ICESP XIII, September 2013, Bangalore, India

Renovation and Modernization of Pollution Control Equipment to meet the challenges of high resistivity fly ash in Indian Thermal Power plants

G. Gunasekar gunasekar@bhelrpt.co.in
D. Visuvasam dvisuvasam@bhelrpt.co.in
M. Ravichandran mravi@bhelrpt.co.in

Engineering Development Centre
Bharat Heavy Electricals Ltd
Ranipet - 632 406
Tamil Nadu, India

Abstract

Electrical thermal power in India is produced mainly from fossil fuel fired boilers. During the initial phase of power development, coal with high calorific value and low ash content was available abundantly and emission was not a factor to be taken seriously. Over a period of time, quality of coal available for power plants got deteriorated. In addition, the emission has become very critical due to the fact that Central Pollution Control Board started issuing stricter norms. This has compelled the authorities to revisit the existing precipitators performance.

The coal ash produced in thermal power plants are low sodium/potassium, low flue gas moisture with high inert content - all leading to high fly ash resistivity. Any attempt to improve the performance had to be looked into these factors as well. The extent of emission reduction required goes with number of years of boiler working, present operating condition and the pollution norms. This necessitated plant owners to go in for ESP renovation.

In this paper, the authors describe the need for precipitator retrofit, approaches followed, various methods of renovation in Indian context and also made a case study as how the renovation of a precipitator installation in an Indian power plant (Plan X) was meticulously evolved and executed.

1.0 Introduction

The Renovation and Modernization (R&M) of pollution control equipments have become a focus point in India. The first phase installations of older plants, capacities less than 200 MW were commissioned well before 1980 with mechanical dust collectors. Most of these plants were already retrofitted with Precipitators.

Now, the plants that were commissioned after 80's and of capacities 200MW and above are due for renovation & modernization. R &M is aimed at to mitigate the pollution level so that the plants are operated to their fullest capacity.

Further, there are felt needs as advocated by latest technology in enhancing capacity of existing plants under program called LEEP (Life extension of existing plants) through retrofit & modernization.

Today, ash content in coal is high, there is a demand for emission reduction, equipments are older and above all the resistivity of Indian fly ash is high - all these needs better technology along with expertise in handling such type of ashes and preparing layouts to suit Indian condition.

2.0 Need for Precipitator Retrofit

In India, there is a wide supply demand gap on the electricity and industry need huge investment. Cost economics show that renovation of boiler or up-rating of boiler is a good option as compared to installing new plants and therefore planners in India is attaching high priority to this area. Further, Central Pollution Control Board (CPCB) and the State Pollution Control Boards (PCBs) have made the emission norms stringent. All these converge to the point of revisiting the existing precipitator installations.

Major attributes for precipitator R&M include:

- Deteriorating coal characteristics (ash content, 45% as compared to the original design of 25 to 30 %)
- Higher original design emission, more than 250 mg/Nm^3
- Ageing of boiler (over 25 to 30 years of operation)
- Boiler up-rating utilising the latest improved technologies (200 to 215/225 MW, 110 to 120 MW)
- Introduction of better contemporary design and technology of ESP components .
- Present stringent pollution norms

3.0 Precipitator - Renovation & Modernization approaches

Renovation and Modernization of Precipitator installations becomes site specific, considering the design, operating conditions, range of fly ash resistivity and feasibility of up-rating the boiler, space constraints etc.

The steps to be followed shall include:

- Finalization of Coal characteristics, outlet emission and specification requirements.

- Conduct of Performance Evaluation Test (PET) to assess the present operating parameters.
- Calculating the predicted parameters in case of boiler up-rating.
- Study of layout constraints like space, ID fan connection, APH connection, etc.
- Evaluating the operation and reserve capacity of existing ID fans.
- Assessing the ID system pressure drop requirement.
- Study of the Interface engineering issues.
- Assess the minimum boiler shut down time for implementation.
- Study the feasibility of using old civil foundations
- Ensuring Flow distribution among ESP passes and inside ESPs.
- Ensuring easy approach for maintenance of the equipments.

