



Treatment and Recovery for Flue Gases: a Review

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Abstract:

In the industries such as petroleum, sugar, chemical, fertilizers, dyes, textiles, etc., the composition of flue gases contains sulphur dioxide, carbon dioxide, oxides of nitrogen and particulate matter. Stringent flue gas emission standards call for effective treatment method for flue gases. The presence of these flue gases in environment can affect ecological cycle. Many physical separation methods can be used for particulate matter. The gaseous emissions can be dealt with by using various absorption, adsorption and catalytic treatment methods. The present review summarizes studies and research for treatment of flue gases in industries.

Keywords:

Absorption; adsorption; pretreatment; reuse; emission; efficiency

Introduction

Conservation of environments is as important as the industrial and economical growth. Sustainable development calls for effective methods for effluent treatment. Wastewater can be treated by primary, secondary and tertiary methods [1,2,3,4]. Methods including physical, chemical and biological principles can be used for wastewater treatment[5,6,7,8]. For the treatment of flue gases, various biological, chemical and physical methods can be used[9,10,11,12,13]. Cyclone separators, electrostatic separators, bag filters etc can be used for particulate matter. Biofiltration of waste gases can be used for removal of oxides. Absorption and adsorption methods are also

used for selective removal and recovery of oxides. The present review summarizes the research carried out for treatment of flue gases in chemical and related industries.

Studies on Flue Gas Treatment and Recovery

Chaperl and Mariz presented a paper on commercial trends in recovery of CO₂ from flue gases[14]. According to them, recovery of CO₂ is being propelled by multiple factors like the merchant CO₂ market, renewed interest in enhanced oil recovery (EOR), and the desire to reduce greenhouse gas emissions. Their studies also recapped key process design and operating issues for amine chemical solvent CO₂ recovery processes and summarize the competitive processes for CO₂ recovery. Coal burning results in generation of large quantities of coal residues, which contains very fine particles. Shanthakumar et.al. Studied Flue gas conditioning for reducing suspended particulate matter from thermal power stations[15]. Devices such as cyclone separators, bag filters and electrostatic precipitators (ESPs) are normally used for SPM treatment of flue gases. Also flue gas conditioning (FGC) is practiced to increase the efficiency of ESPs. They concluded that as SPM emission control methods are less effective, FGC becomes the inevitable choice for improving the performance of the ESPs. Oilgae reported a research document on capture of CO₂ Emissions using algae[16]. The document was prepared as a free report for those interested in knowing more about algae-based capture of

CO₂ emissions. They found that NO_x or SO_x can be effectively used as nutrients for microalgae. According to them, a flue gas containing 2 to 5% CO₂ can be fed directly to the photobioreactor. According to the estimates, approximately 2 T of CO₂ will be required to produce one T of algal biomass. Williams et.al. studied flue gas treatment system design considerations for the city of Hamilton oxygen firing demonstration[17]. According to them use of oxygen instead of air can reduce the mass input to the combustion process. This results in possibility of flue gas being recycled back to the boiler in sufficient quantity to increase the mass flow for heat transfer in the convection pass and to lower the adiabatic flame temperature in the boiler. In their work, Mansourpoor and Shariati used waste cooking oil and methanol as feedstock together with sulfuric acid and potassium hydroxide as catalysts to produce biodiesel[18]. They burnt biodiesel and petrodiesel in a wet base semi-industrial boiler to study the emissions. They measured CO, NO_x, SO₂ and CO₂ with a flue-gas analyzer at a wide range of air-to-fuel ratios and two levels of energy. Their results indicated that that produced biodiesel meets ASTM standards for flash point, heating value, specific gravity, kinematic viscosity, copper corrosion, acid number, cetane number, carbon residue, and total sulfur. They also observed that CO, NO_x, SO₂ and CO₂ emissions of biodiesel were lower than those of petrodiesel at different air-to-fuel ratios and two levels of energy. Iwasaki et.al. presented studies on large scale flue gas CO₂ recovery and CO₂ enhanced oil recovery[19]. CO₂ can be injected into reservoirs in order to increase crude oil production. This enhanced oil recovery (EOR) utilizes CO₂ recovered from flue gas of power generation plants. They found that CO₂ recovery costs greatly affect oil recovery cost. They also studied the parameters which have impact on CO₂ recovery cost. Robertson et.al. studied the use of a single staged wash and crystalline matrix encapsulation (CME) treatment process for the immobilization of flue gas treatment

residues[20]. The flue gas treatment residues flue gas treatment residues (FGTR) arising from are hazardous since it contents heavy metals and chlorides. They found that a novel metal matrix encapsulation (MME) process allows low level engineering processes to be employed. Aouini et.al studied pilot plant for CO₂ capture from waste incinerator flue gas using mea based solvent[21]. They employed the absorption/desorption process using MonoEthanolAmine (MEA) solvent. Dehghani and Bridjanian studied flue gas desulfurization methods to conserve the environment[22]. They discussed wet absorption and dry absorption methods for the desulphurization. By using absorption by sodium sulfite solution, they observed that the flue gas pollutant content is reduced from 4500-6000ppm to about 580 ppm. They observed HCl and HF elimination is about 98% and that of SO₂ is 90% by absorption by calcium hydroxide solution. Also, Limestone and magnesium oxide, can absorb SO₂ by a concentration of about 5500ppm. Other methods such as dry absorption by copper oxide, catalytic oxidation method can also be used. According to them the catalytic Flue Gas Desulfurization ,FGD method was more economical. Graf and Zimmer presented application of high-efficiency circulating fluid bed scrubber[23]. They described the development of dry and semi-dry flue gas scrubbing using circulating fluid beds. According to them GRAF / WULFF technology was beneficial for the treatment. Korenev and Johnson presented use of high-power electron beams to reduce the environmental impact of coal and oil-fired power generating plants by removing harmful materials from flue gases[24]. From practical application, it is important to reduce the accelerator costs increase the efficiency. They proposed a simple electron accelerator with a wide beam to reduce costs. They proposed a plasma reactor for desulfurization and selective catalytic reduction. According to them, the main advantages of this technology are increase in the efficiency of electron accelerator in total power, a decrease in

the thermal loads on the foil window for output electron beam from vacuum chamber to air and input to plasma reactor, an improvement in radiation processing. Basfar et.al. also reviewed electron beam flue gas treatment (EBFGT) as a multicomponent air pollution control technology[25]. They observed that the removal efficiency of pollutants as high as 95% for SO₂ and 70–80% for NO_x can be obtained.

Conclusion

The composition of flue gases depends on raw material and process. It is important to have adequate knowledge of these aspects while selecting treatment methods. Various chemical conversion methods are effective for the treatment of flue gases. The recovery of components from flue gases involves adsorption, absorption, stripping, and desorption methods.

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