एनटीपीसी NTPC

50 YEARS OF POWERING GROWTH

Indian Power Stations 2025

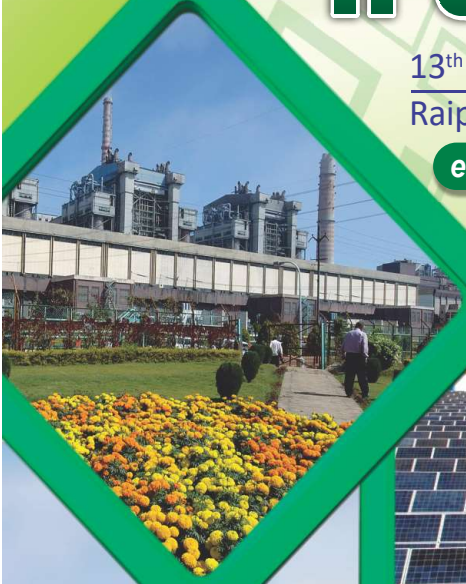
O&M Conference

IPS 2025

13th to 15th February

Raipur, Chhattisgarh

e-Compendium of Paper Abstracts



THEME

Reliable & Sustainable Generation,
Asset Management and Energy Transition

एनटीपीसी लिमिटेड
(भारत सरकार का उद्यम)
NTPC Limited
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Ravindra Kumar
Director (Operations)

MESSAGE FROM DIRECTOR (OPERATIONS)

It is our pleasure to convey that NTPC is organizing the prestigious International Power Plant O&M (Operation and Maintenance) Conference, **'Indian Power Stations-2025'** at Raipur, the capital city of Chhattisgarh. NTPC hosts this annual mega event on February' 13th every year on the day in which first Unit of NTPC in Singrauli began its operation in the year 1982. This year also NTPC is organizing the event from 13th to 15th Febraury'2025.

NTPC, India's leading integrated power company with an installed capacity of over 77 GW, acknowledges the importance of energy transition and has set a challenging target to add 60 GW of renewable energy capacity by 2032. Meanwhile, India has ambitious target to achieve non-fossil generation capacity of 500 GW and meet 50% of its energy requirement from renewable energy by 2030. The increased integration of highly variable renewable energy necessitates higher flexibility and resilience from the thermal fleet and storage solutions such as Battery Energy Storage Systems (BESS) and Pump Storage Plants (PSP) etc. In the era of energy transition and increased demand, disruptive changes will become new normal.

NTPC has aptly chosen the theme for this year's conference as, **"Reliable & Sustainable Generation, Asset Management and Energy Transition",** with an aim invite best minds from India and abroad to deliberate & brainstorm on Energy Security, Asset Management & Energy Transition. Concurrently, the "Techno Galaxy" exhibition allows vendors and professionals to showcase the latest and the most innovative technologies and solutions. I am delighted to learn that, once again this year, the event has received an overwhelming response from both national and international professionals. The NTPC COS team has compiled an e-compendium featuring abstracts of selected papers submitted by these experts. I am confident that this e-compendium will be highly valuable to all stakeholders in the power sector.

Ravindra Kumar

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Executive Director (OS)

Foreword

Power Plant O&M Conference, organized by NTPC, is an annual event to commemorate the synchronization of our first generating unit on February 13th, 1982, at NTPC Singrauli. NTPC welcomes esteemed authors, distinguished guests, esteemed delegates, business associates, and all stakeholders to this year's conference, Indian Power Stations 2025 (IPS2025), commencing on February 13th, 2025, in the vibrant city of Raipur.

Over the years, NTPC has grown from thermal power to energy major with a current installed capacity of over 77 GW and 16% of India's capacity. NTPC is committed to generating efficient and affordable power and aims to achieve 130 GW by 2032. We are dedicated to addressing environmental and climate change issues by installing Flue-gas desulfurization (FGD) plants and De-NOx systems in our existing and upcoming plants. We embrace a diverse fuel mix, integrating fossil fuels, gas, hydro, nuclear, and renewable sources to minimize our carbon footprint.

The theme for IPS2025, **'Reliable & Sustainable Generation, Asset Management, and Energy Transition'** is apt for conference, as energy transition to renewable is happening at a rapid pace. IPS2025 promises to provide a unique platform for all stakeholders and energy sector professionals to gain valuable insights and knowledge that can be effectively applied.

There is an overwhelming response from authors with a total of 426 papers submitted. 90 papers have been shortlisted for presentation at the conference, which includes papers from international organisations, OEMs, IPPs, Academic & Research Institutions. IPS2025 will undoubtedly provide a unique opportunity to share innovative ideas, operating experiences, and understanding of critical issues related to fossil fuel-fired power generation and renewable energy, and our perspectives on emerging and long-term technological needs. This conference will offer an excellent platform to network with professionals from diverse specialties. This significant event will surely enhance our knowledge and technical know-how, enabling us to work towards a just energy transition. The conference will help us align our ideas with the needs of end-users and meet stakeholder expectations. I am confident that the distinguished professionals participating from India and abroad will engage in meaningful discussions and share their knowledge objectively during the concurrent sessions and participate in the Techno-Galaxy exhibition. I wish IPS2025 a grand success.

(A K Manohar)

Contents

Session - 1: Theme Session - Reliable & Sustainable Generation, Asset Management and Energy Transition

Theme Paper

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The Indian power sector is undergoing a rapid transformation, driven by the need for reliability, sustainability and energy transition. This theme paper explores key aspects of reliable and sustainable power generation, asset management, Energy Transition and NTPC's role in shaping India's energy future and achieving Viksit Bharat - 2047.

Paper includes the overview of the Indian power sector, highlighting NTPC's contribution to installed capacity and projected growth trends. The transition toward sustainability is examined through efficiency improvements, new initiatives like Green Hydrogen, CO_2 to Methanol and Biomass Cofiring etc., AI/ML-driven initiatives, energy conservation strategies, and the integration of renewable sources. NTPC's business portfolio, including international ventures, joint ventures, and new technology adoption powering the growth journey beyond the country shows our agility and commitment.

A significant focus is placed on NTPC's energy transition strategy, targeting 60 GW of renewables by 2032 and India's net-zero goal by 2070. Key initiatives include green hydrogen projects, waste-to-energy solutions, and pumped storage projects. Furthermore, NTPC's Net-Zero Roadmap for its townships and offices is showcased, demonstrating a commitment to decarbonization.

This paper also highlights the advancements in asset management, emphasizing real-time monitoring, predictive maintenance, and digitalization for enhanced efficiency. Lastly, we outline NTPC's roadmap for reliability enhancement, covering modernization, environmental compliance, and operational excellence.

Through these initiatives, NTPC is positioned as a key enabler of India's energy transformation, balancing reliability with sustainability to ensure a resilient future.

Green Hydrogen for grid balancing, 2029-30

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The paper has been formulated adopting measures towards energy transition like integration of solar & wind generation, green hydrogen production, ammonia synthesis, electricity generation in Gas Turbine using green hydrogen /ammonia, flexible operation of coal fired power plants etc. for meeting grid demand. A series of analysis has been executed for meeting the power (MW) demand in year, 2029-30 where balancing has been attempted without battery storage system in the grid. The green hydrogen production by electrolysis of water has been proposed using surplus grid power which will offer additional load in the grid during daytime. The hydrogen will be stored in containers to use during non-solar period in Gas Turbine for electricity generation. Green hydrogen may take an important role in achieving net zero goal in future. The overall efficiency of the system "power to gas to power" has been considered in the range of 25-30%. In the paper, the demand and generation scenario for year, 2029-30 has been taken into consideration where 292 GW solar & 100 GW wind capacity have been anticipated and balancing simulation study for the year, 2029-30 has been successfully conducted without Battery Energy Storage in the grid.

The analytical paper has quantified the capacity of electrolysis plants with Max./Min. size of units needed to absorb entire surplus power. Similarly quantified the capacity of Gas Turbine as well as Max./Min. size of units essential for generation of electricity using green hydrogen/ ammonia during non-solar period. The capacity of coal-based power plants needed in the year, 2029-30 has also been projected.

Risk-Informed Approaches to Optimize Asset Management Approaches

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With growing demand for electricity, driving a lower power generation industry carbon footprint whilst safeguarding reliable power plants and delivering power at competitive rates, make it a strategic imperative for power utilities to ensure plant reliability through effective O&M practices and optimum maintenance strategies. As many utilities are now also diversifying their power plant fleets with more renewable energy technologies, the application of standardized approaches is essential to enable leading practice asset management and reliability management frameworks across all fleet assets.

Increasing pressure to optimize O&M costs requires adoption of a more risk-informed approach that can enable utilities to develop maintenance strategies that will support business objectives, long-term resilience, and sustainability.

