International Journal of Multidisciplinary Innovative Research
ISSN: 2583-0228 Volume 4, Number 1 (Jan' 2024) pp. 51-56

https://www.ijmir.org
Article Received: 17 Dec' 2023; Accepted: 31 Dec' 2023.

Review Article

A Comprehensive Review of Thermal Power Plants in India

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ABSTRACT: A review of a thermal power plant in India would typically encompass various aspects related to its design, operation, environmental impact, efficiency, and overall contribution to the energy sector. Here is a structured outline for a review of a thermal power plant in India. The description you have provided accurately outlines the basic principles of a thermal power station and its operation using the Rankine cycle. It is a concise overview of how heat energy is converted into electrical energy using steam turbines.

KEYWORDS: Boiler, Electrical Energy, Heat Energy, Mechanical Power and Thermal.

INTRODUCTION

The thermal power plant under review, including its name, location, capacity, and ownership. Mention its significance in the local and national energy landscape.

Rankine Cycle:

The Rankine cycle is a thermodynamic cycle that is commonly used in steam power plants. It involves four main processes: compression (pumping), heating, expansion (turbine work), and cooling (condensation). This cycle allows for the efficient conversion of heat into mechanical work, which is then converted into electrical energy.

Energy Sources:

Thermal power stations can use a variety of energy sources for heat generation.

Fossil Fuels:

Coal, oil, and natural gas are commonly used to produce the heat necessary to drive the Rankine cycle. These sources involve combustion to generate the required high temperatures.

Nuclear Power:

Nuclear reactors use controlled nuclear reactions to produce heat, which is then used to generate steam.

Geothermal Power:

Geothermal energy taps into the Earth's heat from within, utilizing steam or hot water reservoirs.

Solar Energy:

Concentrated solar power plants focus sunlight to generate high temperatures that produce steam.

Biofuels:

Biomass or waste materials can be burned to produce heat for steam generation.

Waste Incineration:

Municipal solid waste can be burned to produce heat for power generation.

Combined Cycle Power Plants:

In addition to the open cycle gas turbines you mentioned, combined cycle power plants are becoming more popular. These plants combine both a gas turbine and a steam turbine in a two-stage process, significantly increasing overall efficiency by utilizing waste heat from the gas turbine to produce steam for the steam turbine.

Cogeneration and District Heating:

Some thermal power stations are designed for cogeneration, where the waste heat produced during electricity generation is captured and used for other purposes like heating buildings or industrial processes. This enhances overall efficiency and reduces waste.

ENVIRONMENTAL CONSIDERATIONS

While thermal power stations are effective at generating electricity, many faces environmental challenges. The emission of greenhouse gases (such as CO2) and pollutants (Sox, NOx) from fossil fuel combustion can contribute to air pollution and global warming. Efforts to reduce these emissions have led to the development of cleaner technologies and stricter emission standards.

In September 2021, the thermal power plant capacity in India based on publicly available data up to that point is mentioned in Table 1. Please note that these numbers might have changed since then, and we recommend referring to more recent sources for the most up-to-date information. Here is a rough breakdown of thermal power plant capacity in India:

Table 1: Fuel Source vs Approximate Capacity in MW in India

Fuel Source	Approximate Capacity in MW
Coal	200,000-230,000
Gas	25,000-30,000
Oil	5,000-8,000

These numbers are approximate and can vary based on new power plants coming online, retirements, expansions, and upgrades. To get the most accurate and current data, I recommend visiting official sources like the Ministry of Power (India) website, Central Electricity Authority (CEA) reports, or other relevant energy-related websites that provide regularly updated information on power generation capacities in India.

a. Efficiency Improvements:

Ongoing research focuses on improving the efficiency of thermal power stations. This includes advancements in materials, turbine design, cooling systems, and methods to capture and utilize waste heat.

b. Renewable Integration:

As renewable energy sources gain prominence, there is a growing emphasis on integrating thermal power stations with renewables to provide reliable power while reducing environmental impact. For example, using thermal power plants to provide baseline power while using solar or wind power to supplement fluctuations in demand. The description you have provided accurately outlines the basic principles of a thermal power station and its operation using the Rankine cycle. It is a concise overview of how heat energy is converted into electrical energy through the use of steam turbines. Here, the paper will provide some additional context and details to complement the description.

