ISSN 2277-2685
IJESR/Jan-Mar. 2026/ Vol-16/Issue-1/308-314
B. Deepika *et. al.,* / International Journal of Engineering & Science Research
Full Length Research Article

A Study On Power Interruptions, Reliability And Turbine Operations At KTPS Power Plant

Ms. Ch. Shravani[1], B. Deepika[2], K. Navya[3], O. Manasa[4]
[1]Assistant Professor, Department of Electrical and Electronics Engineering, Bhoj Reddy Engineering College for Women, Hyderabad, India.
[2,3,4]B.tech Student, Department of Electrical and Electronics Engineering, Bhoj Reddy Engineering College for Women, Hyderabad, India.
omanasa061@gmail.com

Accepted 22-03-2026

Abstract :
Kothagudem Thermal Power Station (KTPS) Stage-5 and Stage-6 units play a vital role in meeting the base-load power demand of the region.
Thermal power plants play a crucial role in meeting continuous electricity demand, and their performance is strongly influenced by reliability, efficiency, and generation cost. This study presents a detailed case analysis of power interruptions and reliability issues in a thermal power plant, with specific reference to large capacity units. Reliable and uninterrupted power supply is a critical requirement of modern power systems. Thermal power plants, being major contributors to base-load generation, often face challenges such as forced outages, equipment failures, efficiency degradation, and rising production costs.
Steam turbine efficiency plays a major role in determining the overall performance in thermal power plant. Efficiency degradation occurs due to blade erosion, steam leakage, condenser vacuum deterioration, and improper steam parameters. These methods help in enhancing overall plant efficiency and reducing heat rate.
This case study concludes that effective reliability management and efficiency improvement strategies can significantly reduce power interruptions and improve the economic performance of KTPS Stage-5 and Stage-6 units.

Keywords: *Kothagudem Thermal Power Station (KTPS), Thermal Power Plant, Power Interruptions, Reliability Analysis, Steam Turbine Efficiency, Generator Performance, Preventive Maintenance, Predictive Maintenance, Forced Outages, Heat Rate Improvement, Power Generation Cost, Equipment Failure Analysis, Base-Load Power Generation, Operational Efficiency, Maintenance Strategies.*

1. Introduction

The **Kothagudem Thermal Power Station (KTPS)** is one of the oldest and most significant coal-based thermal power plants located in the Bhadradri Kothagudem district of Telangana, India. It is owned and operated by the Telangana State Power Generation Corporation Limited (TSGENCO). KTPS plays a vital role in meeting the electricity demand of Telangana and the southern region of India.

The power station has a total installed capacity of 1,800 MW, comprising multiple generating units of varying capacities, including 250 MW, 500 MW, and 800 MW units. Strategically located near Palvancha on the banks of the Godavari River, the plant benefits from an adequate and reliable water supply necessary for cooling and other operational processes.

KTPS primarily utilizes coal as its fuel source, which is supplied by nearby mines operated by the Singareni Collieries Company Limited (SCCL). To minimize environmental impact, the plant employs pollution control technologies such as electrostatic precipitators and adheres to environmental regulations aimed at sustainable operation.

In addition to its contribution to power generation, KTPS holds significant economic importance by providing employment opportunities and supporting regional industrial development through a stable power supply.

2. Power Interruptions and Their Reliability

2.1 Power Interruptions

Power interruptions are an inevitable aspect of thermal power plant operations due to the complexity of generation, transmission, and distribution systems. At KTPS, interruptions may arise from technical faults, operational challenges, or external disturbances.

Power interruptions can be classified based on duration and cause as follows:

- **Momentary Interruptions:**
  These are short-duration outages lasting a few seconds, typically caused by lightning, switching operations, or transient faults. Power is usually restored automatically.

