# RETROFITTING POLLUTION CONTROL EQUIPMENT IN INDIAN POWER PLANTS and OTHER INDUSTRIES TO MEET THE PRESENT MORE STRINGENT NORMS

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## Abstract

Electrical energy produced in any country is one of the measures of the development taking place in that country. The energy produced is mainly based on the resources available such as water flow, coal, oil, gas, nuclear fuels etc. The richness of coal in India prompted the Power Plant Planners to install Thermal Power Stations. During the pre-independence and post independence era in early 50s, the need was to generate power and hence much attention was not paid to the Pollution aspect and this continued upto late 70s. The awareness created on the Pollution effect on the Society and the enormous amount of erosion subjected to the equipment forced the authorities to make the pollution norms more stringent. This compelling norms which came into existence in 80s necessitated the Power Plant Personnel to change the Pollution Control equipment in the existing Power Plants installed during early days. India can ill- afford to replace all the ESPs with the new ones.

To renovate the existing pollution control equipment, following methods are being practiced

- Filling the dummy fields (Casing without internals were installed at the initial stage)
- Introducing intermittent charging
- Adding series fields to the existing ESPs
- Adding Series ESPs in a place available very close to the boiler
- Placing one more ESP parallel to the existing ESP
- Replacing the internals and adding new internals by increasing the casing height
- Introducing New ESPs in the existing space.
- Introducing bag filter in the existing ESP casings

The above approaches have been implemented and operating in India for more than 100 installations which include applications like Coal fired boilers, FBC boilers, stoker fired boilers, recovery boilers, cement plants (kiln, clinker cooler, coal mill) etc.

Each case is unique in nature and to be evolved with due consideration to many in-situ factors

Since the pollution norms are becoming stringent in many other parts of the world, e.g. South Asian Countries, the above methods of retrofit would be useful to enhance the pollution control equipment.

This Paper deals with the need for retrofitting, the various options available, the constraints being faced normally, selection criteria for the particular option, the benefits accrued, the response of users with case studies.

## Introduction

The society felt the ill-effects of pollution and therefore the authorities had to tighten the particulate emission within limit. The pollution control legislation keeps on changing continually with the availability of technology and resource. A need has arisen to bring up the old pollution control equipment to the latest level and the concept retrofitting evolved. The retrofitting concept have revolutionized from the simple PART to PART replacement to renovation, refurbishment, enhancement, upgradation, life extension, total replacement and incorporation of latest art of energisation. The users, consultants and manufactures of precipitators applied their mind together to arrive at suitable site-specific solutions. The different solutions and the implementation part of it in Indian context is analyzed each with a case study.

## Pollution Control Legislation in India

The majority of power plants in India ranging from few MW to 500 MW are of pulverized fuel fired boilers utilizing low calorific, low coal sulphur, high ash content sub- bituminous coal except the plants at NEYVELI and KUTCH, which are lignite fired.

Precipitators had been and continue to be the main pollution control equipment in power plants. The design and use of precipitators in India have undergone tremendous change over the years as a result availability of good technology, expertise acquired and stringent environmental norms.

Precipitators were installed during the early days of industrialization with an aim of “good neighbor approach”. This trend continued till “Central Board for the Prevention and Control of Water Pollution” has issued an Emission Regulations in July 1984 based on the directive of Air (Prevention and Control of pollution) Act, 1981 enacted by the Government of India. This regulation specified the particulate emission from thermal power plants in the following manner:

| **Boiler size** | **Protected area** | **other area** | |
|---|---|---|---|
| | | **Old (Before 1979)** | **New (After 1979)** |
| Less than 210 MW | 150 mg/ $Nm^3$ | 600 mg / $Nm^3$ | 350 mg / $Nm^3$ |
| 200 MW and above | 150 mg/ $Nm^3$ | - | 150 mg/ $Nm^3$ |

A protected area is one that it already polluted from being a metropolitan/industrial location or the area is sensitive because of its proximity to the national parks, forests, historical monuments and health resorts

The legislation also permitted individual State Pollution Control Boards to make emission more stringent than those given above, depending on the location of the plant, especially if it is protected area.

The Ministry of Environment and Forest Notification in May 1993 revised the particulate emission to 150 mg/ Nm3 and later in March 2003, advised the Central Electricity Authority to

- Examine the possibility to reduce the particulate matter emission to 100 mg/ $Nm^3$ in the existing thermal power plants and submit the report by March 2004.
- Accord clearance to new power projects coming up on or after April 2004 with particulate emission level of 100mg/ $Nm^3$.

