Council of Enviro Excellence

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New Delhi

FLEXIBLE OPERATIONS IN THERMAL POWER PLANT

Flexibilisation Measures & Retrofit Of Thermal Power Plant Assets

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Flexibilisation Measures & Retrofit Of Thermal Power Plant Assets

- ANNUAL CONFERENCE ON FLEXIBLE OPERATION OF THERMAL PLANTS 2024

COUNCIL OF ENVIRO EXCELLENCE

PRABHAT SINHA ,SR CONSULTANT

Outline

- Present Scenario Of Power Generation
- Impact Of Flexible Operation/Cyclic Loading
- R&M/Retrofit Needs & Benefits For Flexible Operation
- Implementation Strategies
- Some Case Studies Of Successful R&M

Power Generation- Imp Facts In India

As on Mar 24 Installed capacity was 441.9 GW :

- Renewable Contribution - 190.5 GW - 43 %
- Fossil Fuel Contribution – 211.8 GW – 50.7%
- Other Contribution – 42 GW

With Renewable Power Penetration , Thermal Generation is Ramping Down to app 60% of capacity

Projected Installed capacity of Power Gen as per "National electricity Plan-May 2023" is app 900 GW by 2032 .

- Renewable will be app 615 GW - 69.4%
- Fossil Fuel will be app 285 GW - 30.6%

(App 90% will be Coal/Lignite Based Plants)

With Further Penetration of Renewable Power Thermal Generation may Ramp Down to avg 40 % Tech Minimum of Capacity

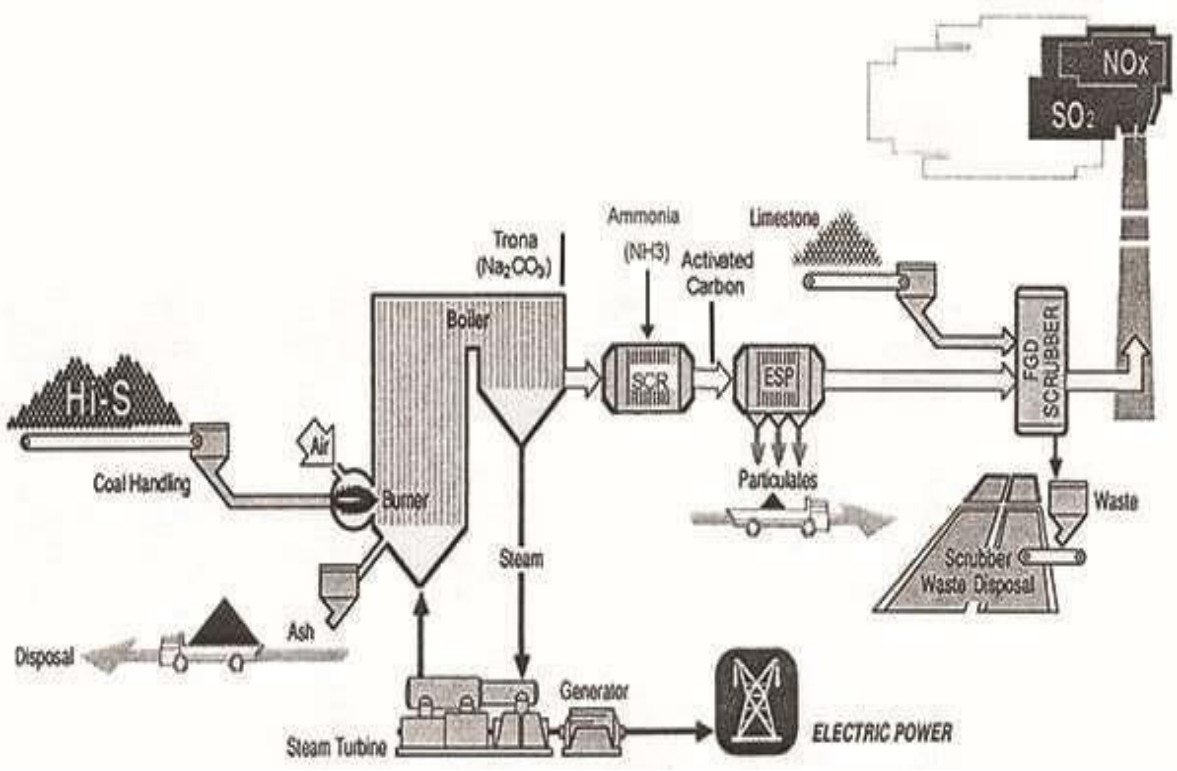
Cyclic Loading of Thermal Plant touching ~ 40% will aggravate Asset Degradation

Source Of Data- CEA , PIB GOI

Flexibilisation Measures In Nut Shell

- **Faster Load Adjustment** – Increasing ramp rates and enabling low-load operation.
- **Reducing Start-Up Time** – Quick-start technologies and optimized boiler systems.
- **Improving Efficiency at Partial Loads** – Retrofitting equipment and using advanced control systems.
- **Lowering Minimum Technical Load** – Allowing plants to run safely at lower outputs.
- **Enhancing Fuel Flexibility** – Adapting to multiple fuel types, including cleaner options.
- **Adjusting Emission Controls** – Ensuring pollution controls function at different load levels.
- **Using Digital Tools** – Employing real-time monitoring and AI for predictive maintenance and operational optimization.

