How to Select a Cooling Fan

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Introduction

In most manufacturing operations of parts and components, or their subsequent assemblies, the dissipation of heat is a major consideration. Heat buildup can result in reduced performance of equipment and processes, in premature deterioration of components and lubricants, and can raise safety considerations for operating personnel and end users. Cooling fans are often used to dissipate heat buildup. When selecting the right fan for any operation, a thorough selection process is critical to their successful operation and ultimate ability to deal with heat. The first step in this process is a thermal analysis.

Thermal Analysis

The point of a thermal analysis is to determine the amount of heat generated inside a piece of equipment or during a process so the volume of air required to cool a system can be computed.

Temperature, thermal resistance, and heat dissipation will all help to dictate the airflow that is necessary to cool the system. This process is begun by investigating the origin of the heat and measuring the amount of heat emanating from each source using sensors and other devices. Surface temperatures are typically measured using one or a combination of six different types of sensors: thermocouples, resistive temperature devices, infrared radiator or sensors, bimetallic devices, fluid or liquid expansion devices, and change-of-state sensors. Data delivered from these sensors can indicate where heat problems exist while helping to map the necessary airflow to provide cooling.

Thermocouples consist of two strips or wires made of different metals and joined at one end. Changes in the temperature at the juncture of the two wires or strips induce a change in electromotive force between the other ends. The electromotive force rises as temperatures increase.

Resistive temperature devices use a process whereby the change in electrical resistance of a material is measured as temperatures rise. There are two basic types of resistive temperature devices: Metallic devices (RTDs) rely on resistance change in a metal. Thermistors note the resistance change in a ceramic semiconductor.

Infrared radiators or sensors are non-contacting devices. They are able to gauge temperatures by measuring the thermal radiation given off by a material.

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Bimetallic devices measure temperatures by noting the difference in the rate of thermal expansion between two different strips of metal.

Fluid-expansion or liquid expansion devices are available in two forms—mercury and organic-liquid—and function like the common household thermometer.

Change-of-state temperature sensors include a material—usually liquid crystals, pellets, crayons, or lacquers—whose appearances will change when surface temperatures reach a certain level.

Most of these devices have their pluses and minuses. Some are not as accurate as others; some are portable while others are stationary; some do not require power; others do not generate data that can be easily recorded or transmitted; some will not respond to transient temperature changes; and recordings on some cannot be reversed.

It is important that this initial measurement includes the heat sources' typical and worst case heat dissipation scenarios. Armed with this information, the amount of airflow required is then calculated. Once the amount of airflow is determined, the cooling air path is mapped using sensors and software to ensure that all major sources of heat receive the air required to adequately cool them.

System Impedance

The next step in the cooling fan selection process is to determine the system impedance. As air travels between fan inlet vents and exhaust vents, the air pressure will drop. System impedance is simply the sum of this pressure drop. In the event of multiple air paths, individual impedances are totaled. Alternatively, air chambers can be used to create a model system to make these impedance calculations. Once system impedance as well as overall airflow requirements has been identified, the system's static pressure at the required airflow can be gauged.

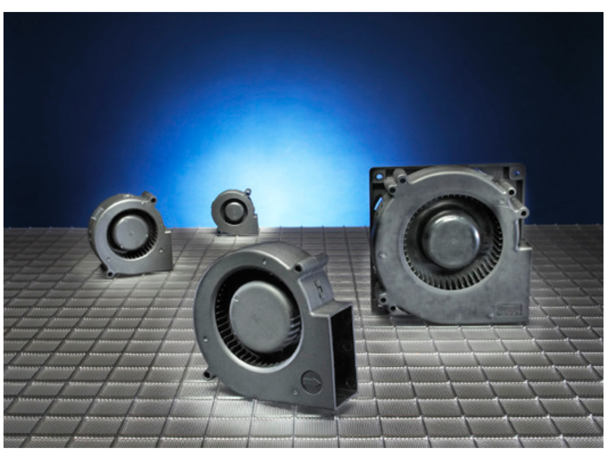
Fan or Blower?

Once these critical data points have been calculated, it is time to decide what equipment will deliver the best solution: a fan or a blower. Fans and blowers differ primarily in their flow and pressure characteristics. Fans, which tend to work against low pressure, deliver high flow rates of air parallel to the fan blade axis. When blowers deliver air, it is perpendicular to the blower axis, at lower flow rates, but against high pressure. Blowers can generate much higher pressures than fans, but are typically noisier.

To meet cooling needs, reliability is critical, and ball bearing fans deliver the most reliable bearing technology when compared to sleeve bearing fans. These fans can endure intense levels of heat and mounting variations do not shorten their life span.

