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Generation of Thermoelectric Power Utilizing Alternative Sources of Energy

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ABSTRACT: In latest days' environmental issues such as pollution, particularly global warming and energy resource constraints, has led in extensive research into new electrical power generating methods. Thermoelectric power generators have emerged as an intriguing prospective green technology owing to its many advantages. Thermoelectric power production has a potential application in the direct conversion of waste-heat energy to electrical power, when the cost of the thermal energy source is not taken into consideration. The adoption of this alternative green technologies for directly converting waste-heat energy into electrical power would also improve the overall efficiency of energy conversion systems. This article offers a viewpoint on the basic principles of thermoelectric power production, as well as a research and discussion of contemporary thermoelectric power generation with intriguing and practical uses of waste-heat electricity.

KEYWORDS: Energy, Electrical Power, Green Technology, Thermoelectric Power, Thermoelectric Power Generation.

I. INTRODUCTION

When the words thermoelectric and electric are combined, the term thermoelectric is formed, and as the name implies, thermal refers to heat energy and electric refers to electrical energy. These devices convert the difference in temperature between two junctions into electrical energy by converting the difference in temperature between two junctions to a voltage. Seebeck effect is a physical phenomenon that affects the functioning of thermoelectric generators. According to this concept, an Electromotive force (EMF) develops in a loop between two dissimilar metals when the temperatures of the two junctions are maintained at different temperatures. As a consequence, it is alluded to as Seebeck Energy Production in some quarters. A thermo-electrical producer is consisted of a source of heat that is kept at a high enough temperature as well as an absorber plate that is sustained at a temperature lower than that of the heat source, correspondingly. It is conceivable that electrical current will flow through with a load as a consequence of the temperature differential that occurs here between source of heat and heat sink. Because there is no intermediary energy transfer in this kind of energy conversion, it is also referred to as direct power conversion or direct energy conversion [1]. The electricity provided by Seebeck power generation is continuous phase Direct Current (DC). Raising the temperature differential between the cold and hot ends, or connecting numerous thermoelectric electric generators in succession, enhances both the power output and the output power. Increasing the temperature differential between the hot and cold ends The electricity will start to flow so long as warmth is delivered to the hot side and withdrawn from the cold end. A coal-fired thermoelectric power plant is shown in figure 1. It is important to note that the current generated by thermoelectric or Seebeck power production is direct current (DC). This current may be converted to alternating current (AC) by using inverters, and its voltage level can be raised even higher by utilizing transformers. It is possible to alter the direction of energy flow in thermoelectric or Seebeck power production because the energy transfer technique employed is reversible. When the load is removed from the piezoelectric power generator as well as direct current (DC) power given across the endpoints where the load were previously attached, heat may be swiftly expelled from the generator [2].

A piezoelectric power supply is a solid-state gadget that, through the Seebeck effect, transforms thermal energy (heat) generated by a temperature difference into electrical energy. Because it acts with electric charge (electrons) as the coolants, the thermoelectric power cycle conforms to the fundamental principles of thermodynamics and is closely linked to the power cycle of a conventional heat engine in terms of efficiency. The low conversion efficiency of thermoelectric power generators is the primary drawback of these devices (generally 5 percent).