TPPs In work Today …



Some Key Control Systems In Place :

- Distributed Control System
- BMS/FSSS
- ATRS

They have key functions to –

- Control
- Protect
- Interact
- Communicate

In a close or Open loop within the given loops like Boiler , Turbine , CHP, Off Site etc

They have Limitations to interact and provide key information to operator in Totality , so manual dependences

Impact Of Cyclic Loading

- Increased Start-Up & Shutdown Cycles and thermal stresses during load changes will cause accelerated wear and tear.
- Thermal cycling Transients added with plant condition will contribute to fatigue causing rapid degradation of all high temp system/equipment viz – Boiler, Turbine, Pipelines, Valves, Dampers etc.
- Quick response for corrective actions is having human interface

Asset Degradation Adversely Affect Flexibilisation

STEAM TURBINE / BOILER DAMAGE Manifestations

- ***High Cycle Fatigue*** – Vibration
- **Creep** - Steady stress at elevated temperatures
- ***Environmental*** - Stress Corrosion Cracking (SCC)
- ***Low Cycle Fatigue*** – Thermal and mechanical Cycling
- ***Foreign Object Damage*** - Flow path liberation
- ***Embittlement*** – Time and temperature exposure
- ***Erosion*** – Water droplet and solid particle
- ***Rubbing*** – Axial and Radial
- ***Event Driven*** – Water Induction, Overspeed

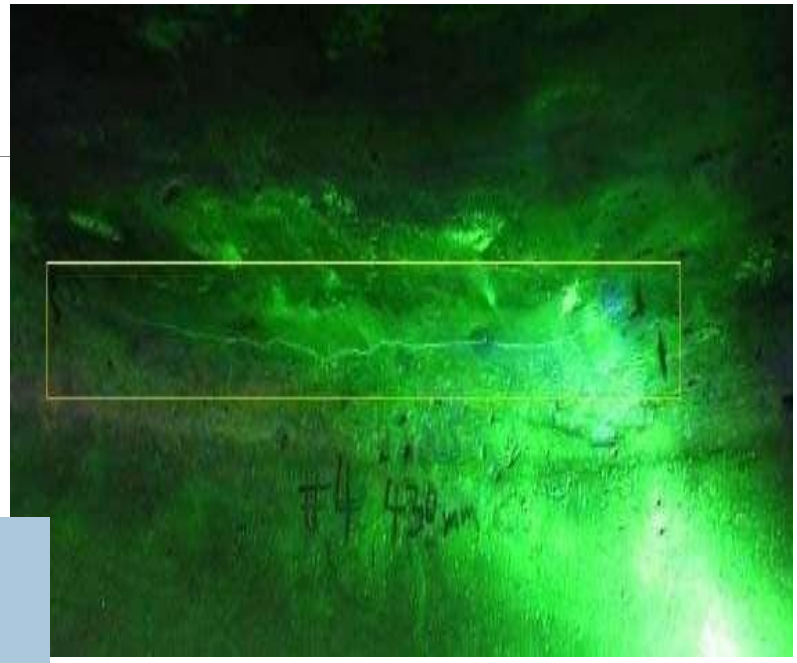
Minimum Load Regime

- Primary Failure Mechanisms
  - High cycle fatigue
  - Low Cycle Fatigue
  - Solid particle and water droplet erosion
- Secondary Failure Mechanisms
  - Stress corrosion cracking

- Operational Manifestations:
  - Turbine differential expansion
  - Increased vibration levels
  - Turbine water induction
  - Boiler issues
  - Overheating at LP exhaust

Cyclic Load Regime

- Primary Failure Mechanisms
  - Low cycle fatigue cracking of rotor, blades, casing, generator
  - Rotor bow and rubbing
  - Solid particle erosion
- Secondary Failure Mechanisms
  - High cycle fatigue cracking



- Operational Concern
  - Vibration
  - Turbine Water Induction
  - Differential Expension
  - Boiler Issues
  - Overspeed

Other Reasons of Performance Losses

IMPORTANT TRENDS IN THERMAL PLANT - PERFORMANCE DETERIORATION

Age Structure	Indicates the share of ageing plants / technology obsolescence in the total generation mix of the country
Heat Rate	Combined effect of Heat Rate and Auxiliary consumption indicates the net plant efficiency. Lower the combined effect of the two, lower will be the fuel cost/ cost of power generation.
Auxiliary Consumption	
Plant Availability, Forced Outage & PLF	Indicates the quantum and reliability of energy availability. Better the plant availability higher is the generation / reliability of generation.

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R&M/LE of Thermal Plants In Past & Now -

R&M programme was started from 7th Five Year Plan (1985-90)

- 34 nos. of TPS / 163 units / 13570 MW
- Benefits –
  - PLF – 46% to 56% (Avg Rise 10%)
  - Electricity Gen Rise – 7k to 10k MU(Avg Rise 40%) P/A

Why It did not work Consistently :

- Scope Identification
- Surprises during execution
- Completion Period Extension
- Cost Escalation
- Weak framework of Contract
- Project management

- Up To 11th Five Year Plan (2012-17) R&M/LE of app 610 Units with 77500 MW were successfully done under different plans under various scheme
- Estimated rise in Generation was 40k MU/PA and 6700 MW equivalent addition was done

Objective of R&M Now :

- Operational Improvement
- Life Extension with/Without Uprating
- Compliance of Environmental Norms
- ***Flexible Operation for Renewal Integration***
- Bio Mass Co Firing Capability

