DEALING WITH ESP ASH EVACUATION PROBLEMS – EXPERIENCES AT DADRI & TALCHER KANIHA

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Typical Ash Distribution In a Boiler
Typical Dry Fly Ash Handling Arrangement at a Power Station

- Vacuum Conveying
- Pressure Conveying

Diagram showing the typical dry fly ash handling arrangement with ESP hopper, buffer hopper, storage hoppers, filter, exhaustor, and silo.
DADRI II
COMMISSIONED : Unit # 5 On 31st January 2010 &
Unit # 6 On 30th July 2010

SYSTEM PARAMETERS : In Each Unit
Fly Ash (ESP + APH) Collection Rate – 249 T/H (62.25 x 4)
Total nos of Hoppers – 168 (ESP-160 nos + APH-8 nos)
Fly Ash Transportation Line Capacity – 125 T/H
Nos of FATL – 3 nos (2W + 1S)
IAC Capacity – 600 m3/hr at 8 kg/cm2
Nos of IAC (for 2 Units) – 4 nos (2W + 2S)
TAC Capacity – 5650 m3/hr at 1.5 Kg/cm2
Nos of TAC – 3 nos (2W + 1S)
Vacuum Pump Capacity – 2980 m3/hr at 16 inch Hg
Nos of Vacuum Pump – 8 nos (4W + 4S)
PROBLEMS IDENTIFIED

Equipment Related:

• Frequent Chockings of Bag Filters of Buffer Hoppers.
• Frequent Outages of Equalising Valves of Buffer Hoppers.
• Low instrument air header pressure even with standby compressors running.

System Related:

• Frequent pressurization of FATL.
• High evacuation cycle time leading to ash build up inside hoppers.
• ESP field outages and Field damages.
• Frequent breakdowns in the system (3-4 hrs in a shift)
Bag Filter Chockings

- Header pressure of Pulse jet air, required to clean the bag filters, was found low.

- Minimum Instrument air header pressure recommended is 6 kg/cm² for jetting to be effective.

- Instrument air pressure was subsequently improved to 5 Kg/cm² and frequent chockages of Bag Filters were avoided.
PROBLEM AND REMEDIAL ACTIONS

Outages of Equalising Valves

• **Swivel type** equalising valves, provided initially were frequently failing.

• These valves were replaced with **reciprocating type** valves. However these valves were also failing frequently owing to smaller diameter shaft size and leakages from the body of the valves.

• Subsequently valves of bigger size **stem diameter** were used.
PROBLEM AND REMEDIAL ACTIONS

Low Instrument Air Header Pressure

- Header pressure was only 3.5 Kg/cm² with all four compressors (2W + 2S) running against a recommended header pressure of 6 Kg/cm².

- **Servicing** of compressors were carried out.

- **Pressure drop across IA dryers** was found to be more than 0.5 Kg/cm². These dryers were serviced and pressure drop across the dryer was reduced to 0.3 Kg/cm².

- **Air leakages** were identified at different times by various teams. These leakages were attended in a time bound schedule.

- **Air receiver tanks** at Buffer hopper area and at Silo area were also erected.

- These actions finally lead to a header pressure of **5 Kg/cm²**, though with all the four compressors running and **without main plant support.**
PROBLEM AND REMEDIAL ACTIONS

Frequent Pressurisation of FATL

- Each FATL is about 560 meters in length in Unit #5 and 590 meters in Unit #6, with pipeline sizes of 300/350/400 NB in each of the lines.

- First step in pipe line from 300 NB to 350 NB was provided at a length of about 120 meters and second step from 350 NB to 400 NB at length of about 240 meters along the direction of flow, against a design layout stepping of 262 meters for the first step and 445 meters for the second step respectively.

- Looping near chimney was avoided by rerouting the lines.
PROBLEM AND REMEDIAL ACTIONS

Performance Improvement of Transport Air Compressors

- **Suction filters** were getting frequently choked due to ash & dust in the environment. Filters were replaced & compressor room was sealed subsequently.

- **Pressure drop across dryer was high**. The flow path of air in the heat exchanger was modified.