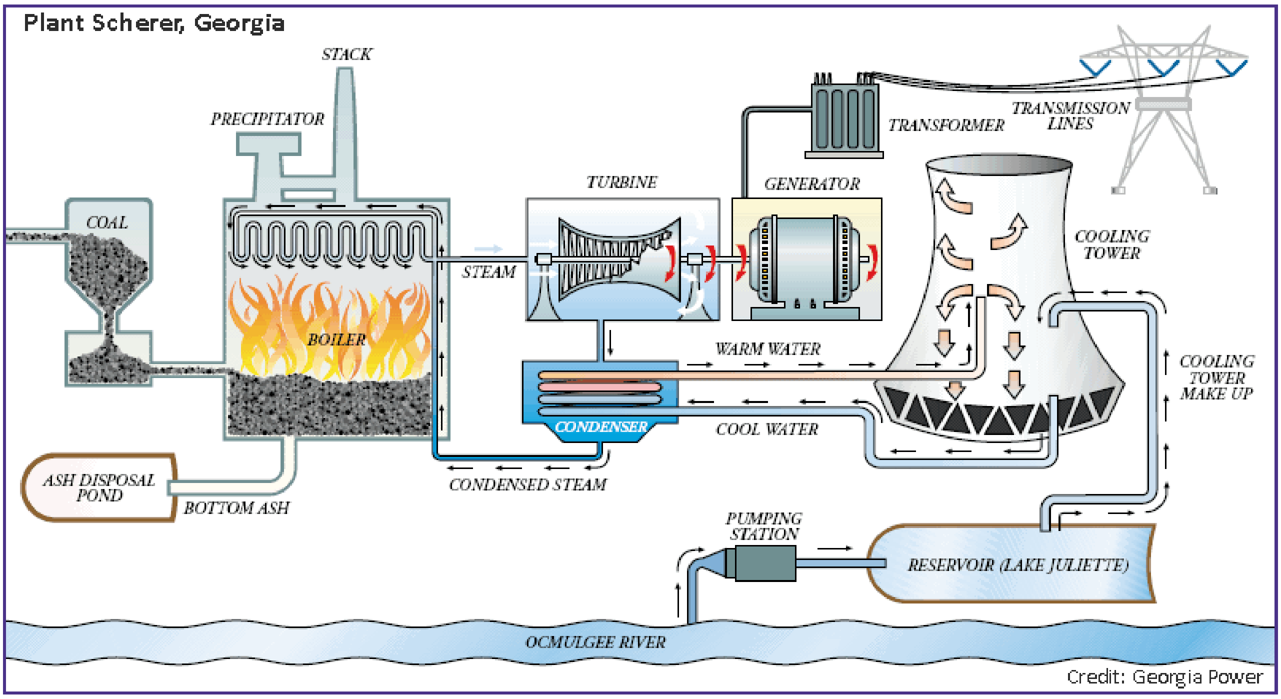


Figure 1: A Coal-Fired Thermoelectric Power Plant [USGS].

Due to this, their usage in electrical power production has been restricted to a small number of specialized areas with limited applications where efficiency is important but cost is not. Over the last decade, commercial instrumentation, naval, medical, and aviation applications, and also portable or isolated power generation, have all been used in various applications. However, increasing public concern about environmental degradation, notably global warming, has resulted in substantial inquiry into non - conventional electrical power producing technology in recent years, with thermal power production appearing as a viable green alternative option. Excess heat is discharged into the environment in large quantities, with the majority of it being at temperatures that are too low to be recovered by conventional electrical power generation systems. It is made feasible by thermoelectric power production to convert low-grade thermal energy, such as waste heat energy, into electrical energy in a direct and efficient manner. Thermoelectric generators, which are less costly than expensive gasoline-powered engine generators, have also been utilized to provide small amounts of electrical power to remote regions such as Northern Sweden [3].

The low conversion efficiency of thermoelectric power generators is not a major drawback in this waste heat powered thermoelectric technology since the cost of the thermal energy source is immaterial in this waste heat powered thermoelectric technology Furthermore, they may now be utilized to improve the overall efficiency of energy conversion systems by converting waste thermal energy into electrical power in certain methods, such as those employed in cogeneration systems. This is particularly true for solar energy systems.

This is especially true for a thermoelectric power generator, which has a cost that is a mixture of two components: the unit cost as well as the operating cost.

The operating cost of the engine is defined by its conversion efficiency, while the unit cost is determined by the cost of installing it in order to produce the required electrical power output. Because the conversion efficiency of a module is rather low, thermoelectric production from waste heat energy is the most appropriate use. Because the cost of energy input (fuel) is minimal or non-existent in this scenario, the cost of maintenance is negligible in contrast to the cost of the module [4].

The reduction of the cost per watt of the systems, as a consequence, is a major objective in the thermoelectric power generating industry that uses waste heat energy. Furthermore, by improving the device design, increasing manufacturing efficiency, or simply operating the device at a higher temperature difference, the cost-per-watt may be reduced to the absolute minimum. Furthermore, many research efforts have been concentrated on enhancing the thermoelectric characteristics of materials as well as device optimization in the building of high-performance thermoelectric power generators, as well as on the development of new materials. Manufacturing more improved thermoelectric materials as well as inventing more complex thermoelectric power unit designs will continue to be crucial to the performance and cost competitiveness of thermoelectric power systems.

A. Advantages of Thermoelectric Power Generators

1. They are very robust and silent in operation due to the absence of mechanical moving parts, and they need much less maintenance due to the fact that they are simple, lightweight, safe, extremely tiny, and virtually weightless in comparison to other options.
2. They have the ability to function at high temperatures;

3. As a result, they are well-suited for small and distant applications typical of rural power sources, where electricity is inadequate or non-existent.
4. They are considerate of others and the environment.
5. They are not influenced by their location; and
6. They may be used as a variety of power sources.

