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A STUDY OF THE METHOD OF FLUE GAS DESULPHURIZATION PROCESS TO BE ADOPTED FOR SOx EMISSION REDUCTION IN 250 MW THERMAL POWER STATION OF CHHATTISGARH POWER GENERATION COMPANY LIMITED

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ABSTRACT

Indian coal contains sulphur in the range of 0.2 per cent to 0.7 per cent by weight. With this sulphur content, it is estimated that domestic coal-based plants emit Sulphur Dioxide (SO2) in the range of 800-1,600 mg/Nm3. This is beyond the range specified in the emission norms of flue gas set by the Ministry of Environment, Forest and Climate Change (MoEFCC) to achieve desulfurization in India as specified by govt in 7th December 2015. All public/private companies and government organizations are, therefore, retrofitting thermal power plant (TPP) units with SOx-control technologies using flue gas desulfurization techniques.

One of the most widely used technologies for Sulphur Oxide (SOx) control is wet flue gas desulphurization (FGD) based on limestone. Under this post-combustion SOx elimination method, SOx is passed through a bed of lime or limestone and is oxidized to form gypsum, which can then be eliminated as a byproduct. Apart from limestone, seawater and ammonia can be used in wet flue gas desulfurization (FGD) as reagents. This study aims at knowing the suitable technique of SOx removal from the flue gas emitting from coal combustion of 250 MW thermal power plant.

KEYWORDS: FGD, MoEFCC, SOx emissions, LSFO

INTRODUCTION

Coal is the only natural resource and fossil fuel available in abundance in India. India's dependency on coal for its energy needs, having low calorific value and very high ash content, as high as 55%–60%, with an average value of about 35%–40%, has consequently resulted in the generation of huge quantities of SO2, NOx and ash over the years. Out of the total installed capacity of over 350 GW, nearly 60 % of power industry is coal based, the majority of which comprises of domestic coal with a high ash content of 30 to 35%. Thermal power companies, which produce three-quarters of the country's electricity, account for some 80% of India's industrial emissions of sulphur- and nitrous-oxides in India, which cause lung diseases, acid rain and smog. Recognizing the central role thermal power plays in worsening air quality, the Ministry of Environment, Forest & Climate Change (MoEF&CC) in its latest amendment issued tighter standards for coal-based thermal power plants in December 2015. Hence, attempts are being made to reduce the adverse environmental and ecological impact of coal-fired power plants.

The Ministry of Environment, Forest & Climate Change of Government of India (MoEFCC) has introduced emission limits for SOx, NOx, Hg and suspended particulate matter from any thermal power plant vide the Gazette of India on 7th

December 2015. The new standards of emission limits are aimed at reducing emission of PM10 (0.98 kg/MWh), Sulphur dioxide (7.3 Kg/MWh) and Oxide of Nitrogen (4.8 kg/MWh), which will in turn help in bringing about an improvement in the Ambient Air Quality (AAQ) in and around thermal power plants. The technology employed for the control of the proposed limit of Sulfur Dioxide - SO2 & Nitrogen Oxide - NOx will also help in control of mercury emission (at about 70-90%) as a co-benefit.

Emissions from a coal based thermal power stations

Dr. Shyama Prasad Mukherjee Thermal Power Station (DSPM TPS) is a coal based thermal power plant having total generating capacity of 500 MW (2 units of 250 MW each) in Chhattisgarh Power Generation Company Limited. The first 250 MW unit of DSPM TPS was commissioned on 30 March 2007 and second 250 MW unit was commissioned on 11 Dec 2007. Since commissioning the conventional method of flue gas emission has been adopted in both the units. The conventional method of emission includes flue gas travelling from boiler to APH to ESPs and then to Chimneys forced through ID fans for exit in to the atmosphere. The stack emission mainly consists of SOx, NOx, Hg and suspended particulate matters (PM10 & PM 2.5).

