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MEPA - an Innovative way for ESP upgrade for Cleaner Environment in Pulp & Paper Plants

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Abstract: ***With increased stringent regulatory act imposed by MoEF & CC for CPP of Pulp & Paper mills relating to Stack gas pollutants, all of them are having ESP at the back end of the boiler for controlling particulate emissions. The same is the case with Chemical Recovery Boilers . In this context, the success of patented MEPA scheme of Enviropol in the spent wash fired boilers taking care of sticky and fluffy particulates in flue gas , EGB as an add-on to the existing ESP in operation [termed as MEPA in short] is the answer for achieving SPM in stack gas discharge of all the boilers -CPP & CRB. As the particulate in flue gas characteristics are as bad as that of Chemical recovery Boilers, if not worse, the collection efficiency of integrated EGB is expected to be of a very high order.***

In case of CPP firing indigenous Coal of high Fly-ash resistivity, EGB and not ESP field addition is the answer. Because of the attributes of EGB, it is recommended to go in for increasing boiler cycle efficiency through increasing the feed water temperature to economizer and the attendant increase in flue gas temperature [with tightening air ingress in the back end equipment, the flue gas temperature leaving MEPA would increase -which shall be negated with heat recovery through small extended feed / condensate heater. This shall in turn increase marginally thermal efficiency of the boiler under review. Through the proposed scheme, MEPA with integrated heat recovery is being discussed -through which both cleaner environment as well as energy conservation attributes are clearly brought out.

Keywords: Air Pollution Control,Captive Power Plant, Chemical Recovery Boiler, Daurala Sugar Works, Electrified Gravel Bed, Electrostatic Precipitator, Maximum Efficiency Particulate Abatement (MEPA).

Introduction : Leading Pulp and Paper mills have installed High Pressure solid fuel [Coal and Biomass] fired Cogen as also Chemical Recovery High Pressure Cogen Boilers firing Black liquor solids (BLS) of high concentration [65% to 75% solids] as fuel. Whereas Biomass is one of high moisture low grade with diverse characteristics, BLS is derived from Wood or Bagasse or Wheat / Rice Straw as source.

In all of the Boilers, the particle laden flue gas with high Suspended Particulate Matter (SPM)and fine particulates [Fig.1] is sent to 2 pass-3/4 field ESP for dedusting. [Refer Fig-2A & Fig-2B].

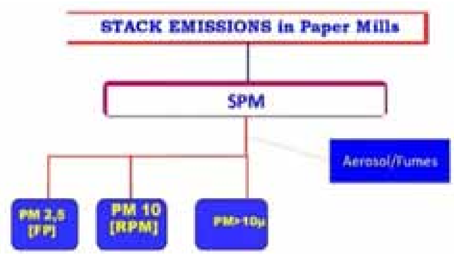

Fig-1 : Break-up of Particulate matter in Stack flue gas

EXISTING STATUS OF STACK SPM EMISSIONS OF CPP & CHEMICAL RECOVERY BOILERS

In Coal / Biomass fired boilers, MoEF & CC stack SPM norms [30 & 50 mg/Nm3 in stack flue gas] are stringent as can be seen from the next section. In existing Chemical Recovery Boiler [CRB] with ESP at back-end, the cleaned flue gas with lowered SPM content [50 to 100 mg/Nm3] is led to the ID fans from where the flue gas is discharged to the landscape through the connected stack. The stack emissions fluctuate heavily during soot blowing of boiler tubes.

Fig-2A : Coal fired High Pressure Boiler- CPP

Fig-2B : Chemical Recovery Boiler

WAY FORWARD FOR CLEANER STACK OF CPP &CHEMICAL RECOVERY BOILER

MoEF & CC Gazette Notification have come into force for limiting Stack flue gas pollutants for all Captive Power plants of Pulp and Paper sector [Fig.3] in line with that promulgated for Thermal Power plants [6].

