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The design of duct systems for air transmission, the objective is to provide a system that, within prescribed limits of velocities, noise intensity, and space available for ducts, efficiently transmits the required flow rate of air (cfm) to each space, while maintaining a proper balance between investment and operating cost. When the heating, cooling, or ventilation load is established, the total flow rate of air required can be determined by methods shown in Chapters 26 and 27. The problem is then to adjust the design air quantities of the various spaces for duct heat losses or gains between apparatus and spaces conditioned, as shown in a later section, Heat Losses from Ducts, and transmit the resultant compensated air flow.

Pressure changes in a duct system are caused by friction losses, dynamic losses, and pressure losses in elbows, tees, and other fittings. The total pressure loss in a duct system is the sum of these losses. The static pressure is the pressure exerted by the air on the walls of the duct. The velocity pressure is the pressure exerted by the air on a surface perpendicular to the flow. The total pressure is the sum of the static and velocity pressures.

The total pressure H is a measure of the total mechanical energy at a cross-section. In any duct system, the total pressure always decreases in the direction of the air flow. Static and velocity pressure are mutually convertible and either can increase or decrease in the direction of flow. Typical pressure changes in a duct system are illustrated in Fig. 1. Between Sections A and B, the static and total pressures decrease uniformly because of friction between air molecules along the sides of the duct. Pressure losses in straight pipes are termed friction losses and are characterized by dependence upon Reynolds number. (See Chapter 6.) Section BC is a converging section. The duct area is reduced and, consequently, the flow is accelerated. This is a stable and efficient process and the loss in total pressure is small. The marked decrease in static pressure is caused by conversion of static to velocity pressure in accordance with Equation 2.

Section CD presents the friction loss in the section of smaller duct. Since friction losses increase with nearly the square of the velocity, the pressure line falls much more rapidly than in Section AB. An abrupt expansion occurs at DE. The duct area is abruptly increased and the flow decelerated. The process is an inefficient one and the loss in total pressure is therefore large. The velocity pressure is decreased at E in accordance with Equations 2 and 3, and the static pressure rises. This

Pressure Changes, Friction Losses, Circular Equivalents of Rectangular Ducts, Dynamic Losses, Pressure Losses in Elbows, Pressure Losses in Divided-Flow Fittings, Losses Due to Area Changes, Duct Design Methods and Examples, High-Velocity Duct Design, Duct Construction, Heat Losses from Ducts

CHAPTER 31

AIR DUCT DESIGN

IN THE design of duct systems for air transmission, the objective is to provide a system that, within prescribed limits of velocities, noise intensity, and space available for ducts, efficiently transmits the required flow rate of air (cfm) to each space, while maintaining a proper balance between investment and operating cost. When the heating, cooling, or ventilation load is established, the total flow rate of air required can be determined by methods shown in Chapters 26 and 27. The problem is then to adjust the design air quantities of the various spaces for duct heat losses or gains between apparatus and spaces conditioned, as shown in a later section, Heat Losses from Ducts, and transmit the resultant compensated air flow.

PRESSURE CHANGES

A duct system imposes resistance to air flow which must be overcome by the expenditure of mechanical energy; this energy is ordinarily supplied by a fan. The portion of the air-flow rate from the fan that is transmitted to a particular space is governed by the law that the loss in total pressure from the fan outlet must be the same along each air path. This also holds true for the return-air system, except that the loss in total pressure refers to the fan inlet. In air-conditioning and ventilating work, the pressure differences are ordinarily so small that the equations for incompressible flow can be applied. Additional simplification is obtained by considering the air to be at the standard density of 0.075 lb per cu ft.

At any cross-section in a duct the total pressure H is the sum of the static pressure P and the velocity pressure H_v .

$$H = P + H_v \quad (1)$$

Pressures are considered in units of inches of water. The velocity pressure is then given by:

$$H_v = \left(\frac{V}{4005} \right)^2 \quad (2)$$

where V is defined by the equation:

$$V = Q/A \quad (3)$$

where

V = mean velocity of flow, feet per minute.

Q = air-flow rate, cubic feet per minute.

A = cross-sectional area of duct, square feet.

The general responsibility for this chapter is assigned to TC 4.1, Duct Design and Room Air Distribution.

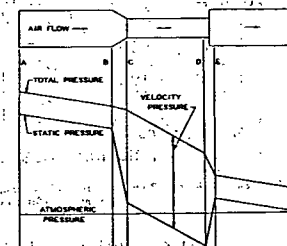


Fig. 1.... Pressure Changes During Flow in Ducts