This means the norms after April 2004, is expected to be 100mg/$Nm^3$ in thermal Power plants.

Though the Pollution Control Board specifies the norms, wherever the new power projects are funded by external agencies, the plant owners are installing the precipitators with design emission level in the range of 20 –50 mg/$Nm^3$ keeping the future uncertainties.

## Need for retrofitting

Precipitator is a static, effective dust-capturing device. After a passage of time, the emission is more than what it is supposed to emit or warrant emitting less. It is acknowledged that the reasons could be one or multiples of the factors outlined below:

1. Change in environmental legislation.
2. Change in fuel properties.
   - Poor quality of fuel, alteration of fuel.
3. Change in boiler behavior.
   - Deterioration of boiler performance, use of multifuel firing, conversion of firing typeand change in the plant rating.
4. Precipitators.
   - Inadequate design of existing precipitators, poor electrical and mechanical condition like improper gas distribution/re-entertainment, unstable operating conditions of precipitator, plant beyond serviceable conditions, lack of process knowledge, low quality equipment, poorly erected and commissioned equipment and ineffective maintenance.

## Methods of retrofitting

### Rehabilitation of mechanical and electrical system.

- Filling of dummy fields.
- Introducing intermittent charging.
- Installing improved collecting electrodes or discharge electrodes or rapping system to the latest version.

### Supplementing of SCA.

- Adding series fields.
- Adding series precipitators.
- Adding parallel precipitators.
- Replacing precipitators internal with new internals.
- Rebuilding new precipitators.

### Conversion of Precipitators into bag filter.

### Flue gas conditioning.

Selection of a particular method is guided by precipitator theory, technical feasibility, practical field experience, inherent limitation of the equipment based on inspection, results of previous studies and findings, discussion with experts, history card of the plant, ageing of the plant, technical advancements in this field. outage requirements, aesthetic appearance and availability of funds.

## Rehabilitation of mechanical and electrical system

### Filling of dummy field

A number of earlier precipitator installations have been provided with an added feature of dummy field either at inlet or at outlet of it. This was included, to increase the collection area at a later date in case of need.

During later stages, these empty sections were filled with active components to provide additional collection area.

The major active components incorporated in the this type of work:

- Complete collecting system including collecting electrodes, discharge system including discharge electrodes, the rapping system, the electrical system, thermal insulation and other steel materials required for covering.

This task can be effected precipitator -wise so that plant can run under normal load without plant shutdown, however with slight increase in particulate emission at the time of installation.

Plants at Tuticorin 1&2 (2 x 210 MW), Kothagudam 7&8 ( 2 x 110 MW ), Koradi 5( 1 x 200 MW), Bhusawal 2 ( 1 x 210 MW), Parli 3 ( 1 x 210 MW ), Nasik 3,4&,5 ( 3 x 210 MW) Ramagundam1,2&3 (3 x 200MW ), Singrauli 1-5 ( 5 x 200 MW) , Ukai 3 & 4 (2 x 210 MW ) and Satpura 7 ( 1 x 210 MW ) were installed with dummy fields

Anticipating the futuristic tough legislation, many plant owners for the green field application, today specify the present emission with one field out of service condition per pass. This means, there will always be one extra live field available and this may meet the future emission norms.

### Introducing Intermittent Charging

The precipitators installed in the early days were energized with full wave Transformer –Rectifier sets. Most of the power supplies are provided with automatic spark limit control, which uses SCR phase control to limit the power input to precipitators to the point of sparking. This has been working well for the low resistivity dusts whereas there was a deficiency in the performance for high resistivity dusts due to back corona. Increasing the power input beyond the onset of back corona, not only wastes power but also degrades the precipitator emission.

The insulating compounds in the fly ash viz $SiO_2$ and $Al_2O_3$ amount to as high as 90 % whereas the conductive compounds in fly ash viz $Na_2O$, $K_2O$, $SO_3$, $H_2O$ are very less and therefore the ash resistivity is in the order of $10^{13}$ ohm-cm. Severe back corona in these installations impair the performance. This problem could be solved either by reducing the resistivity or limiting the current though dust layer.

Limiting the current through dust layer can be done through introducing the intermittent charging device. Intermittent charging controllers were installed in many old power plants to improve the emission level.