This paper discusses how using more risk-informed asset management approaches, enabled by software toolkits that support a more standardized approach, assist utilities to standardize and optimize their maintenance strategies to achieve asset management excellence.

Energy Transitioning with CCUS: Experience sharing of World's Unique CO_2 to Methanol Project at NTPC Vindhyachal

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India shared its vision on Energy Transition when Honorable Prime Minister of India declared Nation's intent to progressively decarbonize Indian economy to achieve Net-Zero by 2070 in 2021 at COP 26 in Glasgow. Through Nationally Determined Contribution (NDC), India submitted a graded action plan wherein it is targeted to reduce carbon intensity of our GDP by 45% wrt 2005 level and to achieve 50% of installed electricity capacity from non-fossil fuel sources. Since then, the growth of Renewable Energy has shown a significant uptrend, but it still will take some time for RE power to be available Round-The-Clock (RTC). As on Dec-2024, India's total Installed capacity stands at 462 GW, with 217.6 GW of RE. Fossil fuels contribute to almost 52.89 % of total generation capacity, with coal-based thermal power capacity alone accounting for around 45.96% (212.35 GW). As per present estimate, 80 GW of coal-based plant need to be additionally commissioned to meet Nation's growing power demand till 2032 wherein coal-based plant shall co-exists along with RE for at least 20-30 years. Thus, it becomes important to reduce CO_2 emission from thermal power plants to achieve the "JUST TRANSITION" ensuring Energy Security as India transition towards Net Zero. In this scenario Carbon Capture Utilization and Storage (CCUS) technologies shall become important for the "Just Transition"

This paper discusses NTPC's initiatives and experiences of technology development and design carried out by NETRA and execution by Green Energy Department at NTPC Vindhyachal. Work carried out in CO_2 Capture using various technologies is discussed along with advantage and disadvantage of each, integration of Green Hydrogen with Captured CO_2 for producing product which meets the scale required for successful commercialization, experience and lesson learnt from design, erection and commissioning of the World's unique CO_2 to Methanol R&D Project (CTM) at NTPC Vindhyachal.

Session - 2: Safety in Power Plants

Bulge Wagon Auto Detection System

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In every thermal power plant, coal is transported through Indian Railway BOXN Wagons & the same is unloaded in two wagon tipplers. Ensuring coal transportation safety is key to coal unloading process. Detecting Bulge wagon is very crucial to avoid any equipment damage during tippling or wagon stuck inside. It is a serious problem for all the plant where Wagon Tippler is used for coal unloading. It also delays unloading process. It ensures safety in human who are involved during coal unloading process.

The wagon Bulge Detection should be installed at a convenient distance from the Wagon Tippler so that after identification of Bulged wagons, we will be able to separate them easily.

As a rake approaches the system, it passes over 3 sets of Track Switches. These switches help in identifying the vehicle type & also helps in counting of Wagons. At this point 2 nos. LiDAR sensors are mounted as shown in the GA. Theses sensors provide information about the bulged wagons.

Technology evolves in course of period and almost in every car having reverse camera so that any blind spot can be seen while reversing the car for ensuring maximum safety.

The system is programmed to count the number of wagons. In case any bulge is detected, it will immediately display the bulged wagon's number on the computer screen. There will also be an audio-visual indication to attract attention of the operators. This system will ensure 100% detection of Wagon Bulge system.

It will display and capture image on which side of the wagon is bulge. Depending on the bulge direction, MGR control will decide in which tippler it has to be placed and if it is both side bulge then it will be unloaded manually.

The information contains: Serial Number of Bulged Wagon, Photos & the Side on which it is bulged. Now CHP/MGR persons can take required action on receipt of this information.

NTPC Employees are dedicatedly working 24x7 for ensuring 100% safe workplace by avoiding any Man and material loss. With this system, we have improved the system and flexibility is rake unloading resulting ensuring safety & demurrage reductions

Enhancement of Safety During Overhauling by a Change in Planning of Permits

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This paper explains about enhancement of safety during overhauling by a change in planning of permits as safety is prime concern. During overhauling large number of permits (approximately-450) are issued in initial 3 days. Issuing large number of permits timely after defining correct isolations in a very short duration with safety is very difficult task as complete isolation of each equipment is to be ensured and SAP (Senior Authorised Person) has to work for long hours. On an average a SAP takes 15 minutes to issue a permit, excluding isolation time taken by AP (Authorised Person). Less time with large number of permits, either creates unsafe conditions, mental stress or cause delay in permit.

To enhance safety and ease the permit issuing process during overhauling, permits shall be created 15 days before overhauling by MTP. Maintenance shall prepare these permits in 3-5 days. Re-commissioning team SAPs shall prepare all these permits upto defining isolations in remaining 10-12 days whenever they get time during their shift. The day when overhauling begins, as isolations are already defined, just only printing of isolation slip is to be done for isolation. This will reduce time taken by SAP to issue a permit from 15 minutes to 7 minutes.

This will strengthen safety of man and machine, improve physical health, alleviate stress, enhance productivity, improve work life balance and help in timely deployment of manpower to start work.

Following this practice, if unit is brought on bar 1 day before schedule date, it will earn SG incentive.

Safety in Power Plants - FirePro Condensed Aerosol System

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NTPC operates critical power generation and distribution facilities, where fire safety in enclosed spaces such as electrical panels, diesel generator (DG) rooms, and uninterruptible power supply (UPS) rooms is of paramount importance. Ensuring safety, operational continuity, and regulatory compliance is essential. FirePro's advanced fire suppression technology offers a reliable and effective solution designed to meet these specific needs.

FirePro TECHNOLOGY OVERVIEW

FirePro employs a condensed aerosol fire suppression system that quickly detects and extinguishes fires. It operates by generating environmentally friendly aerosol particles that interrupt the chemical chain reaction of combustion without depleting oxygen or causing harm to equipment and personnel. The system consists of compact Condensed Aerosol Generators (CAGs), automatic detection and activation mechanisms, and non-toxic, ozone-friendly compounds.

ADVANTAGES

FirePro's technology is characterized by its ability to rapidly suppress fires, preventing their spread and minimizing damage. Its compact and modular design allows seamless installation in confined spaces like electrical cabinets, tailored to various room sizes. The system is low-maintenance, with generators offering a lifespan exceeding 15 years. FirePro's environmentally safe formulation ensures the safety of personnel during deployment and avoids harm to sensitive equipment. Its compatibility with existing fire detection systems facilitates easy integration and retrofitting.

APPLICATIONS

The system provides localized protection for critical power distribution in electrical panels, safeguards DG rooms from fuel and machinery-induced fires, and prevents overheating in UPS rooms without disrupting their operation.

CONCLUSION

Adopting FirePro systems will enhance NTPC's fire safety, protect assets, and ensure uninterrupted operations, aligning with its goals of operational excellence and sustainability in India's power sector.

Improving Behavior Based Safety through the concept of Safety Acts Index

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Problem definition: In more than 95% of the cases, the incidents happening in India & abroad, the root cause is unsafe behaviour of the workers. The issue is how to correct the unsafe behaviour of the workers at workplace?

A new tool known as safety Act Index was developed for the first time in our country for observing unsafe acts/unsafe behaviour of workers. Workers' behaviour was observed from a distance without imposing any punitive action. Efforts made to establish the root cause of unsafe behaviour. A formula has been developed to arrive at weighted average of unsafe behaviour. From weighted average of unsafe behaviour, Safety Act Index is calculated. The safety Act Index score is plotted on a graph to observe the trend of unsafe behaviour. This provides inputs for training needs of workers & also to address the bad habits of the workers. This tool demonstrates that we really care about improving safety.

It is a method to keep track of how people are working. It is a powerful tool to address unsafe behaviour of workers in a non-threatening manner. Positive behaviour is to be reinforced by rewarding safe behaviour of workers instantly. This way we can show & demonstrate that we really care about improving safety.

The Case studies, graphs, tables & results of station X demonstrates the effectiveness of SAI concept. The proof of the pudding is in its eating. This SAI tool is a fool proof strategy to ensure injury free environment in our workplaces.

Session - 3: Asset Management

A Digitalization Roadmap and Methodology for Asset Management Excellence

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As the electric power industry continues to evolve, utilities are increasingly tasked with reducing operations and maintenance costs, whilst maintaining a high level of reliability and efficiency of power plants and the equipment necessary for reliable energy production.

Pressures to optimize O&M cost and leveraging technical skills makes it imperative to have the requisite asset management (AM) information available in an EAM/CMMS platform that will allow the utility to maximize the operations, maintenance, reliability and performance of the assets in the fleet with more limited resourcing whilst also leveraging the benefits of more informed decision making capability that digital technology and integrated asset management software systems bring.

