Diagnosing Performance Problems of Air-Cooled Exchangers

Air-cooled **exchangers** generally operate for a longer period of time between maintenance intervals than do shell and tube ***exchangers***. However, performance problems do arise.

Below are listed, in order of frequency, common causes of impairment, ways to detect them, and their remedies:

I: Fouling of Extended Surface: Airborne contaminants accumulate on and between the fins of air-cooled exchangers. Contaminants include, but are not limited to dirt, lint, insects, and overspray from nearby painting / sandblasting operations.

Impairment occurs due to reduced airflow across the tube bundle.

Note: The practice of spraying water on air-cooled exchanger extended surface to increase capacity during maximum ambient conditions, in addition to accelerating corrosion, generally leads to deposition of external foulants. These foulants cannot be removed without damaging extended surface.

DETECTION: Inspect bundles from underneath. Finned tubes of induced draft units are in plain view. View finned tubes of forced draft units through the fan ring.
REMEDY: Most foulants can be removed by water wash of extended surface when unit is off line. Detergent may be required to removed corrosion from aluminum fins. Notes of caution on washing:

Water wash should generally be avoided while the unit is in service. Most Air-cooled exchangers are hot enough that thermal shock, and consequent roll leaks could result.
Water blasting should not be used. Aluminum fins are easily bent.

Apply water spray in a plane parallel to the fins only, to avoid bending. Exercise extreme caution in washing serrated-type fins. Serrated fins are formed, and thus it is not possible to maintain spray in a parallel plane.

II: Drive-belt slippage: Most air-cooled exchangers utilize belts as fan drives. Multiple “V”–belts are the most common. Slippage of these belts will lower fan RPM, and severely limit airflow across the tube bundle.

DETECTION / REMEDY:

Most slipping belts will emit a screeching sound, readily noticeable to personnel walking under the fan. Slippage accompanied by screeching can usually be remedied by tightening or replacing the belt.

Slippage due to a severely worn sheave will frequently not be accompanied by screeching. Extreme sheave wear allows the belt to ride against the bottom of the sheave. Inspect for this condition by measuring fan RPM with a strobe tachometer. Compare actual RPM to design RPM on Manufacturer’s Data Sheet.

Remedy for this type of slippage generally requires replacement of the entire drive.
III: Incorrect Fan Blade Pitch: Fans on process Air-cooled exchangers of five feet or greater diameter generally are specified to have adjustable-pitch blades. Most units are pre-assembled at the vendor’s shop, with the pitch preset.

Except in the case of automatic variable pitch fans, blades must be set so that under summer ambient conditions, motor horsepower draw is less than nameplate. If motors were loaded to nameplate at summer ambient, they would be overloaded during winter.

The above is necessary since as a constant velocity machine, a fan will move the same volume of air regardless of air temperature and, consequently, density. An identical volume of cold air weighs more than hot, and its movement will result in more work done, and more horsepower expanded. If fans have been pitched back during winter, they may deliver insufficient airflow during the summer.

DETECTION: Motor amperage draw during design ambient conditions should correspond with fan horsepower stated on the Manufacture’s Data Sheet. Design ambient is located on this document also.

Note: Low amperage draw may be due to belt slippage, as well as too little pitch.
REMEDY: Use Fan Manufacturer’s Curve to determine correct pitch. Prior to setting pitch, consult Manufacturer’s instructions. Improper torquing of blade clamp bolts, etc. can cause the fan to fail violently.

NOTE: Avoid overpitching fans. When operated beyond maximum design pitch angle, the fan will “stall”, and deliver a smaller volume of air.

IV: Cooled Air Bypass/ Hot-Air Recirculation: Thermal design of air-cooled exchangers is performed on the assumption that all the air delivered by the fan(s) will cross the extended surface of the unit. A second assumption is that, once heated by the process, air will be directed upward and away from the unit, and not pulled back into it.

