Air Pollution Control Technologies
for
Improved Particulate Emissions

SANKAR THAKUR
KC COTTRELL INDIA PVT. LTD.

Our Commitment for Sustainable Environment
by Technology & Experience
KC Cottrell is one of the world's leading specialists in air pollution control.

Its plants are characterized by their low capital costs, high efficiency, minimum maintenance, low running costs and industrial utilization of by-products.

A unique combination of people and technology together with sound business ethics and a focus on product development all contribute to KC Cottrell's capability to offer the most suitable system for any given application.

As regulations on emission levels become ever more stringent, KC Cottrell rely on innovative technology together with know-how and vast experience to produce the most cost effective emission control solutions every time.

Lodge Cottrell India offers a complete range of gas cleaning equipment and services from a single specific item to complete turnkey installations involving initial design through to plant commissioning and testing followed by a range of plant services.
## KC Cottrell Co., Ltd.

<table>
<thead>
<tr>
<th>Establishment</th>
<th>27th Nov. 1973</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Area</td>
<td>Dust Collection System, Flue Gas Treatment System, New renewable energy, Industrial Machinery.</td>
</tr>
<tr>
<td>Head office</td>
<td>160-1 Donggyo-dong, Mapo-gu, Seoul, Korea 121-817</td>
</tr>
<tr>
<td>Factory</td>
<td>253, Seounsingi-gil, Seoun-myeon, Anseong-si, Gyeonggi-do, Korea 456-853</td>
</tr>
<tr>
<td>Homepage</td>
<td><a href="http://www.kc-cottrell.com">www.kc-cottrell.com</a></td>
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## KC Cottrell India Pvt. Ltd.

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<th>Establishment</th>
<th>19th Nov. 2008</th>
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<tr>
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<td>Spazedge Tower-B 5F, Suite No 502-504, Sohna Road, Sec-47, Gurgaon, HR 122002, India</td>
</tr>
<tr>
<td>Branch</td>
<td>Ashram, GN 32/2, 4th Floor, Sector-V, Salt Lake, Kolkata – 700 091, West Bengal,</td>
</tr>
<tr>
<td>Homepage</td>
<td><a href="http://www.kc-cottrell.com">www.kc-cottrell.com</a></td>
</tr>
</tbody>
</table>
Major Business

Dust Collection
- Electrostatic Precipitator, DeTar
- Fabric Filter, e-BF
- Wet Scrubber, Cyclones
- Flue Gas Conditioning
- Fly & Bottom Ash Handling

Flue Gas Treatment
- Flue Gas Desulphurization
- Flue Gas De-Noxification
- Semi Dry Reactor
- De-Dioxin
- VOC Removal/Recovery

New Renewable Energy
- Solar Power
  - Solar Power Generation
  - BIPV Development, Household System
- Wind Power

Industrial Machinery
- Sludge Incinerator
- Solid Waste Incineration
- GGH (Gas Gas Heater)
- Dampers, Expansion Joints
- Air Cooled Heat Exchanger
Strength of KC Cottrell India

Various Experience in Air Pollution Control

- Supplying Over 6,000 units worldwide
- Accumulated Experiences in Various Application
- Greenfield & Brownfield Business

Maximum Engineering Capability

- Utilizing Engineering Manpower in India, UK, USA and Korea
- Operating the Engineering Center in Kolkata
- Diversified ESP Design (‘K’, ‘C’ & ‘L’ Type)

