Bag filter Retrofit Option for Indian Utilities – Challenges and Solutions

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Abstract:

Solid particulate emission (SPM) control is the key today to start new coal fired utility project as well as to run older coal based power plants. Considering prevailing economics, the existing plants want to extend their life and hence to retrofit the emission control equipment. There are two major options of retrofit to mitigate SPM i.e. Electro Static Precipitator (ESP) and bag filter (BF). Such retrofits are not new for worldwide older plants as well in India. There are more number of methods available to carry out ESP retrofit and almost all methods got executed and fructified over last two decades in India at various plants. But the number of Bag Filter retrofit is very few. Both options have their own merits and de-merits. Even though retrofit of bag filter for older coal fired plants require less floor space than required for ESP, it has more challenges with regard to boiler operation and maintenance. Bag filter can be a better choice for finer particle collection and for lower emission levels. However it is sensitive to boiler operation particularly with regard to oil firing and higher flue gas temperature. Aged boilers with older technology of fuel firing have more problems & challenges to be addressed to go in for bag filter retrofit.

The paper brings out salient points to be taken care during bag filter retrofit. This will be very much useful to power plant owners when they specify system design requirements for bag filter retrofit.

1.0 Introduction

India is the fifth largest electricity producer in the world with around 210 GW as of now and 66 % is of coal fired utilities. In 12th and 13th Five Year Plans capacity of 76 GW and 93 GW respectively will be added, most of which would be of coal based plants. This will be an indicator to seriously explore solutions to control particulate emission. With increasing power generation there is an increase of SPM emission that too with finer particulate. The term 'solid particulate emission (SPM)' is added to PM_{10} and $PM_{2.5}$ dimensions today. Further to the above scenario, the operation of existing older power plants immediately needs retrofit for controlling SPM so that they stay in operation. There are two major options available to retrofit i.e. Electro Static Precipitator (ESP) and bag filter. Retrofitting with Electrostatic precipitator (ESP) is the proven option in India. But there are only few cases of bag filter retrofit. When both options has their own merits, ESP stands taller with regard to economics of design, investment and plant operation and it suits better to Indian conditions in all aspects. However, bag filter has its own advantage over ESP, specifically with consistent lower emission levels and in controlling finer particles. Based on their learning and experience, the authors bring out the technical challenges in bag filter retrofit and suggest a suitable approach.

2.0 Retrofit Options with Electrostatic Precipitator & Bag filter

Electrostatic Precipitator: ESP is the best and the most economic technology (low pressured drop, least maintenance and low power consumption) being adopted extensively in India and abroad to control of SPM for old plants. With lower investment and O&M cost, ESP has become an invincible partner in coal fired utilities. The merits of ESP over bag filter:

- Proven technology for various types of coal
- Can be designed for lower emission levels as low as 20 mg/Nm3.
- Lower operating pressure drop of 15 to 20 mmWc against 120 to 150 mmWc of bag filter
- Lesser ID fan capacity and so the auxiliary power consumption
- Not sensitive to variation in flue gas temperature and chemistry unlike bags
- No recurring O&M cost like cost of bag replacement
- Can effectively handle large quantities of abrasive type fly ash
- Marginal increase of flue gas flow may cause more additional pressure drop in bag filter

In spite of above listed merits, larger ESPs are required to deal with high resistive fly ash. To deal with high resistive fly ash, continuous technological advancement is taking place on ESP controls viz. intermittent charging, gas conditioning, agglomeration, etc. In India, ESPs that were installed before 1990 were designed for coal with lower ash content and higher emission. But as of today the emission norms become almost less than one forth and coal ash become more than double. Hence older plants are necessarily to go in for retrofit. The option of ESP retrofit need more floor space than bag filter and may need additional ID fan for series configuration. The capability of ESP in collecting finer particle is limited when compared with that of bag filter (**Refer Table-1**).

Bag Filter: Most of the older power plants in India are retrofitted with proven ESP option to meet the emission norms. The bag filter option needs a technically sound and practically viable design and implementation concepts. It needs dedicated operational support from O&M point of view. Its merit is that it is the best for high resistive dust and to control finer particles with consistent lower emission levels. A little change in flow or temperature will not increase emission as in case of ESP. The emission levels as low as like 10 mg/Nm3 can also be achieved with bag filter. The demerits of bag filters are:

- More pressure drop than ESP and more ID fan power
- Sensitive to higher operating flue gas temperature and flue gas chemistry
- Oil firing cannot be resorted to in boiler (start up and part load), else bag filter to be bypassed.
- Higher O&M cost (bag replacement and pulse air compressors)

Cost comparison: Bag filter Vs ESP: Some of the techno economic comparison of bag filter against ESP for similar capacity boilers are presented in Table-2. It may be noted that bag filter has lesser foot print area, lesser weight, less number of ash collection points (so less AHS system components). But it may be observed that power consumption & bag replacement costs are very high when compared with ESP. The capital cost of bag filter may be less but with increased operating cost.

