals have a high level of inherent ash, which is also highly erosive and can influence the behavior of some NO_x control systems and thus affect the selection process.
Guannan Geng et.al .[21] discussed "Daily emission patterns of coal-fired poer plants in China based on multisource data fusion" Daily emission estimates are essential for tracking the dynamic changes in emission sources. In this work, we estimate daily emissions of coal-fired power plants in China during 2017–2020 by combining information from the unit-based China coal-fired Power plant Emissions Database (CPED) and real-time measurements from continuous emission monitoring systems (CEMS). We develop a step-by-step method to screen outliers and impute missing values for data from CEMS. Then, plant-level daily profiles of flue gas volume and emissions obtained from CEMS are coupled with annual emissions from CPED to derive daily emissions.
Honglei Ding et.al. [22] proposed "The total particulate matter (TPM) is a crucial indicator when evaluating flue gas emissions from coal-fired units. TPM contains solid and liquid contaminants and condensable particulate matter (CPM), which is mainly composed of sulfate and various anions, cations, and metal ions. This study selected three typical large-capacity coal-fired power plants in Shanghai retrofitted with ultra-low emission technology and monitored their emissions of $PM_{2.5}$, SO_3, and CPM during power generation.
Senmao Xia et.al.[23] say's "Did an ultra-low emission policy on coal-fueled thermal power reduce the harmful emission? Evidence from three typical air pollutants abatement in china" Thermal power generation based on coal-fired power plants has the advantages of stability and controllability and has been the largest source of electricity supply in China. Coal-fired power plants, however, are also accompanied by high carbon emissions and the release of harmful substances (mainly including sulfur dioxide, nitrogen oxides, and smoke dust), and are even regarded as the "chief criminal" in terms of air pollution. However, thermal power is also a pioneering industry involved in several environmental regulations and cleaner production techniques before other industries.
S. Moazzem et.al.[24] discussed "A review on technologies for reducing CO_2 emission from coal fired power plants" In recent years, global warming has been a major issue due to continuous growth of greenhouse gas emissions from different sources. It has been estimated that the global average temperature will rise between 1.4 –5.8 C by the year 2100 (Williams, 2002). The contributors to greenhouse effects are carbon dioxide (CO_2), chlorofluorocarbons (CFCs), methane (CH_4), and nitrous oxide (N_2O). The contribution of each gas to the greenhouse effects is CO_2- 55%, CFCs - 24%, CH_4 - 15%, and N_2O - 6% (Demirbas, 2008).

Paolo Blecich et al.[25] discussed the "Advanced ultra-supercritical coal-fired power plant with post-combustion carbon capture: Analysis of electricity penalty and CO_2 emission reduction" the performance analysis of a 700 MW future planned advanced ultra-supercritical (A-USC) coal-fired power plant fitted with post-combustion carbon capture and storage (CCS) technology. The reference A-USC unit without CCS achieves a net efficiency of 47.6% with CO_2 emissions of 700 kgCO_2/MWh. Relatively to subcritical units, the net efficiency of the A-USC is 8%-pts higher while CO_2 emissions are 16.5% lower. For a CO_2 removal rate of 90%, the net efficiency of the CCS integrated A-USC unit is 36.8%. The resulting net efficiency loss is 10.8%-pts and the electricity output penalty is 362.3 kWhel/tCO_2 for present state CCS technology .

Zheng LI et.al.[26] say's "Energy conservation in China's coal-fired power industry by installing advanced units and organized phasing out backward production" Coal-fired power is the main power source and the biggest contributor to energy conservation in the past several decades in China. It is generally believed that advanced technology should be counted on for energy conservation. However, a review of the decline in the national average net coal consumption rate (NCCR) of China's coal-fired power industry along with its development over the past few decades indicates that the up-gradation of the national unit capacity structure (including installing advanced production and phasing out backward production) plays a more important role.