The intermittent charging technique blocks certain cycles and allows current flow for a few cycles to achieve the current limit. The aim is to produce high peak voltages and currents for a short time, while maintaining low average current through the dust layer below the onset of back corona. The ratio of ON cycle to ON+ OFF cycle is the charge ratio.

Due to frequent changes in ash properties, gas properties and gas temperature, it is difficult to get an optimum charge ratio and manual selection is very tedious. The intermittent charging system is programmed to automatically seek the optimized operating point at intervals. The automatic optimization process adjusts the charge ratio to eliminate back-corona. The controller also supplies additional base charge current to maintain the corona onset voltage.

Eliminating the back corona power by reducing the dust layer current improved precipitator collection performance and reduced power consumption. The promising results shown in **TABLE –1** proves this point. Intermittent charging reduces the dust layer current while increasing the peak voltage values resulted in substantially better performance than was obtained with the conventional waveform.

The inbuilt diagnostic feature such as peak and valley voltage measurement available in the controller gives an useful diagnostic feature for precipitator maintenance.

### Installing improved collecting electrodes or discharge electrode or rapping system

This is implemented in Kothagudam Unit 4 and is presented under the caption " adding parallel precipitators, Kothagudam 1,4 (2x 60 MW)".

## Supplementing SCA

### Adding series field

This is implemented in Talcher 4 x 62.5 MW and is presented under the caption "Replacing the precipitator internals with new internals, Talcher 1-4 4x 62.5 MW."

### Adding series precipitators, Kothagudam -7 &8, 2 x 110MW

Andhra Pradesh Power Generating Company (APGENCO) had installed 2 nos.110 MW power plant along with multi-cyclone separators and precipitators in series as pollution control equipment supplied by M/s. BHEL in 1977-78 at Kothagudem. These were designed for a set parameters of gas volume 195 $m^3$/sec, gas temperature 161° C, inlet dust concentration 50 gm/$Nm^3$, outlet emission of 390 mg/$Nm^3$ and collection efficiency of 99.22 %.

Considering the poor quality of coal and ageing of boiler, APGENCO have taken up a modernization program of the boiler plant including precipitator. The shutdown period was the essence of this project and the precipitator renovation program consisted of:

- Replacement of unserviceable components and servicing other components.
- Placing series precipitator to increase the collection area.
- Removal of cyclone separators.

The work was executed in the following manner to limit the outage time to bare minimum.

- Connection of a by- pass duct from the outlet of existing precipitator to ID fan availing a short shutdown after dismantling the mechanical dust collector.
- Modification of the existing precipitator outlet funnel and duct for proper connection to inlet of the new series precipitator.
- Installation of new precipitators above the ID fans.
- Provision of RCC platform below precipitator to avoid any possible spill- over of ash over ID fans.
- Provision of complete PC based control system for the old as well as new precipitator including intermittent charging controller, microprocessor based rapper controller.

- Installation of ash handling system and integrating it with the existing system.
- Dismantling of the ductwork including existing cyclone separators.
- Complete design and execution of civil work.
- Erection and commissioning of all the supplies.
- Proving the performance.

**TABLE-2** shows the combined ESP performance data.

The success of this project is attributable to the project team that cleared all the interfering ID fan handling arrangements, its foundations, all the over-ground/ under-ground facilities, nearby building and executing it within the limited outage time. This is done to achieve the emission level of 115 mg/Nm$^3$ in line with the Andhra Pradesh state Pollution Control Board norms.

### Adding Parallel precipitators,Kothagudam - 1&4, 2 x 60 MW

Andhra Pradesh Power Generating Company had four more installation of capacity 60 MW each supplied by M/s. Hitachi/Japan along with multi-cyclone separators in 1966-67 at Kothagudem. These cyclone separators were later replaced with precipitators in 1988-1989 with design parameters of gas volume of 105.6 m$^3$/sec, gas temperature of 150 °C, inlet dust concentration of 108.74 gm/ Nm$^3$, outlet emission of 400 mg/Nm$^3$ and collection efficiency of 99.63 %

- Unit –1: A three-field precipitator of BHEL make each served by one 70kV/1200 mA set.
- Unit –4: A four field precipitator of APHMEL, the licensee of Environmental Elemental Corporation/ USA, each field was served by 90kV/500 mA for fields 1,2 and 90 KV/750mA for fields 3, 4.

