THERMAL POWER STATION

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Abstract:

Thermal power plants (TPPs) convert the heat energy produced by burning fuel—such as coal, natural gas, or fuel oil—into mechanical and electrical energy. Their main components include a boiler, turbine, generator, and cooling system. This abstract examines the advantages and disadvantages of TPPs, their environmental impact, as well as opportunities for modernization and integration with alternative energy sources.

Keywords: Thermal power plant; energy generation; steam turbines; boiler units; electric generators; fuel types (coal, natural gas, fuel oil); heat energy conversion; thermal conversion processes; energy efficiency; cooling systems; environmental impact; thermal pollution; heat exchange; flue gases; carbon dioxide emissions (CO_2); environmental safety.

Introduction:

Today, thermal power plants are the most widely used type of power generation facilities. They operate on organic fuels that release thermal energy during combustion. The primary function of a thermal power plant is to efficiently convert heat energy into electrical energy. A thermal power plant (TPP) is a type of power station that produces electricity by converting the heat generated from fuel combustion into mechanical energy, and subsequently into electrical energy. The basic principle of a thermal power plant involves burning hydrocarbon fuels such as coal, oil, or natural gas to produce heat, which is then used to heat water and convert it into steam. This steam is expanded in steam turbines, causing them

to rotate and drive electric generators that produce electricity. The operational concept of thermal power plants is not limited to electricity production; they can also provide thermal energy. This thermal energy can be supplied to consumers, for example, in the form of hot water for heating purposes. Approximately 76% of the world's electricity is generated by thermal power plants. This high prevalence is explained by the widespread availability of organic fuels and the convenience of transporting them from extraction sites to power stations [1-2]. The operation of thermal power plants is based on the possibility of utilizing waste heat, which helps reduce energy losses and cooling water consumption. Thermal power plants can be classified according to the type of energy they produce. If a power station generates only electricity and does not supply heat energy to consumers, it is referred to as a condensing thermal power plant (CTPP). In such facilities, steam turbines are used instead of heating boilers to generate electricity for heating and hot water purposes. These stations are also equipped with devices for steam extraction and pressure regulation. In thermal power plant operations, the reuse of waste steam as a secondary heat source is considered a priority, as it reduces heat loss and minimizes the consumption of cooling water. Condensing power plants (CTPPs) are among the most common types of thermal power plants globally and play a vital role in meeting the energy demands of modern society. Thermal power plants can be categorized into different types depending on the system used for generating both heat and electricity.

By Type of Fuel:

These plants use coal as the primary fuel source. Coal is burned in boilers to heat water and produce steam, which then drives the turbines to generate electricity. Gas-based: In gas thermal power stations, natural gas is the main fuel used for gas turbine engines. It is burned to heat air or gas, which is then utilized to operate the turbine connected to the power grid. Fuel oil-based: These stations operate using fuel oil (mazut), which is burned in specially designed boilers to generate the necessary heat for electricity production [3-5].

The primary function of a thermal power station is the generation of electrical energy. The steam exiting the turbine is condensed and reused for heating water, creating a closed-loop system. Cogeneration thermal power plants: These facilities produce both electricity and thermal energy (e.g., for heating purposes). The thermal energy released during electricity generation is utilized for industrial or municipal needs, increasing overall energy efficiency.

Unit-based systems: In such stations, each unit has its own boiler and turbine. If one unit fails, the entire station does not shut down. Interconnected systems: In this configuration, boilers can supply steam to various collector lines, providing operational flexibility and reliability. Thermal power plant classifications based on steam pressure levels: Thermal power plants can also be categorized by the initial steam pressure into the following types: subcritical, low-pressure, and medium-pressure systems. Classification by initial parameters: Based on the initial steam pressure level, thermal power plants are classified as follows:

Subcritical pressure thermal power plants – up to 22.1 MPa pressure. Low-pressure thermal power plant – 3.4 MPa. Medium-pressure thermal power plant – 8.8 MPa. High-pressure thermal power plant – 12.8 MPa. Ultra-high-pressure thermal power plants – above 23.5 MPa. Supercritical pressure thermal power plant – 30 MPa, with steam temperature of 600–620°C [6-9].

High Energy Generation Capacity. Thermal power plants are capable of generating large amounts of electricity sufficient to supply major industrial centers. They can produce thousands of megawatts of electrical energy per day.

Stable Operating Mode. These plants can operate continuously and independently of natural conditions such as weather or seasons, making them more reliable compared to solar or wind energy sources.

Fuel Flexibility. Thermal power plants can utilize a variety of fuels, including coal, natural gas, fuel oil, and even waste materials. This provides a strategic advantage in regions where such resources are readily available [10-12].

Established Technological Expertise and Infrastructure. There is extensive experience in the construction and operation of thermal power plants, supported by well-developed infrastructure, which facilitates more efficient management and maintenance.

Relatively Low Initial Construction Costs (in some cases). Compared to other energy sources—particularly nuclear power—thermal power plants may require lower capital investment under certain conditions [13-15].

Environmental Pollution. The combustion of fuel releases harmful gases into the atmosphere, including carbon dioxide (CO_2), nitrogen oxides (NO_x), and sulfur dioxide (SO_2), contributing to the greenhouse effect and air pollution.

Depletion of Natural Resources. Commonly used fuels such as coal, natural gas, and fuel oil are finite natural resources. Over time, their availability may decrease and costs may rise, leading to resource-related challenges.

Dependence on Water Resources. Thermal power plants require large quantities of water for cooling systems. In arid or water-scarce regions, this dependency reduces overall efficiency and operational feasibility [16-19].

Energy Conversion Losses. A considerable portion of energy is lost during the conversion process from heat to electricity, with typical thermal efficiency rates ranging from approximately 30% to 40%.

Waste and Ash Management Issues. Especially in coal-fired power plants, large volumes of ash and industrial waste are generated. Storage and disposal of these byproducts pose both environmental and economic challenges.

Conclusion

Thermal power plants remain one of the key components of the global energy system today. The electricity generation process in these plants is technologically well-developed, enabling continuous and stable power supply. This type of facility serves as a primary source of electricity, particularly for industrial regions and large urban areas. The main advantages of thermal power plants include high production capacity, operational stability, technological reliability, and the ability to utilize various types of fuel. However, they also pose significant environmental challenges. Emissions of carbon dioxide and other harmful substances contribute to global warming, air pollution, and public health issues. As the modern world increasingly demands environmental sustainability and a transition toward green energy, modernization of thermal power plants has become essential. This includes improving energy efficiency and implementing technologies aimed at reducing greenhouse gas emissions. Moreover, integrating thermal power plants with alternative energy sources can help optimize their performance and reduce their environmental footprint. In summary, thermal power plants currently represent essential infrastructure for global energy production. Nevertheless, their future largely depends on advancements in environmental safety, energy efficiency, and their integration with renewable energy systems.

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