

An Insight into Removal and Recovery of SO₂ and CO₂ in Petroleum Industries with Emphasis on Absorption

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Abstract: *The exhaust gases from petroleum refineries contain carbon dioxide, sulphur dioxide and oxides of other compounds. Methods such as adsorption, absorption, membrane separation, chemical conversion and electrostatic separators can be used for the removal of these gases from the gaseous mixtures. The recovery of the valuable gases, which can be reused in the processes, is also important aspect of waste gas treatment. Membrane related treatment methods are effective but high cost limits their use to specific applications. Adsorption is also effective in some applications. Regeneration and solid disposal is inconvenient. Absorption is most widely used method for recovery of gases. Current review summarizes research and studies on absorption for removal and recovery of carbon dioxide and sulphur dioxide in petroleum industry waste gases.*

Keywords: *solvent, recovery, capture, cost, regeneration.*

1. INTRODUCTION

The waste gases from refineries contain oxides of sulphur and carbon along with oxides of nitrogen. Sulphur dioxides concentration in air needs to be maintained below the limits prescribed by the regulatory authorities and also from human health point of view. The air pollution control includes removal of particulate matter and various gases from the waste gases. Cyclone separators, electrostatic separators and bag filters can be used for separation of particulate matter from the flue gases [1-5]. Removal of gases like carbon dioxide and sulphur dioxide can be carried out by methods like adsorption and absorption [6-11]. The current review is aimed at summarizing research and studies on sulphur dioxide and carbon dioxide removal from waste gases of petroleum refineries and industries with emphasis on absorption.

2. AN INSIGHT INTO REMOVAL AND RECOVERY OF SO₂ AND CO₂ IN PETROLEUM INDUSTRIES WITH EMPHASIS ON ABSORPTION

Mandal and Krishna conducted experiments to find the better suitable amine solutions to facilitate the maximum SO₂ absorption from flue gases [12]. In their investigation, they also checked the possible solvent degradation. They conducted experiments to check the effect of CO₂ present in effluent while absorption taking place. They observed that the rate of absorption was more in absence of CO₂ for two solvents. For other solvents there was no effect of CO₂. Songolzadeh et.al. Carried out review on carbon dioxide removal from flue gases [13]. According to them, carbon capture and storage (CCS) is a major strategy that can be used to reduce GHGs emission. They studied various technologies for CO₂ capture including absorption, adsorption, cryogenic distillation, and membrane separation. According to these studies, flue gases properties (mainly concentration of CO₂, temperature and pressure) are the most effective factors for selection of suitable process for CO₂ separation. According to these studies membrane and adsorption processes need to be developed further in terms of simulation and modeling. Chapel et.al. Studied commercial trends in removal and recovery of CO₂ from flue gases [14]. According to them, the interest of investigators in CO₂ recovery is driven by factors like the merchant CO₂ market, renewed interest in enhanced oil recovery (EOR), and the desire to reduce greenhouse gas emissions. They also discussed key process design and operating issues for amine chemical solvent CO₂ recovery processes. Also they summarized the competitive processes for CO₂ recovery from flue gases. The recovery cost varies with the plant size, the market price of CO₂, the flue gas source, and government regulation. The results of these experimentations revealed that chemical absorption process produces the least costly CO₂.

