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A bnp media PUBLICATION

September 2018 • Volume 25, Number 9

RISK MITIGATION in Temperature Calibration Procedures

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One ammonia-free SCR system utilizes the diesel exhaust fluid, a liquid urea solution commonly used in diesel-powered on-road vehicles.

6 TIPS for Improving Efficiency and Reducing NO_X

Several practices and some new technology choices are available to achieve both low emissions and high efficiency.

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It is no secret that emissions regulations are continuing the downward trend that we have seen in the last decade. Current regulations in many areas of the country — and even some corporate policies — are focused on single-digit NO_X levels of 9 ppm. What is more, we are beginning to see a push for even more stringent protocols. The discussion at various air-quality-management districts in California, in particular, is for performance as low as 2.5 ppm NO_X.

In addition to reducing NO_X — as the precursor to ground-level ozone — it is important to achieve the lowest greenhouse gas emissions while maintaining the highest thermal efficiency. Several technology choices are available to achieve both low emissions and high efficiency. These include design and operational practices involving flue-gas temperature, excess air, low flue-gas recirculation and selective catalytic reduction (SCR) technologies.

Typically, a boiler will consume the equivalent of its initial capital expenditure in fuel usage within its first year (based on continuous operation). With that said, increases to a boiler's efficiency by just a few percentage points can amount to substantial cost savings. Here are six ways to increase a boiler's efficiency while reducing NO_X.

1. Reduce Stack Gas Temperature to Increase Efficiency

One method of immediate efficiency gains is reducing flue-gas temperature, or the temperature of the combustion gases exiting a boiler's stack. Boiler flue gas contains useful amounts of energy that can be captured with the use of an economizer. Once captured in the economizer, the heat from the flue gas can be utilized via heat transfer to preheat the feedwater entering the boiler. In most cases, a decrease of flue-gas temperature by 40°F (4°C) will increase efficiency by 1 percent.

2. Manage Excess-Air Levels for Optimum Performance

Effectively managing excess-air levels — or the amount of additional combustion air required to burn a given amount of fuel — also can improve efficiency.

Increasing excess air provides process advantages. These include flame stabilization, improved air and fuel distribution, and low CO levels. However, too much excess air also can be associated with reduced efficiency. This is due to increased fan horsepower consumption and increased heat loss up the stack. A burner operating with minimum excess air, at 3 percent O_2, is realistic for optimum burner and efficiency improvements.

3. Utilize Flue-Gas Recirculation for Lowering NO_X Emissions

Flue-gas recirculation (FGR) commonly is used to control thermal NO_X. It does this by reducing the burner flame temperature and staging the combustion of air and fuel. This method typically reintroduces 15 to 30 percent — in some cases as high as 45 percent — of the flue gases into the mixing process, which results in decreased production of thermal NO_X.

Such benefits do not come without costs. Operating with high FGR requires significant increases in fan horsepower. It results in reduced efficiency due to the increases in the volumetric flow and pressure drop of the combustion air and flue gas through the unit. During the FGR process, burner stability and response is compromised, resulting in high O_2 concentrations. Obviously, there are limitations on how much FGR can be introduced based on the burner design.

4. Selective Catalytic Reduction for Ultra-Low NO_X Performance

Ultra-low NO_X emissions can be achieved with the use of selective catalytic reduction (SCR) technology. This methodology is post combustion. It uses a single-reactor unit with catalyst and a reducing-agent delivery system. The unit passes the combustion gases through an injection system in which the reducing agent is added to the combustion gases, thoroughly mixed and then catalytically reduced to remove the NO_X. The process allows the reaction of NO_X (NO or NO_2) and NH_3 (ammonia) to chemically convert to resultant products of nitrogen and water vapor.

$$4\,NO + 4\,NH_3 + O_2 \xrightarrow{catalyst} 4\,N_2 + 6\,H_2O$$

$$6\,NO_2 + 8\,NH_3 \xrightarrow{catalyst} 7\,N_2 + 12\,H_2O$$

Main reactions in the SCR process

Based on the formulas above, the reducing agent utilized within the ductwork for an SCR system is ammonia. Historically, and in many current installations, the delivery of the reactant has been ammonia in the form of anhydrous (pure) or aqueous (in a solution with water). Some manufacturers now offer an ammonia-free solution utilizing urea as the reagent. One ammonia-free SCR system utilizes diesel exhaust fluid (DEF),

Emissions-monitoring systems can provide real-time, unified data. This example provides O_2, NO_X, CO and CO_2 measurements in addition to real-time boiler efficiency, fuel usage and carbon footprint calculations.

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an environmentally safe, 32.5 percent liquid urea solution that is commonly used in diesel-powered on-road vehicles. This is an option for users averse to handling and storing ammonia but interested in the NO_X reduction and operating performance of an SCR system.

Typical performance of such units will see NO_X levels reduced from 30 ppm to below 5 ppm, or up to 95 percent reduction. In addition, SCR systems can perform efficiently across a flue-gas temperature range of 325 to 1000°F (163 to 538°C) for boilers, gas turbines and fired refinery equipment. Specifically for boiler applications, SCR can minimize fan requirements by eliminating or greatly reducing the need for flue-gas recirculation. This savings in electrical load, in addition to a more stable burner during load swings over time, could provide the payback when making a decision on what equipment to purchase.

5. Combine Economizers and SCR Systems for Emissions and Efficiency Gains

When an SCR system is combined with an extended-surface economizer and standard burner, both the benefits of low emissions and high efficiency can be achieved. The first phase — the SCR system — uses catalyst and a reagent (ammonia or urea) to convert NO_X to nitrogen and water. The second phase is accomplished with the extended-surface finned-tube economizer, which captures waste heat and sends it back into the boiler feedwater or makeup water.

This process accomplishes significant reductions in operating costs. Operational benefits include flame stability, higher turndown and faster response to load swings.

6. Monitoring Emissions and Efficiency Performance

Facility owners today want information regarding emissions, efficiency and carbon footprint. In addition, having such infor-

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mation often is a requirement for reporting purposes.

The majority of analyzers used in the package boiler market measure O_2 and stack temperature, offering calculated CO_2 value and corresponding efficiency. In order to measure NO_X emissions, an additional analyzer typically is required. Continuous emissions-monitoring systems (CEMS) can be used for reporting both NO_X and CO, but they are typically large, complicated systems.

One emissions- and efficiency-monitoring system alternative was designed to provide real-time, unified data from a single source. This system utilizes electrochemical cells to measure O_2, NO_X, CO and CO_2 readings as well as calculating real-time boiler efficiency, fuel usage and carbon footprint. Putting a monitoring system in place will provide engineers and operators with the peace of mind that their facility is meeting the current emissions requirements while running plant equipment at the most efficient rate possible.

In conclusion, these strategies have been successfully implemented and have established benchmark results for many systems. It is up to the end user to ensure that a proposed solution incorporates the best possible performance standards available. When selecting your solutions provider, go with one that can help you ensure that future emissions compliance and energy efficiency benefits are achieved sooner rather than later.

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