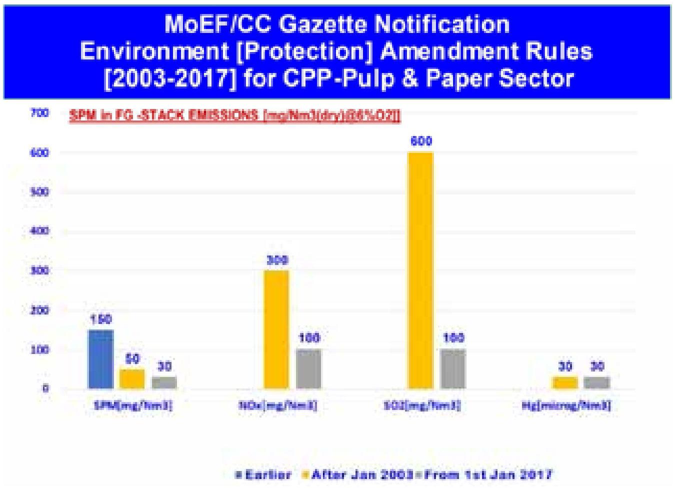

Fig-3

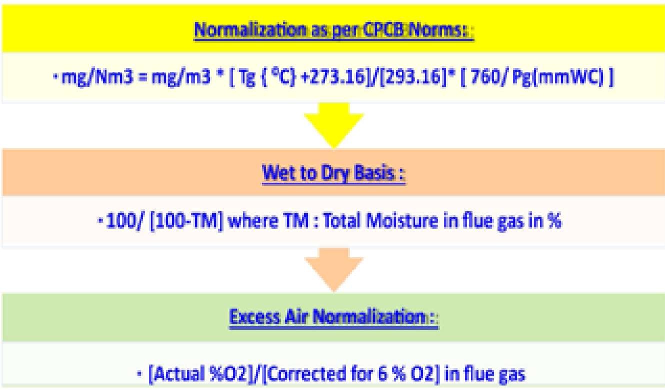

Fig-4 : Normalization Worksheet for SPM in Flue gas estimation

It should be noted that MoEF & CC gazette notification calls for SPM in stack flue gas limiting to 30mg/Nm3 [@6%O2-dry]. The importance in stressing the above facet can be realized from the following attribute normally prevalent in Industrial practice in reporting [Fig.4].

Illustration:

SPM in stack flue gas reported : 48 mg/Nm3 [as such i.e., wet basis] after correcting for flue gas temperature normalized from say 140°C to 0°C [i.e., 30 mg/m3*(140 +273)/(0+273)].

For high moisture Enviro-Coal / NLC Lignite / chipper dust as fuel , with say 14% to 15 % moisture in flue gas, it would relate to 60 mg/Nm3 [dry].

In case the O2 in flue gas is at 7% in stack flue gas, the corrected figure for the above normalization would result in 65 mg/Nm3 [@ 6% O2-dry]. To sum -up the factor of 35 % on the unnormalized figure would call for high collection efficiency with APCD in place.

Extending the above logic, for achieving 30 mg/Nm3 , it would be one of ~20 mg/Nm3 [as measured on wet basis].

With soot blowing being carried out in few boilers and when one field of ESP is down, the resultant SPM in stack flue gas would rise further.

Issues with Biomass Drying is Blue Haze formation

Organic acids and resins are present in flue gas at Boiler back end and in Stack flue gas discharge and cannot be contained by existing ESP in operation. Hardwood contains ~1 % resins.

The condensed acids & resins form aerosols of 0.1 to 0.5 micron size that reflect blue light is called Blue Haze [9]. It also leads to increase in Opacity.

With the above facets in place, MEPA [EGB integrated to existing ESP] is the ideal choice for ensuring SPM in stack flue gas below 30 mg/Nm3 [@ 6% O2 -dry] at all times of operation on a continuous and sustained basis.

Time is not far, when the above emission control regulations shall be extended to Chemical Recovery Boilers [Fig.5]. Space is a constraint for adding additional fields to the existing ESP in place. Moreover, the characteristics in terms of high fines, fluffiness and stickiness of particulates would be a deterrent for enhancing particulate collection in the add on field.

Keeping this future in mind, based on the recent success of its Patented MEPA (DESP+ EGB) in Distillery- Spent wash (SW) fired Incineration boiler and its capability to limit emissions to even below 30 mg/Nm3 [3],

Fig-5

the authors and their overseas collaborator do strongly recommend its use for Coal & Biomass fired units & BLS fired Chemical Recovery Boilers.

For ease of comparison and similarity between BLS [2] & SW[5], refer Fig-6 and Fig-7 as below.