The emission from these plants was around 800mg/ Nm$^3$. Hence the precipitator had to be upgraded to limit the emission. APGENCO have decided to refurbish the existing precipitators and add a parallel precipitator. They imposed a tall penalty to the bidders to the tune of 4.02 Million INR (91000 USD) for every increase in emission of 16mg/Nm$^3$ to a maximum of 115 mg/Nm$^3$ and beyond that rejection of precipitator.

The precipitator designer and the project executor had meticulously done the following to achieve emission of 50 mg/Nm$^3$ and the design data considered for is presented in **TABLE –3**.

- Replacement of complete internals of modular roll formed mechanically interlocked collecting electrode into G profiled huck bolted collecting electrode, the Rigitrode type discharge electrodes to spiral type discharge electrodes, mechanical rotating type rapping system into tumbling hammer type rapping for UNIT- 4.
- Servicing, replacement of unserviceable components into new ones for UNIT-1 precipitator
- Installation of new parallel precipitator internals, steel works, thermal insulation, electrical.
- Providing complete PC based control system for the old as well as new precipitator including intermittent charging controller, microprocessor based rapping controller.
- Interconnection of new precipitator to the existing precipitator including the ductwork and supports.
- Supply of ash handling and integrating it with the existing system.
- Providing electrically operated gas tight guillotine gate at the inlet and outlet of new precipitator.
- Ensuring proper distribution of gas flow between existing and new precipitators.
- Conduct of flow model study.
- Ensuring that the ID fan takes care of two-precipitator operation.
- Dismantling of the ductwork, erection and commissioning of all the supplies.
- Laying the inlet duct of new precipitators of UNIT-1 over the existing control room and taking RCC supports from Control room.
- Complete design and execution of civil work.
- Proving the performance.

The precipitator was erected independently, hooked up with the main stream and commissioned within 10 days of the boiler shut down. The existing precipitator refurbishment work was taken up allowing the boiler

to work through the new precipitator. The performance of the new precipitator without existing precipitator in service was reported to be very good.

### Replacing precipitator internals with new internals, Talcher 1-4 , 4 x 62.5 MW

4x 62.5 MW Thermal Power station at Talcher was supplied by M/s. Babcock Wilcox/USA along with cyclone separators to M/s. Orissa State Electricity Board in 1967-69.The cyclone separators were later replaced with 2 nos. each having 5 fields with the field dimension of 3.413 x 6.0 x 12.90m(length x width x height). This was designed by M/s. Voltas Limited, the license of M/s. Research Cottrell/USA in 1988-89 for gas volume of 120 $m^3$/sec, gas temperature of 140 °C, inlet dust concentration of 50-76 gm/ $Nm^3$ for an outlet emission of 250- 380 mg/ $Nm^3$ with the TR set rating of 78Kv/800mA.

The plant was taken over by the Government owned power producing company, M/s. NTPC in 1995.The particulate emission then was 800 – 1000 mg/ $Nm^3$. In order to meet the pollution norms, M/s. NTPC have embarked upon to replace/retrofit/service the various equipment.

This being the second renovation for this project, a tight specification was drawn for the augmentation of precipitator with the aim of extending the service life by another 25 years.

| Parameters | Guaranteed values | Penalty |
|---|---|---|
| Collection efficiency | 99.85 % | 3.4.69 Million INR ( 77100US$ ) for drop in every 0.05 % in test efficiency. |
| Pressure drop across precipitator | 12 mmWC | 0.265 Million INR (5900 US $ ) for increase in every 1 mm WC. |
| Air in leakage | 1.20 $m^3$/sec | 0.588 Million INR (13070 US $ )for every 1 $m^3$/sec increase of air in leakage. |
| Corona Power consumption | Bidder to declare | 0.125 Million INR (2781 US $) for every KW increase. |

The scope included design, engineering meeting the design data presented in **TABLE –4** and **TABLE –5**, manufacture, supply, erect, commission and prove the performance which broadly covered:

- Addition of two series fields at the rear end of the precipitator after removing the existing outlet funnel and duct.
- Replacement all the existing internals including electrical systems.
- Replacement of thermal insulation
- Utilizing the existing casing, support structures, hoppers, platforms based on the condition assessment report.
- Relocating the existing casing doors.
- Increasing the existing casing height to accommodate the higher collecting electrode height.
- Increase of field length and height.
- Supply of new GD screens at the inlet and outlet.
- Supply of new TR sets along with latest PC based integrated operating control system and opacity monitors.
- The ash hoppers are arranged in such a way that the ash collected from the three fields formed in the existing casing are collected by the existing 5 hoppers.
- Providing Vacuum type ash handling system for the new hopper and integrating it with the existing ones.
- Extension of the existing TR set handling system.
- Providing stainless steel lining at the bottom of all ash hoppers.
- Complete civil work.
- Proving the performance.

