HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

THE ROLE OF MODERN COOLING SYSTEMS IN INCREASING ELECTRICITY GENERATION EFFICIENCY AT THERMAL POWER PLANTS

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Abstract. This article analyzes the role of modern cooling systems in improving the efficiency of electricity generation at thermal power plants (TPPs). The study highlights the technological capabilities of cooling systems in optimizing thermal processes, increasing steam turbine performance, and reducing fuel consumption. The operating principles of dry, wet, and hybrid cooling systems, as well as their impact on energy efficiency and environmental sustainability, are examined. The implementation of advanced cooling technologies is shown to contribute to reducing energy losses, improving the utilization of power generation capacity, and minimizing the environmental impact of thermal power plants.

Keywords: thermal power plant, electricity generation, cooling systems, energy efficiency, steam turbines, condenser, hybrid cooling, energy-saving technologies.

Introduction. Today on the day world energy in the system electricity to the energy was demand increasing progress, energy from resources reasonable use and working release processes efficiency increase issues current from tasks one Especially heat electricity power plants (TPPs) energy working of release main from sources one to be remaining under the circumstances their technical and economic indicators improvement, fuel spending reduce and ecological the impact to reduce aimed at innovative technologies current to grow important importance profession is doing.

Heat electricity at the stations energy working release in the process heat exchange and cooling systems separately place Because steam turbines effective performance, condensation process stability and general useful work coefficient high to be many in terms of cooling of devices work to the efficiency related. Traditional cooling in systems water resources big in quantity consumption, heat of the disappearance’s existence and to the environment impact such as problems is observed. Therefore, modern dry, wet and hybrid cooling systems application through heat electricity stations energetic efficiency increase issue scientific and practical in terms of important to the direction is spinning.

Current in the period developed countries energy in the field energy economical technologies wide current is doing. Modern cooling systems not only electricity stations working release from the power effective use opportunity gives, maybe water consumption reduce, heat waste management and ecological stability to provide service Especially the climate change and natural of resources limitedness under the circumstances heat electricity at the stations cooling processes improvement energy of the policy priority from directions one is considered.

Literature analysis. Heat electricity at the stations electricity energy working release efficiency increase and modern cooling from systems use issues many researchers by studied. A. Bejan heat exchange processes optimization, energy their disappearance reduce and heat of devices efficiency increase according to scientific research take went [1]. RK Rajput heat energy devices, steam turbines and condensation processes research to cool down systems electricity stations general to the efficiency the impact based on given [2].

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PK Nag is in research heat electricity at the station's energy efficiency increase, heat exchange devices improvement and modern technologies application issues [3]. International energy in the reports of the International Energy Agency (IEA) electricity energy working in the release energy economical technologies current water from resources reasonable use and ecological safe cooling systems develop directions analysis [4] by the Electric Power Research Institute (EPRI) take visited in research heat electricity at the stations applicable dry, wet and hybrid cooling systems technician and economic efficiency evaluated [5]. M. Wang and other of scientists scientific in their work modern cooling systems heat efficiency, water spending reduces opportunities and to the environment impact studied [6].

From Uzbekistan of scientist's energy in the field in research and heat electricity stations modernization to do, energy efficiency increases and progressive technologies working to release implementation to grow to the issues attention focused [7].

Materials and methods. Research at work heat electricity at the stations applicable traditional and modern cooling systems analysis. The research was conducted during scientific literature, energy in the field practical information and heat energetic of devices technician indicators Comparative analysis, systematic approach and technical and economic assessment from the methods used. Modern cooling systems (dry, wet) and hybrid (electric) energy working release to the efficiency impact analysis was done.

Table 1. Heat electricity at the stations applicable cooling systems description

Cooling system type	Performance principle	Advantages	Disadvantages
Wet cooling system	Water evaporation through the heat release	High cooling efficiency, wide application	Water expense high, ecological impact there is
Dry cooling system	By air heat exchange done increased	Water expense decreases, ecological safe	Construction and exploitation expenses high
Hybrid cooling system	Water and air cooling methods combination	Energy and water from resources effective use	Management system more complicated

Received results based on modern cooling from systems use heat electricity stations work stability increase, heat their losses reduce and electricity energy working release efficiency improve opportunity to give determined.

Research discussion. Research results this showed that heat electricity at the stations electricity energy working release efficiency in increasing cooling systems work quality important importance has. Cooling process effective organization to be in steam turbines condensation process improves, heat their losses reduces and of devices useful work coefficient increases.

Traditional wet cooling systems high cooling to the efficiency has although, big in quantity water spending demand Water resources limited in the regions and dry and hybrid cooling from systems use to the goal appropriate is considered. Dry cooling systems water consumption reduces with separated if it is, hybrid systems and water and energy expense between optimal balance provides. Analyses based on it turns out that modern cooling technologies current to grow heat electricity stations operational indicators improvement, fuel spending reduce and electricity energy working release cost decrease opportunity Especially automated management systems with equipped cooling devices of the station work mode realistic time during control to do and efficiency increase opportunity creates.

