ENGINEERING LETTER | 11

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SELECTION CRITERIA FOR FAN DAMPERS

INTRODUCTION

Dampers are the most common volume control device used in fan systems. Low in cost, dampers require little maintenance, easily adjust airflow during operation, and need little space. For these reasons, they are often selected over more complex control systems such as variable frequency drives.

To select the best damper for a particular application, it is necessary to understand the requirements of the application as well as the capabilities of different damper systems.

Since dampers may be placed on either side of the fan, they are classified as either inlet or outlet. Both reduce airflow in predictable amounts, but by different means.

Outlet dampers control the air after it has passed through the fan by changing the resistance the fan is working against. Figure 1 shows the effects of various outlet damper settings on a backwardly-inclined fan. It illustrates how the damper controls CFM, static pressure, and its impact on fan BHP.

As the outlet damper is closed, the point of operation moves to the left of the selection point along the fan's static pressure curve. Adding resistance with the outlet damper also moves the fan horsepower to the left on its curve. With radial-blade and forward curved-fans, the dampered horsepower will be less than the wide open horsepower as the fan moves to the left on the BHP curves. With backwardly inclined fans, the dampered horsepower may be less, the same, or more than its wide open horsepower, depending on the original point of operation. For more information see Engineering Letter 3.

Inlet dampers affect the air before it enters the fan. External, internal, or inlet box inlet dampers cause the entering air to spin in the same direction as the fan rotation. Because of this, the fan wheel can not develop full output. This results in lower volume and reduced BHP. When a backwardly inclined fan has an inlet damper, it reacts as shown in Figure 2 as the damper vane angle is changed. For each new damper vane position, new SP and BHP curves are generated. The new point of operation is defined by the system in which the fan is installed. The end result is similar to the change that occurs when slowing down an undampered fan.

The horsepower and electrical power savings of this damper make it attractive for systems required to operate at reduced flow rates for extended periods, such as in variable-air-volume systems. While Figure 2 illustrates an inlet damper's effects on a backwardly inclined fan, the same general results are achieved using inlet dampers on any type of centrifugal fan.

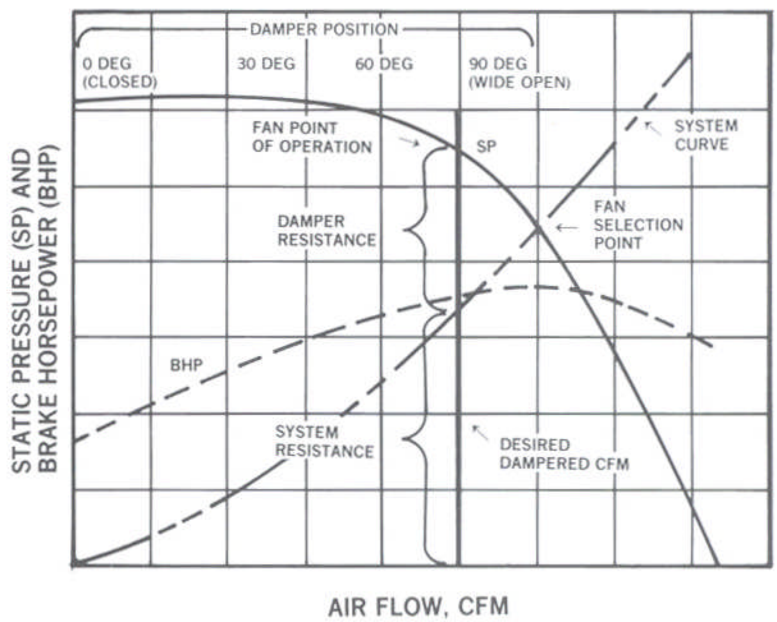

Figure 1 - Static pressure and brake horsepower curves for backwardly-inclined fan with outlet damper. As the damper closes, the point of operation - brake horsepower and static pressure - moves to the left of the original fan selection point to the 90-degrees (wide open) damper setting.

