Research on Energy Metering System Based on Biomass Gasification Coupled Power Generation in a 600MW Power Plant

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Abstract. The biomass gasification coupled power generation project of a power plant is the first biomass gasification and coal-fired coupled power generation project using agricultural and forestry biomass residues as the main fuel in China, and has completed 72+24 hours of full load test run in September 2018. With the formulation of relevant standards, in order to further improve the overall operational capacity of the project, and give full play to the demonstration significance of the national coal-fired coupling power generation technology transformation pilot project, scientific and technological research has been carried out in such aspects as electricity metering. By upgrading the electricity metering system, on the one hand, it can meet the latest technical requirements of the electric power industry standard "Coal fired coupled biomass power generation biomass energy calculation Part 1: Agricultural and forestry waste gasification coupling", on the other hand, it can solve the problems encountered in existing equipment such as short operation time, large maintenance volume, and low accuracy of gas composition detection, improving equipment stability, while reducing heat value loss, and reducing production costs, Improve production efficiency.At the same time, after the heat value analyzer is changed, the measured heat value loss is reduced by 20%. Based on the annual utilization hours of the gasifier, about 6400 tons of biomass fuel loss can be recovered in one year, and the annual fuel cost recovered is about 2.56 million yuan.

1.Introduction

Energy is the foundation of China's economic and social development. Currently, coal-fired thermal power generation is still the main energy supply mode in China, while coal combustion emits a large amount of NO_x, SO_2, CO_2, and other gases as well as fine particles, resulting in a sharp decline in the quality of the atmospheric environment, which is contrary to China's environmentally friendly concept of ecological civilization construction [1,2]. On December 20, 2016, the State Council issued the "13th Five Year Plan" Comprehensive Work Plan for Energy Conservation and Emission Reduction, which proposed the goal of controlling CO2 emissions from power supply units of large power generation groups to within 550 g/(kW • h), which has brought enormous pressure to coal power generation enterprises [3]. Therefore, seeking a clean, green, efficient, environmentally friendly, and renewable alternative energy from coal has become a necessary issue for coal power generation enterprises and for China to fully build a moderately prosperous society [4,5]. China's economy has entered a new normal. In 2016, coal power enterprises had less than 4100 online hours, facing transformation. Biomass gasification coupled power generation is a key focus project [6]. China's biomass energy resources exceed 900 million tons per year, but due to the lack of large-scale and high-value utilization methods, environmental pollution has been caused . Currently, no matter at home or abroad, commercial operation of circulating fluidized bed gasification devices using straw as raw material has been achieved [7,8], and domestic biomass gasification devices are generally small in scale, with shortcomings such as poor feedstock adaptability and low operating efficiency [9,10]. Developing a large-scale circulating fluidized bed biomass gasification device suitable for high ash/high alkali/low ash melting point straw raw materials, establishing a demonstration device, and achieving stable and efficient operation are of great significance for the formation of a biomass gasification coupled power generation technology with independent intellectual property rights in China. The biomass gasification coupled power generation project of a power plant is the first biomass gasification and coal-fired coupled power generation project in China that uses agricultural and forestry biomass residues as the main fuel. The project commenced construction in March 2017, completed 72+24 hours of full load test run in September 2018, and completed performance assessment tests in March 2019.

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project, and give full play to the demonstration significance of the national coal-fired coupling power generation technology transformation pilot project, further scientific and technological research has been carried out in such aspects as electricity metering.

2.Composition of biomass gasification coupled power generation system

The biomass gasification coupled power generation process flow is shown in Figure 1. Biomass is continuously fed into the gasifier through a screw feeder, and air is sent into the gasifier by a blower. Biomass raw materials undergo pyrolysis and gasification processes in the furnace to generate combustible gas. High temperature gas entrains solid particles into a cyclone separator for gas-solid separation. The separated recycled particles enter a return device and are sent to the dense phase zone through a feeder to control the bed temperature. The gas from the cyclone separator of the gasifier enters the dust separator of the purification system to further separate the solid particles in the biomass gas and improve the quality of the combustible gas. The separated ash is recycled after passing through the ash cooler; After being cooled by a heat transfer oil heat exchanger, the high-temperature gas after dust removal is sent to a 600MW boiler through a booster fan, partially replacing coal combustion, and using the original power generation system to generate electricity efficiently.

