SUMMARY

DEMONSTRATION OF ORIMULSION® REBURNING ON A COAL-FIRED UTILITY BOILER

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OVERVIEW

This paper provides a summary of the Orimulsion Reburn Demonstration Project conducted at Illinois Power's Hennepin Power Station during September through November 1997. The demonstration consisted of three major activities:

- Modify the Hennepin Station Unit 1 boiler for Orimulsion reburn
- Deliver Orimulsion fuel to the Station on the Illinois River via double-hulled barge
- Conduct the demonstration through a series of parametric and duration tests

Hennepin Station Unit 1 was selected to host the demonstration because it had been the site of a U.S. DOE Clean Coal Technology (CCT) Program involving natural gas reburn in the early 1990s. Consequently, the modifications required for the Orimulsion reburn system were relatively minor. A double-hulled barge was used to transport about 16,500 barrels of Orimulsion to the plant via the Mississippi and Illinois Rivers and served as the storage facility during the testing. Illinois bituminous coal provided approximately 80% of the unit's heat input, with Orimulsion providing approximately 20%. The objective of the project was to demonstrate NO_x reductions of up to 65% from the original baseline levels with no unexpected impacts on boiler performance or operation.

ORIMULSION

Orimulsion is an emulsion of naturally occurring bitumen, a very heavy hydrocarbon, in water. At approximately 13,000 Btu/lb. and 2.8% sulfur, it is similar to a washed northern Appalachian coal, except for the low ash content of 0.2%. Venezuela holds vast reserves of bitumen in the Orinoco Belt in the east-central part of the country. Orimulsion has been used for power generation around the world since 1991. Existing customers are located in six countries in Asia, North America, and Europe.

HENNEPIN POWER STATION

The Hennepin Power Station is a two-unit coal fired station located in northern Illinois. Unit 1 is a 74 MWe net unit utilizing Combustion Engineering tangentially fired natural circulation boiler.

In order to conduct the Orimulsion Reburn demonstration, the original Flue Gas Recirculation and Overfire Air systems were returned to operational status. The main modifications consisted of replacing the gas supply system with the Orimulsion supply system. A total of fifteen (15) injectors were installed in the reburn system. Four injectors were installed in each corner, except one where only three could be installed due to interference from existing piping. Compressed air was used for atomizing the Orimulsion. Air was selected because of capacity available at the Station.

The logic required to operate the system was developed and implemented into the Unit's Digital Control System. This allowed for the operation of the system by Station Operations' personnel using the existing control system. The operation of the reburn system resulted in no major operational problems. No boiler slagging problems were experienced.

BOILER OPERATION WITH ORIMULSION

Startup and shutdown procedures were developed and reviewed with the operators prior to the system startup. Initial operation of the system during the parametric testing phase of the project consisted of day shift operations. This daily routine was conducted with minimal impact on the operation of the unit. The parametric testing was developed to determine the optimum control points for the system. Following the parametric testing, the reburn system was placed in automatic and allowed to operate on a 24-hour basis with the unit on load control. This "duration" operation consisted of periods of seven days and fifteen days. The operation of the reburn system resulted in no major operational problems.

ORIMULSION REBURN SYSTEM PERFORMANCE

Reburn is a NO_x control technology whereby NO_x is converted to N_2 through a sequence of reactions with hydrocarbon fuel fragments. Implementing a reburn system on a boiler requires no physical changes to the main burners or cyclones. The test program was designed to reveal any changes in boiler emissions, thermal performance or overall operation that occurred with Orimulsion reburn. Baseline testing was conducted to provide a comparison for the reburn testing. Parametric and long-term tests were used to characterize reburn system performance and to demonstrate continuous operation under normal boiler operation conditions. A Continuous Emission Monitoring System featuring a 16-point grid at the economizer inlet was used to obtain O_2, CO, CO_2 and NO_x data. The uncontrolled baseline NO_x levels at Hennepin were 0.75 lb/MMBtu. The results from the Orimulsion reburn indicate that Orimulsion reburn over coal achieved NO_x levels of 0.27 lb/MMBtu or a 64% reduction from baseline. By comparison, the previous natural gas reburn operation at Hennepin achieved a similar reduction of 67%.

EER has tested Orimulsion as a reburn fuel at smaller scales and has found its NO_x reduction performance to be superior to pulverized coal and nearly as effective as natural gas. The full-scale results are consistent with pilot-scale data. NO_x emissions decreased as reburn heat input increased. However, limited overfire air capacity prevented further reductions beyond about 16% heat input from Orimulsion. Removing this limitation would have required the addition of booster fans. Predictions for this boiler indicate that more NO_x reduction would be expected without the overfire air limitation, down to approximately 0.20 lb/MMBtu.

REBURN ECONOMICS

The retrofit costs for reburn systems are very site specific. Preliminary engineering must be performed to produce an accurate cost estimate, because the actual system performance depends on a range of factors. An Orimulsion reburn system would cost about 15 $/kW. Orimulsion is attractive as a reburn fuel due to the moderate capital costs and favorable fuel cost differential.

SUMMARY

This project is the first demonstration of Orimulsion as a reburn fuel for a utility boiler in the United States. The overall objectives of the project were met. Fuel transport and handling throughout the entire project was completed without accidental discharge. The data indicate that Orimulsion is nearly as effective for reburning NO_x control as natural gas, which is consistent with pilot-scale results. NO_x reductions of 64% from the original baseline levels were achieved with no unexpected impacts on boiler performance or operation.