3.0 Bag filter retrofit case study - Plant X

The bag filter retrofit shall start with finalisation of the design and guarantee parameters with appropriate margins on operating gas flow and temperature. A performance evaluation test (PET) can also be resorted to. Specification and selection of bag material shall be based on operating temperature range, emission level and expected bag life. Normally coal fired boilers are base load type and shall not have more number of shut downs and start ups. However, following situations may cause more number of shut downs and start ups which are detrimental to bag life.

- Change of coal mills (coal shortage, poor coal quality, etc)
- Recued boiler load (oil gun in service), etc.

Hence, bypassing of bag filter is required to protect bags.

Any sub-systems like air-attemperation (to even out temperature across duct) and water cooling system (reduce gas temperature) shall be designed with adequate care. For example, design of air-attemperation shall check increased oxygen levels considering its effect on bag life. In case of water cooling system complete evaporation shall be ensured so that the water particles are not carried to cause blinding of bags. A better designed & installed air-attemperation (arrangement of gas mixer) inside the inlet duct will even out flue gas temperature (refer **Figure-4)** across the duct i.e. before gas enters bag section. All necessary safety systems for bag filter operation shall be designed with foolproof feedbacks and shall avoid furious signals that may sometime cause unit down.

As bag filter retrofit is a tailor made, the design shall take care with:

- Appropriate compartment design
- Suitable bag & cage arrangement ,

- Compressor selection,
- Anticipated major problems in erection, commissioning, operation and stabilisation to avoid prolonged stabilisation and costly redesigns like change of bag material.
- Integrated PLC design.

In a plant X of 210 MW capacity, the existing four pass ESPs were retrofitted with two passes converted into bag filter and other two passes were retained as bypass. New higher capacity ID fans were envisaged. Typical scheme of bag filter retrofit option for 210 MW is given in F**igure-1**.

3.1 Important O&M features

Bag damage

The bag material of PPS (generally used in coal fired boilers) is sensitive to higher oxygen levels associated with temperature. Typical reasons for bag failure may be higher flue gas temperature, more oxygen levels, mechanical rubbing, touching of ash in hopper, etc. The bag samples shall be analysed periodically for their assessment. In case of damaged bags, its identification and location is important for further analysis. Typical locations where bags are prone for damage include near gas distribution screen, near casing wall and steel structures as bags are installed inside old casing of ESP. (**Refer Figure-3**).

Repeat Bag damages

Secondary damages are nothing but the damage caused by un-replaced broken and leaking bag in its vicinity. Secondary damages can also occur due to sneaked dust settled in the clean gas chamber (**Refer Figure-2**). Such deposit shall be cleaned with higher capacity vacuum cleaner considering inadequacy with manual cleaning. Prolonged non-replacement of damaged bags allows pass-through of coarser ash particles. The bag damage noticed, require immediate replacement without any time lag. Better bag filter design will enable quicker bag replacement.

Pulse air system:

The availability of pulse air compressors and healthiness of pulse air system is critical for continuous operation of boiler at its rated load. Observation on pattern of dP across bag filer and its analysis will help in optimal set limits of values of dP (min & max levels for pulse activation & deactivation) and so optimum consumption of compressed air. The set values during initial commissioning will have to be reviewed at least once in 6 months. A typical pattern (a mild saw tooth pattern) of observed dP with optimal set values is shown **Figure-5**.

4.0 Bag filter option for Indian high ash and high resistive ash

Bag filters can play a major role in SPM mitigation along with ESP for power plants based coal with more ash and high ash resistivity cases like India as bag filters are:

- Effective in collecting finer particles.
- Not sensitive to very high resistive ash.

For collecting more ash of very high electrical resistivity, large amounts gas conditioning is required and hence this option becomes expensive. Fly ash of high resistivity require a larger ESP and therefore the capital and operating cost of bag filter may become favorable for lower emission levels i.e. additional capital cost of the ESP may outweigh the increased operating costs of a bag filter. Use of coal with more sulphur may require FGD. Boiler with semi dry FGD system may require Bag filter. If 50 mg/Nm3 and 20 mg/Nm3 emission standards are implemented, then the total cost of ESP and bag filter are to be compared. For 20 mg/Nm3 case, bag filter may be the better option even though ESP can cater the need.