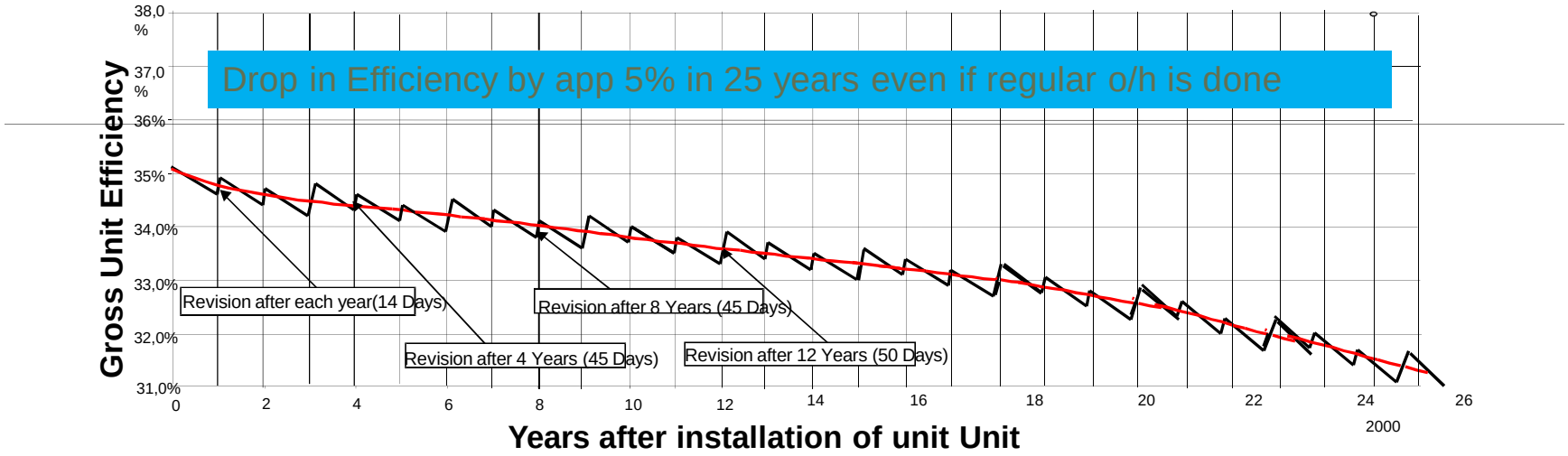
R&M Concept is Powerful for Improvement of the Performance

Objective & Benefits Of R&M/Retrofit For *Flexible Operation*

- Necessary Corrections For Flexible operation and Performance Improvement
- Control up gradation & optimization
- Ramp rate improvement
- Upgrade with modified/augmented latest technology equipment/components/ systems

- Reduction in maintenance requirements, ease of maintenance and enhanced efficiency.
- Environment norm Compliance
- Life Enhancement
- Safety Compliances

Simulation of Unit efficiency ageing



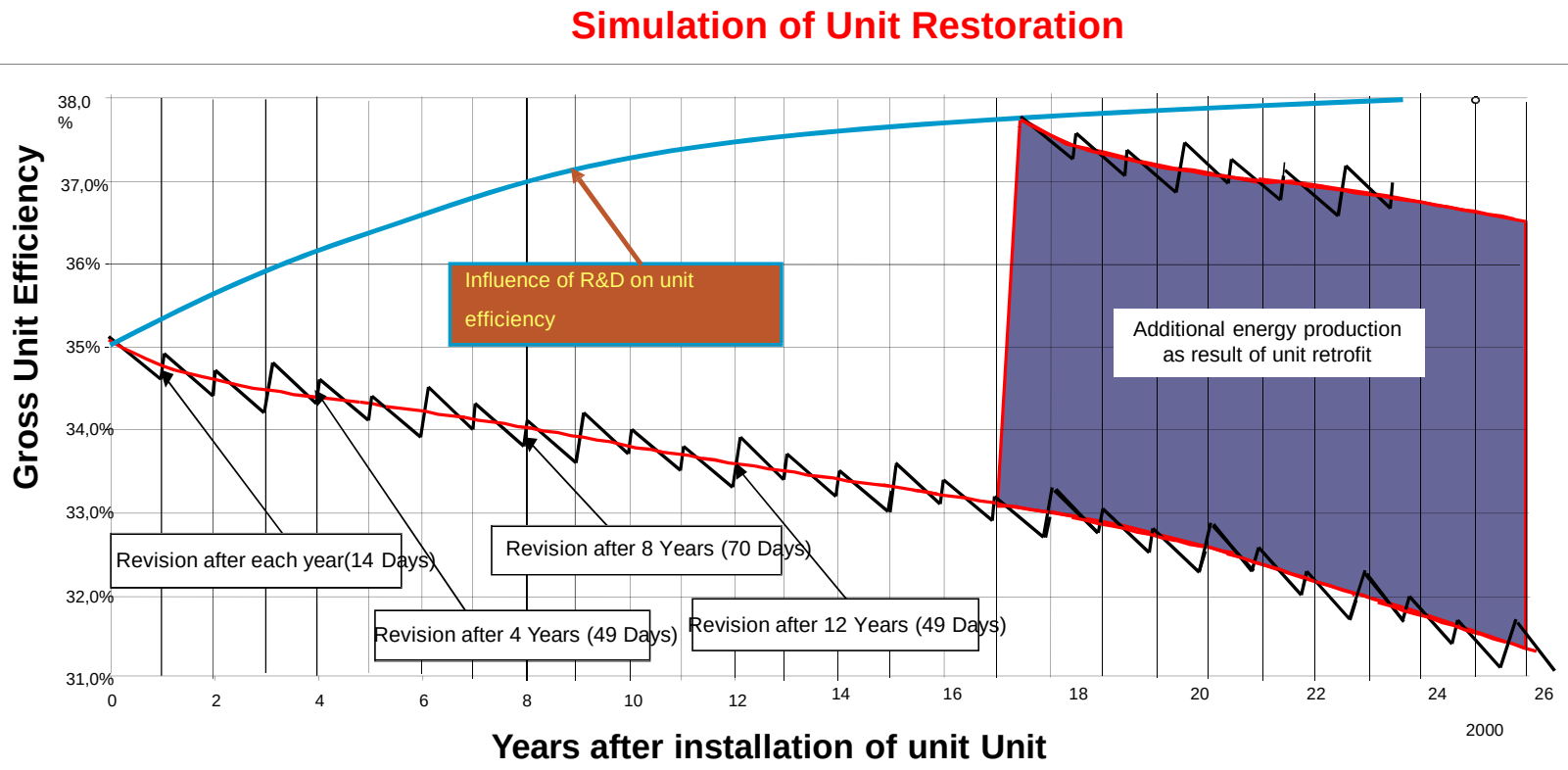
Moral ageing of performances

- geometry of blades' profiles,
- geometry of valve heads and nests,
- geometry of turbine inlet and exhaust area (Bauman stage)

Physical ageing of performances

- erosion and corrosion of blading
- -- damages of sealing elements
- chemical deposits
- -- various deformations of turbine elements

Benefits for R&M



30-09-2024

National R&M Plans To augment Flexible Operation

R&M Plan By CEA For Old Units :