This paper discusses the benefits of having a structured approach in place to enable the fundamental building blocks and AM data needed to support effective implementation and use of Enterprise Asset Management (EAM), Computerized Maintenance Management Systems (CMMS) and digital twin capabilities, specifically when deployed within a 3D augmented or virtual reality environment. It will also briefly touch on a use case of how this is used to support EPRI members to implement this AM Digitalization approach successfully.

A sound asset management digitalization approach and implementation framework are deemed an essential element for achieving Asset Management excellence, and the paper conclude with examples of the typical benefits realization that can be achieved with the approach discussed in this paper.

Process Optimization and technological upgrades for Flexibility to ensure safe, reliable, and sustainable operations

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India's coal-dominated power system is facing a growing demand for flexibility as intermittent and variable renewable energy (RE) sources are increasingly integrated, while electricity demand continues to rise rapidly. This shift is placing an unprecedented strain on thermal power plants, which must now balance the grid more dynamically. As market demands and system conditions evolve, plants are required to handle more frequent load-following cycles, starts and stops, and rapid ramping. These adjustments can lead to system inefficiencies, reduced productivity, and, in some cases, instability, resulting in disturbances such as parametric deviations, altered heat transfer patterns, chemical imbalances, vibrations, and safety concerns. Additionally, the cycles of starts, stops, load changes, and low-load operations introduce complex "cause and effect" relationships, which are closely tied to common damage mechanisms in the system. Understanding these precursors-how specific causes lead to particular effects-can help operators implement best practices to reduce damage, enhance safety, and improve overall system efficiency.

With recent regulatory changes, India's energy market offers significant opportunities for flexible thermal units to optimize profitability. This paper focuses on planning cost-effective solutions to increase the flexibility of coal-based power plants-solutions already successfully implemented in other parts of the world. As India's energy sector continues to navigate the complex trilemma of sustainability, affordability, and energy security, managing the life-cycle costs of flexibility becomes crucial. Achieving this requires a deep understanding of the mechanisms that drive these costs. Investment decisions regarding plant retrofits must therefore be based on thorough cost-benefit analyses, considering the long-term life-cycle costs. In addition to cost management and operational strategies, the paper also highlights innovative, cost-effective techniques tailored to Indian conditions, such as real-time coal quality monitoring, online coal flow balancing, and tracking of cycling-related costs.

The flexibilization of coal-based plants, especially when using low-grade Indian coal, will require investments in retrofits, procedural changes, and capacity-building efforts for plant staff. This paper provides a comprehensive overview of the issues and solutions related to coal plant flexibility, with a particular focus on boiler process optimization.

Centralized C&I Asset Management Solution for NTPC Using Open-Source Tools

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NTPC presently operates over 65 coal and gas-based stations, including joint ventures. Recent initiatives for centralized procurement and various services have been well-received across the Indian power sector. Similarly, centralized asset management of all NTPC stations is crucial for effective asset management.

"Knowing your Assets" is the first step towards any asset management solution. Compiling a wide range and quantity of assets, especially with legacy systems, at a single point is a challenging task. Although an SAP system exists, complete asset compilation and management are not available. This paper discusses using existing open-source tools to deploy an enterprise-wide solution for better and easier management of C&I assets across NTPC. The discussion continues from the initial step of asset inventory compilation to various asset management solutions.

The NTPC C&I Asset Management System generates unique asset labels with QR codes for each asset. These QR codes link physical assets to their digital records, such as datasheets, manuals and drawings, maintained on a centralized server. By scanning the QR code on a physical asset through a mobile application, authorized users can access these documents on the server. A pilot project is in progress, compiling the assets of NTPC Solapur, Darlipali, Talcher, and Korba.

We propose implementing this system for all NTPC stations C&I assets, making the asset management system more efficient and maintainable. This asset information will be input to many future solutions of inventory management, AI & ML solutions like APR & APM solutions.

Study on applicability and scope of AI and Data Analysis Tools for Optimization of Maintenance Practices for Capital Equipments in Thermal Power Plant

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This paper presents a study on applicability of AI & Data Analysis tools for Optimization of Maintenance Practices for Capital Equipment of Thermal power plant. The same is envisaged via considering a comprehensive framework for implementing artificial intelligence (AI) and advanced data analysis techniques through simulation of real data to optimize maintenance practices for critical capital equipments. Present scope of study is kept confined deliberately only to electrical assets but is applicable equally well for Turbine and Boiler assets. The research explores how machine learning algorithms, coupled with real-time sensor data and diagnostic test results, can enhance predictive maintenance strategies and reduce unexpected equipment failures. A specific case study focusing on Extra High Voltage (EHV) transformer maintenance demonstrates the practical application of these techniques through the analysis of dissolved gas analysis (DGA), winding tan delta measurements, and partial discharge monitoring. Moreover, AI can be extremely helpful in controlling inventory, procurement cost and procurement lead time optimization. The results indicate that AI-driven maintenance optimization can reduce maintenance costs while improving equipment reliability and extending asset life cycles.

Session - 4: Steam Generator and Aux. Systems

Ensuring long-term reliability of Boiler

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Supercritical boilers offer highest efficiency and hence are very essential in today's competitive environment. A single Boiler tube leakage in 800 MW boiler incurs minimum Rs 18 Cr loss to exchequer. Some issues, if not taken care during erection and commissioning phase, are very difficult, rather impossible to resolve in advanced stages. Hence, an action plan was made to identify the vulnerable areas and road map was developed to prevent any failure in these areas. 800 MW has uttermost operating parameters and hence equipped with advanced metallurgy which brings whole new era of new challenges such as very stringent Storage & preservation of boiler tubes, complex welding procedures etc.

A weld joint failure is one of the prime contributors to boiler tube leakages. An 800MW boiler has around 1,00,000 weld joints, so it was very crucial to make a systematic approach to make every weld joint defect free. To address this issue, measures like stringent welder qualification, strict quality assurance, regular training of IBR welders to reduce repair percentages and continuous monitoring of welding progress with NDT backlogs were adopted. Further to ensure the effectiveness of these measures, various Advanced NDT methods like PAUT, TOFD, exfoliation checking, robotic boroscopy along with conventional NDT methods were deployed.

Apart from compliances of NDT requirements (RT) on weld joints as per approved EWS (20%) in different circuits of the Boiler, all remaining weld joints (80%) which were not covered by RT in those circuits, were examined by PAUT as per approved procedure. Mapping of Erosion prone areas was done and preventive measures like applying refractory with SS mesh fixing were taken.

The proactive approach, emphasizing quality assurance, advanced NDT methods, and preventive measures for erosion-prone areas, helps ensure the boiler operates efficiently while reducing the risk of weld joint failures. These measures are critical not only for safety but also to avoid substantial financial losses due to leaks or failures.

Enhancing Boiler Reliability: Strategies to Prevent Condensate Blocking in Pendent Coils

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This paper elaborates the experience of NTPC Sipat-boiler team through which site successfully controlled repetitive overheating failures of pendent coils especially final superheater in St-1 supercritical boilers. NTPC Sipat is the first supercritical technology-based power station of NTPC with installed capacity of 2980 MW (3x660MW-Supercritical units & 2x500 MW-Subcritical units).

Total 11 failures occurred in finish superheater (FSH) circuit of supercritical 660 MW boilers over past 10 years and failure rate increased over past five years. Due to these outages, financial loss of 32.16 crores occurred to NTPC Sipat. Based on the location and features of failure, all failures in final super heater circuit were attributed due to overheating.

Possible root causes studied by site, and condensate blockage in lower bends was identified as the root cause for overheating failures in final superheater coils. It was found that lower bends of FSH assemblies always covered under ash which accumulated over extended pass and hindering condensate removal from bottom bends during start up.

As the root cause was established, site adopted new practices to help removal of condensate from lower bends of FSH coils which involves:

a) Opening/closing of boiler vents and drains at higher pressure during shutdown/start-up.

b) Charging of instrument air in pendent coils during shutdown.

c) Ash removal from extended pass floor during opportunity shutdowns.

d) Extended Steam blowing during shutdown & start-up through main steam and hot-reheat electromatic relief valves (ERVs).

In St-1 supercritical units of NTPC Sipat, overheating failures in FSH coils are successfully kept under control from past two and half years. Total 45 no's (approx.) of boiler start-ups done in St-1 660 MW units from last failure i.e. occurred in U3 dated 29.06.22 and till date, no overheating failure occurred in FSH coils after religiously following above practices.

The practices adopted and discussed in this paper will benefit boiler pressure parts fraternity to control overheating related failures in pendent coils.

A Case Study on Failure of Finish Super Heater Tubes in Boilers at NSTPS

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Yet another success story was scripted in the history of NTPC on 6th September 2019, 00:00 hrs when 660 MW Unit#1 of NPGC got commercialized. This commendable feat was repeated once again on 23.07.2021 after COD of Unit#2. Since then both the units have been putting up decent performance, with Unit#1 securing second position in FY 23-24 and Unit#2 securing first and second position in terms of PLF in the FY 24-25 and FY 22-23 respectively amongst all 660 MW units pan NTPC. It was not a cake walk although.