Zare and Anvaripour discussed removal of SO₂ and NO_x from flue gas [15]. In their studies, they used corona discharge to remove SO₂ and NO_x. They connected to an AC power supply with a high-voltage transformer. In their investigation, they observed that as the discharge power of the plasma increased the removal efficiency of three pollutants increased. Also it was shown that at gap spacing of 3 to 5 mm the removal efficiency increased to a maximum. Wang and Han reviewed CO₂ capture with polymeric Membrane [16]. According to them, hollow fiber membrane is highly gas permeable. The problem with these membranes is that they are not selective. Solvent helps in realizing selectivity in the membranes. According to them, Pressure and vacuum combination will accelerate the mass transfer rate, reasonable cost. They also concluded that membrane length can be increased to increase separation efficiency. Parallel membrane devices will also increase the separation efficiency. Rahmandoost et.al. carried out studies and experimentation on CO₂ recovery from flue gases[17]. They presented the results of studies on chemical methods of absorbing CO₂ from flue gases with the new solvent. In their investigation, they also evaluated the effects of operating conditions on CO₂ absorption efficiency. They observed that the CO₂ absorption rate in new solvent was higher than conventional solvent (monoethanolamine). They observed that the CO₂ absorption efficiency increases with the concentration of absorbent. With the absorbent flow rate, also, the CO₂ absorption efficiency increases. It was also observed that with CO₂ concentration, the absorption decreased marginally.

Nagata et.al. carried out experimental studies to reduce SO₃ from flue Gas[18]. Their studies were focused on flue gas emitting from combusting high sulfur content residual materials in oil refinery. Menhali carried out studies on the effects of flue gas recirculation (FGR) ratio and excess air (EA) in a natural gas-fired turbine for an effective CO₂ absorption by amines[19]. In his review, Kulkarni discussed flue gas treatment technologies[20]. According to them CO₂ can be removed by various methods including absorption by chemical solvents, physical absorption, cryogenic separation, membrane separation. The selection of proper method depends on factors such as concentration, cost, resources and characteristics of flue gases.

3. CONCLUSION

The investigations carried out by various researchers indicated that CO₂ can be removed by various methods including absorption by chemical solvents, physical absorption, cryogenic separation, membrane separation. Studies revealed that the selection of proper method depends on factors such as concentration, cost, resources and characteristics of flue gases. Studies indicated that CO₂ absorption efficiency increases with the concentration of absorbent. With the absorbent flow rate, also, the CO₂ absorption efficiency increases. Various investigators have carried out investigations on removal of sulphur dioxides and carbon dioxides from of petroleum industry waste gases. Studies also indicated that the composition of waste gases affected the effectivity of treatment and the absorption is effective for waste gas treatment.

REFERENCES

- [1] Sandeep R Krishnan, Sethuraman K V, Anna Philo Antony,2014, "Comparative Study Of The Conventional Electrostatic Precipitator And The Proposed Smart Electrostatic Precipitator Based On The Various Electrical Erection Challenges", International Journal Of Advanced Research In Electrical, Electronics And Instrumentation Engineering, 3(4), pp.8460-8465.
- [2] Sunil J. Kulkarni, Pallavi M. Kherde,2015, "Studies, Modification and Application of Electrostatic Precipitators - A Review", International Journal of Scientific Research in Science and Technology, 1(4), pp. 1-5.
- [3] K. M. Pandey, M. Ray, 2010, "Experimental Studies On Hydrodynamics Of A Cyclone Separator Employed In A Circulating Fluidized Bed", International Journal Of Chemical Engineering And Applications, 1(2), pp. 123-132.
- [4] Matthew Brennan, Peter Holtham, Mangadoddy Narasimha, 2009, "CFD Modelling Of Cyclone Separators: Validation Against Plant Hydrodynamic Performance", Seventh International Conference On Cfd In The Minerals And Process Industries CSIRO, Melbourne, Australia 9-11 December 2009, pp.1-6.
- [5] Sunil J. Kulkarni, Nilesh L. Shinde, 2016, "Studies and Research on Cyclone Separators: A Review", Int. J. Sc. Res. Sci. Tech, 2(1), pp. 28-31.