The complete analysis of existing precipitator with reference to reusage of the components, adequacy of load carrying capacity of bearings and civil foundation, casing structure- the perfect coordination among all disciplines of engineering enabled the commissioning of the precipitators successfully.

### Rebuilding new Precipitators, Nasik - 3 ,1 x 210 MW

Nasik 3,1 x 210 MW along with precipitator was commissioned in 1980 with the coal calorific value of 4700- 5000 K.Cal /kg and the ash content of 25-28 %. In 1998 there was a fire accident in the precipitator casing. After temporary repair of the structure and replacing the electrodes partially, the precipitator was put into service, ultimately running at low efficiency.

The coal received at the plant now has the calorific value of 3299 KCal/kg and the ash content of 47 %. resulting in higher ash production.

Maharastra State Electricity Board conducted a detailed study to arrive at an augmentation program, which should last for 25 years taking into account **1.** poor quality of coal **2**.present higher emission and stringent pollution control norms **3**.existing precipitators was partially damaged and repaired and put into operation with low efficiency **4.** retaining the existing ID fans, motors and controls **5**.minimum shutdown period of 52 weeks**.6.**Constraints for the additional precipitator fields and **7**.erection feasibility,

The outcome of the study was to dismantle the entire precipitator including ash handling system, electrical, inlet and outlet duct work, the civil foundations, underground/over ground obstructions and installing 4 nos. new larger precipitator complete with latest art of PC based controls and electrical.

The work was assigned for complete engineering, design, manufacture, supply erection, commission and prove the performance and handover the plant with the design data as per **TABLE–6**.Four nos.400 mm pitch, 15m taller collecting electrode precipitators were installed,

This project encompasses three concepts of retrofitting viz **1.** use of wide pitch **2**. use of taller collecting electrode **3**. total replacement. The precipitator was commissioned and tested. There was remarkable improvement in the emission; the measured value is 57 mg/Nm$^3$ as against 80 mg/Nm.$^3$

## Conversion of precipitators into bag filter, Koradi- 5, 1 x 200 MW

This concept was first introduced in India by M/s. Maharastra State Electricity Board (MSEB) in their plant at KORADI unit –6, 210 MW.The encouraged results prompted them to repeat similar retrofit in their other plants at KORADI Unit 5, 7 and PARLI Unit 3, all 200/210 MW. MSEB have opted this because of the layout constraints. This concept may gain ground in other utilities in the immediate future.

Koradi unit 5 was put up in 1978 along with the precipitator with coal as fuel having a calorific value of 4700-5000 kCal/kg and ash content of 25 – 28 %. Precipitator installation at this plant consisted of 2 Nos. each with two-pass arrangement and 5 fields in series. This was selected for a set of design parameters of gas flow 371 m$^3$ /sec, gas temperature of 143 °C, inlet dust loading of 24.80 gm/ Nm$^3$ and outlet emission of 248 mg/ Nm$^3$.

Now, the plant receives the coal with calorific value of 3000 K.Cal/kg and ash content of 45 %. The existing precipitator cannot absorb this broad change of coal characteristics and therefore search was made to pick up a solution for an efficient pollution control equipment which can be accommodated within the available space, using maximum existing facilities resulted the present arrangement of conversion into bag filter.

The main requirement of the retrofit program

- Removing all precipitator internals and electrical of outer passes A & D and converting into bag filters.
- Retaining the precipitator passes B & C to work during oil firing and low load operation upto a load of 120 MW i.e. till the gas temperature exceeds the acid dew point temperature.

