DP CleanTech
Creating value from waste

China's first biomass power plant: Advanced mixed fuel power plant

Shanxian Shandong Province, China

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Introduction

In December 2006, DP CleanTech delivered the first commercial biomass power plant in China. The 30MW plant was delivered to National BioEnergy (NBE), in Shanxian County, Heze City, Shandong Province. DP delivered the complete biomass power plant including fuel handling system, steam boiler and flue gas cleaning system. Originally designed for woody fuels, NBE later commissioned DP CleanTech to optimize the plant to run on a variety of different fuels. Today, after almost 20 years of superior performance, the Shanxian plant is still one of the best performing mixed fuel biomass power plants in China.

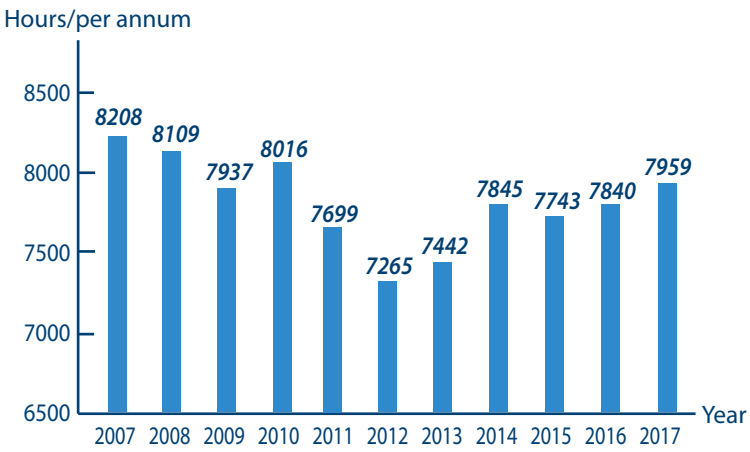
As the first biomass power plant in China, the Shanxian plant was a pioneering example for the successful deployment of advanced HPHT technology for the China biomass industry. The plant's continued excellent and reliable performance after almost 20 years demonstrates the quality of DP's design solution and manufacturing standards. It also highlights the importance of the process of designing a biomass power plant based on a detailed understanding and analysis of fuel, logistics and end user requirements. Shanxian's performance data over the last decade mirrors the development cycle of the China biomass industry.

Since 2006, DP CleanTech has delivered over 1000MW of installed capacity to NBE, which is now part of the State Grid of China. By the end of 2020, NBE owned and operated over 40 biomass power plants in China, making it the largest biomass power generation company in the world.

Plant Performance

The Shanxian plant is designed for a gross nominal load of 30 MWe, and consumes more than 250,000 tons of woody fuels per year. As the availability of fuel types has grown with the development of the China biomass industry, the Shanxian plant is now processing more than 20 different types of fuel every day. Fuel types include corn cobs, wood chips, rice husk, bark, woody manufacturing cutoffs; and agricultural hard straws. DP continues to provide performance - optimising services and solutions to Shanxian to increase fuel flexibility, improve combustion efficiency; and to develop enhanced resistance to equipment erosion and corrosion in order to maintain plant performance and maximize the value from the investment.

Annual Availability Hours Shanxian 2007 – 2017*



*Source: Internal NBE data

Design Data

Fuel	Wood chip, Bark, Straw, Husk
Fuel consumption	25tph
Power output	30MWe
Steam flow	130 tph
Steam pressure	92 bar
Steam temperature	540 °C
Boiler efficiency	91%
Plant efficiency	33%

- From 2007 – 2010, during the initial stage of China biomass development, fuel quality was stable; fuel was readily available, and annual availability was 7900 – 8200 hours.
- Between 2011 and 2013, as the industry developed, more power plants entered the market, and the competition for fuel became more intense. Greater demand facilitated the supply of poor quality fuel, and during this period, there was a significant decline in Shanxian's annual availability due to fuel competition and poor quality fuel.
- Work to improve the flexibility and efficiency of the plant has since enabled optimum efficiency from a greater range of fuels, and from fuels of lower quality. The situation stabilised in 2014, and annual availability hours have consistently been over 7500. Decreased operational costs and improved efficiency have increased plant profitability.
- Compared to similar sized biomass power plants in China which use other solutions, Shanxian has delivered better performance, reliability and efficiency.
- Almost 20 years of consistently reliable operation unquestionably demonstrates that compared to other technologies, DP's HTHP and Water Cooled Vibrating (WCVG) solution has unique and unmatched advantages. As a solution provider, rather than an equipment supplier, DP has unparalleled expertise in ensuring that the plant is correctly designed and delivered.

DP Solution

Fuel Storage and Handling

The plant consumes approximately 250,000 tons of woody biomass per year which is supplied locally from a pool of around 50,000 farmers, each owning less than 1 acre of land. They deliver the fuel to 8 logistics stations located within a 30km radius of the plant. Fuels are shredded before delivery to the plant. Other fuels are supplied from other areas in the province, depending on demand. Fuels are delivered to the plant on trucks which deliver the fuel directly to the storage area. On site fuel storage capacity is more than 7 days.