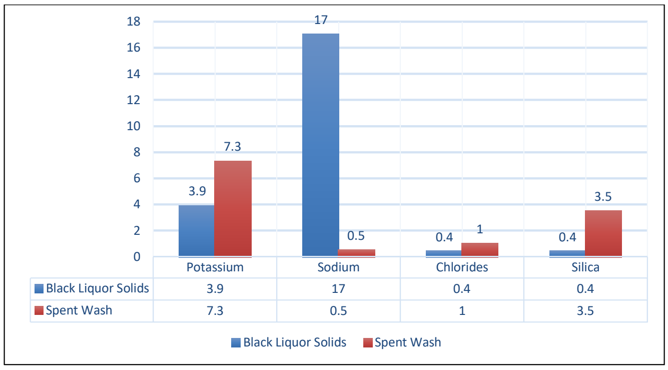

Fig-6 : Comparative Analysis of Non Process Elements [%] in BLS& SW

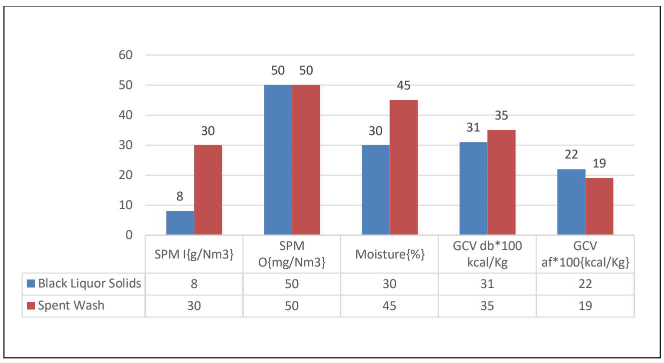

Fig-7 : Parametric Study of BLS&SW for SPM/Moisture/GCV

The present study brings out the various facets and operating principles of MEPA alongwith the successful case-study [3] of Spent wash firing in Distillery plant at Daurala Sugar Works [DSW]-as is very much akin [as can be seen from the above section to stack pollutant mitigation with BLS firingin Chemical Recovery Boiler].

MEPA - INTRODUCTION

MEPA is an integration of DESP with a highly efficient polishing filter known as EGB Precipitator.

MEPA is designed for two stage separation (Fig-8).Primary cleaning is achieved using conventional dry ESP. The final stage seperation is done using EGB to achieve fairly uniform results with no possibility of rapper-entrainment. EGB can be designed to achieve outlet emissions of even below 20 mg/Nm3.

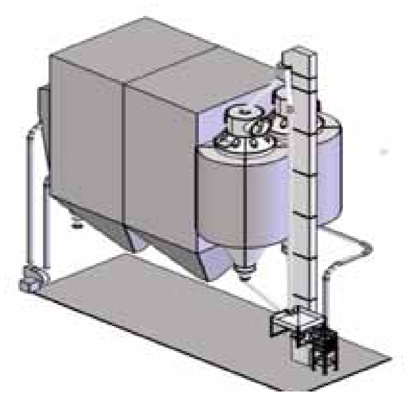

Fig-8 : MEPA

EGB System Description

The gases entering the filter body, passes through an ionizing chamber down into the filter body. In the ionizer, particulates are negatively charged. If necessary the ionizer is cleaned periodically by a suitable automatic brush system. The gases are transported by the fan. The gases, distribute equally, and passes through the polarized filtering bed (Ref- Fig-9).

The gravel bed is a cylindrical ring contained internally by a series of taper-shaped steel rings (louvers), installed in such a way that the gravel cannot spill through them and that the fumes can enter freely. Inside the gravel bed there is installed an electrodes cage. The positive electrical potential is

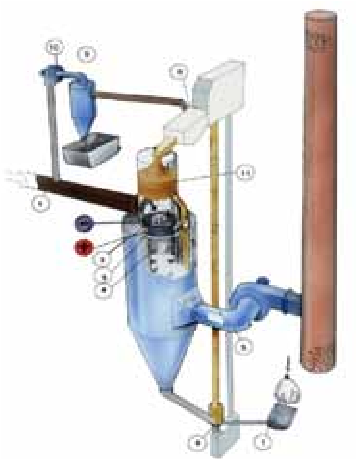

Fig-9 : EGB System

Fig-10 : Pea sized Gravels

10÷20 kV. The particulate in the gases, previously negatively charged, is attracted by the gravel and sticks to it.

The gravel moves slowly downwards. In the bottom the dirty gravel flows through the manifold to a bucket elevator. The gravel flows through a wind-sieve before the cleaned gravel is entering into the surge bin. Also, the gravel can be dumped separately from any single unit in case of maintenance without stopping the filter (Ref-Fig-10).