4.0 Methods of Precipitator Renovation and Modernization.

Before firming up the method, one has to review the resistivity of the fly ash as this is one of the main factors which decide the method of renovation. It is a function of gas temperature, gas moisture, fly ash characteristics, gas properties, coal sulfur etc. The typical Indian coal fly ash has a resistivity in the range of 10^{12}-10^{14} Ohm-cm which is the highest in the world.

The various methods implemented in Indian power plants while renovating the existing Precipitators are grouped in the following manner.

1. Modifying existing Precipitators to replace the internal with latest deign.
2. Enlarge existing Precipitators to add fields of taller electrodes of latest design.
3. Modification of electronic controllers (of intermittent charging i.e. controller up gradation).
4. Installation of additional Precipitators in parallel.
5. Adding new Precipitators in series.
6. Replacement of existing Precipitators with new Precipitators.
7. Conversion of Precipitators into bag filter.
8. Flue gas conditioning.

The methods listed above have their own merits and de-merits. The choice depends on the extent of variation in the inlet parameters, required emission reduction and the availability of space.

5.0 Case Study: Precipitator Retrofit Programs at Plant X units 3 & 4 (2X110MW)

5.1 Installation

This case study describes the methodology followed for retrofit and modernization of precipitators for Plant X Units 3 & 4 and various steps involved in the process.

Plant X consists of four units of 110MW each and these were supplied and commissioned by BHEL in 1974-75 (units 1&2) and 1978-79 (units 3&4) - the boilers envisaged with mechanical dust collectors followed by ESPs of old design. The initial design emission value was 1050 mg/Nm3.

The renovation work is unique in the sense that the retrofit is being carried out two times

- Original design : 1974 : MP + ESP
- First R & M : ESP 1982
- Second R & M : ESP 2005

The original configuration and the two retrofits are schematically shown in **Figure-1.**

5.2 First Retrofit

During 1984's the CPCB have issued pollution norms, refer **Table-1,** which specifies a emission value of 350 mg/Nm^3 for plants of capacity less than 200MW. The first retrofit program at Plant X was aimed at mainly to achieve the emission target of 350mg/Nm^3. Pre-design test conducted, design parameters finalized, available floor space was mapped in consultation with plant authorities.

Based on the space availability, the configuration and feasible size of precipitators augmentation was evolved. The details are presented here:

- **Unit-3**: Two numbers of Precipitators each with 5 fields in series and two bus sections perpendicular to gas flow to meet 200 mg/Nm^3.
- **Unit 4**: One number of Precipitator with five fields in series with two bus section perpendicular to gas flow to meet 300 mg/Nm^3.

The new precipitators were located behind chimney in series with existing old precipitator and existing ID fans. The additional pressure drop arising out of the longer duct length was compensated by removing the mechanical collectors. Performance guarantee test conducted during 1986-87 showed that the values were within the design values.

5.3 Second Retrofit

During 2005, customer desired to uprate the boiler and also to improve the performance of the precipitators to meet revised emission norms of 100 mg/Nm3. This was necessitated due to

- Low boiler PLF
- Increase the boiler output
- Poor coal quality
- Need to reduce emission

A detailed analysis was carried on boiler and precipitator to assess their performance level for initiating an overall R&M project. Order placed by customer in the year 2006 with a commissioning schedule of supply completion 20 months.

The major changes initiated in the process on the precipitator system were:

- Dismantling the old precipitator
- Installation of new additional Precipitator in series with the precipitator renovated during first retrofit phase.
- Changing the ID system.
- Erecting and commissioning the system during boiler R&M/up-rating period.

The layout conceived for these two projects are presented in the Figures 2 & 3. The scheme of the retrofit is presented in figure 1.