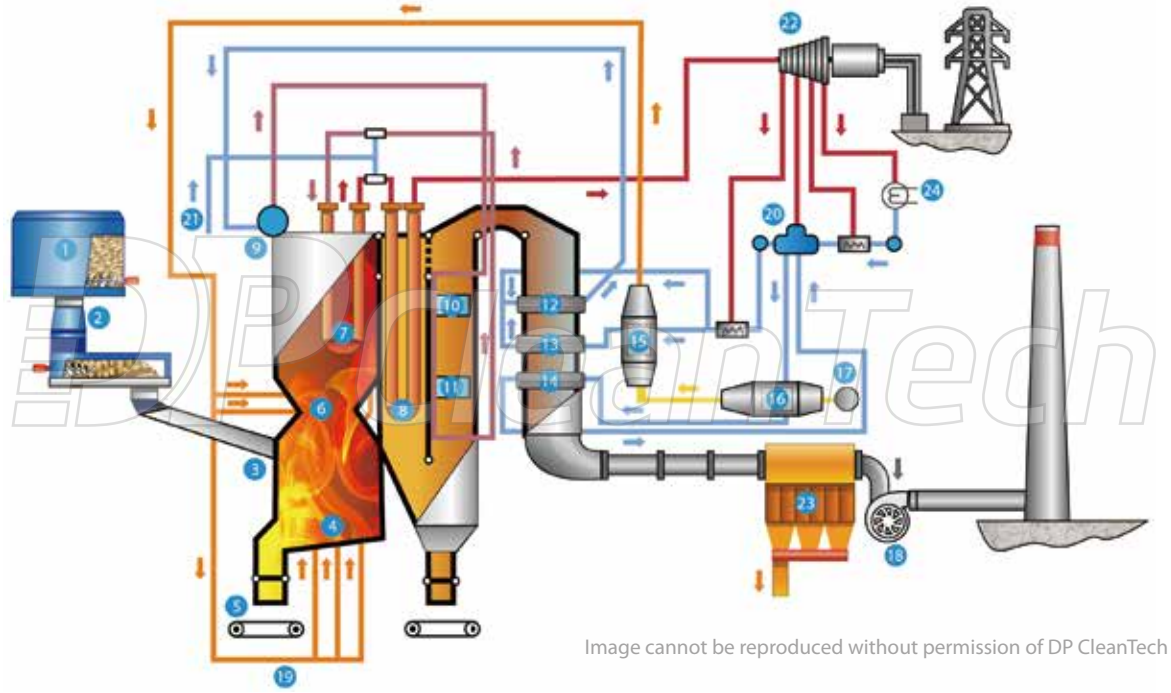
The fuel handling system is flexible and can handle auxiliary fuels such as corn cobs, eucalyptus bark and peanut shells depending on the availability of the biomass. From the silo, the fuel is led to the spreader stokers via dosing screw conveyors. The fuels are then fed into the boiler at the required rate under carefully controlled conditions.

Combustion Process

Fuel is blown into the furnace by spreaders and whilst suspended in the air, the process of combustion begins. The main combustion process takes place on the Water-Cooled Vibrating Grate; the vibrating movements regulate the stages of combustion. Part of the combustion air is fed to the furnace from beneath the grate and further combustion air is led to the furnace through nozzles situated above the grate. The ignition zone of the grate is stabilized by means of a patented ignition air supply system.

The vibrating motion occurs in cycles which alternate between 1.5 – 3 minutes for a period of 3 – 5 seconds at a time. The fuel ash and slag are transported down the grate to the slag fall, along with the final burn out of the fuel.

High Pressure, High Temperature Boiler



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1 Wood chip silo	7 Superheater 3	13 High pressure flue gas cooler	19 Preheated combustion air
2 Dosing silo	8 Superheater 4	14 Low pressure flue gas cooler	20 Deaerator
3 Spreader	9 Steam drum	15 High pressure air preheater	21 Water for atemperators
4 Vibrating grate	10 Superheater 1	16 Low pressure air preheater	22 Turbine
5 Slag conveyor	11 Superheater 2	17 FD fan	23 Bag filter
6 Combustion chamber	12 Economizer	18 ID fan	24 Condenser

The steam boiler is specially designed for high pressures and temperatures. The water tube boiler with hanging superheaters produces 130 tons of steam per hour at 92 bar and 540°C. DP CleanTech's unique and well-proven design uses specific materials and advanced temperature controls to counteract the fouling and corrosive effects of the fuel. The steam produced is used in a conventional steam cycle turbine. The plant supplies approximately 200,000MWh of electricity to the national grid annually. The flue gas, having been cooled in the boiler, is cleaned in a fabric filter before being discharged through the stack.

Water Cooled Vibrating Grate

DP CleanTech's Water Cooled Vibrating Grate (WCVG) was designed and developed specifically for the combustion of biomass fuels. The WCVG is one of the most reliable combustion grates in the world, and is one of few grates able to effectively accommodate mixtures of woody and herbaceous biomass fuel. The vibration inhibits the formation of large slag particles, which are common in straw and waste wood fuels. This makes the grate suitable for burning fuels with high slagging and sintering propensities. In addition, a vibrating grate requires less maintenance than a moving grate because it has fewer moving parts.

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