DP CleanTech

Clean energy, natural solutions

12MW straw-fired boiler
A retrofit case study

Juye Shandong Province, China

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Project Background

The Juye plant in Shangdong Province, China, is owned and operated by NBE (National BioEnergy). It consists of a 12MW biomass boiler with 48tph boiler configured for the combustion of soft straw fuel. The project has been in operation since 11th April 2008, but performance was declining over time. Specifically, the plant was experiencing problems with unplanned shutdowns, improper fuel burnout and below- expected efficiency levels. DP dispatched a team to thoroughly assess and diagnose the problems at the plant. It was ascertained that the problems being experienced were commonly associated with the use of fuel(s) which were different from those of the original design fuel. DP committed to review ways in which to improve the plant's performance, given the new fuel conditions.

Juye Power Plant Challenges

- Low boiler efficiency
- The level of un-burnt carbon (UBC) in both bottom slag and fly ash was as high as 20%; whereas optimal levels should be no more than 10%
- The flue gas exhaust temperature was 148℃, although it should typically range from 135℃ to 140℃
- The operation was unstable, with the automation input rate being less than 10%. This was due to a mismatch in the feeding system and the fuel being used
- Frequent, unplanned shutdowns

These challenges are representative of those experienced by many biomass plant operators in typical emerging markets. Juye was originally designed to handle a single fuel type; and of a higher quality. The reality was that poor quality or different fuel types were often used, causing various problems and performance issues. In many emerging markets, the reliable supply of single, high quality fuels is undermined by undeveloped fuel markets, and variable collection, transportation and storage conditions.

DP Problem Solving Approach

Following the problem diagnoses, DP and NBE agreed to assess the feasibility of a retrofit and re-commissioning of the boiler. The first step was to analyse the actual fuels that were being used in order to assess their effect on performance.

After thorough fuel analysis and testing, DP concluded that performance could be significantly improved, but that this would require design changes. Upgrades to various components were designed to embrace the fuel conditions. A three-week retrofit followed by a month of rigorous testing was completed in October 2014. The performance testing significantly exceeded targets; and the effectiveness of these upgrades has paved the way for the development of a new 'complete solution' design that addresses all of the commonly experienced issues associated with usage of poor quality and mixed fuel types. Our new EcoMulti boiler includes many of these enhancements.

Design Solutions

Elongated water cooled vibrating grate

Faced with the challenge of reducing UBC and optimizing combustion, the DP team worked on the premise that the relatively high moisture level/low calorific content of the fuel required a longer time on the grate to ensure sufficient evaporation, gasification and carbon combustion. The DP team developed an elongated water-cooled vibrating grate which was specifically tailored to handle the low quality fuel being used by the Juye plant. Laboratory testing of the fuel and boiler figures enabled the team to calculate the optimal grate length for the retrofit; and the grate was sufficiently extended without needing to modify the boiler size.

High temperature air preheater

The Juye boiler retrofit also included an additional primary air-preheater and a higher combustion air temperature for drying the fuel. This capitalized on the longer retention time for fuel on the grate by expediting fuel moisture evaporation. By enhancing the furnace with this additional ignition system, fuel drying is expedited thereby allowing for more thorough combustion and the minimization of UBC in slag and fly ash.

Feeding system overhaul

In order to improve automation, adjustments to the feeding system were needed. Ensuring the correct stable and steady flow of fuel without jams or interruptions required some redesign and additional componentry. Alterations to the feeder diameter as well as the inclusion of a stainless steel plated water cooling duct significantly reduced fuel jams and increased feeding automation from 10% to 90%.

Combustion air system optimization

Another major irregularity was the high level of fly ash. This was mostly attributable to dirt in the low quality fuel. The high levels of fly ash were creating extra stress on the bag filters, causing an overall pressure drop and unprecedented UBC levels in the slag and fly ash. By redesigning the structure of the combustion air system DP was able to significantly enhance performance and reduce UBC levels.

Commissioning & automation

A full re-commissioning was conducted after the retrofit. The commissioning included revised on- site controls for:

- Feed water and pressure
- Air preheater and flue gas cooler
- Instrumentation and air flow measurements
- Primary and secondary air
- Furnace pressure
- Drum level drain
- Steam temperature
- Combustion air and 0^2 correction
- Ignition air
- Grate vibration

Supplementary training in automation management was provided to the operators to ensure that the control systems were properly deployed.

Main Customer Benefits

The Juye case demonstrates DP's pursuit of excellence and our commitment to customers. DP's fuel knowledge and technical capabilities were successfully used to identify and deliver a number of operational solutions which have delivered significant economic benefits for NBE.

Item	Unit	Before Retrofit	After Retrofit
UBC in slag	%	20	6.78
UBC in fly ash	%	20	7
Heat loss (total)	%	14.69	9.91
Thermal efficiency based on LHV	%	85.31	90.09

√Decrease in straw fuel consumption by nearly 8%

√Decrease in plant maintenance costs due to limited UBC in fly ash and slag

√Overall dramatic increase in plant automation, improving combustion optimisation

√Overall significant increase in plant availability

√Overall improvement in plant management due to thorough training of operators

√Estimated to save over 1.5 million RMB per year on fuel consumption

Training

Training sessions were conducted by DP throughout the commissioning process to educate plant operators and personnel in underlying combustion and boiler operation concepts. This enabled them to recognize and properly implement optimal combustion parameters using the new automatic systems.

Training covered the following important areas for optimized performance:

- New automatic load control for the fuel feeding system
- Implications of O^2 levels in the flue gas on the combustion and overall performance of the boiler
- Automatic operation of O^2 control
- Changes in the combustion air system; relationships between different combustion air groups and their contribution to furnace combustion
- Design data for the combustion air system
- Automatic operation of combustion air system during grate vibrations
- The ideal flame shape and colour on the grate
- Adjustments of grate frequency, vibration time and pause time
- Automatic operation of furnace pressure control with ID fan – normal and during grate vibrations
- The sequence in which a control system should be put in automatic operation
- How the boiler is protected against high temperature corrosion
- How the boiler is protected against low temperature corrosion

Ongoing Development

The retrofit process and modifications have been a fundamental part of the development process for the DP EcoMulti boiler product range. Whilst the enhanced components are being standardized for new-build EcoMulti projects, the improvements are not limited to DP boilers. Individual components and modifications can improve the performance of a variety of boiler types and sizes.

At DP, we respond to the ongoing challenges of developing optimized boiler solutions for single, multiple and specialist fuels by working with our clients on a continuous improvement program that contributes to a virtuous circle of knowledge and product development.