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Industrial Silicon Furnace Flue Gas Waste Heat Utilization

As a key link in modern industry, the industrial silicon furnace industry consumes huge amounts of energy. According to statistics, China consumes more than 13,000 kWh of electricity for every ton of industrial silicon produced. If 1 million tons of industrial silicon are produced annually, the electricity consumption will be as high as 13 billion kWh or more. Given that China is committed to building a resource recycling system for the whole society and deepening energy conservation and emission reduction, the industrial silicon industry, as a major energy consumer, has made it imperative to recycle waste heat from flue gas.

Analysis of Industrial Silicon Furnace Flue Gas Waste Heat Power Generation Technology

In order to respond to the country's call to build a conservation-oriented society, while reducing corporate costs and enhancing market competitiveness, it is particularly important to implement energy-saving technology transformation, recover waste heat, and improve comprehensive energy efficiency. At present, research on power generation technology from waste heat from flue gas of industrial silicon furnaces is in-depth.

Industrial Silicon Flue Gas Waste Heat Characteristics

Industrial silicon furnace flue gas waste heat has the following characteristics: first, it is medium-temperature waste heat, with less waste gas flow and relatively low thermal grade; second, the parameters of flue gas waste heat (such as temperature and flow) flue gas waste heat have a large fluctuation range; third, the silica ash (silicon powder) in the flue gas is extremely fine, has strong adhesion, and has high thermal resistance. After the heated outer tube wall is adhered to the ash, the heat exchange rate will be significantly reduced.

Analysis of the Situation Before the Transformation of Flue Gas Waste Heat Power Generation

An industrial silicon furnace plant originally had two submerged arc furnaces. The high-temperature flue gas (400℃~600℃) discharged by the factory was cooled to 220℃~230℃ by mixed air, and then first entered the double-effect cyclone dust collector for dust removal. The dust (SiO_2 powder) obtained by dust removal is discharged and packaged by the unloader. The flue gas after dust removal is cooled down again by spraying cooling water before entering the fan, so that the temperature of the flue gas drops to about 180℃~200℃, and then enters the bag filter for purification through the induced draft fan, and finally discharged into the atmosphere. Although this treatment method can meet environmental protection requirements, it consumes a lot of electricity and water resources, and the heat energy of high-temperature flue gas is not reasonably utilized, resulting in heat energy waste.

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Waste Heat Power Generation Transformation Plan Design

Waste Heat Resource Assessment

The flow and temperature parameters of high-temperature flue gas determine the installation plan of the waste heat power station, while the smoke composition and its content determine the cleaning method of the waste heat boiler. According to on-site measurements, the flue gas waste heat parameters of the two submerged arc furnaces in the industrial silicon plant are as follows: the total flue gas volume is 2×70000Nm³/h, the flue gas temperature is 450℃, the smoke dust components are SiO_2 (86%~90%), Al_2O_3 (0.2%~1.7%), Fe_2O_3 (0.3%~6.0%), CaO (0.2%~0.5%), and the smoke dust content is 7g/Nm³.

Installation Plan Dormulation

According to the mature waste heat power generation process, the temperature of the flue gas can be reduced to about 200℃ after being used by the waste heat boiler. According to calculations, the waste heat of flue gas that can be used per hour by each submerged arc furnace is 2415×10⁴kJ/h. Considering the efficiency of the waste heat boiler and the generator set, the installation plan for this project is determined to be 2×8t/h silicon industry flue gas dedicated waste heat boiler and 1×3MW pure condensing steam turbine generator set.

Process Description

The high-temperature waste heat flue gas generated by silicon refining is sent to the waste heat boiler through the flue for heat exchange, and the high-temperature and high-pressure steam generated drives the steam turbine generator set to generate electricity. The cooled flue gas enters the original dust collector for dust removal and is discharged. The power generated by the generator is stepped up by the step-up transformer and connected to the busbar of the silicon furnace 35kV distribution device to achieve grid-connected operation, and all the power generated is used for the load of the entire plant.

In order to improve energy utilization efficiency, according to the principle of flue gas waste heat cascade utilization, the heat of the utilized flue gas can still be used to generate waste heat boiler supplementary steam after it comes out of the waste heat boiler. The flue gas with further reduced temperature can be used to generate hot water, and the flue gas finally cooled to below 120℃ can be treated in the bag filter in accordance with the standard.

Analysis of the Key Points and Difficulties of Waste Heat Power Generation Technology Transformation

Flue Gas Parameter Measurement

The flow rate, temperature and other parameters of high-temperature waste heat flue gas are crucial to the rated output and economic benefits of waste heat power plants. However, most industrial silicon plants cannot provide flue gas monitoring parameters, and there are dangerous factors such as high-temperature live electricity operations and high-altitude falls on site.

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Therefore, it is recommended to entrust a professional thermal measurement team to conduct field measurements to obtain direct original design parameters.

General Layout

Most industrial silicon plants lack unified planning during construction, and the use of sites is limited. Therefore, how to use limited sites to reasonably arrange new facilities to meet project requirements, save land, and facilitate management is a major issue facing the design. It is recommended to collect the original design data of the original plant buildings and structures and their foundations, and consider using the original equipment supports and hangers and plant area pipe racks for design under the premise of reliability, economy and conducive to the optimization of the general layout. Otherwise, all new construction should be considered, which puts higher requirements on the optimization layout of the general plan of the waste heat power station.

Boiler Cleaning Method Selection

Waste heat boiler is one of the key equipment of the project. The silicon micropowder in the industrial silicon flue gas is extremely fine, has strong adhesion and high heat resistance. If it is not cleaned up, it will affect the normal operation of the boiler. Taking into account the heating surface form and cleaning method, this project selected a waste heat boiler with acetylene (C_2H_2) deflagration and ash removal method on the heat pipe light pipe heating surface. It is suggested that similar projects should increase the efforts to collect funds, understand the main heating surface forms and cleaning method combinations of waste heat boiler plants through investigation and visits, and then select suitable waste heat power generation boilers based on the actual flue gas parameters of the project.

Analysis of the Benefits of Comprehensive Utilization of Waste Heat Power Generation

The successful implementation of the industrial silicon furnace comprehensive utilization of waste heat power generation project will optimize the energy use of the enterprise production system, improve energy utilization efficiency, reduce product costs, achieve energy conservation and consumption reduction, and enhance the sustainable development capabilities of the enterprise. At the same time, it also plays a positive demonstration and promotion role in the large-scale energy conservation, emission reduction and comprehensive utilization work in the regional industry.