The scope of work covered:

1. Conditional assessment of the casing, its supporting structure and strengthening it.
2. Assessing the load bearing capacity of the existing civil foundation.
3. Removing the precipitator internals of passes A & D.
4. Increasing the casing height of passes A & D and installation of special type of access doors, special viewing glass.
5. Placing the bag filter component and accessories, which include:
    - Filter bags, galvanized mild steel cage. The major concern is the selection of bags suitable for the ash particle size distribution **(TABLE –7),** the fly ash properties **(TABLE –8)** and the SO2, NO2, moisture and Oxygen, temperature of the flue gas **(T ABLE –9)**.
    - Baffles, division plates/perforated plates and inlet/outlet plenum.
    - Pulse air valve, pulse air supply and air distribution system including compressor, air dryers.

- Gas tight dampers at the inlet and outlet of bag filters for switching over from precipitator to bag filter and vice versa.
- Air attemperation system at the inlet of bag filter to reduce the temperature from 160 °C to 150 °C by atmospheric air dilution.
- Water spray system at the inlet of bag filter duct to reduce the temperature as an emergency protection for bags during temperature excursion.
- Implosion protection system at the outlet duct of the bag filter to save the bags from excessive suction pressure.
- PLC based control system including all electrical.
- Physical flow modeling and CFD modeling.

6. Installing new funnel and duct work at the inlet and modification of the outlet funnel and ductwork upto ID fans.
7. Supplying new ID fans and motors as per **TABLE –10** and to install it in the existing foundation.

## Flue gas conditioning

Injecting conditioning agents of $SO_3$ or $NH_3$ or $SO_3$ /$NH_3$ modify the fly ash properties such as resistivity, agglomeration and cohesistivity. In some plants water is also added in the form of spray, which increases the surface conductivity of the dust. The effect is to improve the precipitation rate parameter thereby reduction in collection area. For effective performance 1.Sufficient treatment time 2.Optimum dosing 3.Even distribution of the reagent are to be ensured.

In a retrofit application, sufficient space may not be available between the air preheater and precipitator hence the system may not perform the way it has to perform. The conditioning process can sometimes adversely get affected by the baffle plates and similar devices placed inside the duct. Frequent maintenance is required. Partial over –conditioning often leads to trouble with the dust conveying system, the quality of the collected dust and also excess opacity. The undesirable aspects outlined above, if addressed properly, the flue gas conditioning is a good preposition in combating the emission

The plants at GNDP Bhatinda 3 &4 - 2 x 210 MW, Ukai 4- 1 x 210 MW, Kolaghat 1 x 210 MW – all these plants were retrofitted with $NH_3$ conditioning system.

NTPC is installing the FGC system in a green field plant at Rihand 3 &4- 2 x 500 MW and Vindhyachal 7- 1 x 500 MW as stand by.

# Conclusion

Precipitator performance is a function of the precipitation rate parameter and specific collection area. In an existing plant the situation demands 1. restoring the precipitator to its original design performance 2. precipitator to perform with very high efficiency than it was designed for. In either case, the precipitation rate parameter or specific collection area have to be enhanced.

Further, it is going to be tough task for the owners of the old plants in India to reduce the emission once the legislation becomes more stringent after April 2004.This paper outlines briefly the various methods available and implementation part of each methods. This will give an insight into the retrofitting arena for the users in India.

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5 BHEL- Documents on retrofitting in Indian Power Plants

**TABLE –1**
**Results from retrofit Intermittent charging Energisiation**

| Project | With CR 1: 1 | | With varying CR 1: 159 | | Reduction in emission in Percentage | Reduction in corona power in KW |
|---|---|---|---|---|---|---|
| | Outlet mg/ $Nm^3$ | Corona power In KW | Outlet mg/ $Nm^3$ | Corona power In KW | | |
| **Plant - A** 500 MW | 353 | 916.4 | 147 | 164.30 | 58.35 | 82.07 |
| **Plant - B** 500 MW | 375 | 1401 | 112 | 171 | 70.13 | 87.79 |
| **Plant -C** 500MW | 395 | 447.80 | 150 | 57.60 | 62.02 | 87.14 |
| **Plant - D** 200 MW | 371.60 | 428 | 145 | 40 | 60.98 | 90.65 |
| **Plant -E** 210MW | 175.70 | 310 | 61.90 | 75 | 64.76 | 75.81 |
| **Results from dummy field filling and intermittent charging** | | | | | | |
| **Plant -F** 210MW | 203.3 | 280 | 50.80 | 120 | 75.01 | 57.14 |
| **Plant-G** 210MW | 200.20 | 280 | 64.10 | 120 | 67.98 | 57.14 |
| **Plant –H** 200 MW) | 277.90 | 250.80 | 88.30 | 52.80 | 68.22 | 78.95 |
| **Plant-I** 200MW | 441.10 | 124.80 | 127.60 | 38.40 | 71.07 | 69.23 |

