Odor Control using Cold Plasma

For industrial and commercial scale applications

Uses electricity to destroy odors.

by: Doug Lanz
Air Phaser Environmental Ltd. (BC, Canada)
• There are about 300 Cold Plasma systems installed worldwide
• Majority of them in Europe
• With some installed in:
  • China
  • South America
  • Asia
• and just a few in North America
Industrial Applications

- Municipal Solid Waste (MSW), Sludge waste
- Aqua feed, Animal feed, Pet feeds
- Human foods, meat packing, disposals
- Tobacco industry
- Oil seed processing
- Rubber tire production
- Other applications
- Future: Paint emissions, industrial VOC’s
Industrial Application Characteristics

- Air volumes from 5,000 to over 100,000 m³/hr
- Air can be:
  - Moist to point of condensing
  - Have entrained dust
  - Have aerosol oils
  - Highly odorous
  - Wide temperature range, from 0°C to nearly 100°C

Two major types of Cold Plasma systems in Industry
Pulsed or DC Corona

- Corona Discharge method applies high voltage via thin metal wire coaxially located in tube
- Not unlike electrostatic precipitator or electronic air cleaner in furnace.
- It is strongly affected by the conductivity of the air passing through the tube.
- Tubes are usually large, 2 or 3 meters in length and 400mm diameter, so a group of them will need large enclosures.
- Last photo was this type.
Corona System G.A.
Parallel Corona Systems
Silent Discharge Plasma (SDP) or Dielectric-Barrier Discharge Fundamentals

Illustration of SDP Reactor

- Dielectric-Barrier Discharge (DBD) invented by W. von Siemens in 1857
- Referred to as Silent Electrical Discharge by Andrews & Tait, 1860
- Used for over 150 years to produce ozone
- Is a non-thermal plasma (electrons are ‘hot’, while ions & neutrals are ‘cold’)

Illustration of Microdischarge

Microdischarge Properties

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel radius</td>
<td>( r )</td>
</tr>
<tr>
<td>Microdischarge duration</td>
<td>( t_d )</td>
</tr>
<tr>
<td>Electron density</td>
<td>( [e] )</td>
</tr>
<tr>
<td>Reduced electric field</td>
<td>( E/N )</td>
</tr>
<tr>
<td>Average electron temperature</td>
<td>( T_e )</td>
</tr>
<tr>
<td>Current density</td>
<td>( J )</td>
</tr>
<tr>
<td>Electron drift velocity</td>
<td>( v_d )</td>
</tr>
</tbody>
</table>

Typical values:
- \( r \sim 100 \, \text{um} \)
- \( t_d \sim 2-3 \, \text{ns} \)
- \( [e] \sim 10^{14} \, \text{cm}^{-3} \)
- \( E/N \sim 100-200 \, \text{Td (or 10^{-17} \text{V-cm}^2)} \)
- \( T_e \sim 4-5 \, \text{eV} \)
- \( J \sim 1 \, \text{kA/cm}^2 \)
- \( v_d \sim 2 \times 10^6 \, \text{cm/sec} \)
Non-Thermal Plasma: Dielectric Barrier Discharge

- Only electrons are ‘hot’.
- Gas can be passed through discharge resulting in treatment.
- Gas remains relatively cool, hence the common term of ‘cold plasma’. Similar to a neon sign.
- Active species for oxidation include $N_2^+$, $O_2^+$, $N\cdot$, $O\cdot$, $\cdot OH$, $\cdot O_2 H$, and $O_3$. 

Electron Avalanches Charge Dielectric Surface (No Conduction Path Due to Dielectric)

Individual Micro-Arcs Are Quenched (Non-Thermal Plasma)
Dielectric Barrier Discharge (DBD)
Dielectric Barrier Systems (DBD)

- DBD systems can be very compact
- Plasma fields viewed through the two windows
- This DBD system is from Canadian company
DBD System from European Company
Parallel DBD Systems
Sizing A Cold Plasma System

• Example: MSW tipping floor needs 0.6 watts / cubic meter / hr. (pilot test)
• Building space volume: 10,000 m³.
• 6 air changes / hr = 60,000 m³/hr
• 60000 m³/hr * 0.6 watts = 36kW watts
Sizing – Corona System

Corona Unit Specs:

• Air flow maximum: < 20,000 m³/hr
• Power maximum: 15 kW

Design requirement: 36 kW, 60,000 m³/hr
• Conclusion: 4 units needed due to air flow maximum limits.
Sizing – DBD System

DBD Unit Specs:
• Air flow maximum: < 4,000 m³/hr
• Power maximum: 15 kW

Design requirement: 36 kW, 60,000 m³/hr
• Conclusion: 3 units needed to match kW requirements. Configure as an injection system
All air duct modules to be bolted together using M12 fasteners, washers, and nuts.

Activated clean air

Main air flow
Dirty air to be treated

Treated air
Cold Plasma Injection System
Cost Savings

• The plasma field for 20,000 cfm uses ~ 25 to 30 kW, far less power than a biofilter fan.

• 30kW * $0.07 * 24 hrs * 365 days = $18,396

• Variable power levels, automatic feedback adjusts plasma levels to match odor load at any given time and conditions.

• Results in optimal use of electricity.
DBD project: 100,000 cubic ft air/min
Technical Advantages

- Proven technology that treats all gaseous compound emissions and transform to harmless state
  - IPPC BAT Reference Document for Food, Drink, and Milk Industries: 75-96% reduction in emissions depending upon design, process conditions, odour characteristics
  - Results from fish meal production facilities: Inlet–16,000 OU/m³  Outlet–1600 – 3200 OU/m³ or 80 – 90% effective
Cold Plasma Features

- Uses only electricity (renewable resource).
- Replaces older tech that uses:
  - Fossil fuels to burn odor (carbon savings).
  - Chemicals to react with odor (disposal issue).
- Lower energy use than bio-filter I.D fan.
- Cold Plasma intensity (energy usage) can be optimized to respond to varying process conditions automatically.
- Can be used as secondary treatment to existing, non-optimal systems
Air Phaser Environmental Ltd.

Odor treatment using Non-Thermal Plasma
(Cold Plasma)
for industrial and commercial scale applications.

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