iJRASET
International Journal For Research in
Applied Science and Engineering Technology

# INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

**Volume:** 13 **Issue:** VIII **Month of publication:** August 2025

**DOI:** https://doi.org/10.22214/ijraset.2025.73594

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue VIII Aug 2025- Available at www.ijraset.com

# Individual Steam Turbine Had Unique Thermal Memory and Cooldown Pattern

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## I. BACKGROUND

The catenary design of each turbine model plays a vital role in its operation, especially during hot trip conditions. During erection, bearing pedestal grouting with the concrete structure can deviate the actual catenary value. This deviation is referred to as the seal bore error. To improve barring speed, particularly during hot tripping, this error finally corrected as closely as possible to the original catenary value during final alignment of rotor. If the rotor aligns with the original catenary, in each bearing oil flow and pressure of jacking oil pump near to designed value are required to rotate the shaft. However, if there is a significant deviation, higher flow and pressure are needed. In some cases, the rotor can become jammed after a hot trip because change in catenary during operation (change in oil flow and pressure).

## II. LEARNING FROM SITE INCIDENTS

1.One such incident occurred on 21st February 2024 in Unit #5, CPP, Mahan Aluminium, where the turbine rotor got jammed after a hot trip. During barring gear operation (after hot trip machine on barring gear), the AC jacking oil pump was showing a pressure of 130 Kg/cm². Suddenly, the rotor jammed, and zero pressure was observed in DCS and at the LP turbine rear bearing pedestal. This indicates temporary sagging of the rotor due to oil temperature being below 45°C. As the rotor gradually cooled, the barring gear operation was resumed the next morning, when the rotor temperature had dropped to around 339°C.

1) *One point lesson above incident: - Other four machines are on barring gear after hot trip and one facing rotor jammed issue. However, all machines are same model.*

2.Another incident occurred (in the month of May 2024) at a different plant where a turbine tripped, and the C&I team decided to replace the solenoid valve (which is malfunctioned many times). Meanwhile, the operations team attempted to engage the machine on manual barring gear without monitoring the oil temperature. This oversight caused the rotor to jam. When the barring gear motor resumed by default, it damaged the motor shaft’s anchoring point and dislodged the motor. Unfortunately, the operator present at the time for manual barring was fatally injured due to the impact of the broken motor turning the mechanical failure into a fatal accident.

2) *One point lesson above incident: - Operation team not aware about of impact of lubrication oil temperature on rotor.*

a) *Thermal memory of steam turbine*

Thermal memory refers to the residual thermal stresses and distortions retained in turbine rotors, casings and other hot parts due to their operational thermal history. Every start-up, shutdown, trip, or load fluctuation leaves a thermal signature on the metal parts. These are not only in terms of temperature but also in expansion, bowing and residual stress patterns.

b) *Unique for individual steam turbine of same model*

Material behaviour changes due to aging, creep, fatigue and repairs (like welds, line boring etc). manufacturing tolerances, assembly clearances and site-specific operating conditions ( like cooling water temperature, ambient air, load cycles) create a unique thermal response. Hence no two turbines even of same model have identical thermal memory.

## III. INDIVIDUAL COOL -DOWN PATTERN

It is influenced by: -

1) Material thickness variation (rotor cools slower than casing)
2) Rotor -Casing heat transfer dynamics (through steam/air pockets)
3) Shaft bearing heat sinks
4) Ambient conditions (air cooling, turning gear RPM)
5) Previous load and soak time.
6) In turbine rotor thermal co-efficient

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### *A. Parameters Responsible For Thermal Memory & Cool Down*

Following are the parameters needs monitor: -

1) Rotor axial and radial shaft expansion (differential expansion)
2) Casing metal temperature (casing shrinking pattern & mismatch detection)
3) Bearing metal temperature (heat sink capacity and bearing oil wedge consistency
4) Rotor bow (vibration under limits)
5) Rotor thermal gradient -axial profile (detects differential cooling across rotor length)

## IV. CONCLUSION

Each turbine possesses a unique thermal memory that significantly influences its cool-down patterns following operation or emergency shutdowns. Ignoring these individual thermal characteristics can lead to severe mechanical issues such as misalignment, rotor jamming, and ultimately mechanical failure. To mitigate these risks, it is mandatory to perform detailed rotor thermal profiling after every emergency trip for each machine. This analysis should focus on developing plant-specific thermal cool-down curves, complementing or refining the original equipment manufacturer (OEM) curves provided during installation. These tailored curves allow for more accurate monitoring and preventive maintenance.