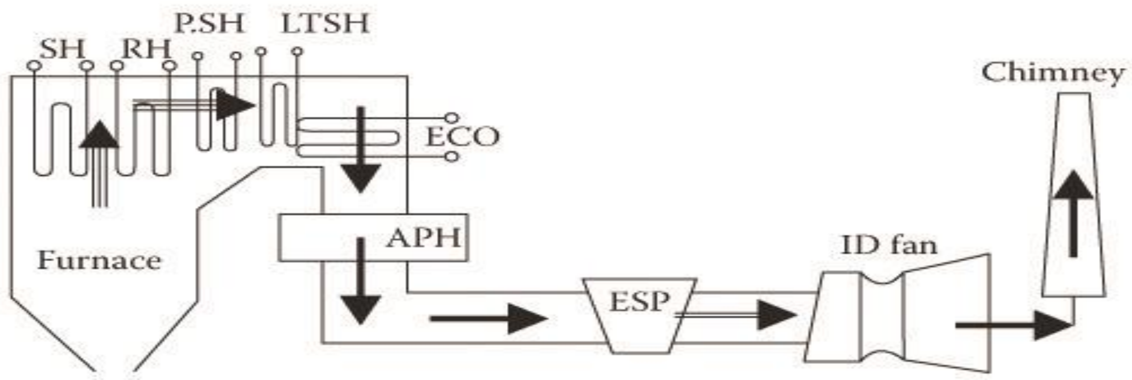


Fig. 1 General Layout of Coal Based Thermal Power Plant

Need of FGD technology

SO2 is a corrosive gas created by the oxidation of sulphur-bearing materials such as coal, oil, and natural gas. SO2 emission is a particularly acute problem in the power generation industry. Sulphur oxides are produced as a result of oxidation of the sulphur present in the coal at the combustion zone.

To minimise the adverse effects of sulphur oxides (SO2 and SO3) on environment, many power plants and industrial facilities use Flue Gas Desulphurisation (FGD) scrubbers to remove SO2 and SO3 from combustion gases.

The SO2 emission levels would vary depending on the sulphur content and the composition of the coal fired. The weighted average of sulphur content in the coal is varying from 0.30 per cent to 0.55 per cent and the corresponding estimated SO2 levels works out to be around 1254 to 1650 mg/Nm3 at 6 per cent (dry basis of flue gas) therefore, the sulphur content in the coal of particular power plant is the main consideration for FGD design.

Need and Schedule of FGD Installation

The Environment Ministry had notified emission norms on December 7, 2015 for Sulphur dioxide (SO2) for coal/lignite based Thermal Power Plants (TPPs), which were to be implemented within two years from the notification, i.e., December 7, 2017. Subsequently, in December 2017, the timeline for implementation of new emission norms was extended. Later due to disruptions caused by the COVID-19 pandemic, the deadline was once again extended.

As per the latest notification issued by MoEF & CC on March 31, 2021, a task force has been constituted by the Central Pollution Control Board (CPCB) comprising of representatives from MoEF & CC, Ministry of Power (MoP), Central Electricity Authority (CEA) and CPCB to categorise Thermal Power Plants in three categories. As per the amended norms, about 596 units have been grouped under three categories, A, B and C. The deadline for installation of Flue Gas Desulphurization (FGD) technology for Category A (79 units of 22.9 GW capacity) plants that are within 10 Km radius of National Capital Region (NCR) is until December 31, 2022. Category B TPPs (68 units of 23 GW capacity), which are within 10 Km radius of critically polluted areas, must install FGD technology by December 31, 2023. And the remaining thermal power plants come under Category C (449 units of 163 GW capacity) and must comply with the government's directive by December 31, 2024. A penalty of 10-

20 paise per unit for non-compliance beyond the assigned time limit payable by the power industries has also been specified under the amended rules.

