Retrofit Damper Drives—Helping Tangentially Fired Boilers Meet Future NO_x Emission Standards

Repeatable and accurate positioning of OFA and windbox dampers found on Alstom Power, Inc., / Combustion Engineering, Inc., boilers helps lower NO_x emissions by as much as 25% to 50%.

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Like a lasso around the neck of the power industry, ever-tightening air quality standards complicate the best efforts of utility engineers and plant managers to maintain a balance between emission control, increasing fuel costs, and rising demands for energy. Nowhere is this balance more critical than in controlling Nitrogen Oxide (NO_x) emissions from tangentially fired boilers. It is a well accepted fact that tangentially fired boilers, in general, produce lower NO_x than other boiler designs. However, controlling and reducing NO_x is still a concern because of the popularity of this type of boiler. Tangentially fired boilers manufactured by Alstom Power, Inc., (formerly Combustion Engineering, Inc.) represent more than 42% of the boilers installed in the electric power industry. Because of their ubiquity and the sheer number of dampers found on this style of boiler, some owners are increasingly turning to a new type of damper drive mechanism supplied by Type K Drives as added strategy to help reduce emissions by improving OFA and windbox damper position control. Improving damper positioning control along with other proven strategies like OFA, improved air flow and fuel flow monitoring, can stabilize and better regulate the overall combustion process and decrease NO_x emissions by as much as 25% to 50%, thus allowing owners to cost effectively upgrade their tangentially fired boilers to help meet present and future emission regulations and improve overall cost of operations.

A PERVASIVE PROBLEM

The large number of tangentially fired boilers operating in the electric power industry in the United States alone represents a huge potential opportunity to reduce stack emissions from generating stations. Adding urgency to the need to reduce emissions are the stringent emission requirements set by the U.S. Environmental Protection Agency. The Acid Rain Program from the 1990 Clean Air Act Amendments (CAAA) assigned an annual cap of 9.47 million tons for NO_x emissions (for the years 2000 through 2009) from utility boilers. To achieve the reductions necessary to meet that cap, tangentially fired boilers must meet the Phase II, NO_x limit of 0.40 lbs/mm Btu. On top of these reductions, utility boilers from 22 states in the eastern U.S are required to make additional reductions during the summer months (May through September). NO_x allowances are provided to regulate sources at an emission rate of 0.15 lbs/mm Btu. Any emissions above that rate will typically require purchasing additional allowances. As a result, utilities are searching for the most cost-effective solutions for NO_x reductions.

BACKGROUND

NO_x is formed during the combustion process through the oxidation of nitrogen in the combustion air and in the fuel matrix. Measures to reduce NO_x in flue gas emissions can include, but are not limited to, Selective Catalytic Reduction (SCR), low-NO_x burners, and global air staging. However, some of these measures can prove prohibitively costly—up to $3,000 per ton of NO_x removed with SCR, by some estimates.

As a result, many power stations are resorting to global air staging, where a portion of the combustion air is directed above the main firing area. Therefore, an increasing reliance on Over-Fire Air (OFA) ports, which help isolate some of the burning above the primary combustion area, has become a popular method to reduce emissions. Precise control of existing windbox and OFA dampers also helps to reduce NO_x emissions by reducing peak flame temperatures.

In a study titled “Reducing NO_x emissions in Tangentially-Fired Boilers–A New Approach” presented at the July 2000, ASME International Joint Power Generation Conference, Miami, Florida, NO_x reported that emissions were cost-effectively reduced by approximately 25% to 50% through bulk staging techniques such as OFA.

THE NEED FOR PRECISE DAMPER CONTROL

Impressive gains in NO_x reduction, whether through over-fire air staging or other cost-effective solutions, such as low-NO_x burners, better combustion air flow and fuel flow measurement, hinge upon accurate and repeatable control of the combustion air. Controlling combustion air is accomplished through precise and immediately responsive damper operation.