Units are constructed with seals to keep air from bypassing the extended surface. These seals may loosen over time due to vibration, corrode away, or be removed during maintenance and misplaced. Corrosion of plenum bottom panels is another common cause of cold-air bypass. Hot-air recirculation (air being sucked back into the unit), occurs when multiple units are fairly near to one another, but gaps are existing between units.

Recirculation also occurs when the wind is parallel to a bank of units. ***Exchangers*** are usually placed so that the bank is not parallel to the prevailing wind.

A third cause of recirculation is blockage of wind by structures immediately downwind of the unit.

DETECTION/REMEDY: Conditions leading to cold air bypass are readily discernable through visual inspection, either from beneath, from header ends, or in the case of induced-draft units, down through the fan rings. Tighten or replace structural components.

Inspect for recirculation by walking under the unit on motor servicing walkways. Significant recirculation will be evidenced by a noticeable increase in air temperature.

Recirculation can frequently be controlled by wind walls and air seals between units.
V: Deteriorated or Bent Extended Surface: Extended surface of process air-cooled exchangers usually consists of helically wound, aluminum fins, 5/8" high, 0.016" thick, and from eight to ten fins per inch. This surface is easily bent, and prone to corrosion when subjected to acid atmospheres (not uncommon when units are located downstream of a stack, in a humid environment).

Additionally, aluminum fins can lose contact with the process tube if upset conditions push them beyond their temperature limit. This **temperature** frequently is considerably less than the ASME Code design temperature. Thermal blanketing occurs when the process tube corrodes under the fins. This condition is generally not a problem, unless the unit has been out of service for a long period, in a humid environment.

A last but not uncommon problem is bent fins. This can be due to foot traffic on the upper row; or incorrect washing technique, top or bottom row.

DETECTION: With exception of thermal blanketing, these conditions are discernable through visual inspection.
CORROSION: Bottom-row fins are most prone to dewpoint corrosion, since they see the coolest air. Fins will have a notched appearance, and frequently flake off when touched. It is possible for bottom-row fins to be corroded away completely, and top-row fins to appear as new.

DAMAGE DUE TO EXCESSIVE TUBEWALL TEMPERATURE: Top row fins are most susceptible to this impairment. Fins will exhibit a cupped and laid over appearance. The degree of cupping and bending will usually not be uniform.
THERMAL BLANKETING: This condition is not readily discernible through visual inspection. Should no other impairments be obvious, and considerable under-fin corrosion is evident, blanketing may be suspected.

A full-scale performance test, coupled with computer simulation of actual unit operation is required to verify it.
BENT FINS: Fins will be laid over rather uniformly in certain areas of the bundle.
REMEDY: Bending is the only condition that can be remedied without at least partially retubing the exchanger.
VI: Internal Fouling/Excessive Plugging: Product or foreign matter can accumulate in any tubular exchanger. Likewise, as individual tubes are sealed off due to leakage, **heat transfer** surface is reduced.

Fouling and plugging is not always uniform, and depending on the pass arrangement, the effect on heat transfer may be greater than the percentile reduction in surface.

DETECTION: Except in the case of a material with an extremely low heat transfer coefficient, where a very thin solid layer on the tube wall would impede performance, fouling will be accompanied by an increase in pressure drop. Plugged tubes will always cause increased pressure drop.
REMEDY: Most **air cooler** bundles have plug-type or cover plate headers, with straight tubes; and thus can be readily freed of internal foulants.

In the case of sealed-off tubes, if enough are out of service to cause the unit to be short, at least a partial retube is needed.
VII: Change in Process Conditions: Over time, feed rates, process fluid properties, inlet temperature, or inlet pressure may be changed. Since operating personnel are periodically reassigned, retire, or change jobs, employees who observed the unit when it was new may be long gone.

When confronted with the statement "This exchanger never worked", check to see that existing conditions are similar to design conditions prior to embarking on extensive research.

Tags: Air-Cooled Exchangers, exchangers, temperature