- **Temporary Interruptions:**
  These interruptions last from a few seconds to several minutes and occur when protective systems isolate faults and restore supply after clearance.
- **Sustained Interruptions:**
  Long-duration outages lasting several minutes to hours, generally caused by major equipment failures, permanent faults, or natural disasters requiring repair work.
- **Planned Interruptions:**
  Scheduled outages conducted for maintenance, testing, or system upgrades. Consumers are informed in advance.
- **Unplanned Interruptions:**
  Unexpected outages caused by system faults, overloads, or disturbances, potentially leading to widespread blackouts.
- **Load Shedding:**
  A controlled interruption implemented to maintain grid stability during high demand or system stress.

2.2 Blackout Condition

A blackout condition in KTPS refers to the complete loss of power supply within the plant, including all generating units and auxiliary systems. Such a condition may occur due to grid failure, simultaneous tripping of generating units, auxiliary power failure, or protection system operations.

During a blackout, critical components such as boilers, turbines, pumps, and fans cease operation. Emergency diesel generator (DG) sets are utilized to supply essential loads, and system restoration is carried out through a black start procedure.

2.3 Case Study: Power Interruptions

The **2012 India blackout** represents one of the most significant large-scale power failures in history. On 30th July 2012, the Northern Grid collapsed, affecting several states including Delhi, Uttar Pradesh, Punjab, Haryana, Rajasthan, and Himachal Pradesh. On the following day, 31st July 2012, the failure extended further, resulting in the collapse of the Northern, Eastern, and North-Eastern grids simultaneously.

This event highlights the importance of grid reliability, system protection, and effective management of power systems to prevent large-scale disruptions.

3. Generator

3.1 Principle and Working of Generator

A generator is an electromechanical device that converts mechanical energy into electrical energy based on the principle of **Faraday's Law of Electromagnetic Induction**. According to this law, an electromotive force (EMF) is induced in a conductor when it experiences a change in magnetic flux.

In a thermal power plant, electricity generation is achieved through the conversion of thermal energy into mechanical energy and subsequently into electrical energy. High-pressure steam produced by burning coal is directed onto turbine blades, causing the turbine to rotate. This rotational motion represents mechanical energy.

The turbine is coupled to a synchronous generator consisting of a rotor and stator. As the rotor rotates within the magnetic field, it induces an electric current in the stator windings due to the variation in magnetic flux. This process generates electrical energy, which is then stepped up to higher voltages using transformers for efficient transmission.

Thus, the generator plays a critical role in converting thermal energy into usable electrical power, forming the core of power generation in thermal power plants.

Fig 3.1 Generator at KTPS

4. Rankine Cycle and Environmental Considerations

The operation of thermal power plants such as the Kothagudem Thermal Power Station (KTPS) is fundamentally based on the **Rankine cycle**, a thermodynamic cycle widely used for steam power generation. In this process, water is heated in a boiler to produce high-pressure steam, which is then expanded through a turbine to generate mechanical energy. The steam exiting the turbine is subsequently condensed into water in a condenser and pumped back to the boiler, completing a continuous closed-loop cycle.

This cyclic process ensures efficient energy conversion and a continuous supply of electricity. The overall efficiency of the Rankine cycle is influenced by several parameters, including steam temperature, pressure, turbine design, and generator performance. Higher steam temperatures and pressures generally improve thermal efficiency by increasing the energy extracted from the steam.

To address environmental concerns associated with coal combustion, KTPS integrates advanced pollution control technologies. These include **flue gas desulfurization (FGD)** systems to reduce sulfur dioxide emissions and **electrostatic precipitators (ESP)** to control particulate matter. Such measures significantly reduce environmental impact and contribute to sustainable power generation practices.

5. Maintenance Practices and Efficiency of KTPS

5.1 Maintenance Practices

Maintenance practices at KTPS are systematically designed to ensure reliable, efficient, and uninterrupted plant operation. These practices include routine inspections, preventive maintenance activities such as cleaning, lubrication, and component replacement, as well as corrective maintenance to address operational issues promptly. The plant employs advanced diagnostic and monitoring techniques, including vibration analysis, thermal imaging, and condition monitoring systems, to detect early signs of equipment degradation. The use of high-quality materials and adherence to stringent maintenance standards further enhance equipment durability and performance.