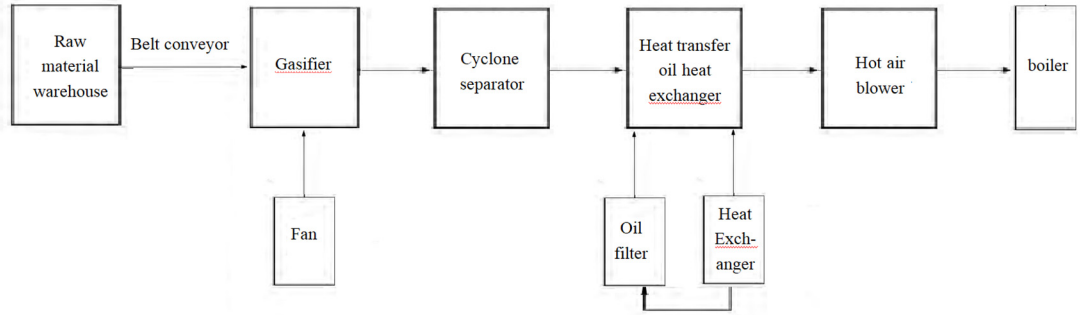

Figure 1. Gasification coupling system process flow diagram.

3.Principle of biomass gasification coupled power generation metering system

3.1.Defects in the original system

Due to the existing metering equipment in a power plant, the ash content of the gas at the outlet of the gasifier is 15g/Nm^3, and the tar content is 2g/Nm^3. The gas needs to be purified before being analyzed by a skid mounted metering station to output the accumulated low calorific value of the hot and wet gas. The existing gasifier gas metering station has the problem of clogging the sampling filter screen and pipeline due to the influence of tar and ash in the front-end sampling device, and the sample gas cannot smoothly enter the analyzer. The complete set of devices cannot operate for a long period of time, resulting in a large amount of maintenance and repair; The front-end sampling filtration does not remove impurities from the gas, and the sample gas entering the analyzer poses a risk of contaminating precision instruments, shortening the equipment maintenance cycle and service life. In addition, the metering station equipment is placed in the open air, and the working environment is harsh, affecting the service life of the equipment. Existing gas calorific value gas analyzers cannot analyze the C_2H_2 and C_2H_4 gas components in gas. Referring to similar domestic projects, C_2H_2 and C_2H_4 account for about 20% of the gas calorific value. When the gasifier operates at rated load, it consumes approximately 25% more fuel, seriously affecting the economy of gasifier operation and failing to meet the requirements of the new standard. The gas analyzer has not been selected based on the actual composition of the gas, and some combustible components have not been analyzed. There is an error between the calorific value of the gas calculated by the metering station and the actual calorific value of the gas. In terms of current electricity metering, currently, the active power of generators, high voltage station transformers, high voltage public transformers, excitation transformers, and other locations can only be obtained using transmitters, resulting in problems such as low signal reliability and remote transmission.

3.2.Principle of biomass gasification coupled power generation metering system

Considering the existing metering equipment problems in a power plant, it is proposed to add a complete biomass gas coupled electricity metering system and retain the original system. On the one hand, it helps to form a comparison effect between two sets of equipment, and on the other hand, it helps to transition the implementation stage of the standard.

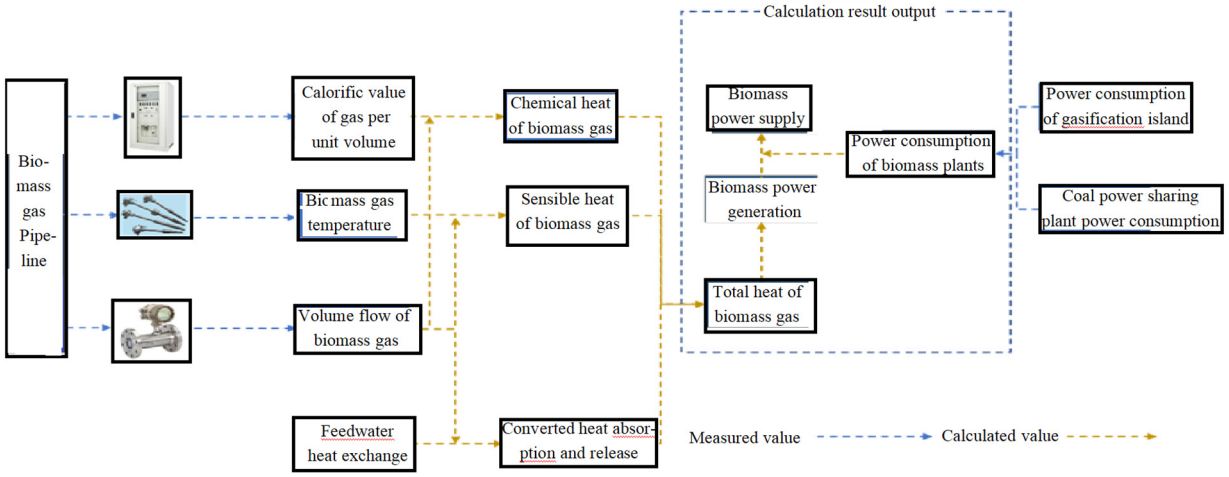

Figure 2. Schematic diagram of biomass gasification coupled power generation metering system.