Due to the strict environmental norms, coal-based power plants across India are in the process of installing & upgrading FGD systems, ESPs and other air pollution control equipment. In fact, about 166.4 GW of thermal power capacity has been targeted to install flue gas desulphurization (FGD) systems in a phased manner by 2022. Apart from this, the thermal power units that are already hitting the operational age of 10-15 years do hold significant business potential for efficiency up-gradation & installing air pollution control equipment in the years to come.

Standards for SOx Emission from thermal power plants

Prior to MoEFCC order, there were no norms for emission control of SO2. The expected SO2 emission in the existing units of capacity below 500 MW is in the range of 700 to 800 mg/Nm3 and in the units of capacity above 500 MW is in the range of 650 to 750 mg/Nm3. According to the amendment the Thermal Power Plants has to comply the following norms specifically on Sulphur Dioxide (SO2) emission.

- Units with capacity less than 500 MW and installed till 31st December 2016 – 600 mg/Nm3
- Units with capacity equal to 500 MW and above and installed till 31st December 2016 – 200 mg/Nm3
- Units which are being installed after 1st January 2017 – 100 mg/Nm3

As per the implementation plan prepared by Central Electricity Authority (CEA), the existing Thermal Power Plants are required to comply with the new emission standards by the year 2022.

With the MoEFCC order, it has become compulsory to install Flue Gas Desulphurisation (FGD) system in the existing and upcoming thermal power plants to curb SOx emissions. FGD is a system which reduces the SOx in flue gas through chemical treatment and converting the captured SOx into a by-product such as Gypsum or Calcium Sulphate or Sulphuric Acid depending upon the type of mechanism used.

Table- 1 New standard for SOX emission from coal based thermal power plant

Pollutants	**TPPs(Units) Installed on or before 31st December 2003**	**TPPs(Units) Installed after 1st January 2004**	**TPPs(Units) to be Installed after 1st January 2017**
Particulate Matter (PM)	100 mg/Nm3	50 mg/Nm3	30 mg/Nm3
Sulphur Dioxide (SO2)	600 mg/Nm3 (Units < 500 MW) 200 mg/Nm3 (For Units ≥ 500 MW)	600 mg/Nm3 (Units < 500 MW) 200 mg/Nm3 (For Units ≥ 500 MW)	100 mg/Nm3
Oxides of Nitrogen	600 mg/Nm3	450 mg/Nm3	100 mg/Nm3
Mercury(Hg)	0.03 mg/Nm3	0.03 mg/Nm3	0.03 mg/Nm3

The provisions for Emission standards from thermal power plant have been further amended vide notification dated 28th June'2018 for stack height post-FGD and water Consumption which are as follows:

Summary of New Amendment

Table- 2 Stack Height post FGD installation

Sl. No.	Parameter	Parameter	Standard
1	Stack Height/Limit in Meters	Stack Height/Limit in Meters	Power Generation capacity : 100 MW and above H = 6.902 (QX0.277)0.555 Or 100 m, whichever is more
			Less than 100 MW H = 6.902 (QX0.277)0.555 Or 30 m, whichever is more Q = Emission rate of SO2 in kg/hr* H = Physical stack height in meter *Total of the all units connected to stack Note: These standards shall apply to coal /lignite based Thermal Power Plant.

- All monitored values for SO_2, NOx and Particulate Matter shall be corrected to 6% Oxygen, on dry basis.
- Specific water consumption shall not exceed maximum of 3.0 m3/MWh for new plants installed after the 1st January 2017 and these plants shall also achieve zero waste water discharge.
- Seawater based plants are exempted from conversion of once through to Cooling Tower based system.

As the units of DSPM TPS (2X250 MW) were commissioned before 31 December 2016; therefore, SOx emission and NOx emission parameters are to be controlled within the specified limit as declared by MoEFCC. Accordingly, a suitable flue gas desulphurization system is required to be installed in order to keep actual SOx emission value well within statutory limit.

