Dampers for DeNOx & DeSOx Applications

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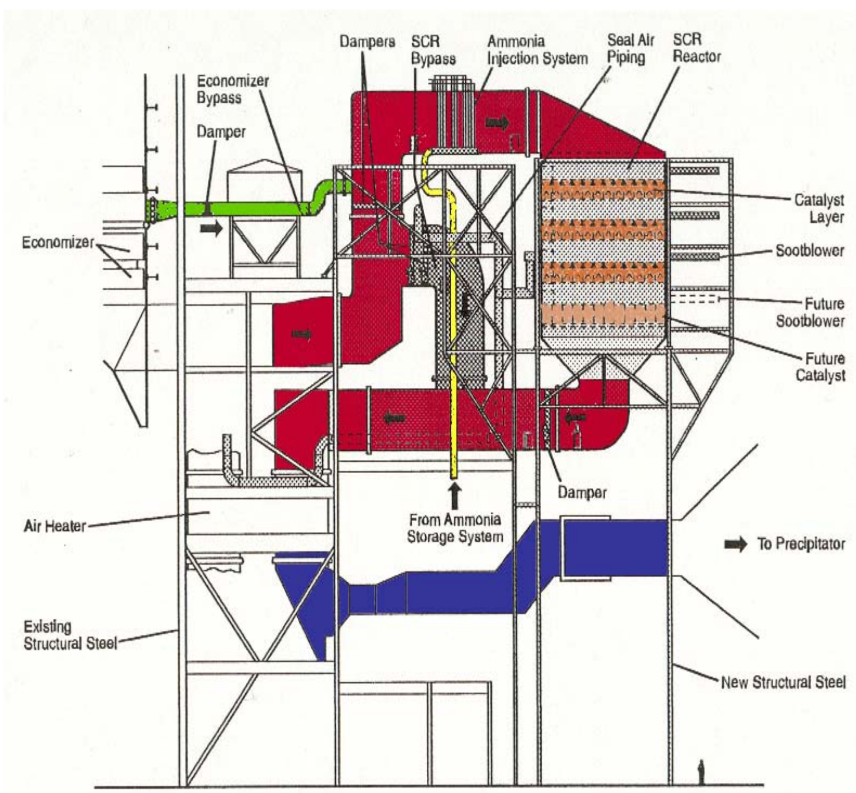
1. Summary

Dampers for DeNOx and DeSOx plants play a vital roll in the successful operation of the systems that in which they are employeed. From control of gases to regulate the temperature of the flue gas entering the DeNOx system to isolation of the DeSOx Booster Fan for on-line maintenance, dampers are the controlling devices. Within these systems the types and design of the dampers used vary greatly based on temperature, pressures, particulate loading and space availability. The design conditions of dampers used in DeNOx systems differ greatly those present in DeSOx systems. DeNOx dampers need to operate in elevated temperatures (350ºC-425ºC), heavy particulate loads, and high negative pressure environments. DeSOx damper design varies from the dry to wet process. Dampers used in a wet process operate at lower temperatures (65ºC – 150ºC) and are subjected to corrosive gas, and positive pressure environments. Dampers used in the dry process operate at higher temperatures (150ºC –175ºC), heavy particulate loading and negative pressure. All of these different but demanding applications require a discerning evaluation of the damper selection.

1.1 DeNOx Dampers



1.1.1 DeNOx Dampers Required

There are a variety of dampers required for the proper operation of DeNOx systems. These include:

- DeNOx Inlet
- DeNOx Outlet
- DeNOx Bypass
- Economizer Bypass
- ReHeat/SuperHeat Control

Damper performance requirement

Damper	Control	Low Leakage Isolation	100% Isolation
DeNOx Inlet	X		X
DeNOx Outlet	X	X	
DeNOx Bypass			X
Economizer Bypass	X		X
ReHeat/SuperHeat Control	X		

The DeNOx Inlet & Outlet dampers are used primarily to isolate the DeNOx system. The Inlet damper is sometimes used to modulate flow to the DeNOx system on warm-up and at lower unit loads. The Outlet damper is sometimes used to regulate the flow of heated air from the module during out of service conditions.

The Bypass damper is used to allow the system flow to be directed to the DeNOx module while it is in service. It is sometimes used in conjunction with the Inlet damper to regulate the flow to the module during heat-up sequences.

The Economizer Bypass damper is used to control the temperature of the flue gas to the DeNOx system in reduced boiler load conditions.

The Reheat/Superheat Control damper is used to regulate the temperature of the reheat/superheater. These dampers are often replaced during DeNOx retrofits to improve overall boiler performance.

