Get to the Heart of Fan Problems

By Bill Howarth, Hartzell Fan

Fans are used in many heating and drying processes. They are the pumps that circulate the heat through the system, carry away the byproducts of drying, supply combustion air, cool the product and even move the product through the system. Fan uses are many, and a fan problem can greatly reduce a process's efficiency.

Identifying the cause of a fan problem can be difficult due to the wide range of fans and applications as well as the operating points for fans. Fan problems generally fall into two categories: mechanical or air-performance problems. Mechanical problems are similar to those encountered on other rotating equipment and can be identified readily by most maintenance personnel. Mechanical problems include V-belt drive looseness, motor problems, shaft and bearing problems, hitting and rubbing, vibration and other similar mechanical problems not related to air performance. While mechanical problems are serious, their causes and solutions usually are straightforward.

Air-performance problems relate to the airflow produced by the fan. They usually occur at system commissioning, after changes to the process or after maintenance procedures. Most air-performance problems are identified shortly after the equipment is started or restarted. The problems vary from system to system, but one example is the filters becoming dirty and clogged.

Air-performance problems also can develop slowly over time. One example I am familiar with occurred in a sand-drying oven at a casting facility. One day the drying oven was not working at all. When the maintenance personnel opened the oven to troubleshoot it, they found the fan wheel sitting on the bottom of the oven. Over a period of years, the sand eroded the fan wheel. The air-performance change had been so slow that the performance degradation and loss of efficiency were not recognized. Eventually, the fan wheel's backplate eroded to the point where it could no longer support the rest of the wheel, and it failed. The blades were eroded halfway back and sharpened to razor-like edges.

Identifying an Air-Performance Problem

Figure 1. Axial fans usually are used in systems with less than 4" static pressure.

When a process is designed, a flow rate is established along with an expected resistance to flow. This "system" is used to select a fan from manufacturers' ratings. In fan systems, the flow rate usually is described in terms of cubic feet per minute (cfm) and resistance to flow in inches of water gauge or inches of static pressure. The fan is specified and selected to achieve the desired flow rate (cfm) given the system's resistance (static pressure). The relationship between flow rate (cfm) and static pressure, along with other factors, will determine the type of fan. Generally speaking, axial fans are used for lower pressure processes with less than 4" static pressure (figure 1). Centrifugal fans are used for higher pressures (figure 2). Fans should be specified as certified to bear the Air Movement and Control Association (AMCA) seal for air performance (figure 3). This will ensure that the air-performance ratings provided by the fan manufacturer are checked by an independent organization and calculated accurately.

Establishing a flow rate is a straightforward process. Estimating or calculating an expected resistance to flow is much more complex. Oversimplification of a system often results in a miscalculation of system resistance. Errors in the calculation of system resistance often are the cause of air-performance problems. When the fan is placed in a process, it will deliver as much flow as possible through the system, based on its performance curve. In other words, fans are load-matching devices: they will produce flow through the system, but the actual system resistance will determine if the flow is at the desired rate.

Overestimating the system resistance results in the fan providing more flow than is required. In some systems, this may be desirable, allowing for higher processing rates. In other systems, this condition upsets the process and a damper must be closed -- in essence, putting the brakes on the flow -- to reduce the flow rate to the desired level. While a quick fix, closing a damper on an overproductive fan uses more energy than adjusting the fan to produce the desired flow rate.

Figure 2. Centrifugal fans typically are installed on higher pressure systems such as this steam process air heater with inlet silencer and filters.

Underestimating the system resistance results in the fan not providing the desired flow rate. This may cause the process to fail or operate at lower rates. The fan also could go into an unstable region of the fan's characteristic performance curve. When a fan operates in this region of its performance curve, air performance cycles up and down, and the fan produces additional noise and turbulence.

Symptoms of an Air-Performance Problem

Figure 3. The AMCA seal for air performance tells fan buyers that ratings are checked by an independent organization.

An air-performance problem first must be identified before it can be solved. Many processes operate satisfactorily with a wide range of flow rates. It usually takes production problems before a system flow rate is investigated. The symptoms of airflow problems and some mechanical problems are similar, and a mechanical problem should be eliminated before an air-performance problem is investigated. Some symptoms of air-performance problems are:

- Lower or higher than expected flow rate.
- Unstable or fluctuating airflow rates.
- Lower or higher than expected static pressure.
- Lower or higher than expected motor amperage draw.
- Noise or vibration.

Once it is established that an air-performance problem exists, some basic inspections should be made:

- The system should be inspected against the design drawings to ensure it was built to specification.
- The position of dampers and slides should be checked.
- A visual inspection of the blades in each damper should be made.
- An operational check of dampers and other system controls should be conducted.
- The operating direction and installation of the fan should be checked. An axial fan installed backward and turning backward will move air in the desired direction, but flow and pressure will be reduced. A centrifugal fan operating in reverse also will move some air through the system in the desired direction.
- The ductwork, inlets and outlets should be inspected for obstructions.
- Filters and burners should be checked for plugging.
- Components around the fan -- elbows on inlets or discharges of fans, walls near fan inlets, cones on discharges of fans, etc. -- that could adversely affect fan

performance should be inspected.