In order to maintain the desired stoichiometric relationship in the furnace, an OFA port or windbox damper blade might move 600 to 2,000 times a day in response to the plant's distributed control system (DCS). Precise manipulation of each separate damper blade allows the operator to center the fireball in the furnace for maximum efficiency. To provide tight control of windbox airflow, it is imperative that damper blades respond to demand signal changes as small as 0.25% full scale. For this reason, many power engineers involved in emissions reduction programs are recommending that the installation of a new style of damper drive should always accompany every windbox retrofit. Ideally, the movement of the damper drive and connecting rod linkages must be free of any unnecessary backlash and deadband. Wherever possible, the damper drive output shaft should be directly coupled to the damper shaft to minimize backlash due to linkage movement and side loading, and to assure damper position precisely follows the demand signal.

The necessity for precision in damper operation especially applies to tangentially fired boilers, because they contain far more dampers than most other boiler designs. For example, a dual furnace boiler will feature eight ports (one for every corner), per elevation, with 10 or more elevations. Today, many older Alstom Power units currently operate with old-style cylinder damper drives that are not as responsive to small input changes as they need to be to insure precise damper control. Based on some anecdotal estimates, 10% of the existing damper drives on some units are not properly functioning at any given time.

To further complicate matters, the Alstom Power split-furnace design (with burner registers on all eight corners) results in a configuration that can produce a harsh environment for damper drives.

On pressurized furnaces (accounting for approximately 25% of the Alstom Power boilers in existence), temperature and dust issues are magnified. Because pressurized furnaces operate considerably hotter than non-pressurized furnaces, damper drives are subjected to sustained high ambient temperatures, resulting in poor performance and, ultimately,

failure. Some damper shafts have recorded temperatures of well over 250° F, as the leakages tend to channel heat up through the corners. Consequently, any equipment that is physically attached to the furnace walls, the damper shafts, or the outer skin of the boiler gets extremely hot.

Fig. 1 Typical T-Fired OEM Windbox Damper Drive

Older-style pneumatically operated damper drives fare much better than electrically operated drives in these high ambient temperature areas. However, they are still subject to a maximum temperature limit of about 185° F and cannot provide the accuracy required, thus, remain a continuing maintenance issue.

To address performance and maintenance issues, many utility owners are increasingly opting to retrofit their OFA port and outdated windbox damper drives with modern drives that provide extremely precise control under all ambient temperature conditions. In situations where high-heat conditions prevail, pneumatic drives become the only option for retrofitting, since some are built to withstand operational temperatures of 300° F.

Fig. 2. Modern Type K T-Fired Windbox Drive

Specifically, the latest generation of pneumatically operated drives from Type K Drives can exert more than the required force to precisely control OFA and windbox dampers, while remaining virtually unaffected by the harsh ambient conditions of temperature, fly ash, and coal dust. In addition, Type K drives offer the advantages of 4-20 mA current input or digital Network protocols and position output signals necessary with today's modern control systems.

With modern retrofitted damper drives, operators can not only contribute to reduced NO_x emissions in a cost-effective manner, but can also restore operational efficiency and reliability to their tangentially fired boilers.

CASE HISTORIES

Because of the increasingly competitive climate resulting from the need to trade NO_x credits, most users of Type K Drives have become reluctant to share their specific experiences and successes achieved in emission reductions, reduced maintenance, and improved operations by installing Type K Drives on their OFA and windbox applications.

Successes in NO_x reduction and improvements in operations are now seen as an integral part of a competitive strategy in the open or deregulated energy market. Ideally, we would want to report on specific named installations. However, we are required to maintain the confidentiality of our sources.

CASE NO. 1 A LARGE URBAN MID-WESTERN UTILITY

Type K Drives were installed as part of a modernization at one unit of a large mid-western U.S. utility online since 1968. This user typically generates approximately 3.3 million MWHRS per year while consuming over 1.5 million tons of coal. This installation on an 8-Corner furnace replaced all the windbox damper drives originally supplied by the boiler manufacturer.
All damper drives were over 30 years old, but were maintained at or near original operational performance. As a part of a major retrofit program, the engineering staff targeted retrofitting the OFA and windbox drives as a primary means of reducing NO_x emissions.

According to the Instrument/Control Specialist at the station, “The old damper drives were simply obsolete and sloppy in their action. We knew we needed new ones for a variety of reasons—such as to reduce excessive maintenance—and not just for reducing NO_x emissions."