Particulates released from the surface of the gravel is separated and transported by the fan, settle in the de-dusting cyclone/BF .The transport gravel re-enters the flue-gas upstream the ionizer.

EGB – PM Collection Efficiency

Collection efficiency of the filter, as a function of the particulate dimensions and of the bed electrodes voltage is shown in Fig-11 [1].

Even in the absence of high voltage field, a good collection of particulates with dimensions> 2.0μ is achieved.

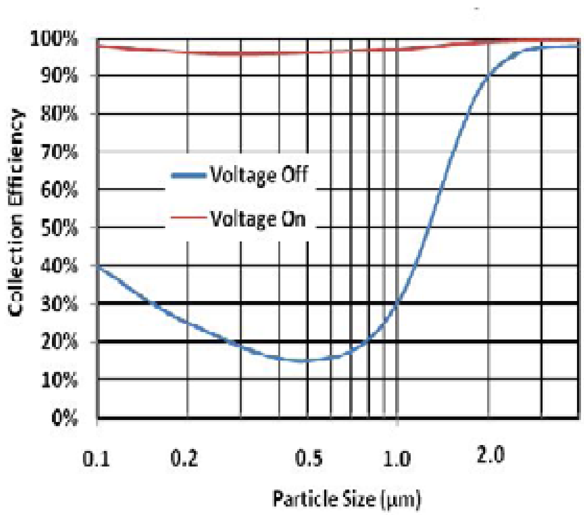

Fig-11 : Collection Efficiency with Particle Size

AREAS OF APPLICATION OF EGB

MEPA/EGB Technology is best suited to achieve very low emissions on difficult applications such as Spent wash, Black liquor, MSW, Paddy straw, mustard husk or any high temperature gas cleaning, where dust is sticky and with high resistivity.

This technology has been used successfully to upgrade existing ESP installations to meet stringent emission norms in power, steel [4]&cement and on coal/lignite fired boiler applications.

CASE STUDY – MEPA IN SPENT WASH FIRED BOILER AT DSW [3]

Based on major advantages of MEPA over other existing technologies [ESP & BF] in vogue,DSW opted for the former APCD in their spent wash fired boiler. The new MEPA system economisedoverall boiler length by ~10m as compared to conventional technologies [Fig-12].

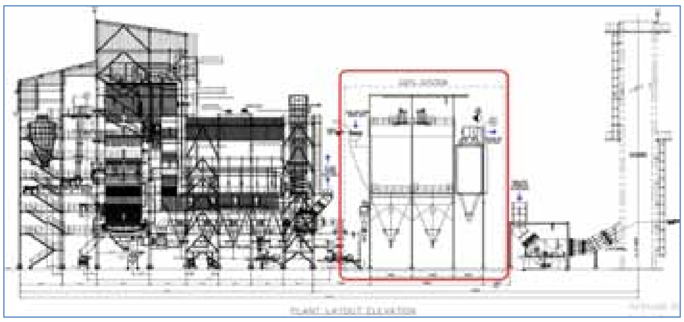

Fig-12: Elevation-Incineration Boiler with MEPA

Order for complete APCD and Ash handling system was awarded to Enviropol under collaboration with US partner for design, manufacturing, supply, installation and commissioning as sub-package toboiler project [Fig-13 & Fig-14]. Boiler was commissioned in Oct 2019.

Fig-13& Fig-14: Actual MEPA Installation at DSW

MEPA system was put in operation and initial figures recorded were 20-27 mg/Nm3 at 60% MCR loading.MEPA performed consistently even at Boiler rated conditions with bagasse/rice husk as supporting fuel. Complete MEPA and Mechanized Ash Disposal System ares controlled and monitored through a dedicated control desk . Fly ash from all boiler streams is collected in a common ash silo and directly loaded in trucks. This ash, being rich in potash, is usually sold for revenue generation.

MEPA is the first installation in the world on this application. With continuous operating experience on this particular application and data available from many installations of EGB by the technolgy provider, no special maintenance is needed for this equipment.In Slop fired Boiler,SPM in flue gas at EGB outlet was around 35 mg/Nm3-with 25 mg/Nm3 [min.].

Soot blowing for removal of particles sticking on pressure parts is being done regularly for 3 to 4 hours daily. Due to the above, there is no disturbance in SPM in flue gas leaving EGB, since it is akin to Bag filter with static charges, as it had been designed for worst operating conditions. Refer Fig-15 [5].