B. Energy-Producing Thermal Power Plant

A thermal power generating facility, often known as a thermal power station, is the most prevalent source of electric energy. Thermal power plants are also referred to as coal-fired power plants and steam turbine power plants, among other names. Thermal power plants are very simple in terms of their operation and theoretical operation. When it comes to power production, an alternator that is driven by a steam turbine is at the heart of the process. High-pressure boilers are responsible for the production of steam.

The amount of volatile matter in bituminous coal varies from 8 to 33 percent, while the amount of ash varies from 5 to 16 percent, depending on the kind. The use of coal powder in the boiler increases the thermal efficiency of the system. During the combustion of fuel (crushed coal) in boilers furnace, the steam boilers in a coal thermal power station creates high-pressure vapor, which is utilized to generate electricity. After that, the steam is heated even further in a super-heater. It is this superheated steam that fills the engine and turns the turbine blades [5].

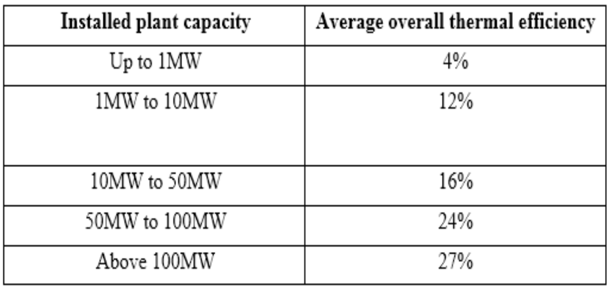
The turbine is physically linked to an alternator in such a way that the alternator's rotor spins in sync with the blades of the turbine. Since becoming a member of the engine, the steam pressure has dropped dramatically, but the flow of steam has increased. After transferring energy to the turbine rotor via the turbine blades, the steam exits the turbine and enters the condenser. With the help of a compressor, the cold water is pushed into the condenser, where it condenses the low-pressure wet steam into dry steam. In a low-pressure water boiler, the accumulated water is warmed by low-pressure vapor, which increases the temperature of a supply water, which is then warmed often under high pressure. Each step of a thermal power plant's operation is broken down into the following categories for easier comprehension:

1. First and foremost, the crushed coal is scorched in the heater of the vapor boiler.
2. The boiler is responsible for producing high-pressure steam.
3. Afterwards, this steam is fed into the superheater, where it is heated even more.
4. This superheated steam is then fed into a high-speed turbine, where it produces electricity.
5. The rotor blades of the turbine are rotated by the steam force, which converts the latent potential energy of the highly compressed steam into mechanical energy, thus generating electricity.

C. Working of a Power Plant

1. After the turbine blades have completed their rotation, the steam loses its high pressure, leaves the turbine blades, and enters a condenser to cool down.
2. The cold water is pushed into the condenser by a fan, which crystallizes the low-pressure wet steam as it passes through it.
3. It is necessary to first pass the condensed water via a low-pressure heating system.
4. The rotor in a thermal power plant serves as the primary mover for the alternator's generator.

Table 1: The capacity of the several installed plant as well as its total thermal efficiency.



Installed plant capacity	Average overall thermal efficiency
Up to 1MW	4%
1MW to 10MW	12%
10MW to 50MW	16%
50MW to 100MW	24%
Above 100MW	27%

The efficiency of a thermal power plant is measured as follows:

An electrical power plant's efficacy and efficiency are measured in terms of the heat equivalent of electrical production divided by the heat of coal combustion, respectively. Depending on the size of the facility, the average productivity of a thermal power station or plant varies from 20 percent to 26 percent of its capacity (Table 1).

II. DISCUSSION

New research suggests that large-scale power plants that are focused on thermoelectric phenomena, such as small temperature fluctuations in ocean water, may generate energy for less money than solar power plants in the long run. Heat will be generated in thermoelectric power plants that will resemble huge barges floating in the tropical ocean, producing energy by heating cold, deep water with warm, shallow water that has been warmed by the sun to produce electricity. This article discusses the unique idea of large-scale green power plants that make economic use of the world's biggest open and renewable energy reservoir, which is described in detail in the next paper. This is due to the fact that the sun warms the surface water to a temperature that is about 20 degrees Celsius higher than the temperature of water 600 meters deep in tropical regions [6].