Jiajia Gao et.al.[27] discussed "Bibliometric analysis on mercury emission from coal-fired power plantds: A systematic review and future prospect" Coal-fi red power plants (CFPPs) are one of the most signifi cant sources of mercury emissions certifi ed by the Minamata Convention, which has attracted much attention in recent years. In this study, we used the Web of Science (WOS) and CiteSpace to analyze the knowledge structure of this fi eld from 2000 to 2022 and then reviewed it systematically. The fi eld of mercury emissions from coal-fi red power plants has developed steadily.

Zunaira Asi f et al. [28] proposed a "Update on air pollution control strategies for coal-fired power plants" Coal is expected to remain a significant power supply source worldwide and shifting to carbon-neutral fuels will be challenging because of growing electricity demand and booming industrialization. At the same time, coal consumption results in severe air pollution and health concerns. Improvement in emission control technologies is a key to improving air quality in coal power plants. Many scientists reported removing air pollutants individually via conventional control methods. However, controlling multiple pollutants combinedly using the latest techniques is rarely examined

Yana Jin et.al.[29] say's "An ultra-low emission coal power fleet for cleaner but not hotter air" Concerns about climate change have provoked global backlash against coal-fired power generation, which remains the backbone of major power systems in China, India, and elsewhere. Air pollution has galvanized opposition to coal-fired power generation, but counting on concerns over air pollution to promote the coal-to-renewables shift in the long run is a risky bet. As the Chinese experience shows, the best available technologies now enable coal-fired power plants to stop producing air pollution. By investing in an ultra-low emission (ULE) coal fleet, emerging countries can solve the air pollution problem in an affordable manner.

Diana Ivanova et.al.[30] discussed "Quantifying the potential for climate change mitigation of consumption options" Around two-thirds of global GHG emissions are directly and indirectly linked to household consumption, with a global average of about 6 tCO_2eq/cap. The average per capita carbon footprint of North America and Europe amount to 13.4 and 7.5 tCO2eq/cap, respectively, while that of Africa and the Middle East—to 1.7 tCO2eq/cap on average. Changes in consumption patterns to low-carbon alternatives therefore present a great and urgently required potential for emission reductions. In this paper, we synthesize emission mitigation potentials across the consumption domains of food, housing, transport and other consumption.

Penghao Ye et.al.[31] proposed "Did an Ultra-Low Emissions Policy on Coal-Fuelled Thermal Power Reduce the Harmful Emissions? Evidence from Three Typical Air Pollutants Abatement in China" Thermal power generation based on coal-fired power plants has the advantages of stability and controllability and has been the largest source of electricity supply in China. Coal-fired power plants,