Providing Full Solution and Service

- Full Range of Air Pollution Control Equipments
- EPC or Turnkey Based Project Execution
- Technical Service & Spare Parts
<table>
<thead>
<tr>
<th>Sl.</th>
<th>Project</th>
<th>Purchaser</th>
<th>Ultimate Client / Plant</th>
<th>Application</th>
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</thead>
<tbody>
<tr>
<td>01</td>
<td>Blast Furnace Complex - Stock House De-Dusting System with ESP</td>
<td>POSCO E&amp;C Co., Ltd.</td>
<td>SAIL, ISP</td>
<td>Raw Material Handling Nuisance Control De-dusting</td>
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<tr>
<td></td>
<td>Blast Furnace Complex-Cast House De-Fuming System with ESP</td>
<td>POSCO E&amp;C Co., Ltd.</td>
<td>SAIL, ISP</td>
<td>Cast House De-Fuming</td>
</tr>
<tr>
<td>02</td>
<td>4 nos. ETP for new CCD of Battery no. 6</td>
<td>Shriram EPC Limited</td>
<td>SAIL, RSP</td>
<td>CO Gas De-Tarrer</td>
</tr>
<tr>
<td>03</td>
<td>Renovation &amp; Modernization of ESP for unit no. IV &amp; V (2X210 MW)</td>
<td>NTPC Ltd., (KC Cottrell)</td>
<td>NTPC, Baddarpur TPS</td>
<td>Coal Fired Boiler using Indian Coal</td>
</tr>
<tr>
<td>04</td>
<td>1 no. ETP for CCD</td>
<td>Tata Steel Growth Shop</td>
<td>Tata Steel Limited</td>
<td>CO Gas De-Tarrer</td>
</tr>
<tr>
<td>05</td>
<td>Cast House De-Fuming System for Blast Furnace#1</td>
<td>RINL</td>
<td>Visakhapatnam Steel Plant</td>
<td>Cast House De-Fuming</td>
</tr>
<tr>
<td>06</td>
<td>Replacement of Internals of ESP for Unit#1</td>
<td>NTPC Ltd.</td>
<td>NTPC, Rihand STP</td>
<td>Coal Fired Boiler using Indian Coal</td>
</tr>
<tr>
<td>07</td>
<td>Dryer ESP for Copper Smelter</td>
<td>Hindustan Copper Ltd.</td>
<td>ICC, Ghatshila</td>
<td>Copper Smelter</td>
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<td>08</td>
<td>Furnace ESP for Copper Smelter</td>
<td>Hindustan Copper Ltd.</td>
<td>ICC, Ghatshila</td>
<td>Copper Smelter</td>
</tr>
<tr>
<td>09</td>
<td>ESP for 2X660 MW Super Critical Boiler</td>
<td>Meja Urja Nigam Pvt. Ltd. (NTPC), (KC Cottrell)</td>
<td>NTPC, Meja STPP</td>
<td>Coal Fired Super Critical Boiler using Indian Coal</td>
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<tr>
<td>10</td>
<td>Replacement of 2 nos. ETP in 1.8 MT Stage</td>
<td>SAIL</td>
<td>Durgapur Steel Plant</td>
<td>CO Gas De-Tarrer</td>
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<tr>
<td>11</td>
<td>Replacement of 2 nos. ETP in 1.0 MT Stage</td>
<td>SAIL</td>
<td>Durgapur Steel Plant</td>
<td>CO Gas De-Tarrer</td>
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<td>12</td>
<td>Renovation &amp; Retrofitting of ESP for Unit no. 1, 2 &amp; 3 (3X200 MW)</td>
<td>NTPC Ltd., (KC Cottrell)</td>
<td>NTPC, Farakka STPP</td>
<td>Coal Fired Boiler using Indian Coal</td>
</tr>
</tbody>
</table>
STOCK HOUSE ESP AT IISCO BURNPUR
Head Office of KC in Seoul
Types of Emissions

Cement Manufacturing Process

- Dust Emission
  - Stack
  - Fugitive
- Gaseous Emission
  - SO2
  - NOx
  - CO/CO2
  - NH3
  - HCl
- Other Emissions
  - VOC
  - H.M.
  - Dioxins & Furans

VOC = Volatile Organic Compound = Benzene, Zylene, Toluene etc.

H.M. = Heavy Metals - Mercury, Cobalt, Nickel, Copper, Lead, Manganese, Arsenic, Vanadium, Titanium, Cadmium etc.
Types of Emissions

Stack Emission

Fugitive Emission
Method of controlling Stack Emissions

Dust separation

Dry Process
- Electro/Mechanical separation
  - Cyclones/Multiclones
  - ESP
- Surface Phenomenon
  - Pulse Jet
  - Reverse air
  - Shaker

Wet Process
- Scrubbing
EMISSION STANDARDS IN KEY COUNTRIES

*India’s recent emissions norms for new plants are at par with global standards (in mg/l Nm³)*