“They had these old cylinder-style purely pneumatic drives on the unit that probably gave decent control back when they started and before emission control became critical, adds Gary Drake, Great Lakes Process Controls, Inc., Farmington Hills, Michigan—a major manufacturers representative since 1981. “So along with adding the SOFA box with modern Type K Drives to reduce NO_x, they wanted to get better control of the older windbox area via improvements in the control of those damper drives.”

The experiences at this installation are similar to those at other tangentially fired units. However, this unit also suffered from excessive temperatures outside the boiler. During the survey process Gary Drake commented about the heat encountered.

"When we were out there in the summer of 2000 to survey this job, we brought an infrared heat gun up there and some of those damper shafts were close to 300°. Every corner was hot, especially those on the inside,” explains Drake.

At Drake's recommendation, the engineers at the station looked into using the Type K OFA/windbox damper drive, a rotary motion pneumatic actuator that sweeps through a 90° arc to directly rotate the damper shaft. Plant personnel also spoke with other users of Type K Drives with similar installations to get their opinions and recommendations.

Ultimately, the station selected Type K Drives because they would be easy to install, withstand the high temperatures, and interface well with the distributed control system. Installation of the new drives took place during October of 2000. In total, 132 drives were installed: 28 in a newly installed SOFA box, and the rest within the windboxes at every corner on every elevation. The drives installed are rated to develop 190 ft. lbs. of torque at 100-psi air supply and have responded very well to the station's existing DCS demand signal.

"The deciding factors for picking these drives were the great amount of torque developed in a small package and the simplicity of the direct mount so they didn't have to fool with the linkage arms anymore," says Drake. "There are similar drives out there, but they all had O-ring seals on the vane that would eventually fail resulting in air leakage."

Fig. 3 Type K Windbox Drives in tight spaces

"Furthermore, the Type K Drive is the only pneumatic drive that can take 300° F on a continuous basis. Electric drives were considered but they are typically limited to a maximum temperature of 150° to 175° F. The old cylinder drives were connected to the damper shaft by means of a lever to get the required 90° shaft rotation, whereas the Type K Drives are directly mounted to the damper shaft, so there's no slop and you get very tight control. We could also configure the positioner location and orientation so that it was near the closest catwalk for easy access by the maintenance crew." Drake added.

According to the Instrument/Control Specialist for the installation, "Quarters were tight and there were a lot of obstructions in and around the burners, so we didn't have much real estate to work

with. We strategically dropped in the new damper drives where the old ones were, without a lot of extra field wiring and additional control system inputs and outputs."

The plant believes (and has the supporting data) that the new damper drives helped the unit lower its NO_x emissions.

"We've had these new damper drives in service for almost ten years now. The improvements in combustion were obvious through visual feedback. As far as the color of the fire and opacity indicated, this saved us fuel," adds the Instrument /Control Specialist.

CASE NO. 2 A LARGE RURAL LOWER MID-WESTERN UTILITY

The owners of the plant described in the previous case history are far from alone in realizing new life from their tangentially fired boilers in terms of improved efficiency and lowered NO_x emissions. For example, consider a unit owned by a large division of a major utility holding company.

This unit, in southern Illinois, is a pressurized, dual furnace Alstom Power boiler rated at 400 MW. The site generates 1.9 million MWHRS annually.

The owners had recently initiated a new DCS system, but sought to achieve further gains in NO_x reduction through the installation of a SOFA box approximately 10 feet above the main wind box. However, the installing boiler contractor would not guarantee further NO_x reductions unless new damper drives were installed on the main windbox. As a result, the existing 88 Fuel Air and Auxiliary Air damper drives were selected for retrofitting. Type K rotary-vane pneumatic drives rated at 190 ft.lbs. were installed as a part of the NO_x reduction project..

As in the previous case history, the consulting engineers for this project recommended pneumatic actuators because of the consistently high ambient temperatures of the boiler—140° F in the walkways and above 200° F near the boiler. These temperatures were present despite the fact that six inches of insulation was placed around the boiler walls prior to the retrofit. While the selected pneumatics were built to withstand temperatures of 300° F, the specifying engineers could not locate suitable electric actuators that were warranted above 185° F.

