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Design and Characterization of Flue Gas Waste Heat Power Generation Plant

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Abstract: This paper proposes a waste heat recovery system based on temperature difference power generation, which aims to utilize the residual heat in the exhaust flue of chimneys or kilns. The system consists of three parts such as heat collection module, semiconductor power generator, and heat dissipation module, and the residual heat is directly converted into electrical energy and output by temperature difference power generation. The voltage and resistance are measured and analyzed on this basis. This design realizes the waste heat recovery of boiler flue gas, prevents a large amount of waste heat from being discharged into the environment, reduces the greenhouse effect and makes secondary use of the waste heat.

Keywords: Thermoelectric; Residual heat recovery; Waste heat generation.

1. Introduction

Temperature difference power generation is the premise of the semiconductor heating piece of the two ends of the temperature difference, that is, temperature difference power generation piece of the need for heat and cold source using the Seebeck effect can produce electricity. After investigation of the boiler flue gas waste heat temperature of 400 ℃ or more, so it is more ideal heat source. The use of water-cooled, air-cooled, or natural cooling methods to generate a cold source, you can use the semiconductor heating plate on the boiler flue gas waste heat recovery.

In recent years, there have been numerous research reports on temperature difference power generation technology both at home and abroad, which have provided rich experience in the development of temperature difference power generation system for waste heat recovery. In the literature [1], in order to improve the energy utilization efficiency, the temperature difference power generation device is combined with the steam turbine power generation system to utilize the waste heat discharged from the steam turbine for temperature difference power generation, which verifies the feasibility of waste heat recovery-temperature difference power generation in improving the energy utilization efficiency. In literature [2], a new heat pipe-assisted-temperature difference power generation waste heat recovery system is built by combining heat pipe and temperature difference power generation technology, and the efficiency of temperature difference power generation reaches 2.02%, and the power generation power of heat pipe-assisted-temperature difference power generation system is increased by 43% compared with the fin structure. In the literature [3], the performance of the exhaust gas waste heat recovery temperature difference power generation system was tested by using the engine waste heat as a heat source, and the method of numerical simulation of the system was established to further validate the feasibility of exhaust gas waste heat power generation using temperature difference power generation. The temperature difference generator can usually be embedded in other waste heat recovery power generation systems to further improve the efficiency of waste heat recovery due to its simple structure and easy application. Literature [4] constructed a small-scale cogeneration system by combining temperature difference power generation with an organic Rankine cycle, and they found that the embedding of temperature difference power generation module will bring certain economic benefits while improving the system energy utilization efficiency. For example, some researchers have proposed to embed a multistage temperature difference power generation system in a typical cogeneration system, and have analyzed the superiority of such a composite power generation system in improving energy efficiency, and they believe that the introduction of the temperature difference power generation module will further bring certain economic and environmental benefits. This paper addresses the problem of flue gas waste heat recovery and utilization in China based on the deficiencies of domestic flue gas waste heat power generation, based on the Seebeck effect using advanced power generation technology, in the booming waste heat recovery and utilization project in China to put forward guiding suggestions, so that China's waste heat recovery and utilization of the integrated innovation path with national characteristics. In the process of technological innovation, further increase the application of energy saving and emission reduction ideas, strengthen the innovation consciousness and innovation ability of technical personnel, so that their future work in the application of the boiler fully recognized the efficient operation of the socio-economic development and improve the economic efficiency of the enterprise is of great significance, so that the pace of technological reform and innovation has been comprehensively improved.

2. Introduction to the Seebeck Effect

The Seebeck effect, also known as the first thermoelectric effect, is a thermoelectric phenomenon in which a voltage difference between two different electrical conductors or semiconductors is caused by a temperature difference between the two substances. The direction of the thermoelectric potential is generally defined as the flow of electrons from negative to positive at the hot end.

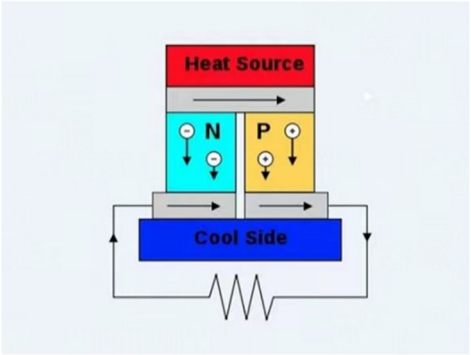

Figure 1. Seebeck effect

The potential difference between the two ends of the conductor can be expressed as

$$U=(\alpha_A - \alpha_B)(T_1-T_2). \quad (1)$$

In the formula, T_1 is the temperature of the hot end; T_2 is the temperature of the cold end; α_A and α_B are the Seebeck coefficients of the conductor. The Seebeck coefficient is an important parameter that reflects the performance of temperature difference power generation, and the larger the difference between the Seebeck coefficient values of the two conductors, the higher the output voltage.