<table>
<thead>
<tr>
<th>Country</th>
<th>PM</th>
<th>SO₂</th>
<th>NOₓ</th>
<th>Mercury</th>
</tr>
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<tbody>
<tr>
<td>INDIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current standards</td>
<td>150-350</td>
<td>None</td>
<td>None</td>
<td>None</td>
</tr>
<tr>
<td>New standards</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Units installed before 2004*</td>
<td>100</td>
<td>&lt; 500 MW: 600</td>
<td>600</td>
<td>&gt;= 500 MW: 0.03</td>
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<tr>
<td>Units installed between 2004–16*</td>
<td>50</td>
<td>&lt; 500 MW: 600</td>
<td>300</td>
<td>0.03</td>
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<tr>
<td>Units installed after December 2016</td>
<td>30</td>
<td>100</td>
<td>100</td>
<td>0.03</td>
</tr>
<tr>
<td>CHINA</td>
<td>30</td>
<td>100</td>
<td>100</td>
<td>0.03</td>
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<tr>
<td>USA-NSPS/NESHAP</td>
<td>14.5</td>
<td>100</td>
<td>100</td>
<td>0.0017</td>
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</tbody>
</table>

*For existing units, norms come into effect beginning 7 December 2017. Source: Ministry of Environment, Forests and Climate Change (MoEF&CC)*
Things that I want to talk about...

- Electrostatic precipitator
- Bag filter
Typical designs of dry ESPs

The black box – what happens inside?
Principle of Operation of ESP

Dust particles face various forces

- Inertia force
- Gravitational force
- Electrostatic force (Migration vel.)
- Drag Force (Gas velocity)
Principle of Operation of ESP

3 steps for particle collection:

1. Migration velocity
2. Gas flow direction
3. Collector exit

Charging – precipitation – rapping
FIGURE 1

ESP Operating Principle

Particles suspended in a gas enter the precipitator; passing through ionized zones around high voltage electrodes. These high voltage electrodes, through a corona effect, emit negatively charged ions into the gases.

The negatively charged gas field around each electrode charges passing particulates, causing the particulates to migrate to the electrode of opposite polarity, the collector plates.

The charged particulates gather on the grounded collector plates. Rappers shake loose the agglomerate which falls into the collection hoppers for removal.
Typical ESP bus section with power supply
MAIN MECHANICAL COMPONENTS
ESP Design and Industrial Applications

Tasks

• ESP configuration (series and parallel fields)
• Discharge and collecting electrodes – various types and suitability to the application
• Mechanical design aspects
• Gas flow aspects
• Optimized ESP for high resistivity applications
• Design of ESP for other common applications
• Moving Electrode Concept
• Wet ESP (WESP) for industrial applications
• Achievable emissions level in modern installation.
INTERMEDIATE ROOF BEAM

C.E HANGER BOLT (S45C)

C.S ANVIL BEAM

M16x40L

GAS FLOW

BOTTOM BATTLE SUPPORTING

M16x40L

COLLECTING SURFACE SUSPENSION
(1st FIELD ONLY)
Discharge Electrode Types

- Weighted wire (shrouded)
- Rigid frame (bedspring)
- Rigid frame (strung mast)
- Rigid electrode (Dura-Trode™)
- Pipe & Spike
DISCHARGE ELECTRODES
OTHER DISCHARGE ELECTRODES
Normal Current / Voltage Curves

**kV - mA CHARACTERISTICS AT DALHOUSIE PS**

SPIRAL WIRE DISCHARGE ELECTRODES

**kV - mA CHARACTERISTICS AT INCE PS**

HIGH EMISSION ELECTRODES IN FIRST FIELD

Field 1
Field 2
Field 3
IMPULSE TYPE RAPPER
COLLECTING ELECTRODE IMPULSE RAPPERS
DISCHARGE ELECTRODE IMPULSE RAPPING
COLLECTING ELECTRODE RAPPING
DISCHARGE ELECTRODE RAPPING MECHANISM
RAPPING HAMMERS
<table>
<thead>
<tr>
<th>Description</th>
<th>Impulse Rapping</th>
<th>Hammer Rapping</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Advantage</strong></td>
<td>1. Easy to check &amp; maintenance rapping parts</td>
<td>1. Transport strong rapping force whole of collecting &amp; discharge electrode</td>
</tr>
<tr>
<td></td>
<td>2. changeable rapping force, interval, sequence by Programmable Setting in the</td>
<td>2. Simple electric structure &amp; control panel.</td>
</tr>
<tr>
<td></td>
<td>rapping control panel.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. possible to visual check in operation condition of rapping system</td>
<td>3. Require less space on the top of ESP for insulator &amp; rapping parts</td>
</tr>
<tr>
<td></td>
<td>4. In case of same size of ESP, It has more collecting surface.</td>
<td></td>
</tr>
<tr>
<td><strong>Disadvantage</strong></td>
<td>1. Require bigger space (penthouse) to install &amp; operation rapping system</td>
<td>1. Require installation &amp; operating space for rapping system in the ESP</td>
</tr>
<tr>
<td></td>
<td>2. Require bigger control panel to control each MIGI rapper</td>
<td>2. Hard to set up rapping force, interval, sequence to each Rapping hammer</td>
</tr>
</tbody>
</table>
SUPPORT INSULATORS
DISCHARGE ELECTRODE SUSPENSION