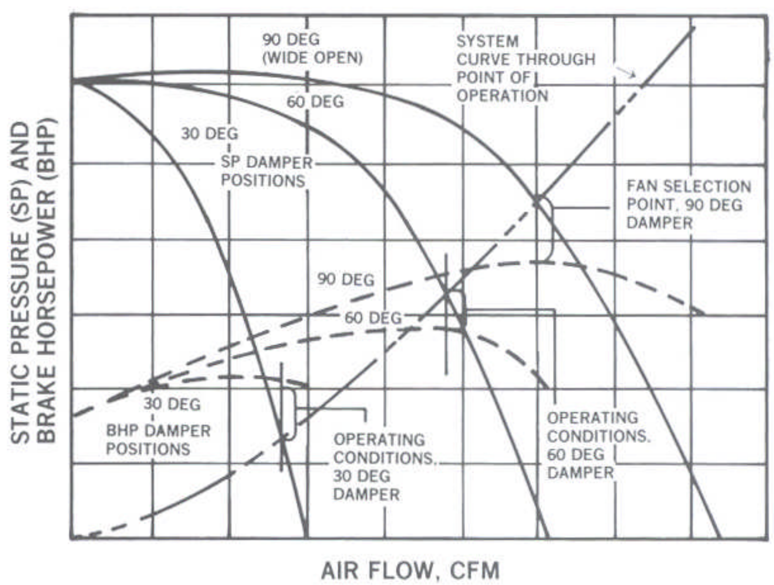

Figure 2 - Effect of applying inlet dampers to the fan in Figure 1. Separate SP and BHP curves are developed for each vane setting. Fan operating points at these settings are determined by system resistance (points where system curve intersects SP and BHP fan curves).

TYPES OF OUTLET DAMPERS

The parallel blade arrangement shown in Figure 3 is the simplest, most economical, and most popular type of outlet damper. The cross-sectional area of a wide-open damper is not greatly reduced until the blades have been moved to the 30 degree open position. Consequently, the outlet damper control arm swings through a relatively large arc to reduce fan capacity a small amount. This makes the parallel-blade outlet damper particularly useful when installed on a continuous process system where sensitive control of air volume between wide open and 70% or 80% of wide-open is desired. The large control arm swing also allows predetermined settings of airflow to be repeated accurately. This damper, being the least expensive of the various designs, also makes it the usual selection for systems that require two position damper operation (either full-open or full-closed). Another common application involves cold starts on a "hot" system requiring a reduction in airflow to reduce BHP until the system reaches temperature.

Opposed-blade outlet dampers, as pictured in Figure 4, are used when a straight line relationship between fan volume and control arm swing is desired. In this design, alternate blades turn in opposite directions. Therefore, the change in volume, with respect to the damper position, is proportional to control arm swing.

The opposed-blade damper is usually selected when it is necessary to maintain an even distribution of air immediately downstream from the damper. Figure 5 illustrates the downstream air pattern of an opposed-blade versus a parallel-blade damper. Opposed-blade dampers cost more than parallel-blade models of the same size due to the increased complexity of the linkage required to provide the opposed-blade motion.

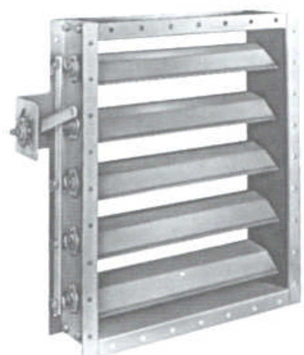

Figure 3 - Parallel-Blade Outlet Damper

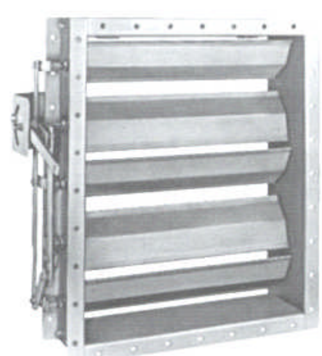

Figure 4 – Opposed - Blade Outlet Damper

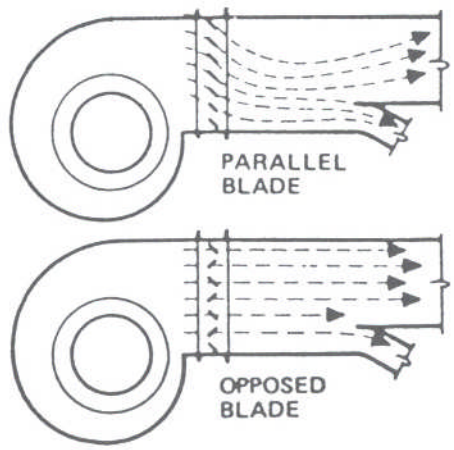

Figure 5 - Airflow Patterns through Dampers

TYPES OF INLET DAMPERS

Inlet dampers can provide a substantial horsepower savings for fans that are operated at reduced capacity for extended periods of time. Concerns for energy conservation and reduced operating expense make this feature desirable and often mandatory when designing a system.