5.4 Design parameters at different stages

The review and finalization of design parameters for precipitator retrofit is very critical considering the present and future need. Table -2 & 3 shows the parameters considered for selection of precipitators and the fuel properties over a period of time. The present parameter is derived based on boiler uprating program.

5.5 Scope of work in the second retrofit

The broad scope of work consist of

- Removal of the old precipitators.
- Dismantling of internals of the existing Precipitators added in phase-I retrofit except the supporting structure, casing, casing structure, hoppers.
- Installing new internals in the existing ESP casing viz. 750mm Collecting electrode, spiral type of emitting electrode and tumbling hammer type rappers for CE, EE and inlet Gas distribution screen.
- Installation two new Precipitators.
- New electrical system for the revamped precipitator and the new precipitator.
- Microprocessor based controller of latest art of technology.
- Remote monitoring of the system through MMI
- Physical flow model study to ensure proper flow distribution
- Supply and installation of new set of ID fans along with drives.
- Supply of complete ducting including gates and dampers.
- Providing all the inputs for civil design
- Conduct performance test at site to prove the emission, efficiency, power consumption
- Table 4 & 5 shows the equipments data respectively for ESP and ID fans

Unit 3 has been commissioned along with the renovated boiler and it is running since September 2012 within design emission value.

6.0 Layout constraints

The major concern was to locate the additional collection area in the available space surrounded by Chimney & Ash slurry pump-house on one side and compressor house & coal conveyors on another side. All these limitations forced us to install separate precipitators at different locations viz. between boiler & Chimney and behind the Chimney with connecting ducts in series with new ID fans.

7.0 Conclusion

The authors have explained their experience in evolving a precipitator retrofit in one particular project.

A fitting retrofit solution viz. arriving at proper design parameters considering the fact that the boiler system has served its life time, meticulously freezing the layout within the space available/constraints executed with proper planning with the backup of a reliable solution provider having rich expertise in the precipitator renovation has yielded the best desired result.

Acknowledgement

The authors wish to thank the management of Bharat Heavy Electrical limited for granting permission to present this paper.

Reference

1. ***K.R.Parker**: Applied Electrostatic Precipitator, Blackie Academic& professional 1997*

2. ***D. Visuvasam Dr. S.Sekar, K.Mariraj Anand:** Retrofitting Pollution Control Equipment in Indian Power plants and other Industries to meet the present more stringent Norms - IXth ICESP held at South Africa May 2004.*

3. ***D.Visuvasam, P.Selavaraj, Dr.S.Sekar**: Influence of coal properties on Particulate emission control in thermal Power plants in India Second International Conference Held at Italy in May 2005*

4.BHEL Documents on retrofitting of Precipitators in Indian Power plants

	Boiler Size	**Protected Area**	**Other Area**	
CPCB'S SPM Emission Regulation – July 1984			OLD (BEFORE 1979)	NEW (AFTER 1979)
	< 210 MW	150 mg/Nm^3	600 mg/Nm^3	350 mg/Nm^3
	> 210 MW	150 mg/Nm^3	--	150 mg/Nm^3
Subsequent Notification of MoEF	Date of Notification		SPM level mg/Nm3	
	19 05 1993		150	
	28 03 2003		100	

Table -1 - Pollution norms Guidelines in India

	Description		**Design Parameters**			
			Original design	**First Retrofit**	**Second Retrofit (#3 ret completed & #4 under progress)**	
			Units 3/4	**Units 3/4**	**Units 3/4**	
					TMCR-DC	**BMCR-WC**
1.	Gas flow rate to ESP	m^3/s	163	200	163	189
2.	Gas temperature to ESP	Deg C	145	145	140	150
3.	Dust concentration to ESP	gm/Nm^3	35	39	52	77
4.	Required ESP outlet emission,	mg/Nm^3	1050	#3 : 200 #4 : 300	90	90
5.	Required collection efficiency,	%	97.0	# 3 : 99.49 # 4 : 99.23	99.83	99.88

Table-2: Precipitator design parameters of Plant X(Original & Retrofits).