1. COVER PLATE
2. HANGER SUPPORT
3. SUPPORT BUSHING
4. MOUNTING PLATE
5. HANGER BOLT & NUT
GAS DISTRIBUTION PLATES
TRANSFORMER RECTIFIER SET
Achievements with dry ESPs

Trends:

- Guarantees are sometimes 10 mg/Nm³ (dry ESPs)
- Trend is toward 5 mg/Nm³
- Increased emphasis on removal of fine particles (PM 2.5)
- Particulate emissions including condensibles
- Reduced rapping losses
High and Low Resistivity Curves

TYPICAL RESISTIVITY FOR HIGH AND MEDIUM/LOW RESISTIVITY DUST

Fly Ash Resistivity ohm-cms

Gas Temperature ºC
Effect of Resistivity on ESP Size

Process - RESREL

RELATIVE INCREASE IN ESP SIZE FOR VARIATION IN FLY ASH RESISTIVITY
FOR PC FIRED BOILERS

Fly Ash Resistivity ohm-cms

Relative increase in ESP size

0 1 2 3 4 5 6

$10^{10}$ $10^{11}$ $10^{12}$ $10^{13}$ $10^{14}$
Basic Sizing Equations – Deutsch equation

Effy = 1 - \exp\left[-[Wk \cdot A]^{0.5}\right]

Where

- Wk is the Migration Velocity
- A is the Specific Collecting Area (SCA) m²/m³/s.
Factors affecting Sizing & Performance of ESP

- Application
- Gas volume
- Operating temperature
- Inlet gas composition (Mainly moisture content)
- Dust resistivity
- Inlet dust load
- Desired outlet emission
- Dust chemistry
- Power input
- Inlet & outlet ducting
Factors affecting Sizing & Performance of ESP

Exponential impact of flow on dust emission

- Clean gas dust content \( r \) [mg/Nm\(^3\)dry]
- Relative gas flow \( Q \) [%]

Design point

Graph shows the exponential relationship between the clean gas dust content and the relative gas flow.
Factors affecting Sizing & Performance of ESP

Effect of gas temperature on Dust resistivity

- Resistivity (OHM-cm)
- Efficiency (%)

Temperature °C
Factors affecting Sizing & Performance of ESP

More Power input improves the dust emission

\[ kW \sim kV_{avg} \times mA_{avg} \]
Factors affecting Sizing & Performance of ESP

Lower dust load at inlet for lower dust at outlet

- Precollector wall (up to 25% less dust, 2 mbar)
- Precollector cyclone (up to 70% less dust, 10 mbar)
Factors affecting Sizing & Performance of ESP

Conditioning with water improves Efficiency

Potential for improvement

e.g.: 35 g/Nm³ more water (4.4 m³/h for a 2'000 tpd kiln) or 60 °C lower CT exit temp.