Both the units suffered unique and challenging issues. One of which was Boiler Tube Leakages in finish super heater zone.

Since its commercialization both Unit#1 and Unit#2 faced 09 numbers of boiler tube leakages in finish super heater (FSH) zone. Out of these 9 BTLs,8 BTLs occurred within seven days of unit synchronization i.e. there was always a tripping /shutdown followed by BTL in the finish super heater zone, thus always occurring subsequently. These BTLs were caused due to short term overheating characterized by fish mouth opening in the boiler tubes.

It is to be observed that all these BTLs in the super heater zone followed a definite pattern pointing towards a specific reason that led to all these eight boiler tube leakages in the boiler finish super heater zone of Unit#1 and unit#2.

Although every laid down start-up operational procedure was followed during the unit light-up, the same seemed to have caused all these BTLs in the finish super heater zone of the boilers.

This paper tries to unravel the reason behind all these BTLs and suggests certain specific changes in the boiler start-up procedure that would have prevented all these 8 BTLs in the finish super heater zones which occurred since COD.

Now that sounds interesting and intriguing as well!! Isn't it?

BTL Reduction Through Skill Development and Identification Scheme (S-DAIS) for IBR Welders

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Weld defects contribute significantly to boiler tube failures across NTPC units. Welders' qualification and skill, adherence to the approved procedures, welding environment, healthiness of welding equipment, suitability of welding consumables are important factors to ensure defect-free welds. A quality-conscious Welding Team, following the best practices can produce quality site weld-joints, having a reduced future probability of failure. At NTPC Kahalgaon, a model, namely S-DAIS (Skill Development and Identification Scheme) is formulated jointly by BMD and FQA towards this end. The immediate benefits of its recent pilot implementation in one 210MW and two 500MW unit OHs are readily observable with a reduction of OH weld repair-rate to <6%. The 'Skill Development' starts with structured quality pep-talks for sensitizing the OH Welding team, elucidating the do's and don'ts. Certified Welding Inspectors carry out site inspections based on Welding Inspection Checklist, for pre, during and post welding stages and provide required on-the-job guidance to Welding personnel. 'Identification' starts with daily joint-wise field data tabulation and welder performance analysis through MS Power BI application based on Radiographic Test results. Analysis results along with Welding Inspectors' observations are discussed in daily OH Meeting and the best welders are felicitated. The next step for 'Identification' is Welders' Performance Rating on specified attributes. Finally, the proposed QLIMS database having details on IBR welders' qualification, skill and performance rating can partly substitute compulsory welder qualification test before deployment on pan NTPC basis. Through the envisaged improved workmanship and work quality, S-DAIS aims to support NTPC's BTL reduction strategy.

Boiler Tube Leakage: A persistent Challenge - Unfolding strategic solutions for reliability

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The economic growth of any country is inextricably linked to its infrastructural development, and availability of reliable, uninterrupted power supply. The escalating demand for efficient power generation has intensified the reliance on supercritical thermal power plants. The efficient and sustainable operation of thermal power plants is paramount to meeting increasing energy demands while minimizing operational costs and environmental impacts. Boiler Tube Leakages (BTLs) continue to be the major cause of Forced Outages in Thermal Power Stations. The loss of availability due to BTLs not only cause huge revenue losses to the plant operator but also affects the overall power scenario of the country.

This paper chronicles the journey of NTPC LARA thermal power plant that successfully reduced boiler tube leakages by implementing innovative techniques in collaboration with multidisciplinary teams across various departments. By adopting a systematic approach that combined advanced material science, predictive maintenance strategies, and real-time monitoring technologies, the plant not only reduced the occurrence of tube failures but also enhanced overall system reliability and efficiency.

This paper provides a comprehensive analysis of the challenges encountered, the methodologies employed and the significant impact on plant performance. Being a pit-head plant with significantly enhanced reliability, evolved site plagued by boiler tube leakages to one of the highest-performing PLF stations, achieving operational excellence in thermal power generation. The successful reduction of boiler tube leakages not only contributes to the plant's sustainability goals but also serves as a model for other facilities seeking to enhance their reliability while embracing cutting-edge techniques.

Session - 5: Water Systems

Water Management in Power Plant

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Odisha Power Generation Corporation Ltd. (OPGC) has implemented an innovative water management strategy using the DMAIC methodology to address challenges in thermal power plant operations. Thermal power plants, among the largest industrial consumers of water, face growing pressures due to stringent regulatory norms, water scarcity, and deteriorating raw water quality. At OPGC, the conventional Demineralized (DM) water plant struggled with efficiency issues related to high conductivity and silica levels in raw water, which led to increased chemical consumption (HCL & NaOH), waste generation, and reduced operational performance (OBR).

By integrating Cooling Tower Blowdown (CTBD) Reverse Osmosis (RO) treated water into the DM plant feed, OPGC successfully improved resource efficiency and achieved significant cost savings. Tools such as brainstorming, fishbone diagrams, and Why-Why analysis were employed to identify root causes and devise actionable solutions. This integration has eliminated the need for an additional RO system, reduced chemical consumption by INR 83 lakhs annually, and minimized wastewater generation. The project exemplifies how systematic interventions, supported by advanced technologies, can transform water management in thermal power plants, ensuring compliance with Zero Liquid Discharge (ZLD) norms and setting a benchmark for sustainable practices in the power sector.

Water Management in Mejia Thermal Power Station- A Case Study

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Water Is One of The Key Input Requirements for Thermal Power Generation required for Process Cooling in the Condenser, Ash Disposal, Removal of Heat Generated in Plant Auxiliaries and Various Other Plant Consumptive Uses.

There is a need to minimize consumptive water requirement for thermal power plants.

As per MOE&F, India notification, 7th December 2015, all existing CT based power plants shall reduce the specific water consumption up to maximum 3.5 m^3/MWh with in a period of 2 years and achieve zero waste water discharge. The paper presents a case study of Water Management at Mejia Thermal Power Station (2340 MW). The plant carried out a water audit and successfully brought down the specific water consumption from 4.00m^3/MWhr to 3.45m^3/MWhr by adopting steps like increase in Dry Ash evacuation, Improving AWRS from Ash Pond, recovery from wastewater drains that include drains from VAG filters, debris filters, condenser sump pit which are collected in settling tank & are reused in Ash handling process after treatment. Also, minor steps like minimizing losses & leakages, installation of water flow meters helped in preventing water wastage. Many existing & proposed steps like fog & rain harvesting in CT plume, installation of CSSP, Hydrobin installation for Bottom Ash separation, online monitoring by AI, upgradation of STP by MBBR technology etc will further lower down the Specific Water consumption & achieve ZLD. By considerable water saving, about 212.87kg/hr of coal saving is possible, and it leads to reduction of CO_2 emission by about 0.26 ton/hr and profit of about 1.25 crores.

Sustainable Generation - Closing on the Crucial Water Linkage

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Water is crucial for life, the power industry included. Thermal power plants are perceived as water 'heavy' in spite of their efforts and outcomes. The fact is that hydel plants and pumped storage schemes consume more specific water than thermal. Evaporation loss as per National Renewable Energy Laboratory (NREL) in such plants are at least ten times more. Water has priority use in irrigation and drinking. In addition to these needs, the country and the states require affordable electricity as well. Water is bound by interstate and international agreements and disputes. Water availability is a seasonal issue, lean season of severe shortage often followed by abundant overflowing and flooding.

Water no longer is 'External' to the business of power industry, after the gazette notification to set up treatment plants & use sewage water for power plants within fifty kms radius of an urban settlement. Like the landed cost of coal, the cost and availability of water is also a prime consideration. At other extreme is obtaining usable water through energy intensive and costly process of desalination of sea water.

Our paper highlights the importance of water for power industry, acknowledges innovative explorations like Air Cooled Condensers (ACC), and water saving by Floating Solar PV (FSPV) delving into the sustainability of sewage water treatment when quality water in abundance can be made available cost effectively through FSPV. SDG6 of Clean Water and Sanitation and SDG 7 of Affordable and Clean Energy are targeted with coherence here. A pragmatic, logical approach is offered backed by real-life data from industry and NTPC FSPV projects at Kayamkulam, Simhadri, and Ramagundam. Paper ends with a positive path forward.

Production of 'Green DM Water' By Using Waste Heat Recovery- An Innovative, Sustainable, Economic Approach for Conserving Natural Resources

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Demineralized water (DM water) is essential in power plants for steam generation in boilers. This DM water is typically produced using established technologies such as the ion exchange method and reverse osmosis (RO). In power plants where freshwater is readily available, conventional ion exchange methods, often coupled with normal pre-treatment processes, are employed. However, in locations with limited freshwater resources, reverse osmosis systems are used to produce DM water from seawater or brackish water.