A good example of how inlet dampers are used to accomplish energy savings can be seen in a typical variable volume heating-cooling ventilation system. In this application much less air is needed for winter heating than for summer cooling. In addition, during summer operation, less air is needed for cooling during the nighttime hours than during the peak daytime hours. Yet, the fan system must be selected for the worst condition/highest air flow. The inlet damper offers the greatest long term savings in VAV applications due to reduced horsepower requirements at reduced volumes.

External inlet dampers, as shown in Figure 6, are mounted external of the fan structure. The configuration is circular with the damper vanes connected to a central hub through pivot bearings. The control linkage is also circular and exposed for easy inspection and maintenance.

Generally, this is the most expensive damper configuration. It is also capable of handling higher velocities and pressures than the internal inlet damper.

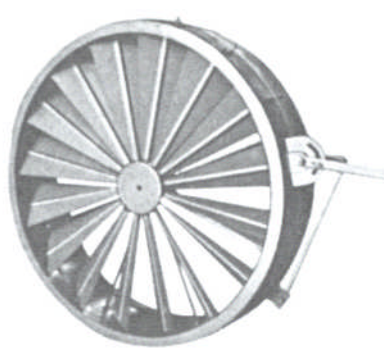

Figure 6 – External Inlet Damper

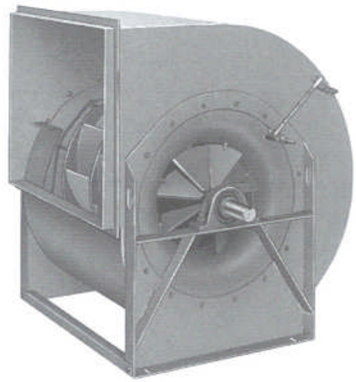

Figure 7 – Internal Inlet Damper

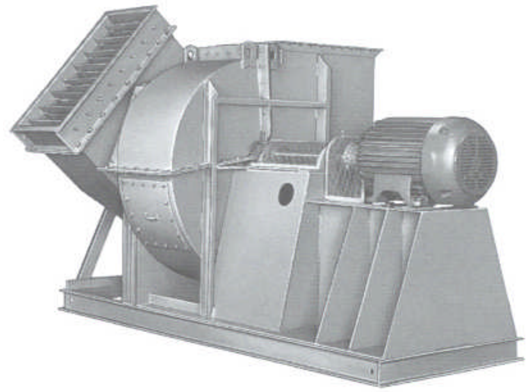

Figure 8 – Inlet - Box Damper Mounted To Inlet Box

The internal inlet damper, pictured in Figure 7, is similar to the external inlet damper with respect to controlling fan performance. The most significant difference is that the internal damper is a self-contained unit furnished as an integral part of the fan inlet cone. This provides considerable space savings and eases installation. The internal inlet-damper design, however, may tend to create some resistance at wide-open, due to the control vanes being in the high velocity region of the fan inlet. Therefore, appropriate airflow reduction factors, as listed in a separate engineering supplement, must be used when sizing a fan with this type of damper. In addition, the damper control linkage is in the airstream on the inside of the fan housing and must be serviced through a cleanout door in the housing.

Inlet-box dampers (Figure 8) are parallel-blade rectangular dampers mounted on an inlet box in such a way that the airflow from the damper produces a vortex at the fan inlet. Inlet-box dampers are generally preferable on fans equipped with inlet boxes and have the same general control requirements as standard inlet dampers. Because the bearings are not in the airstream, inlet-box dampers are often used in airstreams that contain some particulate. Predicting the exact flow reduction with damper angle varies with damper types and products. Normally this is not a requirement since flow should be established using manual reference or feedback from automatic control systems. For all inlet-vane dampers, vane angle versus flow relationship will change when dampers are applied to wheels that have been narrowed to establish specific capacities at direct drive speeds.

Inlet dampers typically improve the stability of most products because they control the flow through the fan inlet. At extreme dampering, about 30° open, inlet dampers can no longer create a vortex and become essentially a blocking damper. This causes the fan to operate far to the left on its curve. When this happens, a fan is subject to the same problems of instability as if the point of rating was established by an outlet damper or other system changes.