Example
Rebuild & Enlarge by Adding Field(s) In-Series
< Additional 1st Field >
Rebuild & Enlarge By Replacing Mechanical Collector, With Added ESP Field In-Series

Field

Before

M.C.  1  2  3

Field

After

1  2  3  4
ESP Enlargement By Increased Height

Increase Typical 10’-12’

Existing

Rebuilt

Existing
### Before

<p>| | | |</p>
<table>
<thead>
<tr>
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### Existing

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### New

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### After

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Rebuild & Enlarge By Adding Parallel Chamber

[KC Cottrell Logo]
ESP Enlargement By Optimizing Plate Length

Existing

- 6'
- 6'
- 6'
- 6'
- 1.5'
- 1.5'
- 1.5'
- 1.0'
- 1.0'

Existing
ESP Enlargement By Optimizing Plate Length

Rebuilt

14' 14'
1.5' 0.5' 0.5'
ESP Enlargement By Optimizing Inter-Plate Distance

Existing

3.5M 3.5M 3.5M

2M 2M

3.5M 3.5M 3.5M

2M 2M
ESP Enlargement By Optimizing Inter-Plate Distance

Rebuilt

4.5M 4.5M 4.5M
0.5M 0.5M
# Indian Utility - Predicted Impact of ESP Rebuild/Enlargement on Particulate Emissions

<table>
<thead>
<tr>
<th>Case</th>
<th>ESP Size</th>
<th>Particulate Emissions, MG/NM3</th>
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</thead>
<tbody>
<tr>
<td>Base</td>
<td>1.0 X</td>
<td>300</td>
</tr>
<tr>
<td>Increase Existing Length</td>
<td>1.2 X</td>
<td>225</td>
</tr>
<tr>
<td>Increase Plate Height</td>
<td>1.3 X</td>
<td>225</td>
</tr>
<tr>
<td>Add One Field-Increase Height</td>
<td>1.6 X</td>
<td>100</td>
</tr>
<tr>
<td>Add Two Fields-Increase Height</td>
<td>1.8 X</td>
<td>70</td>
</tr>
<tr>
<td>Add Parallel Chamber-Increase Height</td>
<td>2.0 X</td>
<td>50</td>
</tr>
<tr>
<td>Add Two Fields-Increase Height</td>
<td>2.3 X</td>
<td>30</td>
</tr>
</tbody>
</table>

Cont.
Reliability Improvements in ESPs During Rebuilds

- Replace wires discharge electrodes with rigid mast type.
- Adding T-Rs reduces % surface loss with any T-R failure.
- Modern high frequency T-Rs maximize power input.
- Modern central controls allow remote operation of ESP.
- Improved gas flow distribution modeling.
### Case Study: 2x210 MW ESP Retrofit in a Power Plant – For Reference

<table>
<thead>
<tr>
<th>Sl.</th>
<th>Description</th>
<th>Unit</th>
<th>Existing ESP</th>
<th>After Renovation</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Existing ESP</td>
<td>New Parallel ESP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Existing ESP</td>
<td>New Parallel ESP</td>
</tr>
<tr>
<td>1</td>
<td>Gas Volume</td>
<td>Am³/sec</td>
<td>370.50</td>
<td>202</td>
</tr>
<tr>
<td>2</td>
<td>Gas Temperature at ESP inlet</td>
<td>°C</td>
<td>146</td>
<td>150</td>
</tr>
<tr>
<td>3</td>
<td>Inlet Dust Burden</td>
<td>g/Nm³</td>
<td>28.30</td>
<td>40.00</td>
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<tr>
<td>4</td>
<td>Outlet Emission</td>
<td>mg/Nm³</td>
<td>90 – 125</td>
<td>28 (after renovation of existing as well new ESP)</td>
</tr>
<tr>
<td>5</td>
<td>Calculated Efficiency</td>
<td>%</td>
<td>99.00</td>
<td>99.03</td>
</tr>
<tr>
<td>7</td>
<td>No. of ESP</td>
<td>Nos.</td>
<td>4</td>
<td>4</td>
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<tr>
<td>9</td>
<td>No. of Field in series</td>
<td>Nos.</td>
<td>5</td>
<td>5</td>
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<tr>
<td>12</td>
<td>Height of Field</td>
<td>m</td>
<td>9.0</td>
<td>9.0</td>
</tr>
<tr>
<td>13</td>
<td>Length of Field</td>
<td>m</td>
<td>3.20</td>
<td>3.20</td>
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<tr>
<td>15</td>
<td>Treatment Time</td>
<td>Sec</td>
<td>17.243</td>
<td>31.64</td>
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<tr>
<td>18</td>
<td>No. of TR sets (Conventional)</td>
<td>Nos.</td>
<td>20</td>
<td>16</td>
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<tr>
<td>19</td>
<td>No. of TR sets (HFTR)</td>
<td>Nos.</td>
<td>--</td>
<td>4</td>
</tr>
<tr>
<td>20</td>
<td>TR Rating</td>
<td>KV(P)/mA</td>
<td>60 / 800</td>
<td>70 / 800</td>
</tr>
</tbody>
</table>
MFTR Case Study 1 - Cement Plant successful trial with demo panel followed installation of actual panel in all 3 fields