According to the latest technical requirements of the electric power industry standard "Calculation of biomass energy for coal-fired coupled biomass power generation Part 1: Gasification coupling of agricultural and forestry waste residues", the principle of the biomass gas coupled electricity metering system is shown in Figure 2. The left part is equipped with temperature and pressure sensors, flow meters, and gas analyzers for measuring data in the biomass gas pipeline. The basic data used for calculation is directly measured by the instrument, and then the chemical heat and sensible heat of biomass gas are calculated. Compared to the enterprise standard, the new standard is more rigorous, and the energy changes caused by heat exchange are fed to water for heat exchange The total heat of biomass gas is obtained by taking into account the converted heat of absorption and release, and then the biomass power generation capacity is calculated. The right part calculates the plant power consumption shared by the gasification island and coal power through the installation of a power meter, and then obtains the biomass gasification coupling power supply amount in combination with the calculation method in the standard.

3.3.Advantages of Existing Systems

The gas output from the gasifier contains a certain amount of ash. Operating adjustments can affect its concentration. The ash content of the gas at the outlet of the gasifier is about 15g/Nm^3, which varies with the output of the booster fan and the efficiency of the cyclone dust collector. When the content of fly ash increases, the effect of the sampling device at the metering station will be affected. In the design of sample gas sampling, it is necessary to consider the influx of a large amount of ash, and set up two sampling pipelines for mutual standby. When one pipeline is blocked and exits for maintenance, the equipment operation will not be interrupted. In addition, consider adding an ash removal buffer tank to one of the sampling devices to reduce the blocking problem caused by a sudden increase in dust, and compare the effect of adding an ash removal buffer tank. Arrange nitrogen soot blowing device to ensure long-term stable operation of sampling device.

To further process the sampled gas, a sample gas preprocessing unit is provided. The gas analysis instrument requires that the gas undergo dust removal, oil removal, water removal, and other processes before entering the analyzer sensor. At the same time, it also requires that the components of the gas to be measured not be changed during the process of dust removal, water removal, and oil removal. The quality of the pretreatment technology directly affects the accuracy, reliability, and service life of the analyzer. The tar content of the gas at the outlet of the gasifier is 2g/Nm^3. The pretreatment unit is equipped with a water and kerosene cleaning device to effectively remove the tar from the gas.

The sample gas is first transported to the bottom of the kerosene storage tank through a sampling pipe to separate most of the tar from the sample gas, as well as the dust carried in the sample gas. The sample gas is then transported to the bottom of the water washer to further dissolve the tar and separate the dust. After the above treatment, the sample gas was initially purified, the tar dust content was significantly reduced, and the components to be measured in the sample gas were completely retained. In further purification, a gas water separator with a filtration accuracy of 5 um is used to filter the sample gas and separate the liquid water. Finally, a precision filter with a primary filtration accuracy of 0.1 um is used to ensure that the sample gas meets the operational requirements of the analyzer.

Using an infrared gas analyzer, it can simultaneously measure the concentrations of CO, CO_2, CH_4, C_2H_2, H_2, O_2, C_2H_4, and C_3H_8, and has an online dynamic compensation function, effectively eliminating the impact of CO, CH_4, and C_2H_2 gases on H_2 detection. The measurement interface of the analysis module is reserved to facilitate the addition of analysis modules and meet the technical requirements of future new standards.

After the heat value analyzer is upgraded, the measured heat value loss is reduced by 20%. Based on the annual utilization hours of the gasifier, about 6400 tons of biomass fuel loss can be recovered in one year, and the annual fuel cost recovered is about 2.56 million yuan

According to the requirements of the new industry

standard, add a data collector calculation program, use the calculation methods in the industry standard to calculate the collected data, and transmit the output data to the power grid company through 485 communication. At the same time, display the output data on the DCS measurement interface.

4.Conclusion

Through the commissioning and monitoring of the electricity metering system for biomass gasification coupled power generation in a 600MW power plant, on the one hand, it can meet the latest technical requirements of the power industry standard "Calculation of biomass energy for coal-fired coupled biomass power generation Part 1: Gasification coupling of agricultural and forestry residues", on the other hand, it can solve the problems encountered in existing equipment such as short operation time, large maintenance volume, and low accuracy of gas composition detection, Improve equipment stability, reduce heat value loss, reduce production costs, and improve production efficiency. Provide innovation and engineering applications of key core technologies such as equipment finalization, system layout, control strategies, and power metering for similar biomass gasification coupled power generation projects in the future.

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