### *A. Addressing Rotor Jamming via Jacking Oil Flow Adjustment*

Following an in-depth study from above explained rotor jamming incidents, it was determined that increasing the flow rate of the Jacking Oil pump from 85 LPM to 110 LPM in each unit provides a sufficient hydrodynamic wedge between the rotor and bearing clearance. This enhanced lubrication film reduces metal-to-metal contact risks, ensuring smoother rotor operation and minimizing jamming in same model installed.

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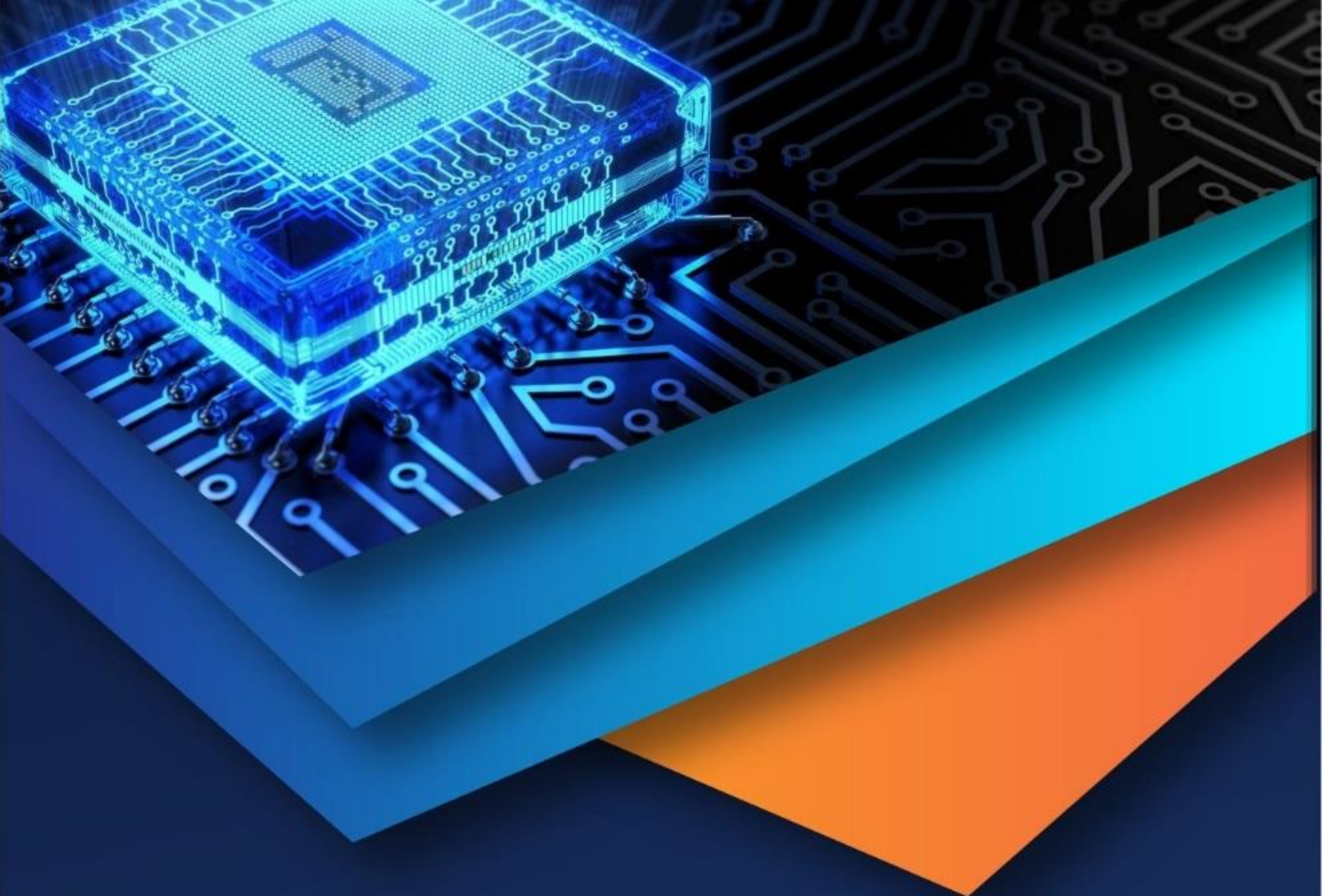


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