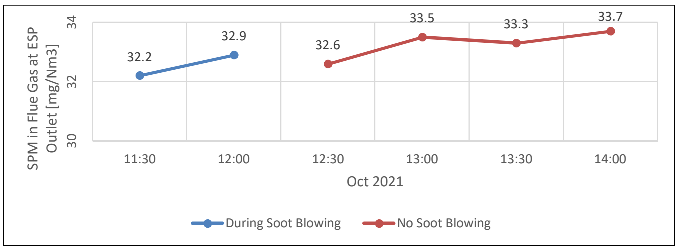

Fig -15. Impact of Soot blowing on SPM in flue gas to stack of Slop fired Boiler

No degradation is reported with EGB in place, as can be seen from the constant SPM figures in exhaust gas randomly taken during last 2 years of Slop fired Boiler in operation [Table-1].

TABLE –1: SPM in flue gas at EGB out of DSW Slop fired Boiler- Steam generation: 27 to 30 TPH; Steam outlet Pressure: 44 kscg; Steam outlet Temperature: 410°C

Year	SPM [mg/Nm^3]
2019	35
2020	33
2021	33

ESP UPGRADE WITH EGB FOR CHEMICAL RECOVERY BOILER [CRB]

BLS is fired mostly without Furnace oil as support fuel. Combustion air preheated by steam in Steam coil Air pre-heater is being admitted at three elevations in combustion chamber for char bed formation and completion of combustion. Combustion chamber is enclosed by membraned water walls for heat absorption and water circulation. Hot flue gas flows past the Superheater coils located at furnace exit. Flue gas is led across the Vertical Economizer tube bank where feed water from Deaerator is preheated and sent to the steam drum. The particle laden flue gas with high Suspended Particulate Matter (SPM) of say 15 g/Nm3 is sent to 2 pass- 3 or 4 field ESP for dedusting.

In case of Chemical Recovery Boilers in Paper Mills, importance is being given to the minimum achieved sub-micronic particulate loading in discharge gas. As can be seen from the above, high particulate collection efficiency at macro level and that too with very fine fluffy particulates at micro-level, with EGB in place at the back end of the Recovery Boiler should ensure SPM in discharge flue gas through the connected stack to $<$ 30 mg/Nm3.EGB, as standalone APC device, can be used for those Recovery boilers who are due to upgrade their old ESP to meet most stringent emission norms, but unable to do so due to space constraint or are suseptible not to achieve the desired emissions even after adding extra fields due to remaining dustbeing very fine ($<2.5\mu$).EGB, being very compact, can be fitted easily within the limited space.Since the characteristics and associated flue gases of Slop and BLS flue gases being similar [Fig.16], and based on the success of DESP-EGB success in Slop fired Boiler, the proposal to replicate the same in Chemical recovery Boiler had been taken up.

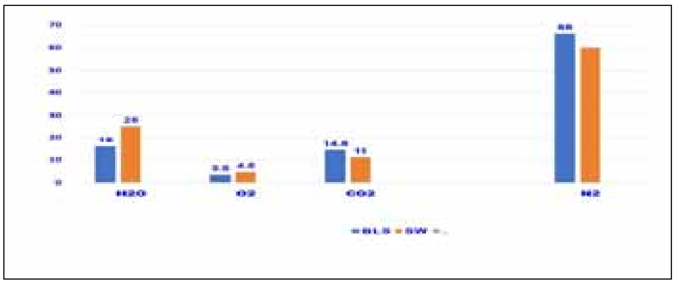

Fig- 16 : Flue gas Analysis [%]- BLS [Chemical Recovery Boiler] vs SW [Slop fired Boiler]

Existing ESP can be easily upgraded adding EGB in the down stream as shown in Fig-17.