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Table 2. Role of modern cooling systems in improving the efficiency of thermal power plants

Cooling System	Main Advantages	Main Limitations	Effect on Power Plant Efficiency
Once-through Cooling	High cooling performance	High water consumption	Very high efficiency, but environmentally limited
Wet Cooling Tower	Efficient heat removal	Water loss through evaporation	Increases efficiency by improving condenser performance
Dry Cooling System	Very low water consumption	Lower performance in hot weather	Suitable for arid regions, with slightly lower efficiency
Hybrid Cooling System	Saves water and maintains efficiency	Higher installation cost	Balances efficiency and water conservation
Smart Cooling System	Real-time monitoring and optimization	High initial investment	Improves operational efficiency and reduces energy losses

Modern cooling systems are essential for improving the performance of thermal power plants because they reduce the temperature and pressure of exhaust steam in the condenser. Better cooling enhances turbine operation, increases electricity generation efficiency, and lowers fuel consumption. Wet cooling systems provide excellent cooling performance but require large amounts of water, whereas dry cooling systems are more suitable for water-scarce regions. Hybrid systems combine the advantages of both technologies, while smart cooling systems use digital monitoring and artificial intelligence to optimize operation, reduce energy losses, and improve overall plant reliability.

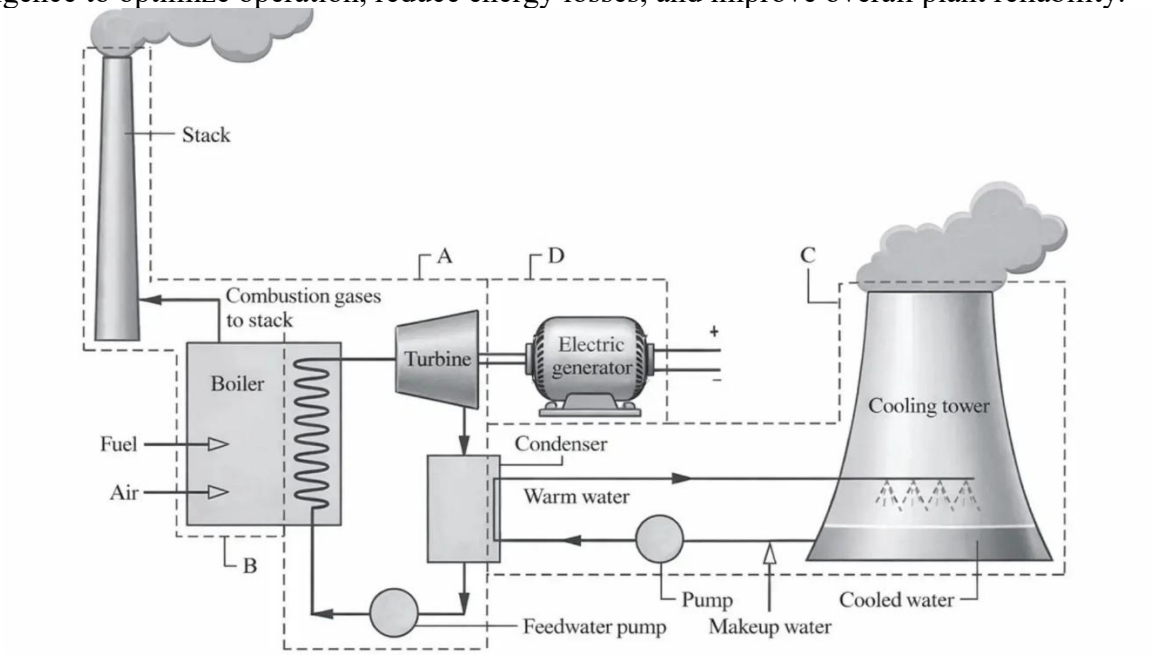


Figure 1. Schematic diagram of a thermal power plant with a cooling tower

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The figure illustrates the basic operating cycle of a thermal power plant (TPP) equipped with a wet cooling tower. It shows how fuel energy is converted into electrical energy through the Rankine cycle and highlights the important role of the cooling system in maintaining plant efficiency.

(B)Boiler. The process begins in the boiler, where fuel and air are supplied for combustion. The heat generated converts feedwater into high-pressure, high-temperature steam. Combustion gases produced during this process are released through the stack (chimney) after transferring most of their heat to the boiler tubes.

(A) Steam Turbine. The high-pressure steam flows into the steam turbine, where its thermal energy is converted into mechanical energy by rotating the turbine blades. As the steam expands through the turbine, its pressure and temperature decrease.

(D) Electric Generator. The turbine shaft is directly connected to the electric generator. The generator converts the turbine's mechanical energy into electrical energy, which is then supplied to the power grid.