This paper explores the possibility of generating de-mineralised water in existing power plants in a net-neutral manner, referred to as "Green DM water." Similar to the concept of Green Hydrogen, Green DM water would be produced using energy and resources sourced from sustainable practices, including waste recycling and renewable energy, such as solar and wind power.

The paper specifically examines the scalability of the existing pilot flue gas-based desalination plant at NTPC Simhadri, which is designed to generate DM water for plant operations. Furthermore, it investigates the potential for transforming the NTPC Simhadri township into a net-zero water compound, integrating sustainable water production technologies to minimize resource consumption and reduce environmental impact. This approach aims to align with global sustainability goals and demonstrate how the power sector can contribute to more efficient and eco-friendly water management practices.

Strategies for Reducing Evaporation Loss in Power Plant Operations: A Path to Sustainable Water Management

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The freshwater requirement of power plants is critical for efficient and sustainable operation, particularly for cooling systems and steam generation. Adequate freshwater access ensures the stability and longevity of power generation, highlighting its pivotal role in the energy sector. However, power plants face significant water loss through evaporation, especially when relying on reservoirs for temporary storage. At RGPPL, evaporation loss averages 8,000 tons per month, presenting a major challenge in water conservation due to limited water resources and the need to reduce specific water consumption.

This study explores strategies to minimize evaporation losses, aiming to improve efficiency and sustainability in power plant operations. Through a detailed analysis and innovative technologies, it identifies practical solutions for responsible water management. Proposed methods include windbreakers, floating hollow triangles, and chemical monolayers, which together offer a comprehensive approach to mitigate evaporation.

These solutions leverage physical barriers, geometric designs, and chemical treatments to achieve a 50% reduction in evaporation losses. Such measures conserve substantial water resources, enhance operational efficiency, and reduce costs. Additionally, they represent a significant step toward sustainable water management, aligning with environmental goals and promoting resilience in power generation. This study demonstrates the potential of integrated approaches to address critical water conservation challenges in NTPC.

Session - 6: Power Plant Efficiency

Enhancing Power Plant Reliability in India_ The Critical Role of Performance Testing for Boilers and Steam Turbines

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India's burgeoning energy demands, driven by rapid economic growth and an increasing population, underscore the critical need for reliable and efficient power generation infrastructure. Steam Generators and steam turbines are fundamental components in thermal power plants, directly influencing the overall performance and economic viability of these facilities. Ensuring the optimal operation of these components is essential not only for maximizing energy output but also for minimizing operational risks and adhering to stringent regulatory standards.

The purpose of this paper is to evaluate the significance of performance testing (PG Testing) for steam generators and steam turbines within the Indian power market. This paper emphasizes both thermal performance testing and vibration analysis, demonstrating how these methodologies contribute to enhancing operational efficiency, reducing downtime, and extending the lifespan of critical equipment. By systematically integrating performance testing protocols throughout the lifecycle of a power plant-from design and construction to operation, maintenance, and decommissioning-stakeholders can achieve sustained performance excellence and regulatory compliance.

Based on the findings, this paper provides actionable recommendations for implementing comprehensive testing strategies tailored to India's unique energy landscape and regulatory framework. These strategies include incorporating testing provisions during the design phase, conducting regular performance assessments during operation, and utilizing advanced diagnostic tools for vibration analysis. By adopting these recommendations, power plant operators in India can enhance their operational efficiency, ensure environmental compliance, and support the nation's goal of sustainable and reliable energy production.

Improvement in Cooling Tower Performance at NTPC Farakka: A Case Study on Identifying and Mitigating Defects in Cost Effective Manner

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At Farakka, there are two M/s NBCC make cooling towers for the ST 3 (1x500MW) unit. Since the PG test dated September 25, 2013, there has been a shortfall of 4.86°C in the approach value. This temperature shortfall has resulted in significant financial loss due to poor condenser vacuum during the summer and monsoon seasons for NTPC. To assess the current shortfall and analyze its causes, performance testing of the cooling towers was conducted on July 18, 2023. The testing revealed several issues contributing to the shortfall, including an improper hot water distribution system, dirty and distorted drift eliminators, poor spray pattern, nozzle choking, hot water pipes choking, heavy algae formation, and broken & choked V bars.

During the unit shutdown for overhauling from January 15 to February 29, 2024, these issues were addressed to the maximum extent possible. A subsequent performance test on September 10, 2024, at CT 6B demonstrated a significant improvement in the CT approach value, reducing it from 11.6°C to 9.5°C, an improvement of 2.1°C. Notably, ambient conditions remained largely similar during both tests. These findings indicate that the corrective actions undertaken during the overhaul effectively mitigated the cooling tower performance issues and improved overall plant efficiency.

AdvX® System For Thermal Power Plant Efficiency Improvement and Heat Management

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The AdvX® system for thermal power plant efficiency improvement by using heat recovery from flue gas. Reduction of thermal power plant efficiency due to variation of boiler efficiency and heat rate variation from design conditions. Normally deviation varies from 5% - 10%. There are number of reasons for high operating gross heat rate:-

1. Un-optimized Boiler Combustion and High Excess air
2. Low Turbine Cylinder Efficiency
3. Inefficient Soot Blowing of Boiler Tubes
4. Inefficient Air Pre-Heaters
5. Low Condenser Vacuum
6. High Air Ingress in the Boiler
7. High Super-heater and Re-heater Spray
8. Poor Vacuum &High Cooling Water Inlet Temperature
9. Milling system output less than Design Value
10. Coal Quality not conforming to Design Coal
11. High Auxiliary Power Consumption
12. High Boiler tube leakage due to internal corrosion

Ljungström has developed the system and new heat exchanger which can installed in parallel to rotary air preheater and recovery the heat from flue gas. Recovered heat can use it for number of Ljungström companion technologies such as

1. Zero Liquid Discharge
2. Boiler Feed Water Preheat
3. Flexible Operation.
4. Stack Gas Reheat

LjungströmAdvX® system provide the flexibility in heat management and improve the efficiency of thermal power plant.

Tool For Digital Furnace Temperature Mapping and Using AIML To Predict Furnace Temperature with The Available Real-Time

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Adani Power Limited, Kawai is 2x660 MW coal based thermal power plant located near Kawai Village of Baran district in Rajasthan. The power plant is based on supercritical, energy efficient & environment friendly technology. It is supplying power to RVUNL (Rajasthan Government) and connected to western grid of India.

The furnace temperature is currently recorded manually using a pyrometer to understand the internal conditions. There are no sensors available for real-time monitoring of furnace temperatures and boiler expansion. Additionally, there is no visualization of the furnace interior to comprehend the temperature profile. Furthermore, there is no existing digitized database of past temperature records.

In the initial phase, a tool was developed to prepare a digitized database of furnace temperature and Boiler expansion. This tool also generates daily heat map to monitor the furnace's condition. In the second phase, after establishing the database, a machine learning model was created to predict real-time furnace temperature.

For database preparation, data was collected using a QR code displayed on the boiler. Subsequently, a tool was developed using Visual Basic, and Power Automate. This tool automatically downloads the responses submitted through the forms. Additionally, it retrieves real-time DCS data from OSI PI, such as mill combination, APH inlet O_2, SADC position, air flow, coal flow, and RCF loading, creating a database with no manual intervention required beyond a single form submission.

Using AIML (Artificial Intelligence and Machine Learning) to predict furnace temperature with the available real-time data in the Distributed Control System (DCS) is done by analyzing patterns and trends in the database, during test the AIML models has provide accurate temperature predictions, helping to optimize furnace operations and improve efficiency.

Important Factors for Better Condenser and Cooling Tower Performance

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In a current competitive scenario power plant operation & maintenance team is trying to improve the overall efficiency of the unit to remain competitive in the market as well as to improve the profitability. Condenser efficiency is critical for improving the unit performance and Cooling water plays a key role in the power plant condenser performance. Quality of cooling water is critical for overall plant performance which is affected by various external and chemical factors. Analysis of each factors provide immense opportunity for improving cooling water quality. Only non-chemical area of the water quality improvement plan has been considered in this paper.

To achieve the maximum efficiency from a condenser, focus is required right from plant designing stage. Selection of right operating condition, chemical treatment program, real-me monitoring, analysis and interpretation of data. Implementation on of best engineering practices helps in improving the equipment health and lifespan. Based on long experience of handling power plant cooling water treatment this paper summarises the probable causes of deterioration of power plant condenser performance and suggesting possible measures with a focus of reducing specific water & steam consumption and improving sustainability.