- **Loading / Unloading system** in compressors which was not provided earlier was subsequently installed to avoid frequent tripping of the compressors.

- **TAC capacity was augmented by 12%** by changing gear ratio in all the 06 compressors. This led to significant reduction in instances of line pressurization.
PROBLEM AND REMEDIAL ACTIONS

Frequent Buffer Hopper Filling

- Air lock tank fluidisation, provided from TAC air, lead to frequent Buffer hopper filling. This is because at low air pressure, fluidisation of air lock tanks were not effective and as a result there was low throughput from Air lock Tanks.

- Fluidisation of air lock tanks was provided with high pressure air of 2 – 2.5 kg/cm², and the problem could be avoided.
RESULTS ACHIEVED

• **Cycle time** reduced to 80-100 minutes against earlier cycle times of few hours to sometimes shifts. Presently 5-8 cycles are completed in a shift up to a coal firing rate of approx 320 T/H.

• **System outage durations** were brought down to less than an hour in a shift, against earlier outages of 3-4 hrs in a shift.

• **IAC header pressure improved to 5 kg/cm²** against earlier header pressure of 3 kg/cm², though with all four compressors running. However, augmentation of IACs is still under process to achieve rated header pressure of 6 kg/cm² with two nos. compressors only.

• With improvement in IAC header pressure, **instances of bag filter chocking** in Buffer hoppers have reduced significantly and in turn improved operating line vacuum of the system.

• Instances of **line pressurizations in FATL** reduced substantially owing to augmentation of TAC capacity.

• Instances of hopper chocking and manual dumping of ash from ESP hopers have reduced significantly which in turn helped in minimizing field outages.
ANALYSIS

Chocking Issue of FATL

• Improvement in system performance was primarily brought about by correcting steps in FATL which were wrongly erected.

• These steps from 300 NB to 350 NB and from 350 NB to 400 NB which were provided much earlier in FATL than required distance as per design, was actually reducing the velocity of conveying air due to increase in pipe diameter at stepping point to less than the minimum conveying velocity required, resulting in line pressurization and choking of FATL.

1\text{st} \ Step \ 300-350 \ NB \ at \ 120 \ meter \ (262 \ meter) \\
2\text{nd} \ Step \ 350-400 \ NB \ at \ 240 \ meter \ (445 \ meters)
**ANALYSIS**

**Evacuation Issue**

- While the system is designed to evacuate Fly ash from ESP and APH at the rate of 249 T/H, it is observed that at a Fly ash loading of more than 100 to 110 T/H, (corresponding to a coal firing rate of 330-360 T/H in a unit), evacuation process slows down and progressively leads to ash build up inside ESP hoppers **because of coarser ash collected at this loading**.
- Further, cycle time increases considerably in ESP hoppers where fields are not in service. This is because the size of ash particles collected in these hoppers are coarser when field is out.
- **Carryover of coarser particles from ECO/APH hopper** in ESP hoppers also increases cycle time significantly.

![Minimum Conveying Air Velocity vs Solids Loading Ratio](image)
ASH PARTICLE SIZE ANALYSIS

At a coal flow rate of 290 T/H

<table>
<thead>
<tr>
<th>Unit</th>
<th>Area</th>
<th>% ABOVE 250 microns</th>
<th>% 150-250 microns</th>
<th>% 75 - 150 microns</th>
<th>% Below 75 microns</th>
<th>Type of Ash</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit # 6</td>
<td>PAPH # 6A</td>
<td>4</td>
<td>50.8</td>
<td>15.2</td>
<td>30</td>
<td>Coarse</td>
</tr>
<tr>
<td>Unit # 6</td>
<td>SAPH # 6A</td>
<td>3.6</td>
<td>44</td>
<td>15.6</td>
<td>36.8</td>
<td>Coarse</td>
</tr>
<tr>
<td>Unit # 6</td>
<td>ESP # 6 B</td>
<td>0.8</td>
<td>22.4</td>
<td>12</td>
<td>64.8</td>
<td>Fine</td>
</tr>
<tr>
<td>Unit # 6</td>
<td>ESP # 6C</td>
<td>1.2</td>
<td>20.2</td>
<td>11.8</td>
<td>66.8</td>
<td>Fine</td>
</tr>
</tbody>
</table>
**ANALYSIS**

- **Improvement in IAC header pressure** from 3 kg/cm² to 5 kg/cm² brought about by servicing compressors, driers and arresting air leakages drastically reduced instances of bag filter chockages of buffer hoppers. This in turn improved **operating line vacuum** in the system and overall improvement of the Vacuum system.