Condenser and Cooling System (C). After leaving the turbine, the low-pressure steam enters the condenser, where it is cooled and condensed back into liquid water. Cooling water absorbs heat from the exhaust steam, becoming warm in the process. This warm water is pumped to the cooling tower (C), where heat is rejected to the atmosphere through evaporation and natural or forced air circulation. The cooled water is then recirculated back to the condenser, while makeup water is added to compensate for evaporation losses.

Finally, the condensed water is returned to the boiler by the feedwater pump, completing the closed steam-water cycle.

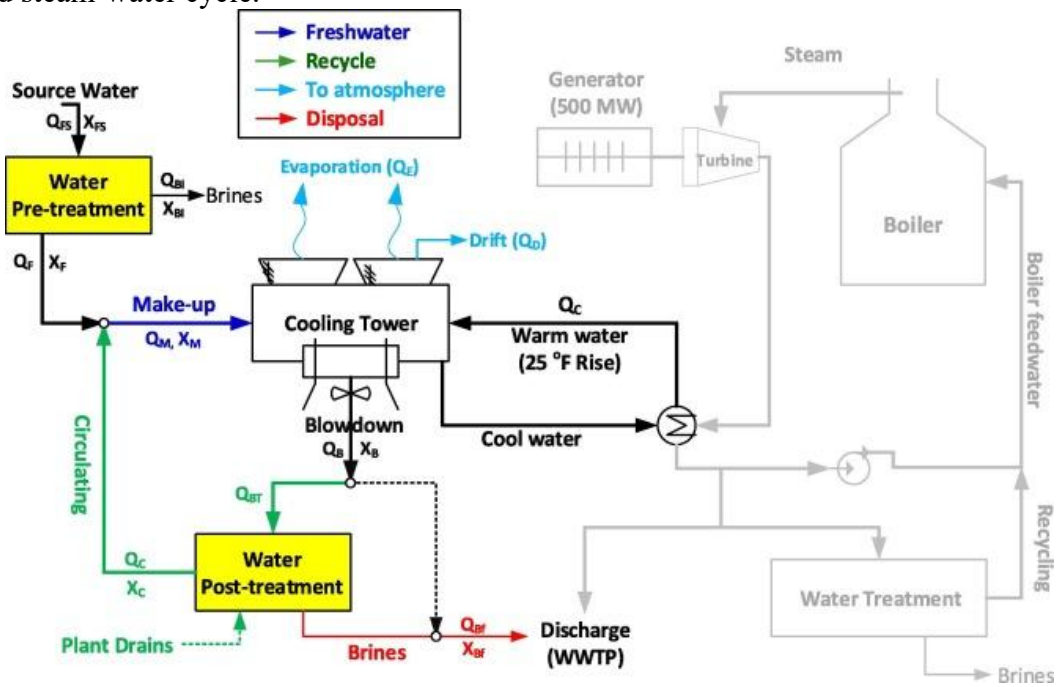


Figure 1. Water management and cooling tower system in a thermal power plant

The figure illustrates the water management system of a thermal power plant equipped with a wet cooling tower. It shows the movement of freshwater, recycled water, wastewater, and cooling water throughout the plant, emphasizing efficient water use and heat removal.

The process begins with source water, which is supplied to the water pre-treatment unit. In this stage, suspended solids, dissolved minerals, and other impurities are removed to improve water quality

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before it enters the cooling system. A portion of the treated water is used as make-up water to compensate for water losses in the cooling tower.

The cooling tower is one of the most critical components of a thermal power plant because it removes waste heat from the condenser. Efficient cooling lowers the condenser pressure, creating a better vacuum that allows the turbine to produce more mechanical work. As a result, the power plant operates with higher thermal efficiency, lower fuel consumption, and increased electricity generation. Modern cooling systems also reduce environmental impacts by minimizing water use and improving overall plant reliability.

Conclusion. Take. visited research results this showed that heat electricity at the stations electricity energy working release efficiency in increasing modern cooling systems important technological from factors one is considered. Cooling process effective organization to be steam turbines and condenser of devices work fertility increase, heat their losses reduce and of the station general energetic indicators improve opportunity gives.

Research during wet, dry and hybrid cooling systems work features analysis done, every one of the systems to oneself typical advantage and restrictions determined. Wet cooling systems high to efficiency has although, water to resources was demand height with separated stands. Dry and hybrid cooling systems and water spending reduction, ecological security provides and energy from resources effective use opportunity gives. Modern cooling technologies heat electricity to the stations current to grow as a result fuel spending reduction, electricity energy working release cost decrease and of equipment work reliability increase possible. Also, digital management systems and from automated monitoring tools use cooling processes to optimize service does. So, heat electricity at the stations modern cooling from systems use energetic efficiency increase, natural from resources reasonable use and ecological stability of providing promising from directions one is considered. In the future innovative cooling technologies develop and them to practice wide current to grow electricity energy of the field efficiency further increase opportunity gives.

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