Reducing NO_x and LOI at the St. Johns River Power Park

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Summary

The St. Johns River Power Park is a 2 x 660 MW station that is jointly owned by JEA (formerly known as Jacksonville Electric Authority) and Florida Power & Light (FPL). JEA is the plant operator. These Foster Wheeler boilers, started up in the mid-1980's, were equipped with the OEM's low NO_x burners. The boilers have 28 burners with four rows on the front wall and three rows on the rear wall, which are fed by seven mills. Normal full load operation of these units is with one mill out of service. Typically, the boilers fire a blend of 80% Colombian coal (or, to a lesser degree, domestic coal) and 20% delayed petroleum coke.

In the spring of 2002, Advanced Burner Technologies (ABT) installed a partial retrofit (8 of 28) of its Opti-Flow™ low NO_x fuel injectors on Unit 2, while utilizing the existing dual registers. Modifications were also made to the secondary air ducts and burner windboxes in order to improve secondary air distribution. NO_x emissions have been lowered by approximately 10%, with a reduction in fly ash LOI of 50%. Unit 1 was retrofitted with a full complement of Opti-Flow™ fuel injectors in the spring of 2003. NO_x emissions have been reduced by over 20%, based on the average of tests conducted with seven different mills out of service. In addition, CO emissions are consistently less than 10 ppm, compared to an average of near 300 ppm prior to the retrofit.

Beginning in 1997, St. Johns River Power Park began firing a blend of 80% bituminous coal and 20% delayed petroleum coke, in order to realize a significant reduction in fuel costs. NO_x emissions are currently limited by the State of Florida to less than 0.5 $lb/10^6$ Btu. To meet this limit, the boilers typically operated with the top row of burners on the front wall out of service during full load operation. Air flow was maintained through the secondary air registers of the out of service burners in order to achieve a simulated overfire air effect. Due to the low volatile content of the petroleum coke in the blend, incomplete combustion was a problem, with both boilers suffering from high CO emissions and fly ash LOI. This problem was exacerbated when Colombian coal was fired in the fuel blend, since it is commonly known to be a hard to burn coal. As a result of this poor combustion, furnace sidewall corrosion has been an ongoing problem at St. Johns, due to the presence of reducing conditions along the sidewalls. Flame stability problems were also encountered at St. Johns with the OEM low NO_x burners, especially for the bottom rows of burners.

Unit 2 was retrofitted with Opti-Flow™ fuel injectors on the front wall bottom row and rear wall top row during March of 2002. This installation was a "plug-in" retrofit of the ABT fuel injector that utilized the existing OEM dual register and inlet scroll. CFD modeling of the burner windboxes and secondary air ducts indicated that a severe imbalance of air distribution existed within the windboxes. Based on modeling efforts modifications, including baffles and turning vanes, were installed along with the fuel injectors to improve secondary air distribution. Subsequent to the retro-fit of the eight Opti-Flow™ fuel injectors, a moderate decrease in NO_x from 0.46 to 0.41 $lb/10^6$ was observed with the typical simulated overfire operation (front wall, top mill out of service). A marked improvement in combustion was also noted due to the new fuel injectors and improved secondary air distribution. CO emissions were reduced from over 500 ppm to less than 100 ppm with any mill out of service. Likewise, fly ash LOI was reduced from the 30 to 40% range to less than 20%. This improvement in combustion resulted in an increase in boiler efficiency of approximately 1% and an annual fuel savings in excess of $600,000.

In March 2003, a complete retro-fit of 28 Opti-Flow™ Mark II low NO_x fuel injectors were installed on Unit 1. Several improvements were incorporated into the design of these new fuel injectors including a fixed inner barrel tip, an inner sleeve damper to control the inner/outer secondary air split and a fixed inner air swirler. Similar windbox and secondary air duct modifications were also made for Unit 1 as had been installed previously on Unit 2. In addition to the fuel injectors and windbox modifications, anti-corrosion ports (ACP's) were installed on the front and rear walls in order to provide a blanket of air along the sidewalls and minimize corrosion. These novel ports were developed by ABT through CFD modeling of the St. Johns furnace.

Subsequent to this retrofit, a significant improvement in performance of Unit 1 has been observed in several aspects including NO_x emissions, CO emissions, flame stability and unit turndown. NO_x emissions have been reduced to below the guarantee level of 0.4 lb/10^6 Btu for full load operation with either of the top mills out of service. An average NO_x reduction of greater than 20% has been achieved for tests with each of the seven mills out of service.

Greatly improved combustion has resulted in CO emissions of less than 10 ppm for operation with the normal mill configuration (top row of front wall burners out of service). In addition, CO measurements along the furnace sidewalls have shown the effectiveness of the anti-corrosion ports and significant improvement in the reducing conditions along the sidewalls. Fly ash LOI has been reduced from 25 to 30% to 15 to 20% after the retrofit. This improvement is less than anticipated based on the performance of Unit 2 and is attributed to poor fineness and coal pipe distribution from one of the mills.

Improved flame stability and turndown have also resulted from the complete retrofit of ABT fuel injectors for Unit 1. As mentioned earlier, normal full load operation is with one mill out of service. Recent testing has demonstrated that flame stability can be attained as load is reduced from 670 to 380 MW_g (43% turndown), with only one mill out of service. Prior to the retrofit of Opti-Flow™ fuel injectors, this turndown could only be achieved with at least two mills out of service. In fact, in the past only 30% turndown to 475 MW could be achieved without having to take at least one more mill out of service. To date, ABT is the first to demonstrate the ability to cofire petroleum coke in a wall-fired boiler with an advanced low NO_x burner that maintains such excellent flame stability.