Session - 7: Turbine & Aux. System

Load Restrictions on Account of Very High TG Bearing Temperatures due to Slope/Catenary Abnormalities in 800 MW TeSTPP Units after Initial Operations

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Telangana 2X800MW both units reported very high turbine bearing temperatures at bearing#1 and #2 accompanied with shaft vibrations at variable loads. Discrepancy in HP and IP differential expansion values also observed. Turbine thrust axial float also found on higher side. Very high differential temperature observed between front and rear part of bearing#2. This differential temperature observed very near to tripping limit of turbine bearing babbitt temperature. These liabilities restrained the units to run under flexible operation at variable loads. Considering the completion of unit commissioning and COD activities, both Telangana units called for the urgency to rectify these major turbine liabilities to enable the units to run under flexible load as per CERC norms.

Consequently, RCA and rectification works followed in consultation with OEM, NTPC CC-OS and Engg. Routine bearing and pedestal inspection works like lube oil supply line checking, bearing NDT checks C&I probes and RTD checks, bearing and pedestal slope inspection carried out. Initial bearing inspection checks carried out as per observations revealed no major abnormalities. Upon completion of routine bearing servicing works, high bearing temperature still prevailed at variable and full loads. This warranted deviation in action plan and engineering rectifications required to be done in bearings and pedestals in addition to routine turbine bearing checks. Consequently, major engineering rectifications taken up like matching of rotor, bearing and pedestal slope, axial runout of bearing w.r.t rotor, shim correction of thrust pads to address high axial float issue, bearing axial keys correction, installation of heat shield to protect differential expansion probe and correction of turbine rotor axial float to address high thrust float issues. Upon completion of these major rectification works, successful unit flexible and full load demonstrated, and all corrective actions taken to address the liabilities recorded for future overhauling and servicing works.

Dry Cooling System in Thermal Power Plants - Need of The Hour, Challenges And Way Forward

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Water conservation in power plants has become increasingly critical as significant emphasis is placed on reducing water consumption per unit of electricity generated. As water, a vital natural resource, becomes scarcer each day, future priorities will certainly shift toward reserving water for human consumption and agricultural purposes. Water consumption for industrial use is being rationed day by day and under such circumstances, ensuring business sustainability for power utilities necessitates transitioning to dry cooling systems instead of conventional wet cooling systems.

While new projects are being designed to ensure sustained operation, some of the existing power plants are struggling to manage the water requirement. There is enough scope for reducing the water consumption for existing thermal power plants. Retrofitting of dry cooling system reduces water consumption substantially. As usual retrofitting of dry cooling technology in older plants has its own challenges like availability of space, higher cost, impact on efficiency, shutdown period, compatibility with existing equipment's etc.

Air cooled condenser is one of the initiatives taken up by NTPC to mitigate the situation. This paper deals with challenges faced by NTPC at its North Karanpura (3x660 MW) thermal power station, having one of the world's largest ACC in terms of number of modules, during erection, commissioning and operation phases. Further, there are interfacing issues arising due to split vendor responsibilities, as well as challenges related to commercialization and performance testing.

Gaining insights from operating such systems, particularly under Indian conditions, is crucial for effectively implementing similar systems in future projects. In this direction, managing air ingress in such large-scale ACCs is a complex task. Beyond causing severe damage to the ACC itself and downstream equipment, air ingress also negatively impacts the overall performance of the unit, resulting in higher operating costs.

This paper deals above issues along with regulatory aspects and techno-economics. A Way forward is also given to deal with these challenges.

Addressing Steam Turbine Maintenance Challenges under Flexible Operation

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Steam turbines, prime movers of the thermal power plant, are subjected to various static and dynamic stresses during transient and steady state operation. Stress level maintains at optimum level while unit operates at steady low, however, thermo-mechanical stress becomes maximum during unit start up and shut down when turbine components go through heating and cooling cycle. Frequent ramp up down of unit from full load to technical minimum load results in changes in steam parameters leading to elevated stress level compared to steady state operation.

With increasing share of renewable energy in Indian energy mix, thermal power generation are subjected to flexible operation. The magnitude of flexibilization is going to intensify further with the ambitious plan of integrating 500 GW renewable energy by 2030. Two shift operation of thermal units are anticipated in new future in India based upon plans of more renewable energy mix.

So far NTPC experience in operating of subcritical and super critical units at base load has been exemplary in terms of PLF, outage planning and O&M cost effectiveness. However, with the present regime of operation, steam turbine fleets are experiencing more frequent forced outages, components life consumption, and planned maintenance downtime increase due to unexpected failures.

The paper deals with the experiences of steam turbine fleet maintenance, especially during planned inspection. Various innovative maintenance practices like modified procedures for turbine assembly, critical quality checks, additional NDT on failure prone areas have been devised based on practical experiences. Initiatives taken for flexible operation will be covered.

A Case Study on Failure of Stellite-6 Coating on Turbine Valve Plugs after Short-Term Operation

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This case study investigates the premature failure of Stellite-6 coating on turbine valve plugs after short-term operation in the governing valves of high-pressure (HP) and intermediate-pressure (IP) turbines at a design main steam (MS) pressure of 291 kg/cm²(g) and a temperature of 600°C. Stellite-6, a cobalt-based alloy renowned for its exceptional wear resistance and thermal stability, is commonly employed in power plant applications to enhance the durability of critical components.

In this case, the Stellite-6 coating was deposited on steel substrates using the Plasma Transferred Arc Welding (PTAW) process. However, the coating exhibited premature failure, manifesting as spallation and cracking. The investigation revealed potential causes, including dilution of iron from the steel substrate and fusion zone into the Stellite overlay, which compromised the coating's integrity.

Countermeasures and future remedial actions have been proposed, including the upgradation of coating materials, such as the development of procedure qualification records (PQR) for Stellite-21, to achieve the desired performance. Additionally, strengthening the quality inspection plan is recommended to ensure adherence to stringent process parameters and material properties.

Detailed failure analysis-comprising visual inspections, microstructural examinations, and hardness testing-underscored the necessity of optimizing coating application processes to mitigate such failures. This study provides actionable insights for enhancing the reliability of turbine valve components under demanding operational conditions.

NTECL U#1 Turbogenerator Revival Case Study

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At NTECL (A JV of NTPC Ltd & Tamil Nadu Govt) a total of three nos of Thermal units are under commercial operation since 2013 having 500 MW capacity each. In August 2023 U#1 was running at 420 MW with all running parameters in normal range. This machine was overhauled just three months back with inspection of LPT blades. Suddenly one of LPT last stage blade got failed causing subsequent failure of another eight nos of blades resulting high mass loss of around 150 KG in fraction of second. This caused the high vibrations in turbogenerator resulting fire in oil pedestals and hydrogen fire in generator stator. All Turbine rotors, bearing pedestals, piping, hangers and civil structure were severely affected and damaged.

The damaged blades hit the condenser tubes just below of LPT and caused the hundreds of tube puncture. Sea water is being used at NTECL Thermal units as source of cooling water inside condenser tubes. This caused the sea water rise inside condenser upto 17 mtr height and caused ingress in all associated steam of turbine, water piping causing chloride deposition inside tubes/ pipes/surfaces.

This incident had caused a huge financial loss to NTECL with unit outage of nearly Eight months (August 2023 to April 2024). Unit was again brought back on bar in April 2024.Nearly all major Turbogenerator parts were replaced. This paper is covering impact of failure on mechanical and civil structure, details of parts replacement, different kinds of methodology adopted for ensuring the integrity of structure and machine parts fitment, challenges faced during fitment of new spares with existing, economic impact on NTECL, future strategies adopted to prevent such repetitions. With God's grace, during the incident or revival process no human harm incident occurred.

Flexible Operation & Reliability Challenges for LP Turbines

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This presentation will explore the impact of flexible operation on the reliability of low-pressure (LP) turbines, specifically focusing on 500MW KWU designs with freestanding rear stages and shrouded front stages. Key areas of discussion include how increased starts, load variations, and layup practices can exacerbate erosion, corrosion, and flow-induced risks. Attendees will gain insights into the unique vulnerabilities of these turbine designs and strategies to mitigate operational and maintenance challenges in an era of increased cycling and flexible demand.

Session - 8 : Digital Initiatives/AI/ML for Power Plants

Unit Controls Performance Monitoring Dashboard for Steam Parameter Analysis

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Load cycling in coal-fired plants is known to negatively impact equipment reliability and availability through increased thermal fatigue to steam circuit components. This is widely attributable to cyclic variations in steam parameters (fatigue), deviations above design operating points (creep) or fast rate of change (short-term overheating or quenching). Thus, an urgent need was felt to benchmark steam pressure and temperature variations across the fleet, to gauge unit performance and prioritize interventions, especially in the context of dynamic regulatory regimes. This paper presents a case study where Microsoft Power BI platform has been effectively utilized in-house to design a big-data analysis dashboard for benchmarking variations of critical steam parameters versus load, using data for 2023 and 2024. The key parameters chosen were main steam temperatures and hot reheat steam temperatures at boiler outlet (left and right), along with throttle steam pressure at different power outputs. Database for the dashboard was built by collecting data for these six parameters from the NTPC Corporate PI (Plant Information) system. Data validation checks have been incorporated to ensure healthy data for analysis. The paper also describes the empirical factors and indices that have been developed based on the statistical outcomes of this dashboard, to quantify the contribution of steam parameter variations to thermal fatigue and the efficiency lost due to steam temperatures running below the design values. The indices also represent the extent of flexibility of the unit in terms of load changes, without causing significant cycling or fast variations in steam temperatures. The dashboard is a very effective tool for aligning control requirements with equipment long-term reliability, while not losing focus on the inevitable grid demand for faster and larger load changes, balancing integration of renewables.