Once installed and integrated with the plant's DCS, the new damper drives made it easier for the system's operators to maneuver the fireball inside of the furnace. This helped the operators obtain additional NO_x reduction gains from their Alstom Power boiler, beyond what had already been achieved by the new SOFA box and the DCS that had been installed 18 months earlier. The following additional comments from plant personnel support the decision to install modern, high performance damper drives.

"I think other utilities would benefit by installing new damper drives as a means to augment other NO_x reduction measures," commented the operating personnel. "Our utility has been pretty progressive when it comes to reducing NO_x emissions at their plants, so they have quite a few NO_x early-reduction credits built up. For any owner, the sooner you take care of your NO_x problems, the better. Whereas if you procrastinate beyond the deadline , you'll have to purchase NO_x allowances from someone else," added the operating personnel.

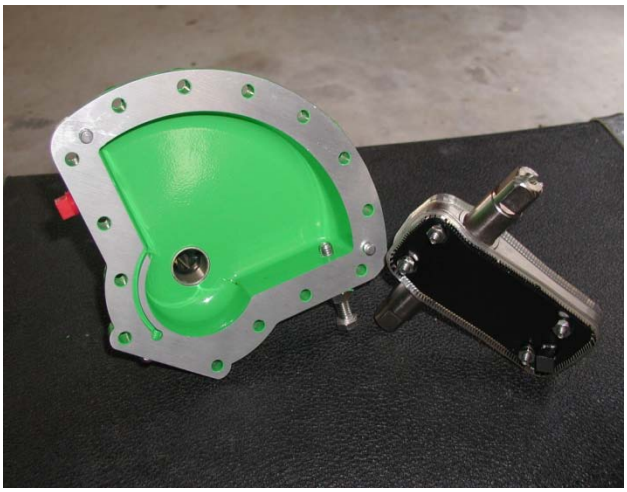
CONCLUSION

Similar experiences have been repeated at tangentially fired boilers throughout the country. The retrofitting of older damper drives stands out as a cost-effective means of helping reduce emissions by better OFA and windbox damper position control while extending the life of these aging boilers, despite the challenges posed by future NO_x reduction targets.

ABOUT TYPE K DRIVES

The unique Type K OFA and windbox drives are manufactured by TYPE K Damper Drives a division of Controls International, Inc., Dallas, Texas, and are designed to operate in harsh environments that include temperatures to 300° F, heavy vibration, coal dust, and fly ash. All Type K Drives provide continuous duty service with smooth, accurate, and repeatable damper positioning. Type K Drives take the lead in designing all their OFA and windbox drives to be easily installed by plant personnel or mechanical contractors using simple hand tools. Individual drives are usually installed in less than one hour.

The Type K design process begins with a thorough on-site survey to develop the dimensional information required for a trouble-free installation. By identifying and locating all obstructions during the design process, Type K virtually eliminates the possibility of unintended consequences during the installation process.



The unique Type K drive utilizes a pneumatic, rotary actuator that has only one moving part, the vane that rotates in a 90°, arc and that features integral lip seals as opposed to O-rings. This rotary motion eliminates the linear-to-rotary conversion found in traditional pneumatic cylinder drives and accounts for its performance, ruggedness, and mechanical efficiency. Each retrofit drive is custom designed for the specific application. After the drive is fully assembled, calibrated, and cycle tested, it is shipped ready for drop in-place installation. All Type K Drives are warranted for three years or 2,000,000 operations.

Fig. 4 Type K actuator with only one moving part

Type K Drives also manufacturer a complete line of pedestal mounted drives designed to match the footprint dimensions and output shaft location of existing older style drives. Both pedestal and direct mounted style damper drives are available to provide torque output ratings ranging from 90 ft.lbs. to 10,416 ft.lbs.

For more information about precise, damper control systems, contact TYPE K Damper Drives at 10410 Vista Park Road; Dallas, TX 75238; (214) 343-9980; fax (214) 343-2658; E-mail: info@typek.com. Or Visit our website at www.typek.com.