Effective maintenance strategies play a crucial role in optimizing operational efficiency, minimizing downtime, reducing maintenance costs, and extending the service life of plant equipment.

5.2 Preventive Maintenance Practices

Preventive maintenance in thermal power plants is a proactive strategy aimed at maintaining equipment in optimal working condition to avoid unexpected failures and ensure continuous operation. This approach involves scheduled inspections, servicing, and replacement of components based on predefined time intervals or operational usage.

By systematically addressing wear and tear, preventive maintenance enhances the reliability and efficiency of power generation systems. It reduces the likelihood of unplanned outages, lowers repair costs, and improves safety standards while ensuring compliance with regulatory requirements.

Preventive Maintenance Practices for Generators

Key preventive maintenance activities for generators include:

- **Regular Inspections:**
Routine visual and operational checks to identify potential faults at an early stage.
- **Lubrication:**
Scheduled lubrication of bearings and moving components to minimize friction and wear.
- **Cooling System Maintenance:**
Monitoring coolant levels and ensuring proper functioning of cooling systems to prevent overheating.
- **Electrical Testing:**
Periodic testing of insulation resistance, electrical connections, and load handling capacity to ensure safe and efficient operation.
- **Battery Maintenance:**
Inspection and testing of battery systems to ensure reliable starting capability and backup power support.

Fig 5.1 Lubrication of bearings

Preventive Maintenance Practices for Turbines

Preventive maintenance of turbines is essential to ensure efficient and reliable operation in thermal power plants. It involves systematic inspections and servicing activities aimed at minimizing wear, detecting faults early, and preventing unexpected failures.

Key preventive maintenance practices for turbines include:

- **Routine Inspections:**
Scheduled visual and operational assessments to identify signs of wear, corrosion, or mechanical damage.
- **Vibration Monitoring:**
Continuous or periodic evaluation of vibration levels to detect imbalances, shaft misalignment, or bearing defects.
- **Lubrication of Bearings:**
Ensuring adequate lubrication of turbine bearings to reduce friction, prevent overheating, and enhance operational life.
- **Condition Monitoring:**
Utilization of sensors and monitoring systems to evaluate performance parameters and detect anomalies in real time.
- **Filter Replacement:**
Regular replacement of air and oil filters to maintain system cleanliness, improve efficiency, and prevent contamination-related issues.

The implementation of preventive maintenance strategies for both generators and turbines significantly enhances plant reliability, optimizes performance, reduces downtime, and extends the lifespan of critical components.

5.3 Predictive Maintenance Practices

Predictive maintenance (PdM) is an advanced maintenance approach that utilizes data-driven techniques and real-time monitoring to predict equipment failures before they occur. Unlike preventive maintenance, which is based on fixed schedules, predictive maintenance relies on the actual condition of equipment to determine maintenance requirements.

By continuously analyzing operational data and equipment behavior, predictive maintenance enables early detection of faults, allowing timely intervention. This approach minimizes unplanned outages, reduces maintenance costs, improves system reliability, and enhances overall plant efficiency.

Common predictive maintenance techniques include vibration analysis, thermal imaging, oil analysis, ultrasonic testing, and data analytics, all of which contribute to accurate fault diagnosis and condition-based maintenance.

Predictive Maintenance Practices for Generators

The following techniques are commonly used for predictive maintenance of generators:

- **Vibration Analysis:**
Monitoring vibration patterns to detect mechanical issues such as imbalance, misalignment, or bearing wear.
- **Thermal Imaging:**
Using infrared thermography to identify overheating components, which may indicate electrical faults or mechanical stress.
- **Oil Analysis:**
Analyzing lubricant oil for contamination, wear particles, and chemical degradation to assess internal component health.
- **Acoustic Emission Monitoring:**
Detecting high-frequency sound waves to identify leaks, cracks, or early-stage mechanical failures.
- **Data Analytics:**
Utilizing historical and real-time operational data to identify trends, predict potential failures, and optimize maintenance schedules.