COMBINED INLET AND OUTLET DAMPERS

Occasionally it is desirable to save more power at reduced capacity while maintaining very sensitive control. In this case, the fan may be equipped with both inlet and parallel-blade outlet dampers. With the outlet damper set at wide-open, the inlet damper is set to give just slightly more air than needed. Exact air delivery is obtained by adjusting the outlet damper. Because the outlet damper vanes require a lot of movement to achieve a slight change in air delivery, sensitive control is achieved.

PERFORMANCE COMPARISON

Figure 9 shows the effects of damper settings on airflow and brake horsepower for parallel and opposed-blade outlet dampers, and inlet and inlet-box dampers. These plots represent generalizations of damper effect on fan performance and can be used to compare one type to another.

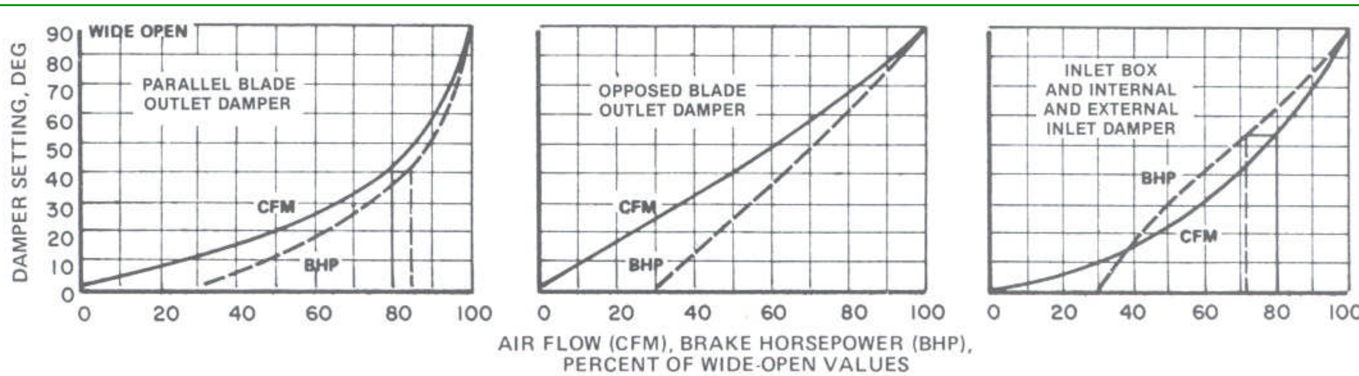

Figure 9

Effect of vane setting on airflow and power for various damper types. When a parallel-blade outlet damper is set for 80 percent of wide-open capacity, the damper setting is 40 degrees, and the fan operates at 85 percent of wide-open horsepower. However, with an inlet damper, operation at 80 percent of wide-open requires a 53 degree damper setting and 72 percent of wide-open horse-power. Note: These curves are representative, not precise. See text.

	Parallel-Blade Outlet Damper	Opposed-Blade Outlet Damper	External and Internal Inlet Dampers	Inlet-Box Damper
1. Cost	Least costly.	1.1 to 1.2 times as much as parallel blade.	Internal - 1.5 to 2.5 times as much as parallel-blade. External - 3 to 4 times as much as parallel-blade.	1.3 to 1.4 times as much as parallel-blade; combined with inlet box 3 to 4 times as much as parallel-blade.
2. Control	Best for full-open or closed requirements or for fine control between 80% to 100% full-flow.	Best for systems where air volume is changed over a wide range and a straight line relationship of volume to control arm swing is desired.	Same as opposed-blade outlet damper.	Used on fan inlet box. Can be used with some particulate in airstream.
3. Horsepower	**Depends upon characteristic BHP curve; Backwardly inclined - same, more, or less than wide-open, FC and Radial – less than wide-open.**		Power consumption at reduced air volumes is less than with outlet dampers.	Same as inlet damper
4. Air flow after fan	Throws air to one side.	Distributes air evenly.	No effect.	No effect.

Figure 10 - Comparison of Inlet and Outlet Dampers

SUMMARY

Each system has its own requirements with respect to the control of air volume. System designers must be aware of not only first cost considerations but, more importantly, of the long term operating savings that can be achieved by a properly engineered system. Each system also imposes limits on which dampers can be used with respect to fumes, control sensitivity, and temperature. No one damper design is best for all applications. Figure 10 provides a comparison to help the designer recognize some of the factors to be considered in damper selection.