Eligible Units for R&M of 20+

- Till Dec 2023
  - *Fossil Fuel Based – 40 GW*
  - *No Of Units – 152*
  - *Unit Sizes – 195 MW to 500 MW*

•Till Dec 2030 - Add 72 Units - 26GW , Unit Capacity Up To 660 MW

For Meeting Flexiblisaton Targets by 2032 :

- R&M Plan notified by CEA For Retrofit/R&M of plants in phased manners from March 24 to Dec 2030 :
  - *Total Unit – 493*
  - *Capacity - 196.5 GW*
  - *Units Sizes 110 to 500 MW*
- In Staggered Manner – Each Unit Shut Down for 1.5 Months

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Contracting Basis

R&M is not New Build

True ‘EPC’ is not applicable for R&M

- Unknown scope at time of bid, hence unknown schedule
- The lowest bid may not adequately address true risk profile
- Serious bids may well be priced out.

Fixed Price and Schedule for a Fixed Scope

- The priced scope needs to be fully defined before a price and schedule can be given for it.
- Contract needs to define how to handle emergent work (i.e. how to handle the surprises)

New Build Specification is Not Appropriate

Preparatory Analysis

- Plant Risk Assessment
- Information Gathering
- Comprehensive Health Assessment

Risk Management

- Must start well in advance of bid documentation Prep

- Preparation is Key
  - Plant Condition
  - Accurate and recent process data
  - Accurate, as current drawings
  - Interaction with suppliers

- Beneficial both to contractor and the utility

- Risks managed before bid For -

  → Better Price

  → Better Guarantees

  → Successful execution

Information Gathering

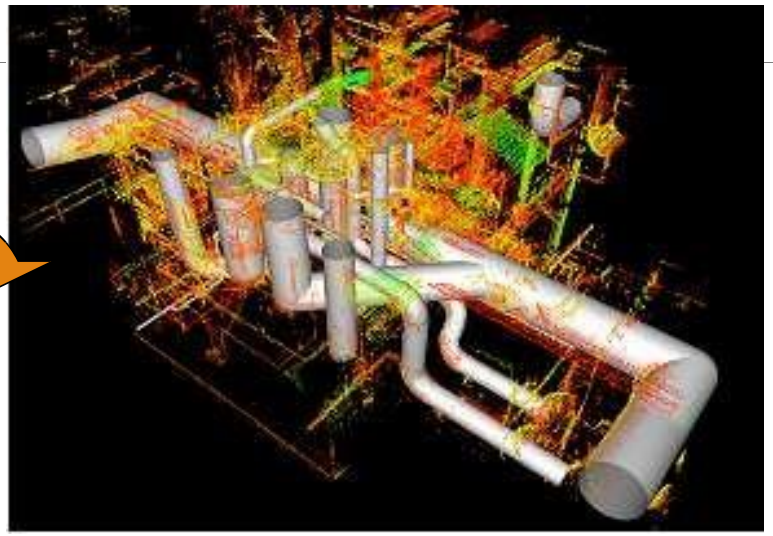
Potentially Available Data

- Full set of up to date P&ID's
- O&M manuals, Drawings & Docs ,
- Current Operating Data including current, accurate boiler process flow (diagrams, fuel analysis, air flows, gas flows, temperatures, pressures, emissions etc.)
- Service History & Information regarding changes made at site
- Planned Outage Schedule

Some Measurements and inspections can only be taken with the unit offline

- Remaining Life Assessment and Condition assessment
- Steam Path Audit
- Component Internal measurements (eg. Turbine internal interfaces, condenser neck, boiler pressure parts)
- Fitting of some performance testing equipment