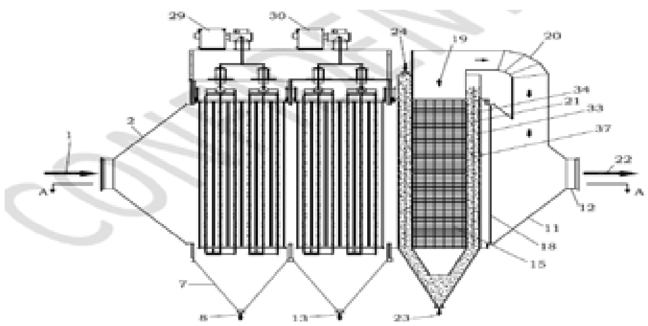

Fig-17 : ESP Upgrade

CONTROL OF EMISSION OF SPM IN FLUE GAS DURING SOOT-BLOWINGIN CRB

In Recovery Boilers, particles depositing on pressure parts is a regular occurrence and of continuous feature. Hence regular soot -blowing using higher pressure steam is being carried out at least once a shift daily for particle removal and keeping pressure parts clean for efficient heat exchange. This would lead to higher particulate loading and also increase the moisture content in flue gas to the existing ESP. Resultant increase in SPM in flue gas to stack during soot blowing is unavoidable as can be seen from the operational feedback elicited in Fig-18.

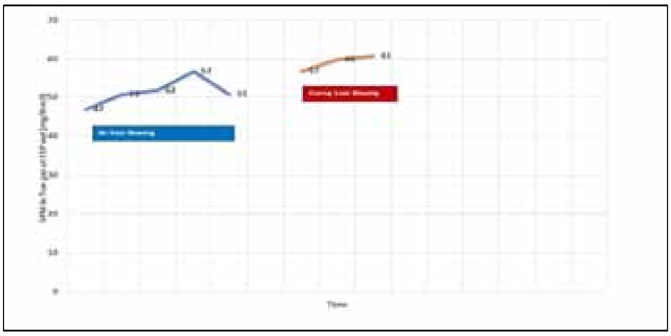

Fig -18 : Impact of Soot blowing on SPM in flue gas to stack of Chemical Recovery Boiler [7]

As EGB had demonstrated low SPM in flue gas with firing of Slop [having high moisture and increased inlet SPM concentration in flue gas] in vinasse fired boiler [Refer Fig.18], hence it is clear that with EGB add-on to ESP of Recovery Boiler, particulate at EGB outlet would be low and SPM in flue gas leaving stack can easily be maintained, even during regular steam soot-blowing in Recovery Boiler as had been shown in the case of DSW Slop fired boiler. This facet is clearly delineated through comparison of EGB/ SFB with ESP/CRB [Fig.19].

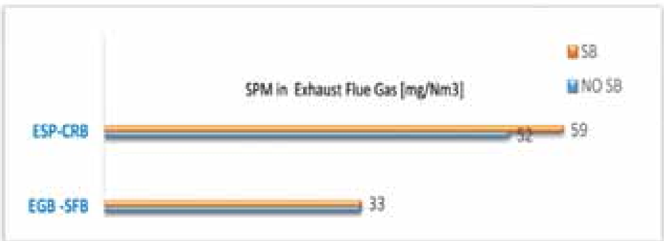

Fig -19 : Comparison of SPM in exhaust flue gas [mg/Nm3] -During Soot blowing & No Soot blowing in CRB [with ESP] &SFB [with EGB]

EGB as an add-on is more beneficial for those CRB with high SPM content in flue gas leaving existing ESP to stack. SPM in flue gas to stack can be greatly contained within regulatory limits and beyond for product gains apart from cleanest stack. Not only stack is clean, collection of product dust in EGB is of constant value addition. [For BLS firing 1450 TDS (dry) in CRB, additional product collected would be to the tune of 2.5TPD on a continued basis].

VALUED FINDINGS WITH MEPA

- EGB is a path-breaking Enviro-scheme in that the Stack particulate emission can be contained to the prescribed /regulatory limits on a continuous basis with the addition of this APCD to DESP at the back-end of the boiler.
- Unlike in case of ESP, with EGB, SPM in stack gas is unaffected during soot-blowing.
- Unlike with ESP, Degradation is expected to be very minimal with DESP-EGB in place.
- Unlike add-on ESP , EGB requires only a smaller foot-print and hence can be easily attached to the existing ESP without impediment of space constraint.
- Since it is neither particle size granulometry nor Fly-Ash Resistivity [FAR] dependant, be it high resistivity coal or sticky lignite fines , inclusion of EGB shall ensure SPM as desired in flue gas leaving the stack.
- EGB can be added in the down stream of existing ESP in series near to the ID fan without calling for any major shutdown for hook up.

EGB is a boon to existing Chemical Recovery Boilers, CPP [Coal/lignite/ biomass] and Pulverized fuel fired Boilers by way of add-on to existing ESP in order to achieve MoEF & CC Gazette notification of SPM[<30mg/Nm3] in flue gas discharging to atmosphere [6].