- **Air receiver tanks** provided in buffer hopper areas of Unit # 5 & 6 and in Silo area also helped in sustaining line pressure in the system.
• **Augmentation in TAC capacity by 12%** by changing gear ratio helped in minimizing line pressurization in FATL and therefore improvement in Pressure transportation system.

• However, if we look at the present capacities of IA compressors and TA compressors provided in the system, they appear to be far from satisfactory from those required to achieve design rated pressure/capacities of respective systems.

  IAC header pressure of 6 Kg/cm² is envisaged with only two compressors running whereas even with all four compressors (2W + 2S) running, the header pressure which could be achieved is only 5 Kg/cm².

• Similarly, even after augmentation in TAC capacity, the throughput which could be transported in FATL is found to be only 70% of its rated capacity of 125 T/H.
ESP Ash Evacuation System Parameters:

- Fly ash (ESP + APH) removal rate – 240 T/H (60 X 4)

- Nos of stream working – 4
- Total numbers of hoppers- 82 Nos (ESP- 72 nos + APH- 10 nos)
- Fly ash transportation line (FATL) capacity – 100 T/H

- Nos of FATL – 3 Nos (2W + 1S) (Units 3 & 4 only)

- IAC capacity – 200 m3/hr at 8 kg/cm2

- Nos of IAC – 2 nos (1W+ 1S) (Units 3 & 4 only)

- TAC capacity – 3600 m3/hr at 1.5 kg/cm2

- Nos of TAC – 3 nos (2W+ 1S) (Units 3 & 4 only)

- Vacuum Pump Capacity : 3634.6 m3/h at 406.4 mm Hg
Problems Associated With Vacuum Extraction System: (As Reported by a Study team of Corporate OS, Engg and Site in March 2011)

- When the coal **firing rate exceeds 360 T/H**, ash evacuation takes more time and progressively leads to ash build up inside ESP hoppers.

- Ash from the **rear field hoppers** not falling into the conveying lines.

- **Evacuation time found much higher when APH hoppers are taken for evacuation**.

- Though **hopper heaters provided in ESP hoppers** are in service, it was seen that the temperature of ash in the hoppers in rear fields was near ambient temperature.

- **Fluidisation system provided for ESP hoppers** is found to be ineffective. While the temperature of fluidising air at blower end is found to be 120-130 degC, it is observed to be only 40-50 degC (when measured with infra red gun) at fluidising pads in most of the hoppers.
Modifications Carried Out by Site:

- **Six parallel conveying streams** (instead of four envisaged) are provided by splitting each of the conveying streams of middle passes B,C of ESP into two and connecting each additional stream to the standby vacuum pump and wetting unit/collector tank. Four independent conveying streams are now available for the middle passes in each unit. **All six streams** are normally required to evacuate the ash in time.
MODIFICATIONS

• **Feeder ejectors have been provided for alternate hoppers in first field** to evacuate ash directly in wet mode. These are used to independently evacuate the hoppers especially when first field is not in service or to clear build up in the hopper. The slurry is directly discharged into the fly ash slurry trench.

• The adaptors below the outlet of ESP hoppers are insulated.

• On an experimental basis, site has installed flexible heaters (wrap around) on spool piece above fly ash intake valve in four hoppers of B&C passes in one unit. Performance is under observation.
ANALYSIS

Flowability Issue:

Ash is quite free-flowing in the first few fields of ESP (fields 1 to 4) as it is relatively coarser and at higher temperature.