Laser Scanning



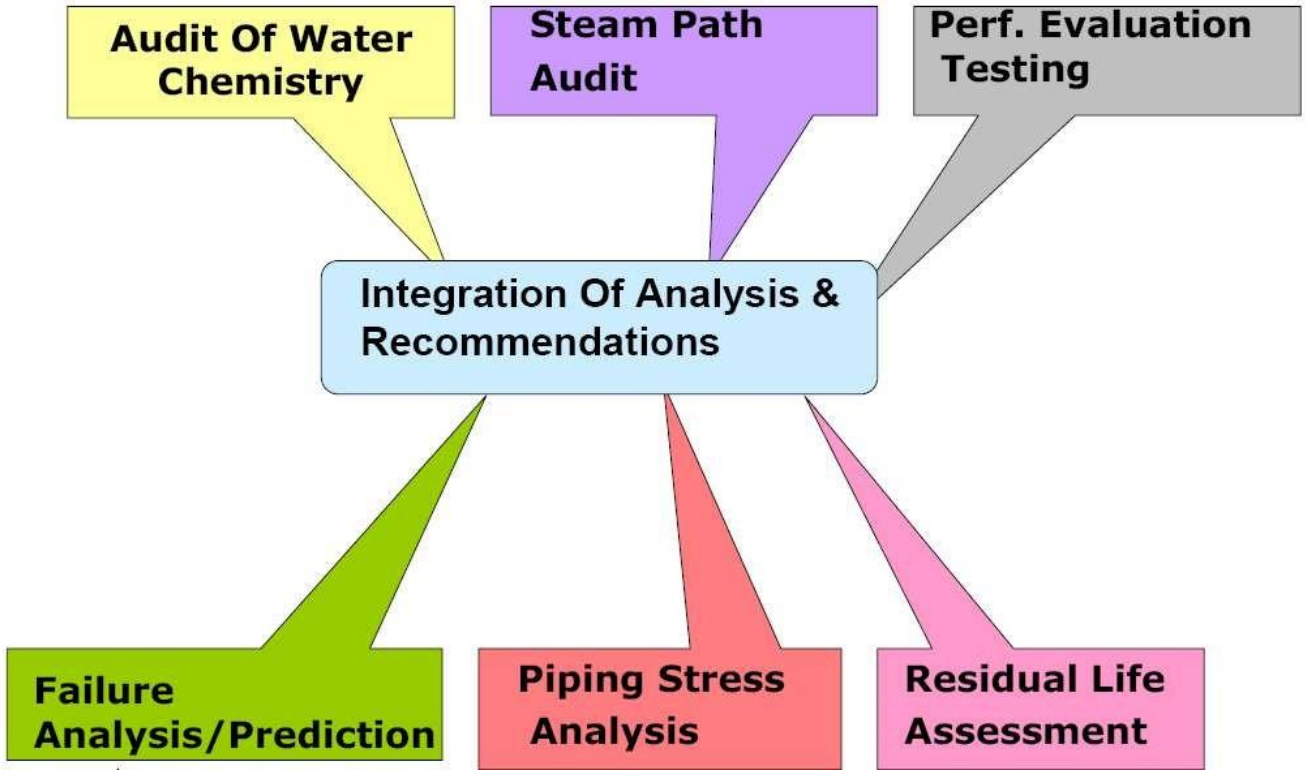
As current equipment layout

3-D Access and Egress planning

Pipe and cable tray as current routing

Turbine hood and condenser neck measurement

Comprehensive Health Assessment (CHA)



Provides qualitative and quantitative data with recommendations to achieve Sustained & Energy Efficient Generation

Modus Operandi of CHA

The assignment is carried out on "Task Force" concept. The Task Force comprises of:

A	*Technology Experts*	Long experience in Power Station Engineering, operation/ maintenance/ trouble shooting
B	*Metallurgical Experts*	Expert knowledge of metal behavior under Different conditions of operation.
C	*Field working Experts*	Long experience in carrying out NDT and other In-situ tests.
D	*Core Specialist*	Specific system and equipment Specialist
E	*Integration Expert*	Expertise in power plant O&M to integrate findings and prepare recommendations

CHA Analysis & Recommendation

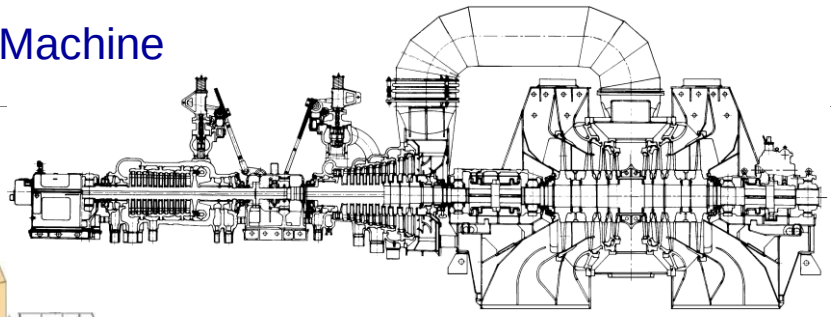
Category I – Immediate Action: Modify or Replace Now
Components with high probability of failure leading to serious consequences. Immediate implementation is Vital for useful life extension and/or performance improvement

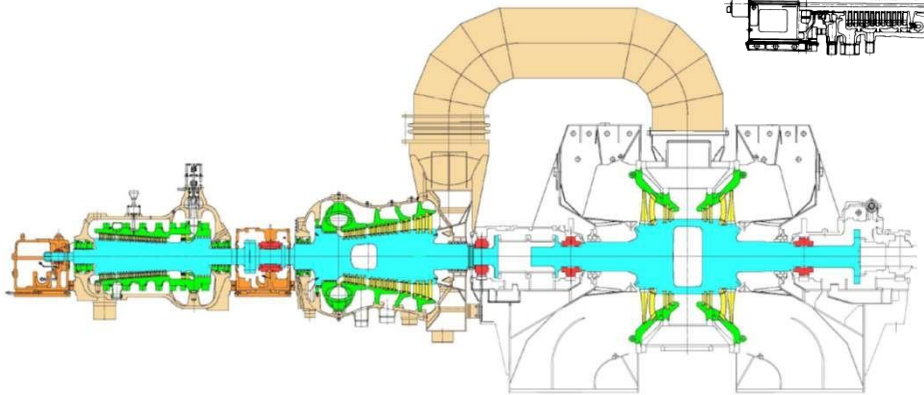
Category II – Maintenance/Rectification/Refurbishment
Components needing Action at the earliest opportunity is essential for useful life extension and/or performance improvement.

Category III – Possible Future Action
Repeated bench marking for comparative rate of deterioration is desirable. Action is essential for useful life extension and/or performance improvement.