Implementation of Artificial Intelligence for Identification of Weld Joint defects during Overhauling & Boiler Tube Failures

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Artificial Intelligence (AI) is revolutionizing industrial applications by automating production processes, enhancing predictive maintenance, and optimizing supply chains. AI-driven systems improve efficiency, minimize downtime, and boost precision in manufacturing. Machine learning algorithms enable data-driven decision-making, while computer vision aids in quality control, safety, and regulatory compliance within industrial operations.

Every year, NTPC conducts around 70 planned Boiler Overhauling's and encounters approximately 210 Boiler Tube Leakages as part of its standard operations. A typical 660 MW BHEL-supplied boiler contains about 48,000 weld joints, while an 800 MW boiler has approximately 53,000 weld joints throughout its project lifecycle.

Currently, the power generation sector predominantly relies on traditional radiographic film development and manual interpretation of these images for weld joint inspections. This approach involves significant radiation hazards, is time-consuming, and is prone to human error due to the repetitive and monotonous nature of the task.

This study presents a groundbreaking opportunity for the implementation of Artificial Intelligence in Non-Destructive Testing (NDT) of weld joint inspections, addressing four critical challenges: -

1. Reducing Radiation Hazards - by replacing Gamma Radiation with X-Ray-based NDT methods.
2. Increasing Productivity - by minimizing radiography film development and interpretation times.
3. Minimizing Human Error - through AI-powered weld defect identification techniques.
4. Better Data storage & retrieval method - All data are stored in digital formats.

At present, our model TRUESIGHT™ 1.0.0 developed by M/s SEPL in collaboration with NTPC-Darlipali 2x800 MW is in minimum viable product stage which can identify weld defects with 95 % accuracy and generating report within seconds - which can be deployed in any computer. Further, generated reports are shared in Mobile Apps (iOS/Android) immediately.

Building Machine Learning-Based Model for Large Induction Motor based Drives in a Typical Thermal Power Plant

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This Paper focuses on developing a machine learning-based model for predicting and analysing the operational regime of the Induced Draft (ID) fan motor drive in a thermal power plant, a critical component of the boiler system with significant impact on Unit operation, Auxiliary power consumption and efficiency. The model development begins by identifying relevant parameters and sensors related to ID fan such as boiler load, motor current, bearing temperatures, vibrations, and flue gas conditions. Parameter data from the Distributed Control System (DCS) is sampled over one year at 15-minute intervals, cleaned, and prepared for modelling.

A regression model is developed to predict the IDF-A current, with key parameters such as boiler load and bearing temperatures, vibrations and some other operational variable as features with the IDF-A current taken as target variable. The model achieved an R^2 score of 0.803, demonstrating its potential to optimize motor current consumption by providing Substantially accurate IDF-current predictions and breaking the current into component wise contribution.

Additionally, clustering techniques, including Principal Component Analysis (PCA) for dimensionality reduction, are applied to detect anomalies in the running condition of ID fan. K-Means clustering is used to group operational states and identify outliers, which can highlight potential issues. K-Means clustering with k=2 and k=3 revealed distinct operational states, with Silhouette Scores of 0.551 (k=2) and 0.520 (k=3) respectively indicating well-separated clusters. The clustering analysis facilitates in establishing reference points for ideal operational, enabling the detection of anomalies and deviations from normal behaviour, and thus help in informed decision-making.

Both supervised and unsupervised machine learning techniques have been used in this model building exercise. The supervised learning part involves regression analysis to predict IDF-A current, utilizing Python libraries like sklearn. linear_model for linear regression and sklearn.metrics for model evaluation. The unsupervised learning portion applies K-Means clustering, enhanced with PCA, to detect anomalies and improve insights, using python libraries such as sklearn.cluster and sklearn. decomposition.

Digital Initiatives for Plant Load Adjustment in auto to minimize the impact of DSM Regulations

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The power generation industry is undergoing a transformative shift with the addition of renewables, regulatory authorities are now more focused on reliability and sustainability of the GRID. DSM (Demand Side Management) regulation in one of the most important compliances which deals to enhance discipline in the Generators and Consumers in their respective roles to ensure Energy Security and helps in preventing the large-scale blackouts and system failures.

At NPL the coal is sourced from approx. 25 locations having GCV variation from 3200 to 4200 kcal/kg. This requires continuous engagement of desk engineer for maintaining the critical parameters such as Main steam temp, Hot Reheat temp, Boiler metal temp etc. Therefore, to maintain the DSM regulation, self-sustained system is developed and implemented.

This paper deals with implementation of "Algo-based module for generation modulation in DCS under DSM regulations as per Indian Electricity Grid code". The implementation is done using the predictive controls methodology to modulate Generation as per schedule considering the dynamics of operating conditions.

This has resulted in precise load control to harness the available margins to the maximum possible extent during frequency fluctuations.

AI based Wireless condition monitoring System for Take up pulleys of CHP conveyors

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Regular temperature monitoring of take-up pulley bearings on all CHP conveyors is essential to prevent bearing failure, which could lead to fires caused by friction. The movement of operators near the take-up pulley platform presents a safety risk, especially as the pulley moves up and down during operation. Many of these platform overhang, making night-time temperature measurements particularly dangerous. Additionally, manual temperature monitoring is labour-intensive and time-consuming.

A study involving the site's C&I, Mechanical, and Operations teams assessed the feasibility of installing a temperature monitoring system for the critical conveyors' take-up pulley bearings. The team recommended a wireless temperature monitoring system due to the pulley's movement. M/s Canopus Engineering Services, which had successfully installed wireless condition monitoring devices in various industries, was consulted for the supply, installation, and commissioning of sensors for critical conveyors 5A, 5B, 15A, 15B, 25A, and 25B.

Using energy-efficient wireless mesh network technology, the sensor data is transmitted to the cloud via a gateway. The system utilizes AI and machine learning algorithms to monitor asset conditions, detect anomalies, and provide alerts via mobile apps, control rooms, and email. From September 8th to 14th, the system detected an anomaly in conveyor 15B LHS pulley, alerting the team with a high demodulation value. Preventive action, including lubrication, was taken to avoid further damage. Since then, no additional abnormalities have been detected.

This AI and ML-powered system offers a cost-effective, scalable solution for monitoring rotating machinery, reducing unplanned downtime, and enabling proactive maintenance planning.

IoT & AI for Efficient and Flexible Operation of Thermal Power Plant for Energy Transition

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India, with the world largest and yet growing population of 1.42 billion, has set an ambitious target of 500 GW renewables in 2030 and carbon neutrality in 2070. India is clear on its vision to achieve carbon neutrality in 2070 by expediting further renewable energy development and keeping its coal fired power plants as part of the mainstay of power generation as well as balancing source for flexibilization that is crucial to grid stabilisation.

However, as the expedited massive development of variable renewable energy (VRE) proceeds without appropriate measures, grid fluctuations will occur due to load variation. In case of such variation exceeding a certain level, it will have impacts on power plants and their power generation equipment, which, in some cases, would cause protection function work to disconnect from the grid by automatic suspension for self-preservation of the power generation equipment. In the worst case, it may develop into a major blackout.

The presentation will introduce details of a few Japanese IoT technologies that will support not only flexibilization for energy transition but also efficient and environmentally sustainable operation for stable electricity supply for the country's economic growth.

The authors believe the near-future application of such technology in India will provide opportunities for the two economies to collaborate further to help third countries to work on the same issues in the power sector.

Session - 9: Hydro and Gas Based Power Plants

Hydel Turbine Restoration - Experience & Learning of Koldam Hydro Power Station

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During the month of September 2024, Unit-3 hydro turbine was tripped due to sudden high turbine vibration and loud sound. Later it was discovered that one of the guide vanes got snapped from its location and obstructed in the running turbine causing damage to the turbine, which resulted in high vibration and loud sound. The objective is to pinpoint challenges related to turbine restoration using various techniques and methods which were also not mentioned in the OEM drawings and manuals. These exercises have been instrumental in refining the restoration methodology and identifying corrective measures to enhance existing practices for successful black starts. This paper details the approaches adopted to bring back the turbine within least amount of time and the experiences gained from the hurdles and setbacks. The paper highlights challenges encountered during controlled black start activities and outlines subsequent remedial actions.