METHOD ADOPTED

FGD is a set of technologies used to remove Sulphur dioxide from exhaust flue gases of fossil fuel power plants, and from the emissions of other Sulphur oxide emitting processes. It is a control device that absorbs and react using the alkaline reagent to produce a solid compound. In this system, equipment such as absorber towers, demister supports, gas outlets, recycle and process piping, process tanks, and agitators are highly exposed to corrosive and abrasive environments like flue gas. Rubber linings have fundamental advantages so that neither the physical nor chemical properties of the scrubbing liquid have any major effect upon its service life.

Flue Gas Desulphurization Technology Selection Criteria

The selection of flue gas desulphurization technology (FGD) is done on the basis of economic, technical and commercial aspects. These include capital cost, operating cost, the efficiency to remove SO_2, performance reliability, space requirement, and a proven track record. On the basis of the reagent used, an FGD equipment can be classified as seawater based, ammonia based and limestone-based. While wet limestone-based freshwater flue gas desulfurization system is techno-economically feasible for inland power stations, ammonia-based FGDs are not very popular because the reagent (ammonia) is considerably more expensive and hazardous than limestone. Besides, there is a risk of ammonia releasing into the atmosphere without any reaction taking place in the flue gas desulphurization system (FGD), which causes environmental hazards. Hence, wet limestone-based FGD is a preferred option because the reagent is easily available and inexpensive and can be easily handled and the byproduct is useful for other industrial purpose. Meanwhile, seawater-based FGD is mostly used in coastal plants. The same can be understood by following flow chart:-