however, are also accompanied by high carbon emissions and the release of harmful substances (mainly including sulphur dioxide, nitrogen oxides, and smoke dust), and are even regarded as the “chief criminal” in terms of air pollution.
Yang Zhang et.al.[32] discussed “Study on Stability and Reliability of NOx Ultra-low emission in Coal-fired Power Plants in China” Along with the rapid progress of flue gas ultra-low emission reconstruction in coal-fired power plants in recent years, the stability and reliability problems in the operation of the project have emerged, among which the denitrification problem is the most acute. Given the present situation of the NOx ultra-low emission in coal-fired power plants, several typical problems about stability and reliability have been analysed and discussed, including flow fields uniformity, low load denitrification, in-line meter accuracy, catalyst life on the basis of extensive and thorough investigation. Relevant guidance and countermeasures are proposed to provide further reference for the following denitrification projects and operations.
Malgorzata Wiatros et.al.[33] say’s “NOx control for high-ash coal-fired power plants in India” Many countries have strict emission limits for nitrogen oxides (NOx); thus NOx control systems are widely deployed. India has recently introduced NOx emission limits, which require that pollution control technologies must be installed on most coal-fired plants. However, operational experience with NOx control systems in India is limited to primary measures only. Additionally, Indian coals have a high level of inherent ash, which is also highly erosive and can influence the behaviour of some NOx control systems and thus affect the selection process.
Ankur Chaudhary et.al.[34] discussed “Coal Power Impacts, Technology, and Policy: Connecting the Dots” The demand for electricity closely linked to human, social, and economic development is expected to rise significantly in the coming decades, especially in developing countries. Coal power currently is, and is expected to remain, an important part of the global electric power mix with much of the future growth again in developing countries. At the same time, coal-based power generation results in multiple, significant externalities with human health and potential climate change impacts being particularly important. This has spurred much effort over the decades to better determine the range and value of the impacts.
Hiroyuki Semba et.al.[35] discussed “Development of Boiler Tubes and Pipes for Advanced USC Power Plants” Development of advanced-USC (A-USC) boiler technology has been promoted in recent years, which features 700˚C steam condition. HR6W and HR35, which can be applied for A-USC boilers, have been developed on the basis of unique alloy design; that is, these alloys employ precipitation strengthening of Laves and/or α-Cr phases without γ’ phase. The 105h average creep rupture strength of HR6W at 700˚C is 85MPa.
Leixing Tao et.al.[36] say’s “Synergistic Emission Reduction of Particulate Pollutants in Coal-fired Power Plants Using Ultra-low Emission Technology” The total particulate matter (TPM) is a crucial indicator when evaluating flue gas emissions from coal-fired units. TPM contains solid and liquid contaminants and condensable particulate matter (CPM), which is mainly composed of sulphate and various anions, cations, and metal ions. This study selected three typical large-capacity coal-fired power plants in Shanghai retrofitted with ultra-low emission technology and monitored their emissions of PM2.5, SO_3, and CPM during power generation.
Tamura Masato et.al.[37] discussed “Among the many types of fuels used to generate power, coal is essential for energy security as it is an inexpensive and abundant resource deposited throughout the world in a wide range of locations. That said, coal has high carbon content and emits a large amount of carbon dioxide (CO_2) per unit heat quantity. Amidst growing concern about recent global environmental issues, the need for reducing CO_2 is increasing. To reduce CO_2 emissions, it is necessary to improve efficiency, promote Carbon Capture and Storage (CCS), and expand the use of carbon-neutral woody biomass.
LV Qinggang et ,al.[38] proposed “ Highly Efficient and Clean Utilization of Fossil Energy under Carbon Peak and Neutrality Targets” Fossil energy utilization faces new challenges under carbon peak and carbon neutrality (“dual carbon” for short) targets. In this study, the present status of fossil energy

utilization in China is summarized. Based on the situation of energy resources in China, the idea of highly efficient and clean utilization of fossil energy under "dual carbon" constraints is proposed.
William Simmons et.al.[39] proposed "Oxy-fuel Combustion Systems for Pollution Free Coal Fired Power Generation " Jupiter Oxygen's patented oxy-fuel combustion systems1 are capable of economically generating power from coal with ultra-low emissions and increased boiler efficiency. Jupiter's system uses pure oxygen as the combustion agent, excluding air and thus nitrogen, concentrating CO_2 and pollutants for efficient capture with near zero NOx production, reducing exhaust mass flow, and increasing radiant heat transfer.
Che Yao et.al.[40] say's "Feasibility Study on Application of Seawater Flue Gas Desulfurization in Ultra-low Emission" As an economical and energy-saving environmental protection technology, seawater desulfurization technology is widely used in environmental protection facilities of coal-fired power plants. With the introduction of the ULE management, the traditional seawater desulfurization technology can no longer meet the increasingly stringent environmental requirements. Based on the theory of gas-liquid mass transfer and nozzle atomization size distribution analysis, this paper investigates the effect and limitation of desulfurization performance enhancement by adding spray layer.

Conclusion

Many papers have been covered by ultra-low emission technologies. By using of this low emission technologies in coal fired power plants we will reduce the pollution in the environment. The main aim of the technologies is to reduce the emission in coal fired power Plant and to increase the efficiency of the plant for this we have to use advanced methods in the power plants . which are already implemented in the other countries by studying all these methods we can know the percentage of the pollutants and the plant efficiency. By keeping the plant clean and using the advanced technics we can reduce the pollution from the coal-fired power plants.

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