Turbine Retrofit Examples

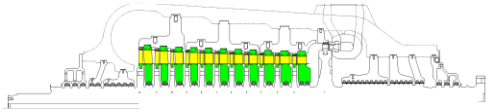
Original Machine



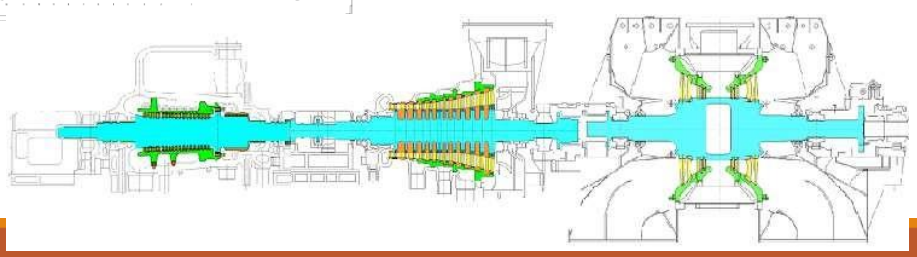


Full Module Retrofit

Re-blade



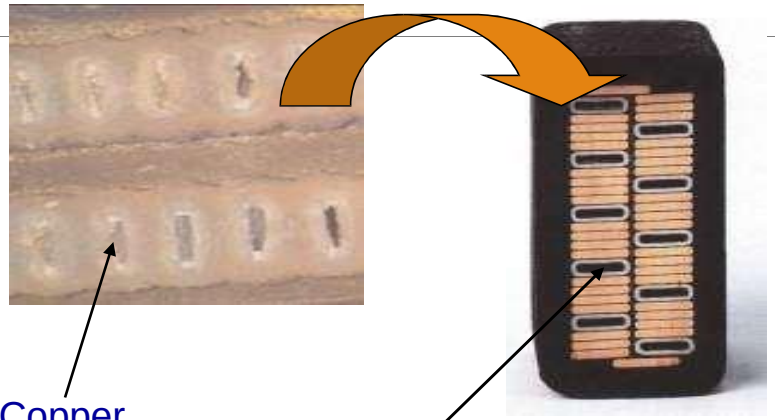
Inner Block Retrofit



Generator Retrofit Examples

Existing Stator Bar

New Stator Bar



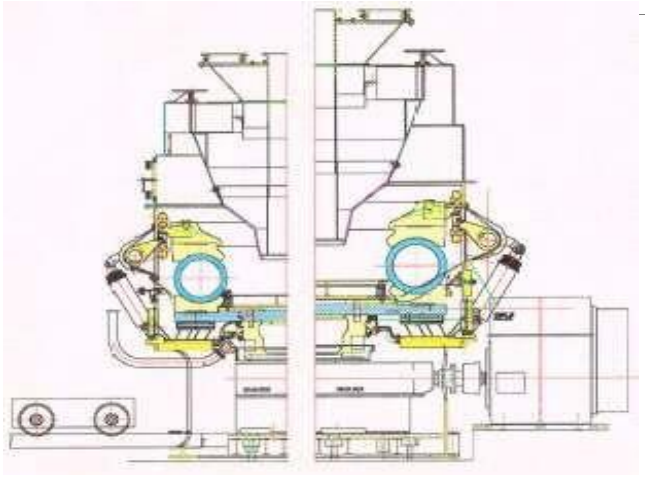
Copper,
Clogging

Stainless Steel
No Clogging

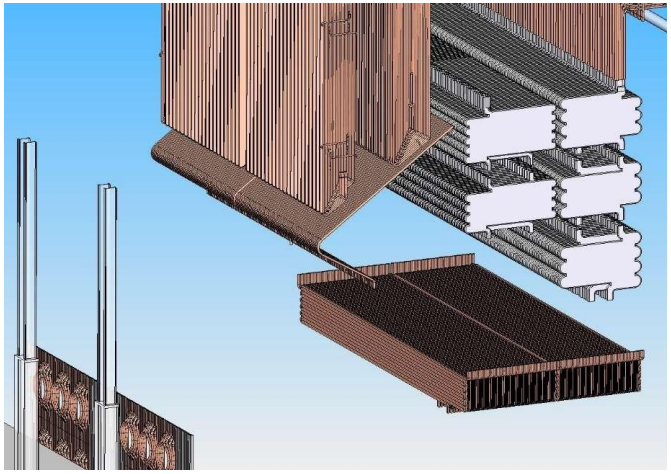
Outlet Manifold

New Thermometers

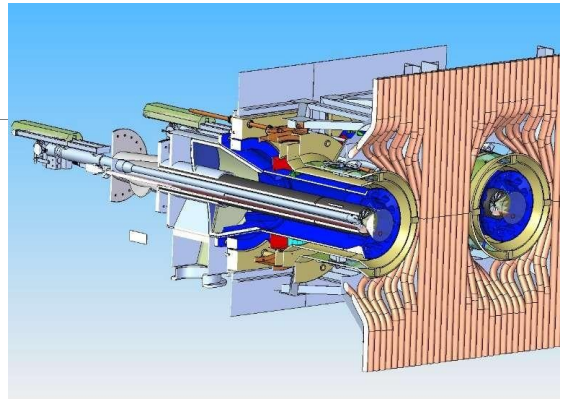
Boiler Examples



Mill Capacity Increase retaining existing baseplate, gearbox and motor



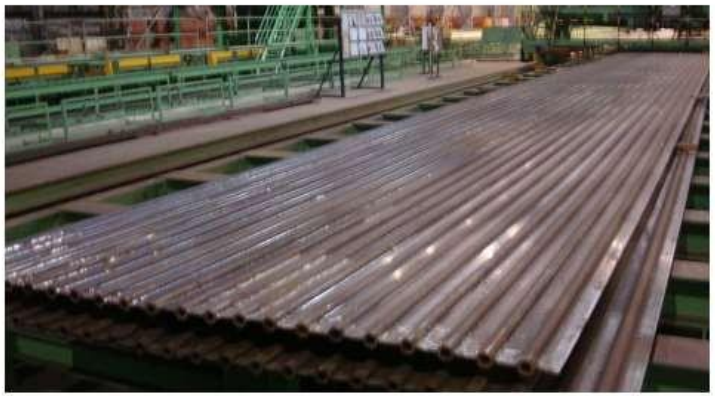
Heating Surfaces



Low NOx Burners

BOILER COMPONENT RETROFIT

Water Wall Panels



Elements

Headers

SOFA Panel

Sphere

Case Study 1 - Recently Completed R&M :

R&M Benefits :

NTPC – RSTPP – Unit 1 -200 MW

Date of commissioning Stage-I –1983-84
Unit # 3 TG Life Extension
Work completed in Dec 2021

Major Scope :

- Complete HP IP Module Replacement
- LPT internals Replaced
- Modernizing Control System
- Uprating From 200 MW to 210 MW.
- Guaranteed Turbine Heat Rate: 1935 Kcal/KWh

Particulars	Before R&M	After R&M
Capacity (MW)	200	210
Turbine Heat Rate (Kcal/KWH)	2101	1919 as per PG test result
Awarded R&M Cost/Unit	122 ₹ Cr	
LE Cost /MW ₹ Cr	0.61	

Case Study 2 - Recently Completed R&M

GSECL WANAKBORI TPS U# 3 (1X210 MW)

Date of commissioning WTPS Unit# 3 –1983-84

Work completed in Dec 2017

Major Scope :

- Complete HP IP Module Replacement
- LPT internals Replaced
- Guaranteed Turbine Heat Rate: 1950 Kcal/KWh

Particulars	Before R&M	After R&M
Capacity (MW)	210	210
Turbine Heat Rate (Kcal/KWH)	2260	1944.14
Awarded R&M Cost/Unit	94.00 ₹ Cr	
Per month saving in fuel cost	Rs. 6.3 Crores.	