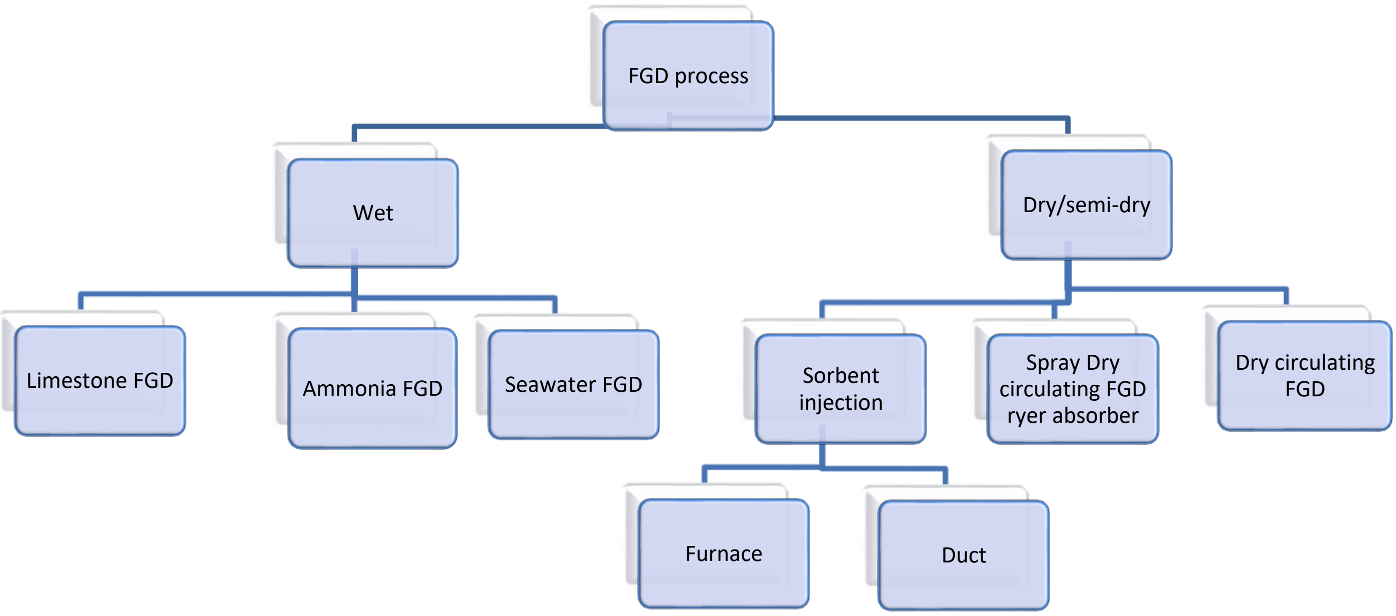


Fig. 2 Flowchart showing FGD Technologies:-

The SO_2 reduction technology shall be done considering following factors:
1: Sulphur Content in Coal.
2: SO_2 removal Efficiency requirement of particular plant.
3: Availability of Reagent (if Any).
4: Disposal and handling of By-product.
5: Locational/Geographical factors of the plant.
6: Plant life.

7: Space requirement for FGD facility.

Globally around 80 per cent of the thermal power plants prefer wet scrubbing technology. In a wet scrubber, a lime or limestone is used as sorbent which is sprayed in a tower where flue gas is passed and scrubbed to form Calcium Sulphite. This Calcium Sulphite is then oxidised to form Calcium Sulphate or Gypsum. This system involves usage large quantities of water. This water usage can be minimized by applying semi-dry scrubbers such as spray dry scrubbers (SDSs).

WET PROCESS

Wet flue gas desulphurization system roughly has SOx removal efficiency of over 90 per cent. Wet flue gas desulfurization system (FGD) comprises four main processes-

(i) Flue gas handling,
(ii) Reagent (limestone) handling and preparation,
(iii) Absorber and oxidation,
(iv) Secondary water and gypsum handling.

Lime / Limestone-Gypsum Forced Oxidation (LSFO) Process

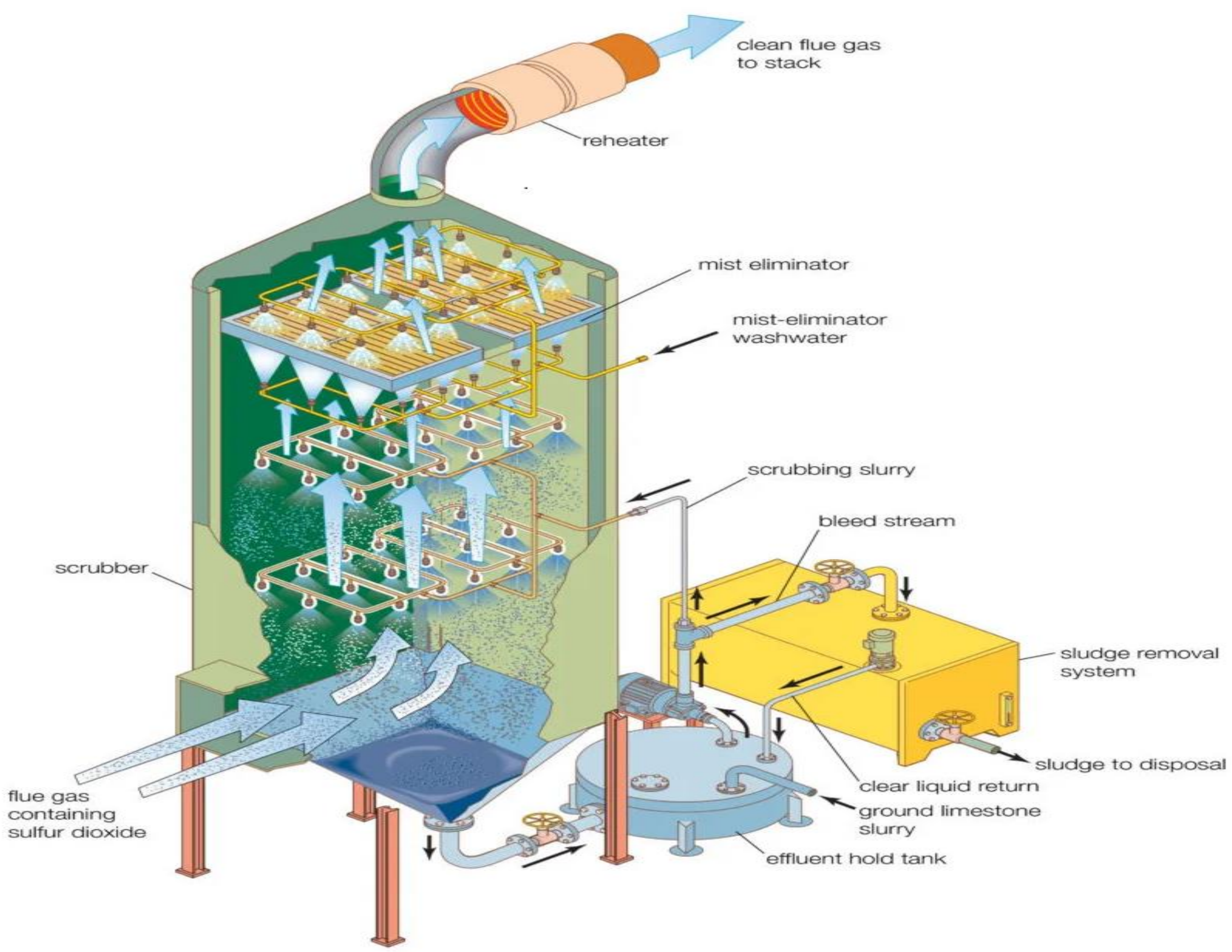
In this process, thin lime or limestone slurry is sprayed in the flue gas path or alternatively, the flue gas passes through a bed of lime / limestone slurry. The reactions between lime / lime stone slurry and SO2 produces a mixture of calcium sulfite and calcium sulfate. The calcium sulfite sludge is further oxidized in an oxidized tank to yield $CaSO_4 \cdot 2H_2O$ or **Gypsum**.