**TABLE –2**
**Kothagudam- 7 &8, 2 x110 MW - Combined Precipitator performance data**

| **Parameters** | | **Existing ESP +NEW ESP in series** | |
|---|---|---|---|
| **Design data of the precipitator** | | | |
| • Total gas flow | $m^3$/sec | 195 | |
| • Gas temperature | ° C | 150 | |
| • Inlet dust concentration, | gm/N $m^3$ | 85 | |
| • Outlet emission | mg/N $m^3$ | 115 | |
| • Combined collection efficiency | % | 99.865 | |
| **Precipitator details** | | **Existing Precipitator** | **New precipitator** |
| • No. of precipitator | | 1 | 2 |
| • No.of passes per boiler | | 2 | 2 |
| • No Series fields per precipitator | | 4 ( F1- F4) | 2 (F5- F6) |
| • Length of each field | m | 3.60 | 4.50 |
| • Width of each field | m | 11.00 | 11.20 |
| • Height of each field | m | 9.00 | 9.00 |
| • TR set rating | kV/mA | 60/1000 | 80/600 |

### TABLE –3
**Kothagudam- 1 &4, (2 x60 MW), Combined Precipitator performance data**

| Parameters | KTPS - 1 | | KTPS - 4 | |
|---|---|---|---|---|
| | **Existing ESP** | NEW ESP | **Existing ESP** | **New ESP** |
| **Design data of the precipitator** | | | | |
| • Total gas flow, $m^3$/sec | 176 | | 176 | |
| • Gas temperature, ° C | 205 | | 205 | |
| • Combined collection efficiency, % | 99.938 | | 99.938 | |
| **Precipitator details** | | | | |
| • No. of precipitator | 1 | 1 | 1 | 1 |
| • No. of series fields per Precipitator | 3 | 4 | 3 | 5 |
| • Length of each field m | 4.00 | 4.50 | 3.00 | 4.50 |
| • Width of each field m | 2x8.40 | 2x9.30 | 16.80 | 14.10 |
| • Height of each field m | 11.00 | 13.50 | 12.50 | 15.00 |
| • TR set rating kV/mA | 70/1200 | 70/1200 | 70/1200 | 70/1800 |

### TABLE-4
**Talcher1-4, (4 x 62.5MW) – Fly ash properties**

| Parameters | Unit | Design Coal | Worst coal | Best coal |
|---|---|---|---|---|
| SiO2 | % | 60.80 | 61.40 | 60.30 |
| Al2O3 | % | 29.50 | 28.50 | 29.80 |
| Cao | % | 1.70 | 1.93 | 1.57 |
| Mgo | % | 0.75 | 0.92 | 0.59 |
| Na2O | % | 0.10 | 0.10 | 0.10 |
| K2O | % | 0.55 | 0.75 | 0.43 |
| Fe2O3 | % | 4.10 | 3.90 | 4.70 |
| P2O5 | % | 0.53 | 0.59 | 0.46 |
| TiO2 | % | 1.70 | 1.60 | 1.80 |
| So3 | % | 0.27 | 0.31 | 0.25 |

### TABLE-5
**Talcher 1-4 (4 x 62.5 MW) Precipitator Design Parameters**

| Data | Design Values |
|---|---|
| **Design data of the Precipitator** | |
| • Gas flow $m^3$/sec | 120.73 |
| • Gas temperature, ° C | 130 |
| • Inlet dust loading gm/ N $m^3$ | 58.233 |
| • Outlet emission mg/ N $m^3$ | 87 |
| • Collection efficiency % | 99.85 |
| **Precipitator details** | |
| • No of Precipitator/Boiler | 1 |
| • No of gas streams | 2 |
| • No of series fields | 5 |
| • Length of each field m | 4.50 |
| • Width of each field m | 6.0 0 |
| • Height of each field m | 13.50 |
| • Pitch of ESP mm | 300 |
| • Gas velocity m/sec | 0.745 |
| • Treatment time sec | 30.20 |
| • Aspect ratio | 1.66 |
| • TR set rating kV/mA | 70/800 |