Benefits :

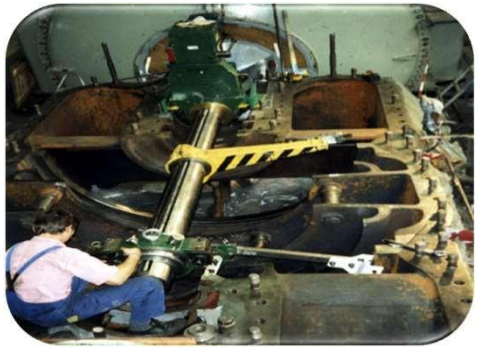
- Life extended by 15 years.
- Improved Turbine cycle heat rate by 315.86 Kcal/KWh
- Modernized TG control system with state of art technology.
- Guarantees met: PG Test conducted in February-2018.
- 100% TMCR HR & Output test cleared. No shortfall Observed

Case Study Torrent Power ‘D’ Station

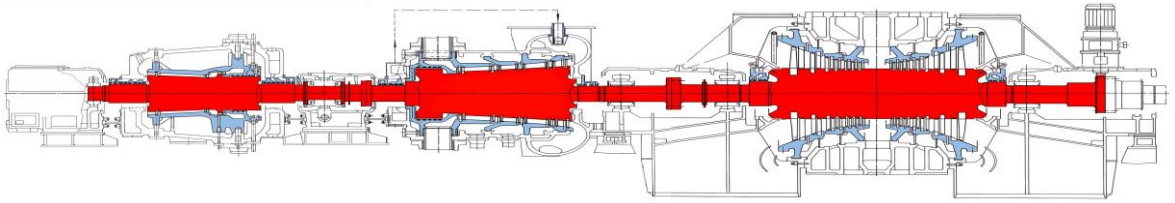
TURBINE : Major Replacements

- New HP/IP module with inner casing
- New LP module with diaphragm
- New design shaft seals

New LP Rotor



In-Situ Machining



Cross section with new rotors, inner casings, stationary blades, blade carries and steam sealing

CASE STUDY 3 - STATION TORRENT SABARMATI 110 MW

PARAMETERS	PRE-R&M	POST-R&M
Turbine Heat rate	2477.3Kcal/kWh	> 18 % reduction in HR
Output	105 MW	120 MW
Availabilty	90.5% (3 Years)	98% (Avg of 36 Months)
Average PLF	> 83.5 %	> 90% (Avg of 30%)
Uninterrupted Continuous run		Known 185 Days
Highest PLF		101 %

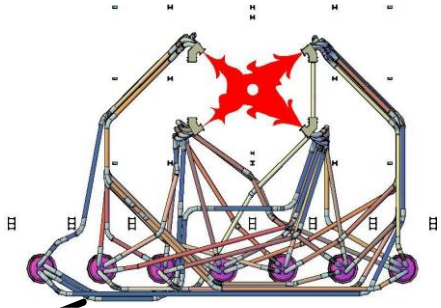
- Higher output with Improved Heat Rate
- Increased interval between overhaul from approx 25,000 Hrs to 100,000 Hrs.
- Life extension & Improved availability of machine
- Lower emission levels per Kwhr generated
- Cost of generation lower.

CASE STUDY NTPC TANDA – 4X110 MW

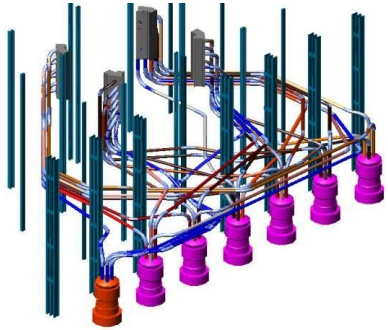
New Mill , Coal Pipe Routing, New Elevation

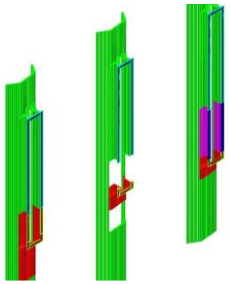
Retrofit of Boiler and C&I in 4x110 MW Units at NTPC-Tanda

Synopsis: It is 4x110 MW Unit with > 20 years of operation in Unit 1,2& 3 and app 13 years in Unit 4; upgraded by addition of complete milling system and auxiliaries with Improvement in availability and Boiler performance



Coal Pipe ROUTING fouling with existing equipment, piping, structures averted by clash checking done in 3D models





Furnace modification to accommodate new elevation

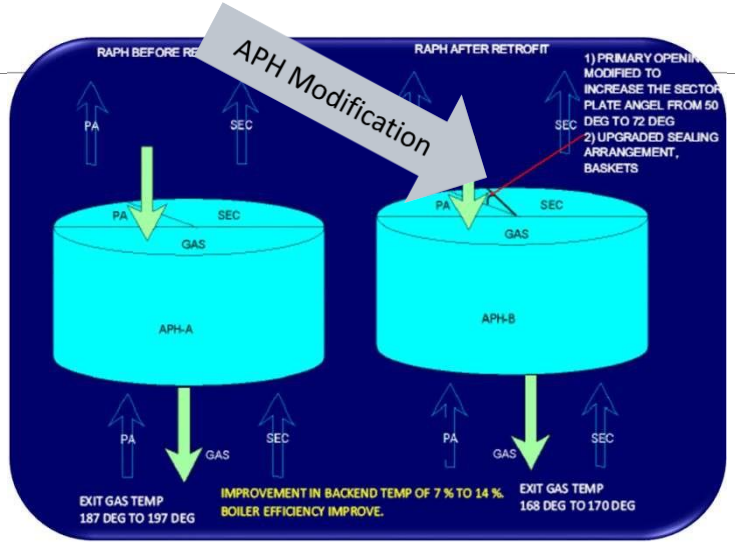
New Mill

Case Study :NTPC Tanda - Walk Down: Solutions

New Boiler Control System & Modified Air-Pre Heater :