$SO_2 + H_2O = H_2SO_3$

$CaCO_3 + H_2SO_3 = CaSO_3 \cdot \frac{1}{2}H_2O + \frac{1}{2}H_2O + CO_2$

$CaSO_3 \cdot \frac{1}{2}H_2O + 1\frac{1}{2}H_2O + \frac{1}{2}O_2 = CaSO_4 \cdot 2H_2O$

The gypsum slurry is bled off from the tank and dried in a Dewatering plant, from where the gypsum is taken for sale. The LSFO process is capable of achieving up to 98% SO2 removal for high Sulphur coals which makes it highly suitable for the proposed plant.



The choice of reagent depends on the availability, cost and other issues like handling. The lime requirement per ton of SO2 removal in a wet process is typically 56% of the limestone requirement. However, this difference is off set by the higher cost of lime as compared to limestone. The availability of high-quality lime from local source is another issue which favors the use of limestone. In view of the above factors, limestone is the chosen reagent for the wet limestone based FGD system.

CONCLUSION

Wet FGD using Lime/Limestone-Gypsum Forced Oxidation Process (LSFO FGD) is the most well proven technology to achieve high desulphurization efficiency with high Sulphur coal, with a large number of reference plants. The high capital cost and auxiliary power consumption of the process are partially off-set by the high sorbent utilization and sale ability of the gypsum by-product.

Further, the process is well proven with a number of operating units and manufacturers. However, the wet LSFO FGD process is a very complex as compared to the dry process and requires a large foot print area.

The above process is the most suited for 250 MW Units of CSPGCL. Other Wet systems are costlier due to higher cost of reagent and higher energy consumption. Accordingly, this system is selected.

EXPECTED OUTCOME

- The study materials so developed shall be useful in our ability to compare the impact of SOx emission factors and ascertain the sensitivity of atmosphere to each of these factors. which will in turn help in bringing about an improvement in the Ambient Air Quality (AAQ) in and around thermal power plants
- This Study will help in planning for emission reduction strategies by optimizing focus on most critical factors.
- Based on this research papers in international journals will be published.

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