Sl No	**Parameters**	**Unit**	**Values**	
			Performance coal	**Worst coal**
1	**Proximate analysis**			
	Fixed carbon	%	32.77	27.38
	Volatile matter	%	21.94	18.0
	Moisture	%	7.56	10.00
	Ash	%	37.73	44.62
	Total	%	100	100
	HHV	Kcal/Kg	4351	3600
2	**Ultimate analysis**			
	Carbon	%	44.13	36.55
	Hydrogen	%	3.07	2.54
	Sulphur	%	0.35	0.35
	Nitrogen	%	0.82	0.68

Table 3 - Fuel Properties

Sl. No.	Description	Units	Design Parameters			
			First Retrofit *		Second Retrofit	
			Units 3	Units 4	Units 3	Units 4
1.	No ESP passes	No	2	2	2	2
	No of fields in series	No	5	5	5 / 2	5 / 2
2.	No of bus section per ESP	No	2	1	2	1 / 2
3.	Total no Fields	No	20	10	28	18
4.	Field length	m	3.6	3.2	3.75/4.5	3.0/4.5
5.	Field height	m	12.5	12.5	12.5/15	15/15
6	Electrode Pitch	mm	300	300	300/400	400/400
7	TR set rating	kV/ mA			Old: 70/800 New: 95/1200	Old: 95/600 New: 95/1200
8	Collecting electrode		G Profile		G Profile	
9	Emitting Electrode		Spiral		Spiral	
10	Rapping System		Tumbling hammer		Tumbling hammer	
11	Controllers		Intermittent charging		Intermittent charging	

*** Old ESP retained** **Table-4: Precipitator data.**

Sl No	Description	Units	Design Parameters			
			First Retrofit		Second Retrofit	
			Units 3	Units 4	Units 3	Units 4
			Old ESP is retained			
1.	No of fans	No	2	2	2	2
	Gas flow	m^3/sec	123	123	107	107
2.	Gas temperature	Deg C	145	145	150	150
3.	Type of fans		Axial	Axial	Radial	Radial
4	Fans control		IGV	IGV	Hydraulic coupling	
5	Motor rating	kW	1000	1000	700	700

Table-5: Fans data.