Fig 5.2 Transportation of Oil Predictive Maintenance

Predictive Maintenance Practices for Turbines

Predictive maintenance techniques for turbines are essential for ensuring reliable and efficient operation by continuously monitoring equipment condition and performance. These methods enable early fault detection and help prevent unexpected failures.

Key predictive maintenance practices for turbines include:

- **Condition Monitoring:**
Continuous observation of critical operating parameters such as temperature, pressure, and rotational speed to detect deviations from normal conditions.
- **Vibration Analysis:**
Monitoring vibration signatures to identify mechanical issues such as rotor imbalance, shaft misalignment, or bearing defects.
- **Oil Quality Testing:**
Regular analysis of lubrication oil to detect contamination, wear particles, and degradation, which provide insights into the condition of internal components such as bearings and gears.
- **Performance Monitoring:**
Evaluation of operational performance indicators to

identify inefficiencies or abnormal behavior that may signal impending failures.

- **Thermal Imaging:**

Use of infrared thermography to detect overheating components within the turbine system, which is critical for preventing severe damage or catastrophic failure.

The implementation of these predictive maintenance techniques enhances operational reliability, improves efficiency, reduces downtime, and lowers maintenance costs for both generators and turbines.

Corrective Maintenance in Thermal Power Plants

Corrective maintenance in thermal power plants refers to the set of actions undertaken to restore equipment to its normal operating condition after the occurrence of a fault or failure. Unlike preventive and predictive maintenance approaches, corrective maintenance is reactive in nature and is performed only after a malfunction has been identified.

This process involves fault diagnosis, repair or replacement of defective components, and system restoration within the shortest possible time. Although corrective maintenance is essential for maintaining system functionality and minimizing downtime, it requires careful planning and efficient execution to prevent extended service interruptions and operational losses.

Corrective Maintenance Practices for Turbines

The following are common corrective maintenance activities carried out for turbine systems:

- **Blade Replacement:**

Replacement of damaged, eroded, or worn turbine blades to restore operational efficiency and performance.

- **Seal and Gasket Repairs:**

Repair or replacement of seals and gaskets to prevent fluid or steam leakage and maintain proper pressure conditions within the turbine system.

Fig 5.3 Blade Replacement

Corrective Maintenance Practices for Turbines (Continued)

Additional corrective maintenance activities for turbine systems include:

- **Bearing Replacement:**

Timely replacement of worn or damaged bearings to prevent excessive vibration, reduce mechanical losses, and maintain operational efficiency.

- **Rotor and Stator Repairs:**

Repairing or refurbishing damaged rotor and stator components, which are critical for the turbine's mechanical and electromagnetic performance.

- **Control System Diagnostics:**

Identification and rectification of faults in turbine control systems to ensure accurate operation, system stability, and operational safety.

The effective implementation of corrective maintenance practices for both generators and turbines is essential for minimizing downtime, restoring system performance, and maintaining the overall reliability of thermal power plants.

5.5 Upgrades and Retrofits Maintenance Practices

Upgrades and retrofits in thermal power plants involve the modification or enhancement of existing equipment and systems to improve operational efficiency, reliability, and environmental performance. These interventions may include the integration of advanced technologies, replacement of obsolete components, and implementation of systems that comply with modern safety and environmental standards.

Such improvements focus on increasing energy efficiency, reducing emissions, and extending the operational lifespan of plant infrastructure, thereby contributing to sustainable and cost-effective power generation.

Upgrades and Retrofits for Generators

Key upgrade and retrofit measures for generators include:

- **Control System Upgrades:**

Implementation of advanced digital control systems for improved monitoring, diagnostics, and operational efficiency.