There are two types of fans: centrifugal and axial, which are characterized by the path of the airflow through the fan. When deciding which to use, consider pressure, airflow rate, efficiency, space constraints, noise generation, drive configuration, temperature range, variations in operating conditions, and tolerance to corrosive or particulate-laden air streams as well as cost, delivery time, and availability.

Centrifugal fans, which are categorized by their radial, forward curved, or backward inclined blade shapes, increase the speed of an air stream with a rotating impeller. The speed increases as the air reaches the ends of the blades and is then converted to pressure. These fans are able to produce high pressures, which makes them suitable for harsh operating conditions, such as systems with high temperatures or moist or dirty air streams. Tip vortices or tip leakage flow produced by the pressure differential across the airfoil section can be problematic with these basic fans.



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Axial fans, which include propeller, tube axial, and vane axial styles, move an air stream along the axis of the fan. These fans work like an airplane propeller—blades generate an aerodynamic lift that then pressurizes the air. Propeller fans embody only a motor and a propeller used to drive the airflow. Similar to a propeller fan, a tube axial fan includes a venturi that surrounds the fan propeller and is designed to reduce the air leakage or vortices created by the spinning prop. A vane axial fan features vanes trailing the rear of the propeller, which straighten out the swirling airflow that occurs when the air is accelerated by the motor. Axial fans are inexpensive, compact, and light, making them a favorite for industrial applications. They are, however, usually noisier than centrifugal fans. Noise can be abated by insulating the duct; mounting the fan on soft materials like rubber or using a spring isolator to reduce the amount of transmitted vibration; or installation of sound dampening material or baffles.

Blowers, which deliver a more concentrated airflow, pull air in from the side and force it out at a concentrated 90° angle. The two main types of blowers are the centrifugal blower and the positive displacement blower.

Centrifugal blowers resemble pumps more than fans. Typically gear-driven, centrifugal blower impellers rotate at speeds up to 15,000 rpm. Multi-stage blowers accelerate air as it passes through each impeller. Single-stage blowers do not include many turns, so their delivery of air is more efficient.

Positive-displacement blowers include rotors that entrap air before pushing it through a housing. Positive-displacement blowers are particularly useful when system pressure varies because regardless, they will continue to provide a constant volume of air.

Regardless of your choice—fan or blower—additional considerations include the structure or the frame size of the equipment, enclosure design, the materials from which it is manufactured, and mounting method and hardware. Depending on the environment of the cooling apparatus, some systems will also require special mounting for noise reduction and vibration isolation.

Performance Curve

Fan characteristics are best represented as a fan curve, which is a performance curve for any particular fan under specific conditions. The fan curve, which represents graphically a number of inter-related parameters, is developed for a given group of conditions, including fan volume, system static pressure, fan speed, and brake horsepower necessary to drive the fan under conditions in a particular application.

Of the many curves that can be generated, the curve static pressure versus flow is particularly important. Where the system curve intersects with the static pressure curve defines the operating point. When the system resistance fluctuates, the operating point also fluctuates. However, once the operating point is fixed, power requirements can be determined by following a vertical line through the operating point to an intersection with the power curve. Then, a horizontal line through the intersection with the power curve will help determine power requirements as depicted on the right vertical axis. So basically, the fan performance curve is plotted by tracking airflow quantity on the horizontal axis and static pressure on the vertical axis.

In summary, select a fan whose performance curve matches the proposed operating point, so that the fan will sufficiently cool the system in question.

Speed Control

Bearing assemblies in fans and blowers predispose them to failure, so their operation should be carefully monitored. Failure monitoring circuits can be used to track performance and potential malfunctions in advance. Some of these fan performance monitoring circuits even include thermal shut downs that will cut the power if overheating is detected.

The fan speed control circuit can also be used to increase the lifespan of fans and blowers. Because fans and blowers that constantly run fast will simply wear out faster, changing fan speeds when applicable can increase the life of fans and blowers. There are four major types of fan monitors and controllers—fan speed monitors, fan fail monitors, fan fail shutdowns, and fan speed controls.

Fan speed monitors require a third lead from the fan as a tachometer signal output, which then allows the system to monitor fan speed.

Fan fail monitors are often installed along with the fan. If the fan fail monitor detects an abnormal signal from the fan, it will force a system shutdown.

Fan fail shutdown monitors also use a third lead from the fan system as a tachometer output. The fan fail shutdown monitors for abnormal signals and after a preset time delay the system will be shut down.