## TABLE –6

**Nasik –3, 1 x 210 MW - Existing and new precipitator design parameters**

| Parameters | | Old ESP design data considered in 1980 | New ESP design data |
|---|---|---|---|
| **Design data of the precipitator** | | | |
| • Gas flow, | $m^3$/sec | 370 | 460 |
| • Gas temperature, | ° C | 135 | 160 |
| • Inlet dust concentration | gm/ N $m^3$ | 19.15 | 64 |
| • Outlet emission | mg/ N $m^3$ | 176 | 80 |
| • Collection efficiency | % | 99.08 | 99.875 |
| **Precipitator details** | | | |
| • No. Of precipitator/boiler | | 2 | 4 |
| • No .of gas paths per Precipitator | | 2 | 1 |
| • No. of gas paths per boiler | | 4 | 4 |
| • No of electrical fields in series | | 5 | 6 |
| • Field length | m | 3.60 | 4.5 |
| • Field width | m | 9.50 | 11.6 |
| • Field height | m | 9.00 | 15.0 |
| • Gas velocity | m/sec | 1.08 | 0.66 |
| • Treatment time | sec | 16.63 | 40.90 |
| • Aspect ratio | | 2.0 | 1.8 |
| • Pitch | mm | 250 | 400 |
| • TR rating | kV/mA | 60/800 | 95/1000 |

## TABLE –7

**Koradi- 5, 1 x 200 MW**
**Particle size distribution**

| Size distribution | Range (%) |
|---|---|
| Less than 5 micron | 15 |
| 5 to 10 microns | 24 |
| 10 to 15 microns | 17 |
| 15 to 20 microns | 20 |
| 20 to 25 microns | 11 |
| 25 to 30 microns | 5 |
| 30 to 35 microns | 1 |
| 35 to 40 microns | 3 |
| 40 to 45 microns | 2 |
| 45 to 50 microns | 2 |

## TABLE -8

**Koradi- 5, 1 x 200 MW**
**Fly ash properties**

| Parameters | Values (%) |
|---|---|
| SiO2 | 63.62 |
| Al2O3 | 25.07 |
| CaO | 1.65 |
| MgO | 0.21 |
| Na2O | 1.08 |
| K2O | 0.92 |
| FeO3 | 4.05 |
| Carbon | 0.25 |
| Sulphur | 0.23 |
| Chloride | 0.006 |
| Copper | 25 PPM |
| Zinc | 60 PPM |
| Cadmium | Traces |

**TABLE–9**
**Koradi 5, 1 x 200 MW - Final arrangement of Bag and ESP details**

| **Parameters** | | **Pass A & D** | **Pass B & C ESP** |
|---|---|---|---|
| **Design Details** | | | |
| • Operating Loading | | Full load | Partial load upto 120 MW |
| • Gas flow | $m^3$/sec | 460 | Varies according to load |
| • Gas temperature | °C | 160 | |
| • Inlet dust concentration | gm/ $N.m^3$ | 64 | |
| • Outlet concentration | mg/ $N.m^3$ | 40 | |
| • Gas properties<br>$O_2$<br>$NO_2$<br>$SO_2$ | <br>%<br>mg/$Nm^3$<br>PPM | <br>9<br>10<br>527 | |
| Bag size | | Dia 150 X 8000mm | |
| No of bags | | 7216 | |
| Type of bags | | Ryton | |
| **Precipitator details** | | | |
| • No. of gas passes per boiler | | Not applicable | 2 |
| • No. of fields per gas pass | | | 5 |
| • Total fields | | | 10 |
| • Field length | m | | 3.60 |
| • Field width | m | | 9.50 |
| • Field height | m | | 9.00 |
| • Pitch | mm | | 250 |
| • TR rating | kV/mA | | 60/800 |

**TABLE –10**
**Koradi- 5, 1 x 200 MW,ID Fan design data**

| **Parameters** | | **Original data** | **Present data** |
|---|---|---|---|
| • No. of fans | | 2 X 50% | 2 X 50 % |
| • Type of fan | | Axial | Axial |
| • Make of fan | | BHEL | BHEL |
| **Design Parameters** | | | |
| • Gas flow | $m^3$/sec | 230 | 272.50 |
| • Gas temperature | °C | 150 | 150 |
| • Total head | mmWC | 350 | 516 |
| • Motor rating | KW/rpm | 1100/980 | 1875/980 |