Analysis of the Operation Principle of Typical Cogeneration Units

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Abstract. Cogeneration is a comprehensive energy utilization technology. While generating electricity, it effectively uses vaporized latent heat for heating, which has many advantages such as high energy utilization efficiency and environmental protection. The technical characteristics of several different forms of cogeneration such as gas turbines, gas-steam and fuel cells are analyzed. It can be seen from this paper that the heating method in the cogeneration area is advanced and reasonable, which has a good reference significance for improving energy utilization, energy conservation and emission reduction.

1. Introduction
Cogeneration systems, also known as distributed energy systems, are also defined as energy for user-side power generation and conversion of waste heat into useful thermal energy, such as steam or hot water for regional heating, refrigeration, domestic hot water and industrial process production [1]. With the rapid development of the world economy, the contradiction between resources, environment and sustainable economic growth is getting worse and worse. In order to solve the problem of resource shortage and improve the living environment, the clean and efficient use of energy and sustainable development have begun to become the key directions of scholars' research [2], and are also the focus of attention of all countries in the world. Title. For existing thermal power units or other forms of systems and equipment that fail to make full use of energy, they are optimized and studied through thermodynamic analysis to achieve energy conservation and emission reduction and comprehensive energy utilization [3]. For example, various residual pressure utilization, low-temperature waste heat recovery, wastewater recycling, multi-generation and other technologies, as well as the utilization of renewable photovoltaic, photothermal, wind energy, water energy, etc. have become topics studied by many scholars [4-5].

In this paper, the technical characteristics of several different forms of cogeneration such as gas turbines, gas-steam and fuel cells are summarized. Through the discussion of this article, it can be seen that the heating method in the cogeneration region is advanced and reasonable. The energy system in the cogeneration area adopts the local energy production mode, which can improve the local energy supply control ability, reduce the dependence on the power grid, and realize energy scheduling that cannot be carried out by a single building. New energy technologies and multiple fuels and energy types can be safely applied, further enhancing the autonomy of the system and the safety and reliability of supply.

2. Analysis of Typical Cogeneration Technology
2.1 Cogeneration System of Gas Turbine
The cogeneration system of gas turbine is mainly composed of gas turbines, steam turbines, waste heat boilers, generators and other auxiliary equipment. The compressor inhales air from the outside to...
complete the air compression process, sends the compressed air into the combustion chamber, and mixes with the incoming natural gas to produce high-temperature and high-pressure flue gas. The high-temperature and high-pressure flue gas pushes the turbine to rotate to work, and then generate electricity. The flue gas temperature discharged from the tail of the gas turbine is generally 500°C -600°C, which is a good driving heat source. The residual heat discharged by the tail of the gas turbine can be recovered through the waste heat boiler, and the water is heated to form high-temperature and high-pressure steam, so as to heat and form a cogeneration capacity mode. This relatively simple cogeneration method of gas turbines can significantly improve thermal efficiency, with small investment, small floor area, short investment recovery period, rapid start-up, stable operation, and can effectively meet the thermal power needs of scattered small areas.

At present, the commonly used natural gas distributed energy systems include cogeneration system (CHP), cold, heat and electricity triple supply system (CCHP) and building cogeneration system (BCHP). Cogeneration (CHP) generates heat and electricity from the same fuel, and its typical structure is shown in Figure 1. With the progress of technology, the cogeneration system (CHP) has gradually been replaced by the cold, heat and electricity triple supply system (CCHP), which further improves the energy efficiency of the system.

![Figure 1. Typical structure of cogeneration (CHP)](image1.png)

2.2 Combined Gas-steam Cycle

The gas-steam combined cycle gas-type cogeneration system is a more effective step-by-step energy production method. It utilizes the high-temperature exhaust of the gas turbine system with a higher average heat absorption temperature as the driving heat source of the steam turbine, carries out secondary power generation, and significantly improves the unit efficiency. The high-temperature flue gas discharged by the gas turbine enters the waste heat boiler to heat the water supply, and then enters the steam turbine to push the steam turbine blades to work and generate electricity. The efficiency of gas-vapor combined cycle is equal to the sum of the efficiency of gas turbines and steam turbines, which can reach more than 60% at present. The triple supply of natural gas, cold, hot and electricity mainly uses a combustion engine to burn natural gas for power generation, and further recovers the residual heat after power generation is used for refrigeration, heating and supplying domestic hot water. Its typical structure is shown in Figure 2.

![Figure 2. Typical structure of gas-vapor combined cycle](image2.png)
The waste heat vapor generated by the gas-vapor combined circulation system can be used for heating, that is, the heat still in the spent steam after working in the steam turbine can be used to heat the primary net water for heating. The general heating system process is to heat the net water in the absorbent heat pump at high temperature or back pressure exhaust in the steam turbine. After dehumidifying, it condenses into water and flows back to the steam turbine for the next cycle, which is similar to the coal-fired condensed cogeneration system. The thermal efficiency has been further improved, but the initial investment is large and the investment payback period is long, which is suitable for large-scale regional power supply and heating with large electric heating needs.

2.3 Fuel Cell Cogeneration System

Fuel cell cogeneration system is a new energy supply mode for small units, which can realize the heating capacity of small units. At present, domestic research on this aspect is relatively immature, and foreign technology is relatively advanced. Microcogeneration systems in some countries have long been commercialized, and the application scope includes household use and merchant-owned use. ETC., IT IS A MICRO-DISTRIBUTED ENERGY WITH A WIDE MARKET. Fuel cell is a device that converts chemical energy in cell neutralizing oxidants into electrical and thermal energy. It is mainly composed of positive and negative electrodes and electrolytes. Common fuel cells include alkaline fuel cells, phosphoric acid fuel cells, proton exchange membrane fuel cells, etc.

Take the cogeneration system of domestic fuel cells as an example. The structure of the cogeneration system is shown in the figure. The reaction of the power generation fuel cell reactor generates electricity and heat energy. The DC energy is adjusted through the AC-DC inverter and uploaded to the home grid and mixed with the power supply of the public grid to the home power supply; the heat energy generated by the reaction is supplied to the heat exchanger. In the heat exchanger, the water in the heating grid system can heat the home, and in summer, evaporative refrigeration equipment can be used to heat the home. Building cogeneration is a building energy system that solves all the needs of building electricity, cold, heat, etc. The typical structure of the cogeneration system of the building is shown in Figure 3.

![Figure 3. Typical Structure of Cold, Thermal and Electricity Supply System (BCHP) in Buildings](image)

3. Conclusions

This paper mainly analyzes the advantages of cogeneration of cold, heat and power generation, and analyzes in detail the energy efficiency of cogeneration of gas systems and cogeneration of steam systems. Distributed cogeneration system is a multigeneration total energy system that integrates cold, heat, electricity and other energy sources. Its biggest feature is the multi-level utilization of energy of different qualities, which has the characteristics of energy conservation and environmental protection, and has received extensive attention worldwide. Thermal energy with low temperature can be used for heating or refrigeration, and heat energy with higher temperature can be used for power generation. Under the guidance of the principle of cascade utilization, co-supply of cold, heat and electricity not
only improves the utilization rate of energy, but also reduces the emission of harmful gases, better solves the problem of environmental pollution and energy class utilization, and better responds to the national energy conservation and emission reduction policy.

4. References

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