PNEUMATIC CONVEYING OF FLY ASH-ISSUES AND THEIR ADDRESSAL

UJJWAL CHOWDHURY, AGM(OS)/NTPC
INTENT OF PRESENTATION

UNDERSTAND ISSUES ASSOCIATED WITH PNEUMATIC CONVEYING OF FLY ASH

ANALYSIS OF ISSUES

ISSUES TO BE CONSIDERED FOR IMPLEMENTATION IN UPCOMING PROJECTS
PNEUMATIC CONVEYING OF FLY ASH IS COMPARATIVELY DIFFICULT THAN WET HANDLING

PNEUMATIC CONVEYING IS LITTLE UNDERSTOOD AMONG THE USERS. MORE SO BECAUSE THE SUBJECT IS NOT DEALT WITH, IN UNIVERSITY CURRICULUM

THERE IS LITTLE OR NO ACCESS TO RESEARCH WORK OR STUDY REPORT ON THE SUBJECT AVAILABLE IN PUBLIC DOMAIN.
Simply put, if a material is to be conveyed through a conveying pipeline from point A to point B, conveying capability will primarily depend upon

- Pressure drop available across points A & B.

- Solids Loading Ratio i.e. mass flow rate of material / mass flow rate of air.

- Minimum conveying air velocity at point A.
CONVEYING CHARACTERISTICS

Figure 5: Comparison of Conveying Characteristics for Fine and Coarse Grades of Fly Ash in IIT Pipeline.
CONVEYING CHARACTERISTICS

Figure 2: Influence of Solids Loading Ratio on Conveying Air Velocity for Fine and Coarse Grades of Fly Ash

Coarse Grade
Fine Grade
Material - Fly Ash

Minimum Conveying Air Velocity - m/s
Solids Loading Ratio
SCALING PROCESS

- Test results are valid for test pipelines at the Lab having specified bore, length of pipeline, no of bends and vertical lift.

- These test results are to be extrapolated to actual plant conditions of conveying pipelines in terms of bore, length of pipelines, no of bends, vertical lift etc to get the values of actual material flow rate, solids loading ratio, air velocity etc at plant conditions.

- This extrapolation is done by a method called Scaling Process.
Typical Ash distribution for 2 pass boiler

- **Furnace (1300 - 1500°C)**
  - Pulverized Coal
  - Bottom Ash: 20%
  - Eco Ash

- **ESP**
  - Electrostatic Precipitator
  - Stage A: 80%
  - Stage B: 17%
  - Stage C: 3%
  - ESP Ash
  - APH Ash

- **Stack**
  - FOCUS

- **Air Preheater (APH)**
TYPICAL FLY ASH HANDLING ARRANGEMENT

Vacuum Conveying

Pressure Conveying
Fly Ash (ESP + APH) Collection Rate – **249 T/H ( 62.25 x 4 )**

Nos of stream working - 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 in pneumatic conveying system can be broadly categorized under following heads.

- Flowability of ash
- System conveying rate
- Equipment and operation related issues
- Fluidisation of ash in hoppers
FLOWABILITY OF ASH

OBSERVATIONS:

• Ash is comparatively free flowing in ESP hoppers of first few fields (1^{st} to 4^{th} Field) of ESP.

• Ash is generally not free flowing in rear field hoppers (5^{th} to 10^{th}) of ESP.

• Throttling air intake valves or putting a low size orifice at air intake to create higher vacuum, are normal methods to take care of this problem.
OBSERVATIONS:

- Systems are designed to evacuate 8 hours of ash collection in ESP & APH hoppers in 6 hours with worst coal.

- This translates to an evacuation & transportation rate of 220-250 T/H of ash from ESP & APH for a 500 MW Unit.

- However, at a coal firing rate of 360 T/H and above, ie at a ash loading of 100-120 T/H, it is seen that evacuation process slows down and eventually leads to chocking in hoppers.
OBSERVATIONS:

• Fluidisation system provided for ESP hoppers is mostly found ineffective.

• While the temperature of fluidising air at blower end is around 120-130 degree C, the temperature of air at hopper end is much less (60-70 deg C), against a requirement of 120 deg C.

• Location of fluidising pads are at a higher elevation in rear field hoppers where the level of ash collected remains at a much lower level.

• Size of fluidising pads also appear to be inadequate, at times.
EQUIPMENT RELATED ISSUES

OBSERVATIONS:

• Stepping in Pipelines

In one of the stations, there was a problem of frequent blockages in Fly Ash Transportation Lines, transporting ash from Buffer hopper to Silo. The problem was difficult to diagnose but eventually it was established that wrong stepping provided in pipelines was the root cause.

• Bag Filter Chockages

Effective cleaning of Bag filters inside Buffer Hoppers (Intermediate Silo) is vital in operation of the system. Pulse jet system provided to clean the bag filters is effective when instrument header pressure required to operate the pulse jet system is above 5 kg/cm2. But header pressure is often found low.
OBSERVATIONS:

• Major operational issues are air leakages in the system. CI pipes used for conveying lines have numerous coupling joints and are points for air in-leakages.

• For ensuring system integrity, followings are to be periodically checked.
  - Shut off vacuum in the system vis-à-vis envisaged vacuum reading.
  - Line vacuum in the system as envisaged in design.
Vacuum Conveying

- **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.
Flowability Of Ash:

Ash in rear field hoppers does not fall freely into the conveying lines. Quantity of ash in rear field hoppers being low, remains mostly in adaptors below hoppers and/or in spool pieces and gets cooled down.

By providing insulation in adaptors and providing effective heating (wrap around heaters) in spool pieces, flowability can be ensured.
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. Hopper heating and fluidisation is also effective in these hoppers.