5.0 Conclusion

There are cases where retrofitted bag filters are reverted back to ESP, but still the fact on bag filter stands valid i.e. the basic strength of bag filter is its capability for delivering clean flue gas to the stack. Even though it operates with higher dP, the compliance to emission is fair. Pressure drop and bag failure are the more important performance criteria. This ordering of concern is opposite to that of ESP where the dP is always satisfactory but the high resistivity is a major concern. The strength of one technology is the weakness of the other one and hence at least the hybrid collector i.e. combined ESP with bag filter could be a good retrofit option. This can be a feasible solution for older plants as well as for new ones for better emission control. The learning and suggestions presented in this paper will definitely help those who are going for a bag filter retrofit along with ESP to meet emission norms and further assist in control of finer particles too.

Acknowledgement

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4. *BHEL Documents on retrofitting of Bag filter*

Particle size interval	Removal efficiency Of ESP (%)	Removal efficiency Of Bag filter (%)
More than 10 µm	>99.95	>99.95
5 µm	>99.95	>99.9
2 µm	>98.3	>99.6
Less than 1 µm	>96.5	>99.6

Table-1: Particulate Removal efficiency: ESP Vs Bag Filter (Ref.2)

			500 MW - PF coal	135 MW CFBC
1	Configuration	ESP	4 ESPs each with 10 fields in series	2 ESPs each with 6 fields in series
		Bag Filter	4 casings each with 10 compartments and 5 in series	2 casings each with 6 compartments and 3 in series
2	Design Emission		23 mg/Nm3	30 mg/Nm3
3	Foot print area of BF		Less by 63 %	Less by 40 %
4	Pressure drop across BF		More by 130 mmWc	More by 130 mmWc
5	Total Weight of BF		Less by 65 %	Less by 50 %
6	No of Ash collection points hoppers in BF		Less by 56 %	Less by 50 %
7	Ash collection pattern in BF		Equal among all hoppers:- 2.5 % each hopper	Equal among all hoppers:- 8.33 % each hopper
8	Continuous power consumption of BF (without ID fan power)		Less by 45 %	Less by 11.8 %
9	ID fan power - continuous consumption in case of BF		More by 60 %	More by 55 %
11	Supply Cost of BF		Less by 33 %	Almost same cost
12	Method adopted for comparison	ESP	Actual - executed contract	Estimation
		Bag Filter	Estimation	Actual - executed contract
13	Apart from the above, bags are to be replaced once in 2 / 3 years on regular basis			

