Project Description

JANSEN Combustion and Boiler Technologies, Inc.

Biomass Capacity Upgrade of Two Boilers
Minnesota Power - Hibbard Station
Duluth, Minnesota

Project Scope

Minnesota Power (MP) operates two identical boilers (called the No. 3 and No. 4 Boilers) at the Hibbard power generating station in Duluth, MN. The boilers were originally supplied by Erie City in the 1950's to burn pulverized coal; they were converted in 1985 to burn a mix of wood and coal on a traveling grate (in a 60:40 heat input split) with a 300,000 lb/hr of superheated steam generation rating. The wood derived fuel (WDF) currently burned is a mix of purchased wood wastes, railroad ties, and short fiber residues.

Historically, the boilers had not been able to reliably achieve the design WDF firing rates. Increased WDF firing (with a lowering of coal firing) would lead to excessive carryover and high amounts of unburned char in the fly ash. Operation was also characterized by high flue gas exit temperatures, and limited induced draft (ID) fan operating margin.

MP desired to increase the WDF firing rates and to eventually eliminate coal firing in the boilers. MP contracted JANSEN to evaluate boiler operation and develop design concepts for meeting their goals. The project was initiated by an engineering site visit where boiler operating data were collected and evaluated to develop a baseline of boiler operation. CFD modeling was carried out to identify limitations for increased WDF firing.

The CFD modeling showed that non-uniform fuel delivery profiles and an ineffective overfire air (OFA) system were the main causes for high char and ash carryover when firing WDF. Modeling with a modern side wall interlaced OFA system, and the installation of "new-style" fuel distributors were shown to significantly improve combustion conditions required to achieve 100% WDF firing.

Poor generating bank (GB) outlet ash hopper design also contributed to high ash carryover rates. This led to higher erosion in the tubular air heater (TAH) and economizer sections and more ash load on the mechanical dust collector (MDC). In addition, insufficient TAH flue gas flow area and economizer surface areas led to increased erosion, reduced heat capture, high flue gas exit temperatures, and lower boiler thermal efficiency. These deficiencies were projected to increase incrementally with increased WDF firing.

A modern OFA system along with redesigned GB outlet ash hopper and a separate fan to supply the char re-injection air were installed on the No. 3 and No. 4 Boilers in 2010 and 2011, respectively. A redesigned economizer (for improved heat capture) and TAH (for lowering erosion and improved heat capture) were installed on the No. 3 Boiler in 2012. The economizer and TAH upgrades on the No. 4 Boiler are scheduled for 2013.

Results

Following the No. 3 Boiler upgrades, boiler efficiency has been increased by 6% points and resulted in 10% increased steam generation for the same fuel firing rate. WDF firing now accounts for ~78% of the fuel heat input. Adequate fan operating margins have also been realized. Finally, the planned fuel distributor upgrades will allow the boilers to realize the ultimate goal of eliminating coal firing altogether.

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