MEPA REPLICATION IN COAL FIRED BOILERS

Excellent for high Resistivity dust: EGB concept operates the opposite way as the conventional Dry ESP. It favors high voltage in the gravel bed. Higher potential difference between dust and gravel leads to better precipitation. Conventional ESP, on the other hand, favors high current. Higher current intensity leads to better migration velocity and precipitation.

MEPA : EGB as add-on to existing ESP of AFBC / Stoker fired boiler firing Indigenous High Fly-ash resistivity coal [8] [Fig.20] would be the answer for ensuring cleaner stack with lower SPM in flue gas discharge. The stringent stack gas particulate emission level of 30 mg/Nm3 can be easily achieved through MEPA.

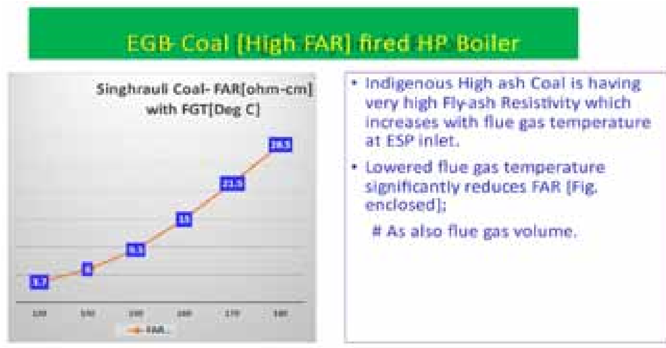

Fig -20

No SO_2 Conditioning of flue gas for reducing FAR of Coal is called for.

EGB has recently been tested for SOx reduction using hydrated lime as sorbent and initial findings are encouraging. Enviropol, is on way to conduct some more tests to validate its use as"Multi-Pollutant Removal System" in varying applications.

INTEGRATED HEAT RECOVERY SCHEME -POST EGB

In few of the Coal fired boilers , the flue gas temperature leaving the APH is at a high of 160 to 170°C. However because of the air infiltration and poor and inadequate insulation of ESP and pre & post flue gas ducting the flue gas temperature at existing ESP outlet would be around 140°C, Hence it is advocated to tighten the above with improved insulation and arrest the air infiltration through attending to the duct and ESP exterior,

After MEPA, with the cleaned warm flue gas, it is proposed for an atmospheric extended heat exchanger for preheating feed water/turbine condensate with flue gas temperature dropping by over 20°C to 140°C through heat exchange. An increased thermal efficiency of the boiler by 1.5 to 2 % is an added revenue accruing on a continuous basis. Even with 10 to 15°C flue gas temperature drop is worth heat recovery through extended heat exchanger.

One can now easily increase feed water temperature to economizer by 5°C through Deaerator pressure setting. As Boiler Feed Pump had been designed for higher feed water temperature, this scheme had been practized in the present HP Boilers of CPP and CRB. Because of compression at high pressures, the resultant increase in feed water temperature to Economizer would relate to increased HP steam generation from HP Boiler through higher cycle efficiency.

As an illustration feed water temperature of 135°C would go up to 140°C and after BFP it would be at a high of 143°C. Marginal increase in flue gas temperature leaving the boiler back end to ESP is to be expected. However with the proposed extended heat exchanger, additional heat available in exhaust flue gas shall be recovered through further feed water heating.

Alongwith this reduction in flue gas volume by 5 % through lowered fuel firing to that extent would compensate to an extent draught losses across EGB & the proposed heat exchanger.

CONCLUSIONS

Based on the successful operation of DSW spent wash fired boiler with EGB at the back-end in terms of extremely low SPM in stack discharge flue gas, MEPA [EGB add-on to the existing ESPs both in Coal/Biomass HP boilers as well as Chemical Recovery Boilers would be the right choice in ensuring particulate in gas emission through stack < 30 mg/Nm3 in line with MoEF& CC Gazette Notification.

Alongside integrating specially designed feed water heater for additional waste heat recovery from flue gas leading to stack increases boiler efficiency.

ACKNOWLEDGEMENT

The Authors are grateful to the Management of DSW for providing this opportunity and taking bold initiative to opt for installation of first MEPA on their new spent wash fired incineration boiler. Authors would like to thank their Swedish and US Technology partners for their active co-operation during the course of development of this concept and successful execution.

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