Table-2: Comparison of general economy of Bag Filter against ESP

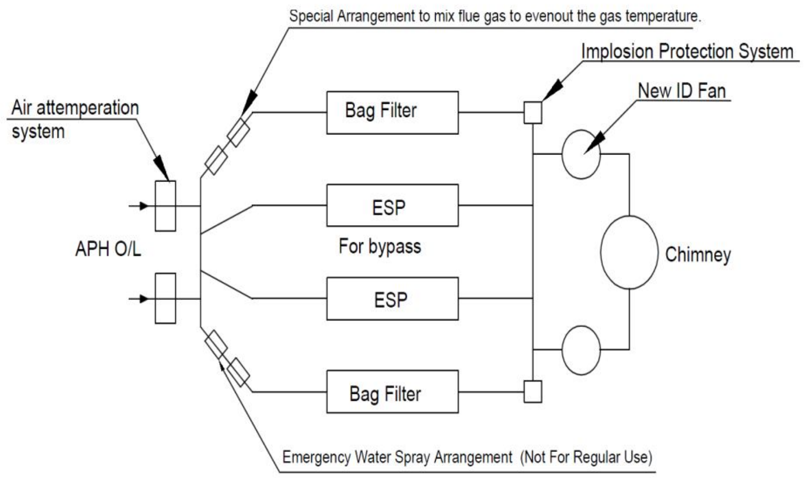

Figure-1 Arrangement of Bag filter retrofit in old ESP casing of a 210 MW boiler

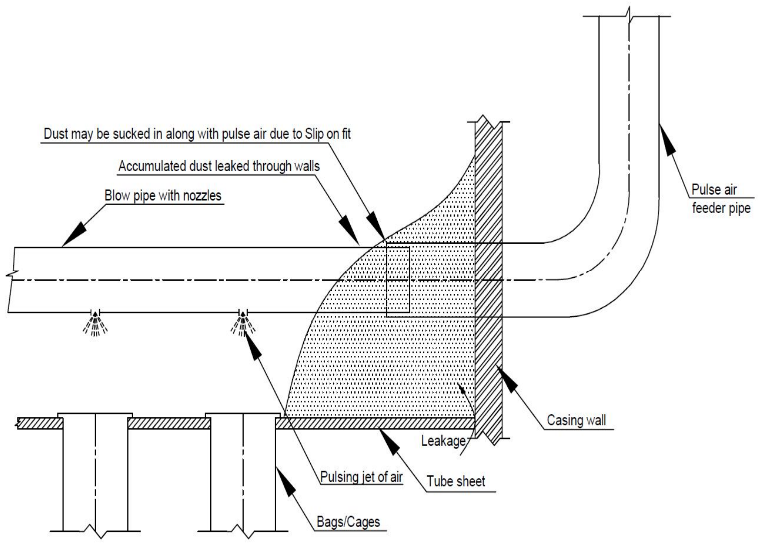

Figure-2 : Leaked dust into clean gas chamber -may cause bag damage

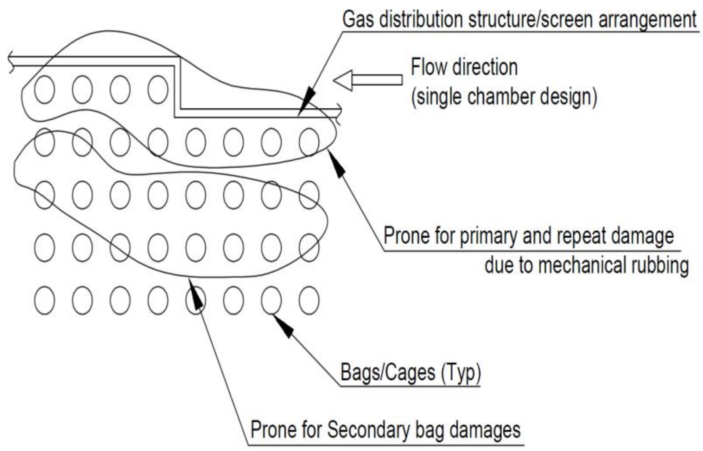

Figure-3 Bag damage (primary & secondary) due to Mechanical rubbing

Figure-4
Measured Flue gas temperature - grid reading (DegC)
after air-attemperation with
gas mixer arrangement at Bag filter inlet duct.

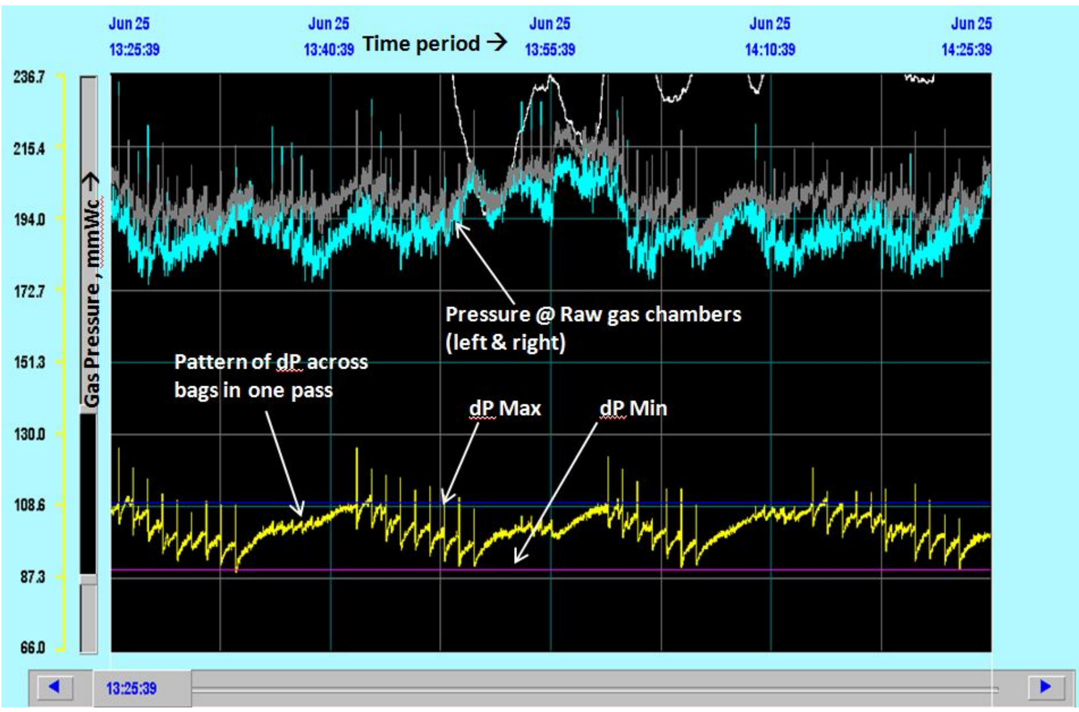

Figure-5
Pattern of dP (in mmWc) - during pulsing cycle