Ash in rear field hoppers does not fall freely into the conveying lines. This is because of ineffective hopper heating and ash being finer in rear fields becomes cohesive and non flowing.

Quantity of ash in rear field hoppers being low, remains mostly in adaptors below hoppers and/or in spool pieces. By providing insulation in adaptors and providing effective heating (wrap around heaters) in spool pieces, flowability can be ensured.
Fluidisation of Ash in ESP Hoppers:

- Fluidisation system provided is not effective. All the hoppers in each unit are supplied with fluidising air simultaneously.

- Fluidisation will be effective, if only the branch lines under evacuation is supplied with air.

- This change will require provision of solenoid valves to direct the fluidizing air to the specific branches under evacuation.

- Fluidisation is to be restricted upto fourth field hoppers only

- Heaters can be located at few strategic locations, nearer to hoppers to be fluidized, in a unit so that by the time air reaches the hoppers, it remains hot.
ANALYSIS

Ash Removal Rate:
This problem involves two aspects.
i) Ash removal from air-preheater hoppers.
ii) Ash removal from ESP hoppers.

Ash Removal From Air-preheater Hoppers.

Ash from air preheater hoppers is much coarser (grits).
This ash requires higher initial conveying velocity (14-15 m/s).
The initial conveying velocities obtained in the existing systems are lower –about 9 m/s.

Separate ash removal system for air-preheater ash to be provided as already approved for implementation.
ANALYSIS

Ash Removal From ESP Hoppers

Two issues to be considered – nature of ash collected in first field hoppers and in the rear field (fields 5-9) hoppers.

Problem in the first field hoppers is caused whenever a large quantity of coarse ash is collected in hoppers. This depends on the coal, firing rate, mill condition and combustion conditions in the boiler.

If the first field is not available, ash collected will be coarse and quite similar to APH ash. This ash requires a higher conveying air velocity and removal cycle gets prolonged.

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>% Above 300μ</th>
<th>% 200-300μ</th>
<th>% 150-200μ</th>
<th>% 125-150μ</th>
<th>% &lt;75μ</th>
<th>Field Status</th>
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<tr>
<td>6D1</td>
<td>1.2</td>
<td>7.7</td>
<td>12.6</td>
<td>0.4</td>
<td>66.1</td>
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<td>6D2</td>
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<tr>
<td>5B1A</td>
<td>14.9</td>
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<td>1.91</td>
<td>23.85</td>
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<tr>
<td>APH # 6C</td>
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<td>38.27</td>
<td>15.87</td>
<td>2.54</td>
<td>23.83</td>
<td>Service</td>
</tr>
</tbody>
</table>
ANALYSIS

Ash Removal From ESP Hoppers (Contd)

• The situation can become serious when higher ash quantities are to be removed corresponding to the higher coal firing rates. (> 360 T/H)

• This calls for higher capacity vacuum pumps while retaining the existing line sizes to increase conveying air velocity.

• For rear field hoppers, the problem can be overcome by providing insulation and additional heating for the rear field hoppers and by lowering the location of existing heaters/making heaters more effective.
ANALYSIS

Operational Issues:

- For ensuring system integrity followings to be checked periodically.
  No load line vacuum with air intake valve as envisaged in design.
  Maximum line vacuum with air intake valve as envisaged in design.

- In case of major deviation from set values, corrective action is to be taken by minimizing air leakages in the system.

- System also demands close monitoring for smooth operation.
Learnings From Training in Australia

Blow Tanks :
Pressure conveying system through Blow tanks below ESP hoppers. This is the present trend owing to its advantages of better system operation, instead of vacuum conveying system.

Air Slides :
- Considered as an extreme form of dense phase conveying upto 100 meters.
- Other advantages include lower capital and operating cost.
- Air pressure requirement is low.
Learnings

Shapes Of ESP Hoppers:

Shapes of hoppers designed to improve flowability
References

1. Pneumatic Conveying Systems – David Mills/ V.K Agarwal


3. Paper on Pneumatic Conveying – Prof. Mark Jones

4. Training Modules at University of Newcastle, Australia
THANKS