Introduction of new FSSS system with HEA igniters, oil guns, trip valves & flame scanner system with new pneumatic control valves and power cylinder

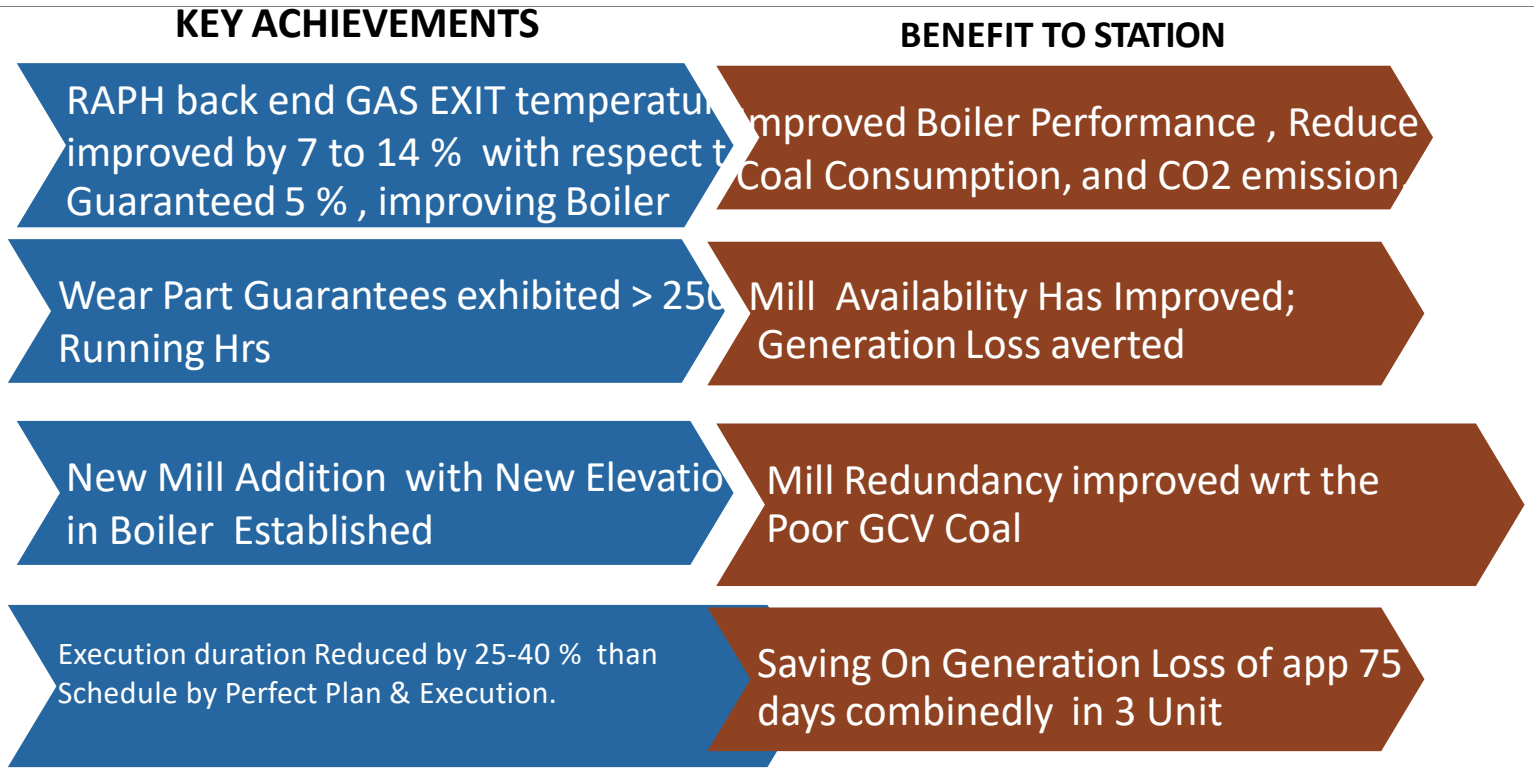
New Control System



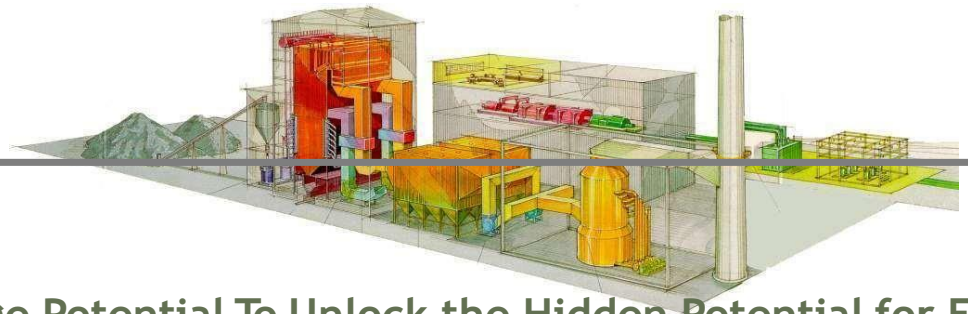
Ljungstrom Rotary Air-Preheater

Replacement of air heater elements and seals. The sector angle was modified to 72° to accommodate the increased primary air flow required.

CASE STUDY : NTPC TANDA - BENEFITS



Conclusions



R & M/Retrofit Has Huge Potential To Unlock the Hidden Potential for Enabling the Assets for Cyclic operation through :

- ✓ Performance Assessment
- ✓ Optimised integrated boiler, turbine & other equipment solutions for performance and further reductions of emissions
- ✓ Control System Upgrade
- ✓ Component R & M
- ✓ Digitalisation

All lead to unlocking ‘hidden’ capacity and efficiency gains within Existing Power Plants

Thanks !!

THANKING YOU!

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Council of Enviro Excellence