Application

Clinker Cooler exhaust with Fly ash Dryer-L3

Operational Field Data Comparison ~ Before and After installation of MFTR ACTUAL Panel in ALL 3 Field

<table>
<thead>
<tr>
<th>Field</th>
<th>Before installing of Demo Panel</th>
<th>After installing Actual Panel</th>
<th>Dust Emission Before Demo Panel</th>
<th>Dust Emission After Actual Panel</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1100 mA/ 80KV</td>
<td>1083 mg/ Nm³</td>
<td>1083 mg/ Nm³</td>
<td>50-75 mg/ Nm³</td>
</tr>
<tr>
<td></td>
<td>mA</td>
<td>mA</td>
<td>mA</td>
<td>mA</td>
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<tr>
<td></td>
<td>KV</td>
<td>KV</td>
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<td>KV</td>
</tr>
<tr>
<td>1</td>
<td>125</td>
<td>402</td>
<td>125</td>
<td>402</td>
</tr>
<tr>
<td>2</td>
<td>250</td>
<td>550</td>
<td>250</td>
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</tr>
<tr>
<td>3</td>
<td>150</td>
<td>705</td>
<td>150</td>
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</tr>
<tr>
<td>3</td>
<td>35</td>
<td>37</td>
<td>35</td>
<td>37</td>
</tr>
</tbody>
</table>

Result

1. Overall mA increase is over 3times with installation of MFTR actual panel as compares to single phase TR, with rapping optimization.

2. Substantial dust emission reduction was > 90%

3. Excessive sparking was taken care with IGBT control system.

4. Actual opacity readings in plant PLC were much lower (25-35mg/nm3). During physical measurement, last field rapping was resulting in momentarily increase in dust emission
### MFTR Case Study II – Power Plant – Demo results (2x 210 MW)

<table>
<thead>
<tr>
<th>Field</th>
<th>Controller Reading</th>
<th>Meter Reading</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>KV</td>
<td>mA</td>
<td>CR</td>
</tr>
<tr>
<td>D1*</td>
<td>50 (35%)</td>
<td>383 (29.8%)</td>
<td>1</td>
</tr>
<tr>
<td>D2</td>
<td>46</td>
<td>264</td>
<td>5</td>
</tr>
<tr>
<td>D3</td>
<td>49</td>
<td>340</td>
<td>5</td>
</tr>
<tr>
<td>D4</td>
<td>33</td>
<td>700</td>
<td>3</td>
</tr>
<tr>
<td>D5</td>
<td>33</td>
<td>272</td>
<td>9</td>
</tr>
<tr>
<td>D6</td>
<td>33</td>
<td>607</td>
<td>9</td>
</tr>
</tbody>
</table>

* Demo Panel

### MFTR

<table>
<thead>
<tr>
<th>Before with Ammonia Dosing</th>
<th>After without Ammonia Dosing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load</td>
<td>176.88 MW</td>
</tr>
<tr>
<td>Coal tons/hour</td>
<td>108.55</td>
</tr>
<tr>
<td>Ammonia Dosing</td>
<td>Yes</td>
</tr>
<tr>
<td>Opacity</td>
<td>60.71</td>
</tr>
</tbody>
</table>

Note: Then we tried effect in opacity with Ammonia Dosing at before & after Comparison for checking the effect of MFPS with Ammonia Dosing also in ESP.
FABRIC FILTERS
Standard Pressure Pulse Jet Bag House
Pulse jet Bag House Cleaning mechanism - ONLINE

- Standard mode (the most common filter and cleaning type)
- No compartmentalization required
- No division walls required and thus dust transport system is simplified
- Can velocity is limiting the filter geometry
Pulse jet Bag House Cleaning mechanism - OFFLINE

- Unusual mode, but good when intensive cleaning required
- Can velocity has no impact on cleaning operation
- On-line maintenance possible (seldom used in kiln filters; safety issue)
- Requires additional inlet dampers
- Allows to shut-off compartment for removal of broken bag
Advantages of High Pressure Pulse Jet Bag House