3. Design of Biomass Boiler Flue Gas Waste Heat Generation

The power generation device is based on semiconductor heating pads to generate electricity, the flue gas into the finned pipe. Pipeline on the hot end of the heating element tightly, due to the economy of the cold end of access to the copper pipeline, above the aluminum heat sink as shown in Figure 2, at this time the semiconductor ends only produce a temperature difference, using the Seebeck effect to generate voltage. This device uses a modular design of a module damage does not affect the overall work for easy maintenance.

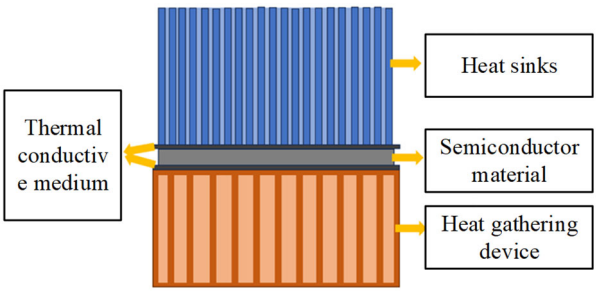

Figure 2. Component of the device

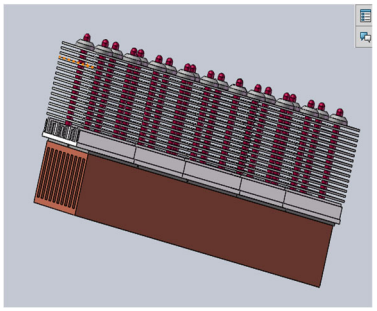

Figure 3. Heat exchange module

References are cited in the text just by square brackets [1]. (If square brackets are not available, slashes may be used instead, e.g. /2/.) Two or more references at a time may be put in one set of brackets [3, 4]. The references are to be numbered in the order in which they are cited in the text and are to be listed at the end of the contribution under a heading References, see our example below.

4. Measurement of Power Plant Characteristics

As the temperature difference between the various positions of the pipe is different, the voltage generated is also different, so the control variables, in the same device at the same time under the conditions of the temperature difference will be changed to measure the voltage, to obtain the experimental data table shown in Figure 4.

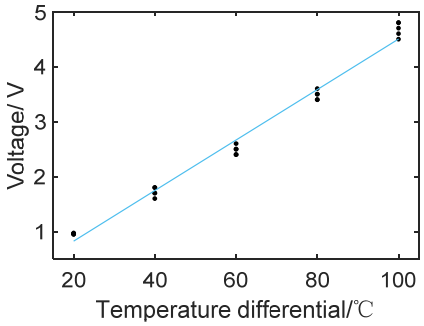

Figure 4. Temperature difference versus voltage

When the circuit is closed to form a loop, the temperature difference generator output voltage U_L can be express as

$$U_L = \frac{UR_L}{R_{TEG}+R_L}. \quad (2)$$

Practical applications should not only know the voltage of power generation, but also need to know the resistance of the internal power generation piece, you can get the desired current size, so do the following experiments. The relationship between temperature difference and resistance of the experimental data shown in Figure 5. The figure can be seen with the temperature difference of the internal load of the power generation piece of the change in proportion to the change can be concluded that if the temperature difference of a larger section of the power generation, he has to the internal resistance will also increase with the increase in temperature difference.

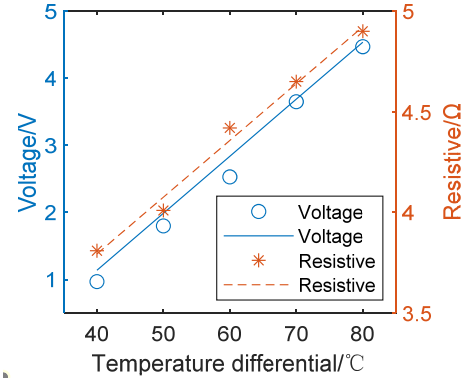

Figure 4. Temperature difference versus resistance

5. Summary

In this paper, a flue gas waste heat power generation device is designed based on the Seebeck effect. The device adopts a modular design, which can effectively improve the utilization rate of waste heat and reduce the maintenance cost of the device. Subsequently, the voltage output characteristics and resistance characteristics of the power generation device were measured, and its linear law was obtained.

Acknowledgment

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