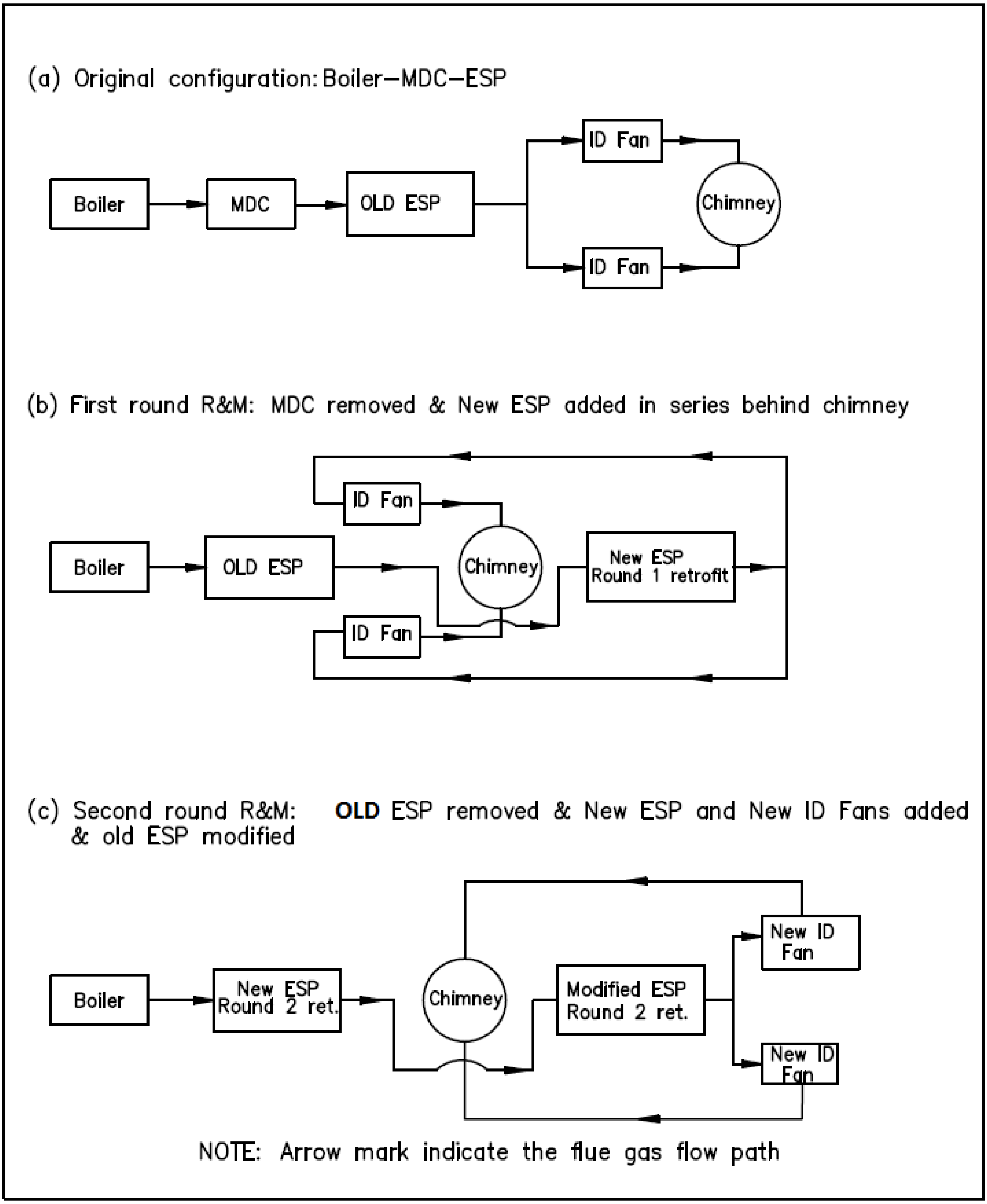

Figure-1
Schemes of ESP retrofit carried out at Plant X Units 3 &4.