Ash in rear field hoppers does not fall freely into the conveying lines. Quantity of ash in rear field hoppers being low, remains mostly in adaptors below hoppers and/or in spool pieces, where it gets cooled down due to ineffective hopper heating arrangement. Ash being finer in rear fields, becomes cohesive and non flowing.

Providing insulation in adaptors and providing effective heating (wrap around heaters) in spool pieces, flowability can be ensured.
ANALYSIS OF PROBLEMS / OBSERVATIONS

System Conveying Rate:
This problem involves two aspects.
i) Ash removal from Air-Preheater hoppers.
ii) Ash removal from ESP hoppers.

i) 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.
- Large number of bends in the piping layout from ESP hoppers to Buffer hoppers adds to the problem.
- Separate ash removal system for APH ash will be a better option.
ii) Ash Removal From ESP Hoppers

Two issues are to be considered – nature of ash collected in first field hoppers and in the rear field (fields 5th -10th) 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, Field availability status.

![](ANALYSIS OF PROBLEMS / OBSERVATIONS.png)

This ash requires a higher conveying air velocity than obtained in the system, and therefore ash removal cycle time gets prolonged.
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.
Fluidisation of Ash in ESP Hoppers

- Fluidisation system provided in some of the stations, 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.
i) Stepping in Pipeline

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

- 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.
ii) Bag Filter Chokages

- Bag Filters are a filter medium located between vacuum pump and ESP hoppers.
- Any chokages of bag filters virtually cuts off the ESP hoppers from vacuum pumps and affects the system performance.
- It must be ensured that a minimum IAC header pressure of 5.5 kg/cm² is available for proper functioning of pulse jet system to clean bag filters.
ANALYSIS OF PROBLEMS / OBSERVATIONS

Operation Related Issues

• Maintaining proper Shut off vacuum & line vacuum is essential for optimum operation of the system.

• The coarser the ash particles are, the greater is the evacuation cycle time.

• Avoid carryover of ECO & APH ash to ESP.

• Prevent field outages to avoid collection of coarser particles in ESP.
ALTERNATIVES TO BE CONSIDERED

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.
Shapes Of ESP Hoppers:

Shapes of hoppers designed to improve flowability of ash.
## Sieve Analysis of Fly Ash

<table>
<thead>
<tr>
<th>Sieve analysis of fly ash</th>
<th>% age by weight</th>
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<tbody>
<tr>
<td>Less than 1 microns</td>
<td>32</td>
</tr>
<tr>
<td>10-20 microns</td>
<td>24</td>
</tr>
<tr>
<td>20-30 microns</td>
<td>14</td>
</tr>
<tr>
<td>30-40 microns</td>
<td>10</td>
</tr>
<tr>
<td>Greater than 40 microns</td>
<td>20</td>
</tr>
</tbody>
</table>

As provided in our Technical Specification

### Actual Size Analysis at one of our Stations.

<table>
<thead>
<tr>
<th>ESP/APH PASS No</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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</thead>
<tbody>
<tr>
<td>ESP 6D1</td>
<td>1.2</td>
<td>7.7</td>
<td>12.6</td>
<td>0.4</td>
<td>66.1</td>
<td>IN SERVICE</td>
</tr>
<tr>
<td>ESP 6D1</td>
<td>1.2</td>
<td>12.1</td>
<td>11.7</td>
<td>0.6</td>
<td>60.4</td>
<td>IN SERVICE</td>
</tr>
<tr>
<td>ESP 6D1</td>
<td>14.9</td>
<td>17.1</td>
<td>28.8</td>
<td>0.8</td>
<td>20.8</td>
<td>OUT OF SERVICE</td>
</tr>
<tr>
<td>ESP 6D1</td>
<td>1.6</td>
<td>36.1</td>
<td>35.3</td>
<td>0.7</td>
<td>14.7</td>
<td>OUT OF SERVICE</td>
</tr>
<tr>
<td>ESP 6D1</td>
<td>5.6</td>
<td>51.9</td>
<td>13.1</td>
<td>0.4</td>
<td>21.9</td>
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<tr>
<td>APH 6B</td>
<td>9.44</td>
<td>41.61</td>
<td>14.24</td>
<td>1.91</td>
<td>23.85</td>
<td>IN SERVICE</td>
</tr>
<tr>
<td>APH 6C</td>
<td>10.91</td>
<td>38.27</td>
<td>15.87</td>
<td>2.54</td>
<td>23.83</td>
<td>IN SERVICE</td>
</tr>
</tbody>
</table>
WAY FORWARD

1. Air preheater ash should preferably be handled independently through wet system, and should not be linked to pneumatic conveying of ESP evacuation system.

2. The type of vacuum conveying system for ESP ash, generally observed across NTPC Stations, has some limitations in the evacuation capacity of the system. It is seen that beyond a coal firing rate of 360 TPH, for a 500 MW unit, evacuation process slows down and gradually ash starts building up inside hopper, even though the system is designed for it. Therefore a relook at the technology option for fly ash evacuation is necessary.

3. The prudence of providing same size of hoppers across all the fields in ESP, irrespective of the fact that almost 95% of the ash is collected in the first four fields – should be reconsidered.
4. Flowability of ash is an issue. Therefore a study should be conducted for a different shape (conical, or any other shape) of ESP hopper compatible with the flow characteristics of ash.

5. Technical specification of our system w.r.t particle size analysis needs to be relooked into, in view of the above observations.

6. A need is felt to set up a Pilot Plant facility to study ash characteristics.
REFERENCES

1. Pneumatic Conveying Systems  - David Mills/ VK Agarwal
2. Report of Study Team of NTPC Corporate OS & Engg
3. Paper on Pneumatic Conveying – Mark Jones
4. Training Modules of "Intensive Short Course on Ash Handling" at University of Newcastle, Australia.
THANKS