If these inspections do not identify the source of the problem, a test of the fan and system is in order. Field-performance tests are an important tool in the identification of an air-performance problem. To accomplish a full test, you will need to measure several characteristics of the fan's performance in the system:

- Fan flow rate.
- Static pressure at the fan inlet.
- Static pressure at the fan outlet.
- Fan amperage draw and motor rating.
- Density of the air going through the fan.
- Operating speed of the fan.

AMCA Publication 203, "Field Performance Measurements of Fan Systems," available as part of the Fan Application Manual, is an excellent reference to use for performance testing. It includes recommendations, procedures, calculations and several examples of fan performance tests.

Figure 4. Fan performance testing helps determine the source of a problem. In one case, a combustion air blower (shown here without the inlet silencer) was not providing the required flow. Testing and an investigation revealed debris on a guard installed between the silencer and fan. The debris was cleared, and performance returned to normal.

In addition, the pressures at the inlet and outlet of the fan should be compared to the expected design values. If the inlet or outlet pressure is out of line, that side of the system should be inspected in more detail to identify and remove the cause.

Take the case of a combustion air blower with an inlet filter and silencer (figure 4). At startup, the fan was not providing the required flow. The static pressure was measured on the inlet and discharge of the fan. All of the pressure drop for the system was on the inlet side, but the inlet static pressure should have been low, with only a new, clean filter and silencer on the inlet side of the fan. An investigation of the inlet side revealed debris on a guard installed between the silencer and fan. The inlet side was cleared, and performance returned to normal.

Using the Test Data

Once a performance test is completed, a fan characteristic performance curve should be obtained from the fan manufacturer (figure 5). The performance curve should show the same speed and gas density as the tested fan's speed and density. If the fan speed or gas density is not per the design requirements used during fan selection, this often

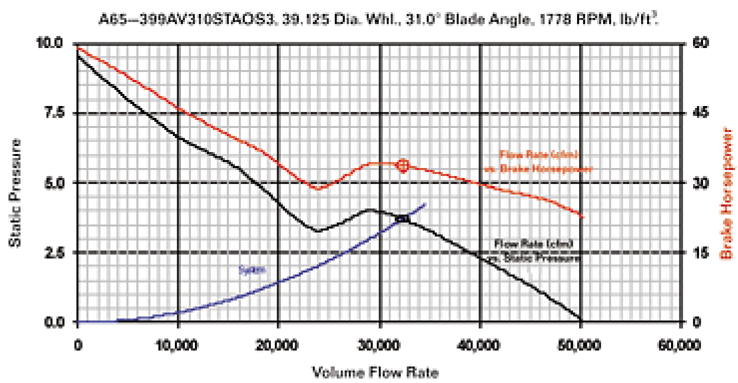

Figure 5. The fan manufacturer can provide a fan performance curve, which shows the expected fan flow and pressure at speed and density, as well as the required horsepower.

is the cause of the problem.

The specified flow and pressure point should be plotted on the fan manufacturer's fan curve. If this point does not fall on the curve, the fan selection is incorrect. A fan speed change might be able to fix this problem.

The test-measured performance also should be plotted on the fan manufacturer's fan curve. The tested point should fall on or near the manufacturer's curve. The uncertainty of field-performance testing should be taken into consideration when determining if the point is near or on the fan manufacturer's curve. However, the test-measured point should not be above the fan manufacturer's curve. This indicates an error in the test or the fan manufacturer's curve, and further investigation is indicated.

If the tested point does not fall on the manufacturer's curve, it should fall below it. This is a symptom of a "system effect." System effects are losses in fan performance due to system components (usually located near the inlet or discharge of the fan) that reduce the fan's performance capability. Reorienting the ductwork or installing vanes within the ductwork can eliminate or reduce most system effects.

If the tested point falls on the manufacturer's curve, the difference in flow rate at the tested point and the desired point, as a percentage, represents the speed change required to achieve the desired flow rate. Changing the speed of the fan usually is not a good choice to increase flow rate. Increases in fan speed require a significant power increase. Noise also will increase with a speed increase. A better remedy to this problem is reducing the system resistance.

If the flow rate is greater than desired, a reduction in speed is a good choice. It will save energy, reduce noise and reduce maintenance requirements. Regardless, check with the fan manufacturer before changing the speed of any fan.

Fans often are the heart of process heating equipment, pumping the air through dryers, burners, exhausters and pollution control equipment. Just like a human heart, their operation directly affects production. Careful calculation of the system resistance, combined with proper fan selection and installation, will reduce the occurrence of air-performance problems. Having a basic understanding of how to investigate air-performance problems will speed the correction of problems and improve process reliability.