- **Efficiency Enhancements:**

Retrofitting generators with high-efficiency windings and improved cooling systems to minimize energy losses.

- **Emission Control Technologies:**

Installation of advanced emission control systems, including improved exhaust and filtration mechanisms.

- **Automated Maintenance Solutions:**

Integration of sensors and Internet of Things (IoT) technologies for real-time condition monitoring and predictive maintenance.

- **Structural Reinforcement:**

Strengthening generator structures and mounting systems to support higher output capacities and meet updated safety standards.

Upgrades and Retrofits for Turbines

Important retrofit and upgrade strategies for turbine systems include:

- **Blade Replacement or Redesign:**
Upgrading turbine blades with improved aerodynamic designs to enhance efficiency and power output.
- **Control System Enhancements:**
Incorporation of modern control systems to improve operational flexibility and efficiency.
- **Material Improvements:**
Replacement of conventional components with advanced materials that offer superior durability and resistance to wear and corrosion.
- **Variable Speed Operation:**
Upgrading turbines to enable variable speed functionality for optimized performance under varying load conditions.
- **Condensate System Enhancements:**
Improvement of condensate recovery systems to increase heat recovery and overall thermal efficiency.

Through targeted upgrades and retrofits, thermal power plants can significantly improve operational performance, reduce environmental impact, and adapt to evolving energy requirements.

5.6 Training and Maintenance Practices

Training in thermal power plants is a critical component for ensuring efficient operation, safety, and effective maintenance. It involves equipping personnel with the necessary knowledge and skills to operate, monitor, and maintain plant systems in accordance with established standards and procedures.

Continuous training programs enhance the ability of operators and technicians to handle complex equipment, respond to emergency situations, and implement maintenance strategies effectively, thereby improving overall plant performance and safety.

Training Practices for Generators

Key training areas for generator operations include:

- **Operational Training:**
Instruction on proper procedures for starting, operating, and shutting down generators, along with adherence to safety protocols.
- **Maintenance Procedures:**
Training on routine maintenance activities such as inspections, lubrication, and component servicing.
- **Diagnostic Skills:**
Development of skills to use diagnostic tools and techniques for identifying and troubleshooting generator faults.
- **Emergency Response:**
Preparation of personnel to effectively manage generator failures, system faults, and safety incidents.
- **Software Training:**
Familiarization with modern control, monitoring, and automation software used in generator systems.

Fig 5.4 Software Training for employee

Training Practices for Turbines

Effective training programs for turbine operations are essential to ensure safe, reliable, and efficient plant performance. These programs equip personnel with the necessary technical knowledge and operational skills required for handling complex turbine systems.

Key training areas include:

- **Operational Training:**
Providing comprehensive knowledge on turbine operating parameters, control mechanisms, and performance optimization.
- **Fault Diagnosis:**
Training personnel to identify, analyze, and resolve common turbine faults using diagnostic tools and techniques.
- **Safety Practices:**
Ensuring strict adherence to safety protocols specific to turbine operations, including emergency handling procedures.
- **Advanced Technology Training:**
Familiarizing operators with modern turbine technologies, digital control systems, and automation tools to enhance operational efficiency.

5.7 Efficiency of KTPS

The Kothagudem Thermal Power Station (KTPS), located in Telangana, India, is a major power generation facility with a total installed capacity of 1800 MW. The plant comprises multiple generating units, including a 1×800 MW supercritical unit along with 250 MW and 500 MW units. The operational efficiency of the plant is a critical factor in meeting regional energy demands and ensuring reliable power supply.

Turbine Efficiency

The turbines at KTPS operate with an efficiency ranging between **85% and 90%**, reflecting advanced engineering design, high-quality materials, and precision manufacturing. These turbines convert thermal energy from high-pressure steam into mechanical energy, which is subsequently used to drive the generator.