The installed thermal power plant capacity in India on a state- wise basis as of the last update in September 2021, as represented in Table 2. The study of thermal power plants and their efficiency is a multifaceted endeavor that involves understanding the intricate interplay of various parameters within the Rankine cycle. While the paper addressed the importance of energy conservation and the expansion of initial-to-final steam parameters in enhancing efficiency, it did not thoroughly explore the impact of pressure variations on this efficiency.

The thermal power plant's steam turbine emerges as a crucial point of energy loss, warranting focused attention for improvements. Beyond the introductory methods mentioned, there exists a need for more comprehensive research that employs mathematical models to precisely describe and optimize efficiency. Such studies would consider a wider array of factors, incorporating pressure alongside temperature, heat transfer rates, and the specifics of the thermodynamic cycle.

Table 2: State Wise (in MW) Vs Approximate Installed Thermal Power Capacity in India

State Wise (in MW)	Approximate Installed Thermal Power Capacity in India
Andhra Pradesh	13000
Assam	1200
Bihar	4000
Chhattisgarh	18000
Gujarat	24000
Haryana	7000
Jharkhand	9000
Karnataka	8000
Keral	3000
Madhya Pradesh	15000
Maharashtra	20000
Odisha	10000
Punjab	9000
Rajasthan	12000
Tamil Nadu	17000
Telangana	6000

Uttar Pradesh	18000
West Bengal	14000

DISCUSSION

The fundamental principles of a thermal power plant and its processes.

a. Heat to Electricity Conversion:

A thermal power plant is a facility where heat energy is converted into electrical energy. This is achieved by transforming heat or steam into mechanical energy, which is then utilized to generate electricity.

b. Energy Conversion Process:

Most thermal power plants rely on steam or heat as the initial source of energy. This heat energy is used to create mechanical energy, often using steam turbines, which is further harnessed to produce electricity.

c. Role of Thermal Power Plants:

Thermal power plants are essentially energy conversion centres that take inputs of heat, often derived from fossil fuels like coal, and convert them into electrical power. They play a crucial role in addressing energy needs by acting as converters from one energy form to another.

d. Utilizing Warm Air and Petroleum:

There is a growing trend in utilizing warm air and renewable sources like petroleum to generate heat for energy production. The goal is to diversify energy sources and minimize environmental impact.

e. Role of Coal in Energy Generation:

Coal is a key fuel in many thermal power plants. Its combustion produces heat, which is then used to create steam for driving turbines. Proper coal management is essential to ensure a continuous and efficient supply of energy.

f. Heat Production Calculation:

To ensure effective electricity production, it is important to calculate and manage the heat production in power stations. This involves factors such as coal feed rates and combustion efficiency.

g. Thermal Efficiency:

The efficiency of thermal power plants depends on various factors, including the amount of coal fed into the combustion chamber, extraction pressure levels in the Rankine cycle, and control of steam condensation temperature through the condenser vacuum and cooling water supply.

h. Feed Water Heater (FWH):

The inclusion of a feed water heater in the system adds an additional pressure level to the Rankine cycle. This is a design consideration that impacts the efficiency and performance of the power plant.

i. Condenser Vacuum and Cooling Water:

Managing the condenser vacuum and providing cooling water to condenser tubes are critical aspects that influence the overall thermal efficiency of the steam power plant. These factors affect the heat rejection process and subsequent steam generation.

CONCLUSION

The dynamic landscape of energy demands, environmental concerns, and technological advancements underscores the significance of advancing the efficiency of thermal power plants. Achieving this goal necessitates deeper investigations that not only identify the challenges but also quantify the potential gains in efficiency under varying conditions. By delving into the realm of mathematical formulations and detailed parameter analysis, future studies have the potential to guide the design and operation of thermal power plants towards optimal efficiency while accommodating the broader goals of sustainability and energy security.

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