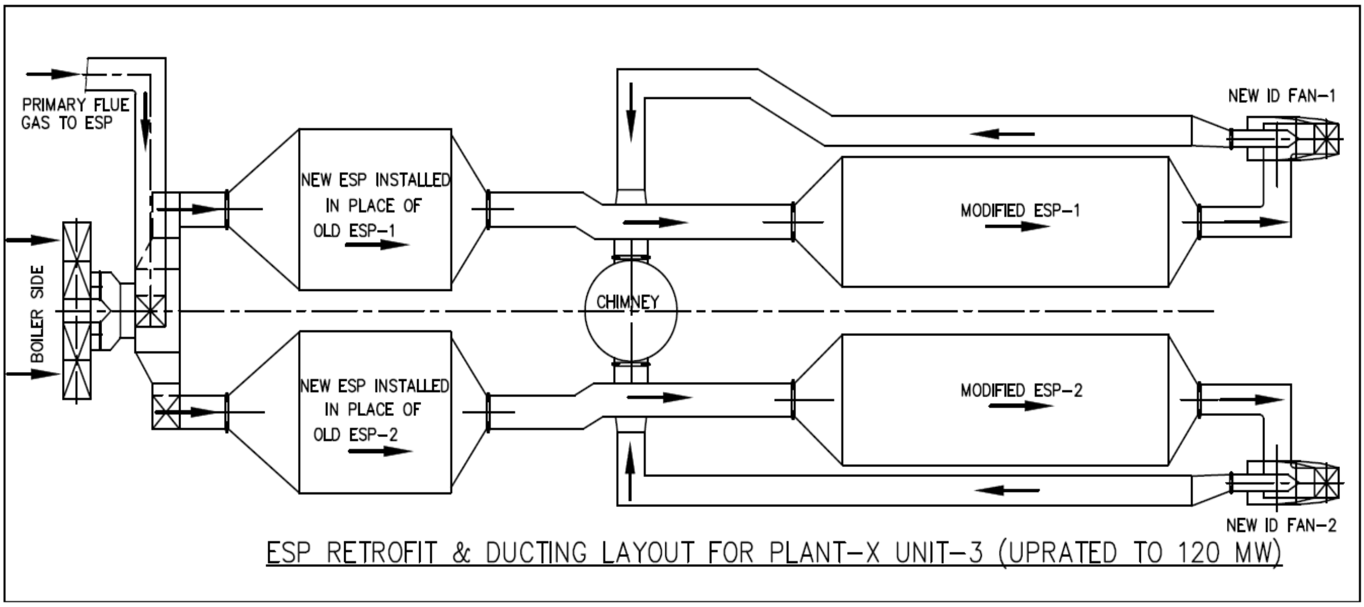

Figure-2: Layout of Round 2
Retrofit of ESP in unit 3

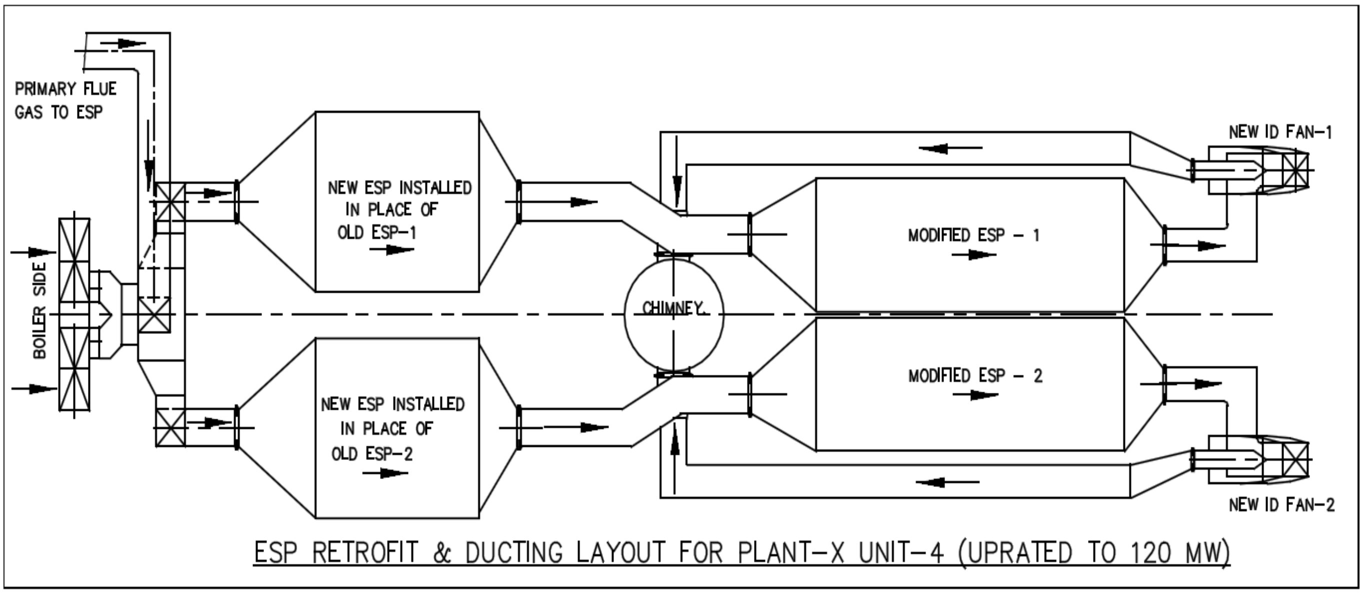

Figure -3: Layout of Round 2
Retrofit of ESP in unit 4