Fans and Blowers - Practical Concepts and Calculations

An Online Continuing Education Course for Engineers

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Fans and Blowers - Practical Concepts and Calculations

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Fans and blowers are one of the most important components of Heating, Ventilating, and Air Conditioning (HVAC) equipment or industrial process systems. In large HVAC and industrial applications, the air movement is most commonly accomplished with either axial flow fans or centrifugal fans. Since they are essential to maintain a comfortable environment or support production, the reliability of operation is very important.

The importance of fan reliability often causes system designers to design fan systems conservatively and add high factors of safety to compensate for uncertainties in the system design. Unfortunately, oversizing fan systems increase energy costs, noise, and increased stress on the fan components. The use of a "systems approach" in the fan selection process will typically yield a quieter, more efficient, and more reliable system.

It is important to have a basic understanding of the fundamental principles, types of fans, and their operating characteristics before making an appropriate selection.

This course provides a quick tutorial on fan and blower systems. Basic guidelines are provided on how to apply fan laws and read performance curves. The course includes a lot of examples and calculations for a practical overview.

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Chapter 1: Basic Overview

1.0. Fans and Blowers

The words "fan" and "blower" are frequently used interchangeably. They are found in an infinite number of equipment and used in a variety of systems, from heating, ventilating, and air conditioning (HVAC) to industrial processes. In HVAC terminology, the term fan may refer to any device used to create a continuous flow of air through the system. A blower is generally considered to be a particular type of fan—specifically, a motor-driven centrifugal fan that delivers air to the conditioned space through ducts, dampers, and other components under pressure.

ASME differentiates blowers as having a ratio of discharge pressure over suction pressure anywhere between 1.11 and 1.2, while fans are defined as having a ratio below 1.11.

We will use "fan" as a generic term in this course.

1.1 Basic Fan Inputs

A proper fan selection depends on four key inputs:

a. Volumetric Flow Rate
b. Fan Static Pressure
c. Inlet Air Density
d. Intended Fan Duty

1.2 Volumetric Flow Rate

The most basic and obvious piece of information for fan selection is the rate of airflow through the fan. We typically calculate and specify the airflow in units of Cubic Feet per Minute (CFM). Users must fully understand the terms: Standard air volume (SCFM) and Actual air volume (ACFM) when making inquiries about fans or reviewing fan performance data.

1.2.1. ACFM vs. SCFM

These two terms are commonly used in design work, and they should not be confused as this greatly influences the fan selection.

a. **ACFM (actual cubic feet per minute) —** Represents the volume of air flowing anywhere in the system independent of its density. ACFM or CFM is the value that is used when selecting a fan.

b. **SCFM (standard cubic feet per minute) —** Standard air volume is air at standard density conditions of 70°F at sea level with an elevation of zero feet (sea level) and inlet pressure of 29.92" Hg giving a density of .075 lb/ft^3.

Fan manufacturers' catalog ratings are based on Standard Laboratory conditions using standard cubic feet per minute (SCFM) for airflow and 0.075 lb/ft^3 for standard fan inlet airstream density. As such, the manufacturer's published ratings can normally be used for fan selection and evaluation when the deviation between standard density and the actual site density at the fan inlet is less than 5 percent. This occurs when the following parameters are met at the fan inlet:

a. The fan inlet temperature is between (+) 40°F and (+) 100°;
b. The fan inlet static pressure is between (–) 12 inch water gauge (wg) and (+) 12 inch wg;
c. The fan inlet airstream moisture content is less than 0.02 pounds of water per pound of dry air, or the dew point is less than 80°F; and
d. The fan installation is between ± 1,000 feet elevation above sea level (asl).

In cases where one or more of the above parameters are not met, the inlet airstream density should be corrected to the actual conditions. This is normally referred to as non-standard air, with fan airflow noted as actual cubic feet per minute (ACFM). Corrections for inlet airstream density are calculated by multiplying the standard density, airflow, pressure, and power by the density factor.

1.3 Air Density

The second piece of information we need for fan selection is inlet air density. We calculate inlet air density using three key factors:

a. Altitude
b. Temperature
c. Moisture content

Actual air density varies because of several factors:

1.3.1. Altitude

The density of air decreases as you gain altitude. If you have ever gone hiking or skiing in the mountains, you know that it is harder to breathe. There are fewer oxygen molecules per volume of air in the mountains than at sea level. This is because there are fewer atmospheres pushing down on the air molecules and pressing them together. At an altitude of 18,000 feet, the weight per cubic foot of air is just one half that of the weight of a cubic foot of air at sea level under the same conditions.

1.3.2. Temperature

The density of air decreases as the temperature is increased. As an example, air at a temperature of 600°F has a density of one half that of standard air at 70°F.

1.3.3. Moisture content

The moisture content of the air being handled influences the density. This effect, however, is so small at temperatures below 100° F that its effect upon density ratio may be entirely disregarded.

Out of these three factors, th

1.4 Fan Pressures

Some of the critical de

1.4.1. Static Pressure

Static pressure is the pr … flow due to ductwork, components, … ally in all directions and is independent of air … ainst a lower static pressure within the duct … tatic pressure is high due to high system r … erefore selected to provide the required flow

To measure the static pres … the duct on any side, and a tube from a pressure gauge … slightly into the duct. The reading will be in inches of