Fan speed control is typically accomplished using temperature step speed controls and temperature on/off speed controls. PWM and linear voltage speed control are the most popular temperature proportional speed controls.

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When an air volume change is required, and provided the fan has the ability to handle it, there are several methods available to alter fan speeds—including a pulley change, damper controls, inlet guide vanes, variable speed drives, in series and parallel operation.

Pulley changes are among the simplest way to alter speeds, but the fan must be driven by a motor using a v-belt system. Increasing or decreasing the diameter of the drive pulley or the driven pulley, or even both pulleys, will bring about the desired change in fan volume.

Damper controls allow the user to alter air volume by simply adding or reducing system resistance. Adding or reducing resistance requires the fan to move up or down along its characteristic curve, which generates more or less air with no change to the fan speed. Their drawback is that their effect on airflow is limited and they are not energy efficient.

Inlet guide vanes change the angle that air is presented to fan blades, which alters the characteristics of the fan curve. At best, they provide only modest reductions in flow.

Variable speed drives provide the widest variety of speed control, but they can be expensive. Simply put, they reduce the speed of the fan to lower the volume of air the propellers move.

Series and parallel operation of fans is yet another way of controlling capacity. Parallel operation is simply two fans working side by side. In a series operation, two fans are arranged to push-pull. Although both of these methods will increase static pressure, flow volume is not necessarily doubled.

Fan Maintenance

All operating systems require maintenance, and cooling fans are no exception. Using either hours of operation or calendar period, devise a basic maintenance schedule that is also based on manufacturer recommendations and experience with fans in similar applications. Basic maintenance should consist of the following:

Belts and Sheaves

Condition, tightness, and alignment of both belts and sheaves should be checked according to maintenance schedules.

Bearings

The condition of bearings should be checked by listening for unusual noises that could indicate wear, checking the operating temperatures of bearings, or by using predictive maintenance techniques like vibration or oil analysis. Bearings should always be lubricated according to the manufacturer's guidelines and when necessary, replaced immediately to avoid damage to other components.

System Cleaning

Clean all fans and system components upon which contaminants can build up according to your maintenance schedule.

Leakage

All ductwork must be checked for leaks regularly. Leakage can result in poor system performance and resultant energy losses.

Condition of the Motor

Testing of the motor windings usually measures insulation resistance at a certain voltage or it measures the rate at which an applied voltage decays across the insulation. Vibration analysis can also indicate certain conditions within motor windings and can help detect problems at the earliest time possible.

Troubleshooting Fans

Belts and Sheaves
Look for belt wear, fatigue, and rupture, all of which can produce belt slippage. But beware: Too much tension on the belt to reduce slippage can backfire and actually increase wear of both of these critical components.

Bearings
Problems common to bearings are noise, excessive clearance, and even seizure problems. Regularly scheduled maintenance and lubrication are both critical to extending the life of bearings.

Motors
Winding insulation is what typically breaks down on a motor, and if this is the case, they can be completely replaced or rewound.

Build-Up of Contaminants
Although some fan types have blade shapes that discourage contaminant build-up, sooner or later particulate build-up can still be a problem that deteriorates system performance. Fans should be cleaned regularly, or in the event of highly contaminated air streams, filters can be used.

Fan Degradation
Corrosive gases or abrasive particles can degrade fan blades, disrupting airflow over the surfaces. If degradation is a recurring problem, consider replacement of the blades with more durable materials.

System Problems
High operating costs, fouling, airflow noise, insufficient delivery, leakage, and unstable operation can all plague air cooling systems. Correcting them requires a look at several factors, including system design and selection of components, incorrect installation, and inadequate maintenance.

About Pelonis

Pelonis Technologies, Inc. ("PTI") is a leading manufacturer of axial AC and brushless DC fans and motors specializing in high technology and Original Equipment Manufacturing solutions. Our unique competitive advantage in Flexible Manufacturing Efficiency enables us to produce high quality innovative products at lower costs and has made us a preferred vendor within our industry.

We manufacture and test our products based on the highest standards of quality and reliability. Our ISO-certified production facilities employ flexible manufacturing techniques that enable us to respond quickly and efficiently to large- and small-scale production requirements.

With over 25 years of product development and manufacturing experience, Pelonis Technologies' management team and engineers are committed to providing exceptional quality, product innovation, and service at competitive pricing. Our company's passion is to improve existing products and to develop new applications that benefit our customers and their constantly changing needs. This dedication has enabled Pelonis Technologies to build long-term partnerships with our global customers. Valued PTI customers come from a variety of sectors, including medical equipment, aerospace & defense, heating & air-conditioning, automotive, and appliances.