- Higher Air to Cloth Ratios
- Less Floor Space Required than Reverse Air Bag House System
- Lower Capital Cost
- Proven Cleaning Concept
- Walk-in Plenum Designs
- Integral Cage Handle for ease of Removal
- Quick Removal of Air Distribution Blow Pipes
- Snap Band arrangement for bag fixing
Reverse Air Bag House

Diagram showing the flow of air and gases through the bag house, with labels for Clean air out, Reverse air, Dusty air in, Dirty inlet gases, Reverse air manifold, Reverse air poppet damper, Outlet manifold, Fabric filter bags, Inlet hopper and gas distribution, Tubesheet access level, and Filter bag suspension access level.
Reverse Air Bag House
Reverse Air Bag House

- Reverse air bag house comprises of the following main items
  - Casing with
    - Individual bag compartments
    - Hoppers
    - Inlet & Outlet plenums
    - Damper compartments for outlet & reverse air poppet dampers
- Modules are isolated from each other by means of partition frames
- Compartmentalized construction, allows offline cleaning by reverse air blown into the chambers by means of reverse air fan.
- Gas flows through a gas passage in the central inlet plenum and then into bag compartments located on both sides of plenum, through specially designed hoppers & chutes which prevent dust accumulation.
- Chutes are provided with inlet butterfly dampers which are used to isolate the chamber for maintenance purpose
- Gas enters in the inside of the bags from the hopper, and is cleaned by filtration
Reverse Air Bag House

- Bags are suspended with the help of a bag suspension arrangement consisting of a ‘J’ hook, spring, and clamps. Anti-collapse rings are stitched into the bags at regular intervals throughout the bag length.
- Tubesheet is located near the bottom part of the casing just above the hoppers where thimbles are welded onto the tubesheet for holding the bottom of the bags.
- Walkways provide ease in approach to the internals.
Reverse Air Bag House

- Clean gas from each compartment is collected in a central outlet manifold through outlet damper box & carried to ID fan.
- Outlet dampers provided are pneumatically operated poppet type and are used to isolate each compartment for bag cleaning purpose.
- Lower part of the casing forms Pyramidal type hoppers, from which dust is extracted by means of suitable dust conveying system.
- Dust discharge is through Rotary Airlock valves into the further dust conveying system.
Reverse Air Bag House

Electricals & Instrumentation

Each bag compartment is installed with a ‘U’ tube manometer and a Differential pressure gauge which help indicate the pressure drop across filter bags in individual module.

In addition to these Differential pressure transmitter is installed across the bag house inlet & outlet to measure the overall pressure drop across the bag house.

Hoppers are provided with level sensors to measure the dust accumulation inside.

Hopper heaters are installed on the lower portion of the hoppers to avoid dust agglomeration on hopper walls due to condensation.

Rotary airlock valves are provided with zero speed switches to ensure continuous evacuation of dust from hoppers.

In addition to the above, RTDs are provided at the inlet of the bag house to measure the inlet gas temperature.

Reverse Air fan takes clean air from the bag house outlet and supplies the same to each bag module for cleaning of the bags.
Advantages of RABH

- Low Air-Cloth Ratios
- Proven Design
- Lower Maintenance Requirements
- >4 Years bag life
- Low Pressure Drop- Low Power consumption
- Quick Bag Change
- Lower Bag Abrasion
- No Moving Parts
# Comparison of PJBH and RABH

<table>
<thead>
<tr>
<th>PJBH</th>
<th>RABH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air to cloth ratio 1.0 to 1.4 m/min</td>
<td>Air to cloth ratio 0.4 to 0.6 m/min</td>
</tr>
<tr>
<td>50% less size and requires lower plot plan</td>
<td>Requires high plot plan</td>
</tr>
<tr>
<td>Lower Capital cost</td>
<td>High capital cost</td>
</tr>
<tr>
<td>Relatively high maintenance</td>
<td>Low maintenance</td>
</tr>
<tr>
<td>Suitable for any flow rate</td>
<td>Suitable only for large volumes (&gt; 3,000,000 m³/hr)</td>
</tr>
</tbody>
</table>
De-dusting Bag filters
De-dusting Bag filters
Hybrid filters
Fabric filter is installed behind the 1-2 fields of ESP
Hybrid Filter

