REDUCTION OF NITRIC OXIDE EMISSIONS FROM COAL-FIRED POWER PLANTS

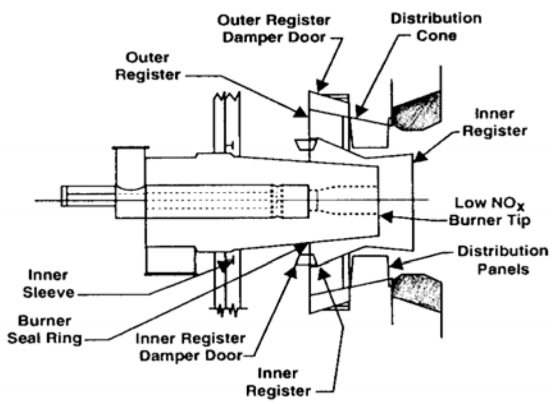
Computer Modeling Optimizes Efficiency Of Testing and Fluid Dynamics

The Clean Air Act Amendments (CAAA) of 1990 require coal-fired power plants to reduce emissions of nitric oxide (NO_X) to the atmosphere. Electric utilities must achieve compliance without sacrificing obiler performance, so the modified configuration must only minimally affect plant operations and maintenance. Selecting the most cost-effective solution can be a challenge.

NO_X REDUCTION METHODS

One solution is replacing conventional burners with low-NO_X burners, which improve mixing and allow greater adjustment (see Figure 1). Conventional burners consist of a port that forces a mixture of pulverized coal and air into the furnace. Only limited adjustment of the burner tip and air mixture is provided.

A typical low-NO_X burner includes a custom coal tip and a dual air register. Major adjustments include outer air register, inner air register, and burner tip position. The inner and outer air



Sectional View

Typical Low-NO_x Burner For Foster Wheeler Furnace

register adjustments provide change in air flow through the register. The burner tip adjustment controls the burner exit velocity and coal distribution pattern.

NO_X emissions also can be reduced by introducing overfire air (OFA) to the burner configuration. This method provides one or two rows of air inlet ports to the wall above the burner grid. Combining low-NO_X burners and OFA configurations is a common solution to reducing NO_X emissions. The effectiveness of a given proposed configuration must be analyzed and tested to achieve optimum results.

ANALYSIS AND TESTING

Testing the actual field conditions is essential to optimizing a configuration. Baseline measurements should include the ASME PTC 4.1 heat loss method evaluation of boiler efficiency, flue gas analysis, burner and furnace observations, windbox balance measurements, fuel balance measurements, and pulverizer testing. The results should list coal fineness, loss on ignition, boiler efficiency in percent, and NO_X emissions in lbs/MMBtu.

Performance testing should take place after installing the low-NO_X burners and OFA ports. The goal is to develop parametric relationships for each of the burner and OFA adjustments. Testing should begin with systematic adjustment of the low-NO_X burner dual air registers, with the overfire air dampers shut to eliminate the effect of OFA on NO_X emissions. An outer to inner register setting ratio may be correlated to NO_X emissions. Once the burner is characterized in the absence of overfire air, the OFA should be fully opened and the outer to inner register ratio again correlated to NO_X emissions.

The results are plotted on a curve with NO_X emissions (or reduction from baseline emissions) on the vertical axis and register adjustment settings on the horizontal axis. These parametric curves separate the effects of OFA and low-NO_X burners, and allow for optimization of the configuration and its adjustments. The final parametrics can then be used in the control system to modulate air register and OFA possiblities.

COMPUTER MODELING

If the required reduction in NO_X exceeds demonstrated experience, a better understanding of the actual combustion process may be needed to achieve the desired emission goals. Computer modeling helps clarify this.

An excellent three-dimensional fluid dynamic model with combustion overlays has been developed by Dr. Bernard P. Breen of Energy Systems Associates in Pittsburgh, Pennsylvania. This type of analysis allows designers to optimize an OFA and burner configuration before purchase and installation.

CASE STUDY

PSI Energy Inc. Selected Burns and McDonnell to design and test a low-NO_X burner and OFA retrofit at its Gibson Station in Indiana. The objective was to meet the NO_X complaince limit at the lowest evaluated costs, with minimal impact on the PSI system.

A testing program similar to that described above was performed. Baseline test results indicated that a 9 percent to 38 percent reduction in NO_X emissions was required for Units 3 and 4. A reduction of approximately 60 percent would be required for Units 1 and 2 to meet the proposed limit of 0.5 lb/MMBtu.

Units 3 and 4 used existing furnace wall openings to implement a compromise OFA configuration. Testing of the retrofitted condition was performed and parametric curves were created. Results indicate that adjsutements to the low-NO_X burner can reduce NO_X emissions by 15 percent without OFA and by more than 38 percent when optimized with OFA.

The higher required NO_X reduction for Units 1 and 2 warranted a computer analysis. An optimum overfire air and burner pattern was selected, and the 32-port dual level OFA system provided NO_X reduction of up to 75 percent after optimization.

CONCLUSION

Electric utilities must economically comply with CAAA limits on NO_X emissions while limiting the regulations' impact on plant operations. A well-researched approach that includes the appropriate level of testing, analysis and optimization can help generating stations achieve their chosen goals and objectives.