1.1.2 Types of Dampers used in DeNOx Systems

Application	Louver	Double/Tandem Louver	Diverter/Flap	Guillotine
DeNOx Inlet		X	X	
DeNOx Outlet	X	X		
DeNOx Bypass		X	X	X
Econ Bypass	X	X	X (Flap)	
Reheat/Superheat	X			

There are many types of dampers used in DeNOx systems depending on the dampers requirement.
Louvers (Single, Double, Tandem) are used for low leakage, 100% isolation, and regulation applications. The advantages of louver dampers are their ability to fit in restricted spaces, while providing superior flow regulation, rapid open/close operation, low torque actuation, and lighter weight. Some of the disadvantages of louver dampers include large cross blade leakage area, high seal air consumption, high pressure drop, multiple frame penetration points and high maintenance requirements.
Diverter/Flap dampers are used for both isolation and modulation, but are less precise in their ability to regulate flow than louver dampers. The advantages of diverter/flap dampers are one diverter takes the place of two dampers, there can be no simultaneous closure of the DeNOx system and Bypass, superior isolation, reduced seal air consumption, minimal pressure loss, can modulate flow, minimal space requirements.
Guillotine dampers are superior for 100% isolation, but are poor regulators. The advantages of guillotines are superior isolation, minimal pressure loss, reduced seal air consumption, and minimized face to face requirements.

Damper Performance

Type of Damper	Louver	Double/Tandem Louver	Diverter/Flap	Guillotine
Max. Sealing Efficiency	99.5%	100%	100%	100%
Seal Air Consuption	NA	HIGH	LOW	LOW
Pressure Loss	HIGH	HIGH	LOW	LOW
Modulation Capacity	HIGH	HIGH	MODERATE	LOW
Space Required	LOW	LOW	LOW	HIGH
Weight	LOW	LOW	HIGH	HIGH

1.1.3 **DeNOx Application Issues**

Dampers for DeNOx systems have many design issues to take into consideration. Those issues include:

- Operational Reliability
- Duct Size
- Pressure Loss
- Effective Isolation
- Effects of Heavy Particulate Loading
- Thermal Effects of High Temperature Differentials
- Space Limitations

Operational reliability is the primary design concern for all dampers not just dampers for DeNOx applications. It is essential that the dampers function as intended for the proper operation of the DeNOx system. The dampers must be designed with proper sized actuation systems to overcome the high differential pressures, particulate loading, seal forces and blade weight. Without the use of proper design safety factors any of these conditions can hinder or interrupt the operation of the damper and in turn the DeNOx system. These design considerations apply to the blade, shafts, linkage, and actuators.

Duct size in DeNOx systems is a design consideration for the blades and sealing systems. Often times the size of the duct along with the width to height ratio plays an important role in the design of the damper blade system. Duct configurations coming off the Economizer outlet or the Economizer bypass duct, sizes of the duct can range up to 60 meters sq. with width to height ratios up to 5 to 1. It is important to limit the length of the blade to a manageable length so that distortion of the blade is minimized during operation. If the blades are too long, the section modulus required to keep deflection low is often very large. The only way to minimize this deflection is to increase the height of the blade profile. This increased duct blockage increases pressure loss in the system. It is important to keep this deflection within the working tolerances of the sealing system to assure proper isolation of the module.

Pressure loss resulting from the use of DeNOx systems can result in the need to increase ID fan capacity and the possibility of the addition of Booster fans for future DeSOx systems. The pressure loss resulting from the DeNOx system dampers must be kept to a minimum to help minimize this effect. The use of the type of dampers in the system must be evaluated in the overall system design in order to minimize the losses effects on system performance. When designing dampers these pressure loss values can be significant. Louver dampers add more losses than do diverter dampers or guillotines. If the fan system is operating close to capacity, the losses imposed by the type of damper used must be taken into consideration.

Effective isolation of the DeNOx system or bypass is critical to the economical operation of the system. While double louver or tandem louvers do provide for 100% isolation, diverter dampers or guillotine dampers provide superior isolation capabilities. Louver dampers require high amounts of seal air for isolation, which can lower gas temperatures and reduce overall plant performance and add to the ID Fan load. Guillotine or diverter dampers require significantly less seal air than louvers there by eliminating the increased flow penalties of louvers.

DeNOx dampers are required to operate in a heavy particulate laden gas flow that can build up on duct floors and create obstacles to operation. The dampers must be designed to function with these loads. With vertically mounted louver dampers a bottom rollover blade can be added to prevent build-up that could prevent operation. Diverter damper actuation systems must be sized to sweep away any build-up that may be present. Guillotine damper blades need to be able to cut through the build-up and still engage the damper sealing system.

Thermal considerations on the dampers include distortion of blades with high temperature differentials of closed units. This is particularly important with double & tandem louver dampers. The dampers experience 350ºC on the live side of the blade and ambient temperature on the downstream side. Another consideration with louver dampers is the differential between hot frames and cold blade linkage. This differential can cause a failure to close the damper completely when isolating. Thermally compensating linkage is often used to rectify this problem.

Space limitations are often the deciding factor in the type of damper to be used in DeNOx systems. In most retrofit applications, there is very little space to use guillotine dampers for isolation purposes because of their height, so a decision has to be made what other options are available. Diverter dampers offer the best isolation solution but are very heavy and require large actuation systems. Louver dampers can usually fit in most restricted space areas but have larger seal air consumption and greater pressure losses. The designer must make a value decision on what is the best solution for each unique situation.

