LEV Integrated with Mechanical Covers to Achieve Energy Savings

Exhaust Systems for Open Surface Tanks

Art Brooks - KCH Engineered Systems

KCH Engineered Systems
Pollution Control Exhaust Systems
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Chemical Process Tanks

- Anodizing (Sulfuric Acid)
- Electropolishing (Sulfuric/Phosphoric)
- Electrocleaning (Sodium Hydroxide)
- Brightening (Nitric/Phosphoric)
- Precleaning (Sodium Hydroxide)
- Etching (Nitric/HF)
- Electroplating (Copper, Nickel, Chrome, etc.)
Proper exhaust rates for Open Surface Tanks can vary

50 CFM/ft² -- 250 CFM/ft²
Factors affecting chemical emissions in process tanks.

- Type of process solution.
- Concentration of chemicals in the tank.
- Amount of exposed surface area to open air.
- Electrification of the solution in the tank.
- Operating temperature
- Vapor Pressure of the liquid
- Part agitation (air v/s eductor)
20,000 AMPS
DIRECT CURRENT
Method for control:

LOCAL EXHAUST VENTILATION
Mechanical Tank covers

- Trash Can Covers and Coffee Cup Lids.
- The substances evaporate from the surface of the tank, then condense on the inside of the cover, and eventually drip back into the tank.
Advantages of a Covered Tank

- Reduce overall exhaust requirements
- Reduces fugitive emissions
- Reduces heat loss and evaporation rates
- Reduces energy consumption
- Reduces calculated surface area for exhaust rates.
Tank Cover Design

- Must NOT be removable.
  - Employees will permanently leave them off.

- Mechanical Operation
  - Single Hinged, Double Hinged or Double Covers
  - Actuators for movement

- Movement Control
  - Manual Push Button
  - Automatic

- Material Selection
  - Stainless Steel
  - Polypropylene
LATERAL EXHAUST HOODS DESIGNED TO BE LOW PROFILE
Utilities routed below rim of tank
Integrating covers with the exhaust system

- Limit switches are installed to indicate whether the covers are in the complete up or down position.
- PLC control to direct operation and interlock with fan or damper controls.
- Exhaust rate adjustment based on position of the covers.
Principle of automatic covered tank ventilation
Local Exhaust Ventilation

- Reduces Fugitive Emissions.
- Must be properly designed per the ACGIH Industrial Ventilation manual (25th Edition)
- Lateral hoods v/s Upright Hoods.
- Push – Pull, Pull – Pull
- Slot Velocities
Methods to adjust exhaust rate

- **Relief Dampers**
  - Ensure Proper Velocity in control device
  - Can suck in dirt
  - Make up air requirement remains the same

- **Internal Volume Dampers**
  - Reduces potential for dust.
  - Increases load on the fan
Best Method to adjust exhaust rate

- Using a VFD controlled Exhaust Fan.
  - VFD adjusts RPM
  - Directed by PLC and cover position.
  - Minimizes tempered Make up air requirements.
  - Reduces energy consumption
  - Optimum for automatic lines.
Variable Frequency Drives to achieve Energy Savings

- VFDs used with a PLC to ramp the system up and down, based on cover position.
- Adjust the Hertz and RPM of the motor.
- More affordable due to maturing technology
- Many tanks are only accessed a few times daily.
- Exhaust Requirements for cover tanks are much lower.
Covers integrated with LEV
Case Study of Energy Savings

- EPA – Environmental Technology Verification Program (ETV)
- Evaluated a Chemical Etch Line utilizing mechanical covers
- Compared operational cost to traditional line without covered tanks
- $62,978 annual operational cost savings

http://www.epa.gov/etv/verifications/vcenter6-12.htm
Standard Design bhp:

50,120 CFM = 62 hp (all six tank covers open)
Ventilation fan motor is not available in 62 hp. The next size up is a 75–hp motor.
The 75 hp is used as the baseline for the calculations.

KCH Design:

17,612 CFM = 26 hp (one tank cover open, five closed)
Ventilation fan motor is not available in 26 hp. The next size up, 30 hp, is used in the calculations for the system verified.
KCH Design:

The design yields a reduction of 45 hp for the fan, based on the 75-hp motor and 30 hp- motor.

To estimate the amount of energy saved, it is necessary to estimate the amount of time the fan runs. The fan is kept running 24 hrs a day/7 days per week.