- Up to 90% pre-collection of dust in EP part, thus lower bag load
- Electrically charged residual dust forms permeable dust layer resulting in low diff. pressure
- Possibly better for PM of 2.5 μ
- High investment, low operating costs
- Attractive if system fan and EP parts can be reused
- Short CO tripping of ESP part has no big impact on operation
- Both filter parts need maintenance (two systems)
Bag Filter Technologies

Factors affecting selection of fabric

- Gas composition
- Dust composition
- Operating temperature
- Water &/or Acid dew point
- Particle size analysis
- Inlet dust load
- Desired outlet emission
## Bag Filter Technologies

### Types of fabrics available

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Available In</th>
<th>Tensile Strength</th>
<th>Abrasion Resistance</th>
<th>Acid Resistance</th>
<th>Alkali Resistance</th>
<th>Supports Combustion</th>
<th>Max. Operating Temp. °F (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>Woven</td>
<td>Good</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
<td>Yes</td>
<td>180 (82) 200 (93)</td>
</tr>
<tr>
<td>Polypropylene</td>
<td>Woven, Felting</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Yes</td>
<td>170 (77) 200 (93)</td>
</tr>
<tr>
<td>Nylon</td>
<td>Woven</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Poor</td>
<td>Excellent</td>
<td>Yes</td>
<td>200 (93) 250 (121)</td>
</tr>
<tr>
<td>Wool</td>
<td>Woven, Felting</td>
<td>Poor</td>
<td>Fair</td>
<td>Good</td>
<td>Poor</td>
<td>No</td>
<td>200 (93) 230 (110)</td>
</tr>
<tr>
<td>Homopolymer Acrylic</td>
<td>Woven, Felting</td>
<td>Good</td>
<td>Good</td>
<td>Very Good</td>
<td>Fair</td>
<td>Yes</td>
<td>260 (127) 284 (140)</td>
</tr>
<tr>
<td>Copolymer Acrylic</td>
<td>Woven, Felting</td>
<td>Average</td>
<td>Fair</td>
<td>Good</td>
<td>Fair</td>
<td>Yes</td>
<td>230 (110) 248 (120)</td>
</tr>
<tr>
<td>Polyester</td>
<td>Woven, Felting, Knit, Spun Bonded</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Fair</td>
<td>Fair</td>
<td>Yes</td>
<td>275 (135) 300 (149)</td>
</tr>
<tr>
<td>Aramid</td>
<td>Woven, Felting</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Fair</td>
<td>Good</td>
<td>No</td>
<td>375 (191) 425 (218)</td>
</tr>
<tr>
<td>Teflon®</td>
<td>Woven, Felting</td>
<td>Average</td>
<td>Fair</td>
<td>Excellent</td>
<td>Excellent</td>
<td>No</td>
<td>450 (232) 500 (260)</td>
</tr>
<tr>
<td>Fiberglass</td>
<td>Woven, Felting</td>
<td>Excellent</td>
<td>Fair</td>
<td>Good</td>
<td>Fair</td>
<td>No</td>
<td>500 (260) 550 (288)</td>
</tr>
<tr>
<td>Ryton®</td>
<td>Woven, Felting</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Very Good</td>
<td>No</td>
<td>375 (191) 425 (218)</td>
</tr>
<tr>
<td>P-84®</td>
<td>Felted</td>
<td>Very Good</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Very Good</td>
<td>No</td>
<td>500 (260) 550 (288)</td>
</tr>
</tbody>
</table>

*Note: Teflon is a trademark of E. I. DuPont Company*

*Note: Ryton is a trademark of Amoco Fabrics*

*Note: P-84 is a trademark of Lenzing Corporation*
Bag Filter Technologies

Needled felt

- Penetration of fine dust particles into fabric and thus continuously increasing diff. pressure during bag life
- Average: <20 mg/Nm$^3$ dust emission
- Enhancement with PTFE-coating possible
- Life guarantee between 2 y and 4 y
Needled felt with PTFE Lamination

- Slightly higher fabric resistance during first few months
- Negligible dust penetration and negligible dust peaks from cleaning pulses
- Average: < 10 mg/Nm³
- Careful installation required
- High gas velocities can cause bag damage more easily
- Life guarantee from 4 y to 4 y + 2 y pro rata
Questions / Remarks ?