2.1 DeSOx Dampers

There are a variety of dampers required for the proper operation of both Dry & Wet DeSOx systems. These include:

- Dry DeSOx Inlet
- Dry DeSOx Bypass
- Fabric Filter Inlet
- Booster Fan Inlet
- Booster Fan Outlet
- Wet DeSOx Bypass
- Wet DeSOx Inlet
- Wet DeSOx Outlet

Damper performance requirement

Damper	Control	Low Leakage Isolation	100% Isolation
Dry DeSOx Inlet			X
Dry DeSOx Bypass	X	X	
Fabric Filter Inlet		X	
Booster Fan Inlet			X
Booster Fan Outlet			X
Wet DeSOx Bypass	X	X	
Wet DeSOx Inlet			X
Wet DeSOx Outlet			X

The damper requirements for Dry scrubbing are very different than those for Wet scrubbing. The dry DeSOx system is operating in fly ash laden gas at higher temperatures and negative pressure and as part of the system a fabric filter (Baghouse) is included.

The Dry DeSOx Inlet damper is used to isolate a module of the SDA(Spray Dryer Absorber). Most SDA's are used on low sulfur coal units and generally smaller boiler units although by using additional modules larger units can be dry scrubbed. When multiple SDAs are used the Inlet Isolation damper is very important. It must provide mansafe isolation of the SDA for maintenance while the other modules are in service. Due to the configuration of the system, the SDA operates under negative pressure so a less costly isolation damper can be utilized, typically an open bonnet guillotine or single louver damper.

The Dry DeSOx Bypass damper is sometimes included to bypass all or some of the flue gas depending on the environmental requirements of the plant. This damper acts as both an isolation device and as a flow regulator and is often a single or double louver damper.

The Fabric Filter Inlet damper is a low leakage louver damper that isolates individual bag compartments in the baghouse to allow online change out of one of the fabric filter module bags while the unit is on line. This damper is exposed to heavy particulate loading and must operate with up to half the flue filled with particulate during isolation. Particular attention must be paid to the ability of the damper to open under these conditions.

On Wet DeSOx systems utilizing an upstream DeNOx system Booster Fans are often added to provide the require pressure to propel the flue gas though the DeSOx system. They are often added when the Chiyoda DeSOx system is used due to the high pressures required to operate this type of system. The ability to isolate these Booster Fans for on line maintenance is critical to the continuous operation of the absorber. The dampers used to isolate the booster fan need to provide 100% isolation with seal air because these units normally operate at a positive pressure. Bonneted guillotine dampers or double louver dampers are typically used in these applications. Another design consideration is the materials of construction. Typically these dampers are operating very close to the dew point of the flue gas so it is important to minimize the amount of seal air that is leaked into the gas stream. Excessive cold seal air will cause localized corrosion in and around the damper.

The Wet DeSOx Inlet and Bypass dampers are used to either isolate the gas flow to the absorber or bypass gas around the absorber where this practice is allowed. With today's larger and more reliable DeSOx systems often only one absorber is utilized per boiler unit, but often the ability to bypass is required on the chance that the absorber is out of service. The Inlet Isolation Damper must be able to provide 100% isolation in this case and is often achieved by using either a double louver or guillotine damper. As with the Booster fan dampers these dampers are operating very close to the dew point of the flue gas so seal air minimization is critical. Double louver damper use far more seal air than do guillotine dampers so this condition must be taken into consideration. The Bypass Damper often does not need to be a 100% isolation devise if it is used to control flow around the absorber for purposes of heating the absorber outlet gas to a higher temperature on low load conditions so a low leakage louver is often used. Materials of construction are very critical for these dampers due to the wet flue gas exposure on the downstream side of the unit.

The Wet DeSOx Outlet damper is only used in applications when multiple absorbers / boiler units use the same stack. The damper is then used to provide the ability to isolate one absorber / boiler while the other unit is still on line. These dampers need to be 100% isolation units to prevent back flow to the out of service unit. Double louvers or Guillotine dampers are often used for these applications and are always constructed of high nickel alloy materials. Corrosion is a very important design consideration for these dampers and again the amount of seal air leakage to the system is a critical component in this corrosion and material selection.

Damper

Type of Damper	Louver	Double/Tandem Louver	Guillotine
Max. Sealing Efficiency	99.5%	100%	100%
Seal Air Consumption	NA	HIGH	LOW
Localized Corrosion	NA	HIGH	LOW
Pressure Loss	HIGH	HIGH	LOW
Modulation Capacity	HIGH	HIGH	LOW
Space Required	LOW	LOW	HIGH
Weight	LOW	LOW	HIGH
Relative Costs	LOW	HIGH	HIGH

3.1 Conclusion

Dampers for both DeNOx and DeSOx systems offer many unique design considerations for the system designer. Both systems have wide ranges of operating parameters that they operate in from performance requirements,(isolation, regulation) to high ash loading and corrosion conditions making damper selection and design critical to the proper operation of a DeNOx or DeSOx system.