The amount of energy savings (ES) for the fan is calculated by using the equation $ES = \text{power} \times \text{time}$. 
Annual Energy Savings Calculation for Fan:

\[ ES_{\text{fan}} = \frac{45 \text{ hp} \times 0.746 \text{ kW} \times 24 \text{ hr} \times 365 \text{ days}}{\text{hp} \times \text{day} \times \text{year}} = 294,073 \text{ kWh/year} \]

Annual Cost Savings Calculation for Fan:

The amount of annual cost savings (CS) for the fan is calculated by using the equation \( CS_{\text{fan}} = ES_{\text{fan}} \times \text{electricity cost} \).

\[ CS_{\text{fan}} = \frac{294,073 \text{ kWh} \times $0.044}{\text{year} \times \text{kWh}} = $12,939/\text{year} \]

Therefore, the estimated energy savings associated with use of the smaller fan is 294,073 kWh/year and estimated cost savings is $12,939/year.
Reduction in Scrubber Size

As the scrubber decreases in size, due to lower ventilation throughput, the amount of water recirculated over the scrubber packing surface decreases as well. A 50,000 CFM scrubber would require a 10-hp pump motor; a reduction of 5-hp is anticipated based on a reduced ventilation throughout anticipated. This water rate can be achieved with a 5-hp motor used to drive the scrubber pump.

If traditional processing is installed containing no lids, the ventilation flow rate is increase to just over 50,000 CFM. At a flow of 300 gpm, a 10-hp motor is required for the pump to maintain this flow rate.
### Annual Energy Savings Calculation for Scrubber Pump Motor:

\[
\text{ES}_{\text{scrubber}} = \frac{5 \text{ hp} \times 0.746 \text{ kW} \times 24 \text{ hr} \times 365 \text{ days}}{\text{hp} \times \text{day} \times \text{year}} = 32,675 \text{ kWh/year}
\]

### Annual Cost Savings Calculation for Scrubber Pump Motor:

The amount of annual CS for the scrubber pump motor is calculated by using the equation \(\text{CS}_{\text{fan}} = \text{ES}_{\text{fan}} \times \text{electricity cost}\).

\[
\text{CS}_{\text{scrubber}} = \frac{32,675 \text{ kWh} \times $0.044}{\text{ year} \times \text{kWh}} = $1,438/\text{year}
\]

The estimated energy savings associated with the use of a smaller pump motor is 32,675 kWh/year and the estimated cost savings is $1,438/year.
Heating and Ventilation (HV) Cost Savings

The facility is climate-controlled to maintain uniform process conditions and uniform working conditions for employees. This requires that any air drawn in for makeup air must be tempered during the year.

One way to estimate annual cost data for tempering of air is shown in the following formula:

\[
CS_{HV} = \frac{0.154 (Q) (dg) (T) (c)}{q}
\]

Where:

- \(CS_{HV}\) = Annual Cost Savings \$/year
- \(Q\) = Airflow Rate \(18,150\) CFM
- \(dg\) = Annual Degree Days \(3,895\) days
- \(T\) = Operating Time \(168\) hr/wk
- \(c\) = Cost of Fuel, \$/unit \$0.00978/ft\(^3\)
- \(q\) = Available Heat/Unit of Fuel \(1,000\) BTU/ft\(^3\)
For a process system with the lid-closing capability that the KCH ACTSWC technology provides, the cost for tempering air would be:

\[
CS_{HV} = \frac{0.154 \times (18,150) \times (3,895) \times (168) \times ($0.00978)}{1,000 \text{ BTU/ft}^3} = $17,888/\text{year}
\]

For a process system without the lid closing capability that the KCH ACTSEC technology provides, the cost for tempering air would be:

\[
CS_{HV} = \frac{0.154 \times (50,120) \times (3895) \times (168) \times ($0.11978)}{1,000 \text{ BTU/ft}^3} = $49,396/\text{year}
\]

The yearly cost savings associated with tempering of the air of the KCH ACTSEC technology is $49,395 - $17,888 = $31,507.

Annual Energy Savings \(ES_{temper}\) can be calculated, using a unit cost to produce one kWh of electricity:

\[
ES_{temper} = \frac{$31,507}{$0.044/\text{kWh}}
\]

The \(ES_{temper}\) is 716,068 kWh.
Table I: Cost Comparisons of Covered and Uncovered Tanks

<table>
<thead>
<tr>
<th>Items</th>
<th>Operational Cost (with Covers)</th>
<th>Operational Cost (without Covers)</th>
<th>Operational Cost Savings Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exhaust fan motor</td>
<td>$8,626</td>
<td>$21,565</td>
<td>$12,939</td>
</tr>
<tr>
<td>Scrubber pump motor</td>
<td>$1,438</td>
<td>$2,875</td>
<td>$1,438</td>
</tr>
<tr>
<td>Tempered makeup maintenance</td>
<td>$17,888</td>
<td>$49,395</td>
<td>$31,507</td>
</tr>
<tr>
<td>Operational and maintenance</td>
<td>$8,547</td>
<td>$25,641</td>
<td>$17,094</td>
</tr>
<tr>
<td>Totals</td>
<td>$36,499</td>
<td>$99,476</td>
<td>$62,978</td>
</tr>
</tbody>
</table>
GLOBAL POLLUTION

- Coal fired electrical production is 35% - 40% efficient
- Reduced fan and pump HP = 326,748 kWh/Year
- 663,298 lbs. of CO$_2$ would be produced
- Total CO$_2$ Not Emitted =869 Tons