- [6] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami & Nilesh Shinde, 2015, "Treatment and Recovery for Flue Gases: a Review", *International Journal of Research (IJR)*, 2(6), pp. 515-519.
- [7] Sunil J. Kulkarni, Nilesh L. Shinde, 2014, "A Review On Hydrogen Sulphide Removal From Waste Gases", *International Journal Of Advanced Research In Science, Engineering And Technology*, 1(4), pp.187-189.
- [8] Sunil Jayant Kulkarni, Ajaygiri Kamalgiri Goswami, 2014, "Adsorption For Waste Gas Treatment: A Short Review", *International Journal For Research In Applied Science & Engineering Technology (Ijraset)*, 2(12), pp.513-514.
- [9] Veena Ramachandran, Tanmay Uttam Gound, Sunil Kulkarni, 2014, "Biofiltration For Waste Gas Treatment- A Review", *International Journal Of Ethics In Engineering & Management Education*, 1(4), pp.8-13.
- [10] Hattenbach, R. Wilson, P., Brown, K., Capture of Carbon Dioxide from Coal Combustion and its Utilization for Enhanced Oil Recovery, Amsterdam, *International Journal of Greenhouse Gas Control*, Vol. 4, p. 217-222, 1999
- [11] Liqiang, D., Mingde, Z., Yongping, Y., 2012, "Integration and Optimization Study on the Coal-fired Power Plant with CO₂ Capture Using MEA", *Energy*, 45(1), pp.107-116, 2012.
- [12] Swarnabh Mandal and BSVSR Krishna, 2015, "Reduction and regeneration of SO_x from flue gases", *International Journal of Recent Advances in Engineering & Technology*, 3(5), pp. 17-20.
- [13] Mohammad Songolzadeh, Mansooreh Soleimani, Maryam Takht Ravanchi, Reza Songolzadeh, 2014, "Carbon Dioxide Separation from Flue Gases: A Technological Review Emphasizing Reduction in Greenhouse Gas Emissions", Hindawi Publishing Corporation *Scientific World Journal* Volume 2014, Article ID 828131, 34 pages.
- [14] Dan G. Chapel, Carl L. Mariz, John Ernest, 1999, "Recovery of CO₂ from Flue Gases: Commercial Trends", Originally presented at the Canadian Society of Chemical Engineers annual meeting October 4-6, 1999, Saskatoon, Saskatchewan, Canada, pp. 1-17.
- [15] Mehdi Zare, Bagher Anvaripour, 2014, "Removing SO₂ And NO_x From Flue Gas Of Abadan Refinery By Nonthermal Plasma", *Sci.Int(Lahore)*, 26(1), pp.239-242.
- [16] Shuangzhen Wang, Xiaochun Han, 2012, "Application of Polymeric Membrane in CO₂ Capture from Post Combustion", *Advances in Chemical Engineering and Science*, 2, pp.336-341.
- [17] Ehsan Rahmadoost, Behrooz Roozbehani, and Mohammad Hosein Maddahi, 2014, "Experimental Studies of CO₂ Capturing from the Flue Gases", *Iranian Journal of Oil & Gas Science and Technology*, 3(4), pp. 01-15
- [18] C. Nagata, K. Miyake, H. Nagasawa, and T. Noguchi, 2011, "Experiences of Systems to Reduce SO₃ from Flue Gas of Combusting High Sulfur Content Residual Materials in Oil Refinery", *International Journal of Plasma Environmental Science & Technology*, 5(2), pp. 135-140.
- [19] Ahmed Mohamed Al Menhali, Abdulla Ali. AL Marzooqi, Abdul Rahman Saleh Alameri, Abdulla Mohamed Al Ameri and Zin Eddine Dadach, 2014, "Simulation of the Effects of Turbine Exhaust Recirculation on the Composition of Flue Gas for A CO₂ Capture Unit", Al Menhali et al., *J ChemEng Process Technol.*, 5(6), pp.1-6.
- [20] Sunil Jayant Kulkarni, 2016, "A Review on Petroleum Refining and Petrochemical Processes with Special Emphasis on Catalysts and Flue Gas Treatment Technology", *International Journal of Petroleum and Petrochemical Engineering (IJPPE)*, 2(1), pp. 1-5.

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