The efficiency of turbines plays a crucial role in determining the overall performance of the power plant, as it directly influences the amount of useful mechanical work extracted from thermal energy. To enhance turbine efficiency, KTPS employs advanced techniques such as steam reheating, regenerative feedwater heating, and optimized blade design.

Generator Efficiency

The generators at KTPS typically achieve an efficiency of approximately **38% to 40%**, representing the conversion of mechanical energy into electrical energy. Generator efficiency is influenced by factors such as material quality, cooling systems, and maintenance practices.

KTPS utilizes hydrogen cooling systems in its generators due to hydrogen's superior thermal conductivity and low density, which enable effective heat dissipation. This cooling mechanism helps maintain optimal operating temperatures and prevents overheating, thereby improving efficiency and reliability.

Additionally, advanced insulation materials such as mica tapes, epoxy resins, and polyimide films are used in stator windings to enhance performance, durability, and operational stability.

Overall Plant Efficiency

The overall efficiency of KTPS has improved significantly over time due to modernization and rehabilitation initiatives. Initially recorded at approximately **25.7%**, the plant efficiency increased to **30.1%** by the fiscal year 2002, with targets set to reach **32.5%**.

These improvements are attributed to technological upgrades, optimized operational strategies, and effective maintenance practices. Preventive maintenance, including routine inspections, cleaning, lubrication, and timely component replacement, has played a key role in maintaining high operational standards and reducing downtime.

6. Conclusion

Thermal power plants continue to play a vital role in meeting global electricity demand due to their reliability and economic viability. However, their environmental impact—including greenhouse gas emissions, resource depletion, and water consumption—poses significant challenges.

The operation of generators and turbines at the Kothagudem Thermal Power Station is fundamental to the plant's efficiency and performance. Turbines convert thermal energy from steam into mechanical energy, which is subsequently transformed into electrical energy by generators. The use of advanced engineering designs, high-quality materials, and efficient cooling systems—such as hydrogen cooling for generators and water-based cooling for turbines—ensures reliable operation under high temperature and pressure conditions.

Maintenance strategies, particularly preventive and predictive maintenance, significantly enhance equipment reliability, reduce downtime, and extend operational lifespan. Furthermore, environmental management practices, including waste management, ash utilization in cement production, and rainwater harvesting, contribute to sustainable plant operation.

Although coal-based power plants remain essential for meeting current energy demands, there is an increasing need to transition toward cleaner and renewable energy sources to minimize environmental impact and ensure long-term sustainability.

In summary, this study highlights that while thermal power plants like KTPS are effective in meeting large-scale energy requirements, continuous improvements in efficiency, maintenance practices, and environmental management are crucial for sustainable operation.

References

1. **"Reliability and Availability Analysis of a Gas Turbine Power Plant" (Global Scientific Journal):**
   Analyzes failure rates, showing Mean Time Between Failures (MTBF) ranging from 66 to 609 hours, with plant availability often below 90% in some regions due to inadequate maintenance and fuel supply issues.
2. **"Reliability of Wind Turbines" (ResearchGate):**

   Evaluates SCADA data to analyze failure rates in wind turbine components, particularly power converters and pitch systems.
3. **"Reliability, Availability, Maintainability Data Review" (ScienceDirect):**
   Reviews onshore and offshore wind energy data, including early reliability databases developed by Lynette and EPRI.
4. **"Effects of Electric Power Blackouts on Steam Turbine Power Plants" (Naeim Farouk et al.):**
   Discusses the impact of sudden blackouts, including lubrication failure and increased friction in turbine bearings.
5. **National Thermal Power Corporation (NTPC) Technical Reports:**
   Provides insights into modern thermal power plant operations, turbine performance, and reliability enhancement techniques.
6. **Institute of Electrical and Electronics Engineers (IEEE) Journals and Papers:**
   Offers advanced research on power generation systems, maintenance strategies, and efficiency optimization.