When ocean waves are harnessed to push cold water from hundreds of meters below the surface up into a lengthy channel, thermoelectric power plants may produce electricity. The process is known as hydroelectric power. Eventually, the cold water will reach the surface and will pass through a heat exchanger, where it will be heated by the surface water on the outside. Because the tubes are constructed of thermoelectric materials, which are capable of transferring heat through their walls and immediately converting temperature differences into energy, the heat exchanger may also be used as an electric generator. Using large-scale, ocean-based thermoelectric power plants has the potential to provide a number of advantages. For starters, the "fuel," which is represented by temperature fluctuations, is completely free, unlimited, and easily accessible. The plants are also not a hindrance to any other activities. They would have minimal maintenance costs because to the lack of moving solid components in their design. In addition, the power production is not influenced by the time of day or the season in which it operates. Finally, the method is ecologically friendly due to the fact that it generates no pollution at all [7].

Among the operating fluids are water and steam. The feed water and steam cycle is the term used to describe this process. The rankine cycle is the optimum thermodynamic cycle that most closely matches the functioning of a thermal power plant in terms of efficiency and reliability. It is the goal of a steam boiler to produce dry superheated steam at the proper temperature by burning fuel in the air of the furnace, and the water in the boiler is heated in this manner. The steam produced is used to power steam turbines, which are used to create electricity. Typically, a three-phase synchronous alternator is used to generate power, and this turbine is connected to the synchronous generator to do the work. Based on its ability of pollution resulting from a rotor to condensate into the waters in the turbine's vapor condenser, suction at very low pressure is created, enabling for the expansion of steam in the turbine to occur at extremely low pressure [8].

When condensing, the main benefits are the increased quantity of energy supplied per kilogram of steam, which increases performance, as well as the condensate, that is recycled back inside boiler. A pump returns the condensate to the furnace, along with some clean makeup feed water, which helps to keep the furnace running smoothly. The condenser is a device that condenses vapor using cooled water. The cooling tower reuses the water that was used to cool the building. After the boiler has been cleaned and filtered, it is permitted to accept ambient air. Furthermore, flue gas escapes from the boiler and is released into the environment via stacks of ductwork. For the exchange of air and flue gas, there exist circuits. In order to maintain static pressure (also known as draught) inside the steam boiler, two fans were used: Induced Draught (ID) fan and the Forced Draught (FD) fan. The basic layout of a contemporary thermal power plant, including the various circuits, is shown in the figure below [9].

There are many heat exchangers inside the boiler, including an economizer, an evaporator, and a superheater. The remaining heat from the flue gas is utilized to heat the feed water in the Economizer, which reduces the amount of energy used. The boiler drum keeps a head in position, which allows for regular flow of a two-phase combination (water vapor plus water) via the water tubes to take place. The boiler is additionally fitted with a heat exchanger, which absorbs energy from the exhaust gases and uses it to raise the temperature of the steam as needed [10].

III. CONCLUSION

As a result of the growing concern about environmental issues such as pollution, particularly global warming, and energy supply restrictions, extensive research into new electrical power generation technologies has been conducted in recent years, with thermoelectric power generation emerging as a potentially viable green technology alternative. More importantly, huge quantities of waste heat are discharged into the earth's atmosphere, with the majority of it occurring at temperatures that are too low to be recovered by conventional electrical power producers. Utilizing excess heat energy to create electrical power is indeed a potential technologies have the ability to alter the way we operate our businesses and homes. As well as providing a historical overview of thermoelectric power production's basic concepts, this article also includes a study and discussion of contemporary thermoelectric power generation, which includes many intriguing and practical uses of waste-heat electricity.

A wide range of practical applications currently rely on waste heat powered thermoelectric generators, which are becoming more popular due to their unique benefits. Based on the quantity of heat waste energy that may be converted directly into electrical power utilizing thermoelectric generators, these applications are classified as either micro-scale or macro-scale applications. Electronic devices, including such microchips, are some of the applications that function on the micro-scale. The fact that perhaps the size where these gadgets may be made and deployed from piezoelectric materials is determined by the microscopic capabilities that are now available is crucial. As a consequence, it is anticipated that future designs in these applications would include nanotechnology elements. Household, automotive, manufacturing, and solid waste heat applications were some of the macro-scale waste heat applications that were used in the study. Large amounts of surplus heat are being released by industry, such as industrial facilities and electricity networks, contributing to global warming. As a consequence, the vast majority of current research efforts on thermoelectric power generating technologies have concentrated on the use of industrial waste heat as a source of electricity. Researchers may focus their efforts in the future on developing more appropriate thermoelectric materials that can resist greater temperatures generated by a variety of industrial heat sources while still providing sufficient efficiency at a reasonable cost. The development of more creative thermoelectric module shapes and combinations is a potential future strategy as well. It is feasible to build more thermoelectric module configurations by the development of revolutionary flexible thermoelectric materials, that will make them more efficient and appealing in circumstances where waste heating elements are of arbitrary shape.

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