CFD Study of Water Conductor System along with under water parts of 4X50 MW Kopili Power Station KHEP

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The paper discusses a Computational Fluid Dynamics (CFD) study of the water conductor system and underwater components of the 4×50 MW Kopili Power Station (KHEP, NEEPCO Ltd.) and its impact on machine performance.

During Oct'2019 accident, complete Inundation of 4X50MW Kopili Hydro Power Station of NEEPCO happened for rupture of Penstock, devastating complete Power House.Prior to inundation, the Plant was operated with certain technical limitations. Maximum station load of 195 MW was possible with unit wise load maximum of around 48.5 MW.

CFD is a numerical simulation technique used to analyze fluid flow, temperature, pressure, velocity, and density. It is typically performed in three steps: pre-processing, processing, and post-processing, utilizing high-speed supercomputers to solve complex fluid motion problems based on the Navier-Stokes equations.

Corporation explored to improve performance by augmenting the hydraulic design of the Runner and Turbine Parts to increase unit wise generation through CFD Study within the existing head and water conductor system. The intention of the analysis was to ensure that the replacement runner and wicket gate designs would have satisfactory performance, power, and cavitation, over the expected operating range of the machine.

The CFD study carried out by M/S Voith Hydro,analyzed the new runner and existing wicket gate designs across a head range of 260 to 345 meters, ensuring performance, power output, and cavitation resistance. The results indicated that a continuous turbine output of 56.670 MW is achievable with a modified design, incorporating a new runner, draft tube cone, seals, and increased servomotor stroke.

Based on the CFD findings, an experimental order was placed with Voith Hydro for supplying modified equipment for Unit #1, aiming to improve the turbine's efficiency and performance.

From Obstacles to Opportunities: Small Hydro's Path to Optimized Performance

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As India transitions to renewable energy, NTPC has set an ambitious target to achieve 60 GW of green power capacity by 2032, aligning with the nation's goal to generate 50% of its power from renewable sources by 2030.

This paper presents a case study of the unique Hydro Plant at NTPC's Vindhyachal Super Thermal Power Station (VSTPS) in Singrauli. The plant faces challenges in maintaining power generation during lean periods, particularly during the rainy season. Our study explores strategies for optimizing water resource management, improving efficiency, and enhancing the plant load factor (PLF) during such times.

The plant's remote location presents additional challenges, particularly in providing essential amenities for the workforce. To address this, we propose solutions for reliable access to clean drinking water and improving living conditions. Furthermore, the plant's reliance on diesel consumption has been identified as a concern. Our study focuses on strategies to reduce diesel use by optimizing power generation processes.

Vendor-related issues also pose challenges, particularly the difficulty in sourcing specialized expertise for small hydro plants in remote areas. We recommend fostering stronger local partnerships and offering incentives to vendors to meet the plant's unique technical requirements.

This case study demonstrates NTPC's commitment to optimizing renewable energy resources, overcoming technical and logistical challenges, and contributing to India's clean energy goals. It serves as a model for improving small hydro plant performance and enhancing sustainable energy production.

Leveraging AI and Operational Data for Enhanced Predictive Maintenance in Power Plants: A Case Study

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In the current power generation scenario, gas turbines are operating continuously in part load and off-design operating conditions. This study explores the application of process data-based AI models in power plant operations, highlighting their potential as effective substitutes for traditional mathematical models grounded in thermodynamics correlations. AI-driven fault diagnosis demonstrated exceptional utility, identifying poor filtration in the inlet air filter system within just 100 hours of operation-an anomaly that would typically remain undetected for months under conventional inspection schedules. By enabling timely identification of such issues, AI models allow for more strategic planning of maintenance schedules, such as aligning inlet filtration system inspections independently of combustion inspection cycles, thereby optimizing resources and operational efficiency.

The study also identifies key AI initiatives for NTPC, including equipment breakdown prediction, boiler tube leakage early detection, flame failure prediction, virtual instrumentation for CO and O_2 measurement, frequency prediction, soot blowing assessment, and bearing health assessment. By integrating NTPC's operational data, domain knowledge, and advanced AI tools, the study highlights a practical framework for successfully deploying AI/ML solutions in power plants. These projects address critical challenges in power plant operations, significantly enhancing predictive maintenance, minimizing downtime, and boosting overall plant performance. Successful implementation of these AI/ML solutions requires a multi-disciplinary approach that integrates domain expertise in power plant operations with proficiency in AI tools. The findings underscore the transformative potential of AI in driving reliability, cost-efficiency, and environmental sustainability in power plants, positioning NTPC as a leader in leveraging advanced technologies for operational excellence.

Innovative Gas Turbine Maintenance Practices at NTPC Dadri Gas

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This paper explores advanced maintenance practices in gas-based power plants, with a focus on In Situ Slow Speed Balancing of Gas Turbine Rotor and Compressor & Turbine Blade Tip Grinding by Vacuum Techniques.

Traditional high-speed balancing, which involves transporting the rotor to specialized facilities, is compared with in situ slow speed balancing. At NTPC Dadri Gas - Gas Turbine Unit No. 1, we adopted the latter method, significantly reducing downtime by approximately 30 days and eliminating the need for rotor transportation, associated risks, and extensive disassembly. Additionally, the limited availability of service facilities and the challenge of obtaining timely service during unplanned shutdowns further highlight the benefits of this approach. The case study showcases the successful implementation of slow speed balancing with the inner casing mounted, saving an additional 4-5 days by avoiding the removal and reinstallation of turbine blades.

Furthermore, the paper discusses the adoption of vacuum grinding for turbine and compressor blade tips during assembly. This technique ensures enhanced precision, reduced contamination, and improved blade longevity by minimizing oxidation and reduces downtime by 3-4 days. The integration of these advanced techniques demonstrates significant improvements in Mean Time to Repair (MTTR), cost savings, and overall turbine performance. In conclusion, adopting these best practices can lead to improved gas power plant maintenance, setting a new standard for the industry.

Future of Gas based Generation in India

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India has a total installed capacity of 462 GW. During the recent years, there has been a growing emphasis on the use of Renewable energy in the country. In the updated INDC of 2022 India committed to increase the share of non-fossil fuel-based capacity to 50% by 2030. While the total installed capacity of the country has grown by 86% from 248 GW to 462 GW from 2014 to 2024, the RE capacity has increased substantially by 497% from 35 GW to 209 GW for the same period.

The gas-based plants have always been supporting pillars of the grid. Their ability for fast start-up, high ramp rates make them attractive sources of power. Up until around 2012, all the gas stations of the country were running on full load and on continuous basis. However, from 2013, reduction in domestic gas production, changes in government policy on gas allocation to various sectors and increase in the cost of imported gas led to a sharp rise in the ECR of gas plants. This led to reduced scheduling of Gas based power. This penetration of RE in the grid has also contributed to this situation significantly.

Due to the seasonal and daily variation in the generation curve of RE and unprecedented increase in peak demand, the frequency of the grid gets affected. To maintain the grid frequency stability, gas plants are being run as peaking load stations multiple times in a day, albeit for short durations.

Through the course of this paper, we shall analyse the growth plans of the Indian power scenario and the effect of VRE on the grid. We shall evaluate the role of gas stations in the changed power expansion plans.

Gas Based Power Plant - Cyclic & Flexible Operations -Present & Future

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The most favoured and reliable technology in the sector of generation - especially - in thermal generation context is combined cycle power plant system. The global energy market has undergone significant shifts due to fluctuating gas prices and increasing emphasis on grid flexibility. Combined Cycle Power Plants (CCPP), known for their higher efficiency &reliability, lower emission & Aux. Power Consumption (APC), Fast Start-up capability, play a crucial role in meeting these demands. This paper explores the operational challenges and strategies for CCPP plants under cyclic operation and flexible load demands - Particularly the gas-based units of GSECL (Gujarat State Electricity Corporation Limited - generating arm of Gujarat state) having installed gas units with capacity of 970 MW shall be representing in the perspective of selected topic. The shifting operating regime of the units has been deliberated with its impact on KPI's (Key performance indicators) and life of the machines - gas turbines and steam turbines. Commercial and regulatory aspect has also been tried to cover up - with aim of realizing the same in future corrections / amendments for surviving the business of gas - turbine operations. The paper evaluates the technical, economic, and environmental implications of these operations and provides recommendations for optimization in the context of current energy scenarios and volatile gas prices. The paper shall be covering realistic position of gas turbines in electricity generation business and an approach in deciding the future of CCPP business.

Session - 10: Flexibilization

Methodology for Prioritizing Investments in Flexible operation of coal Plants for Sustainable Grid Operations

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The country has set an ambitious goal of achieving 50% of its installed capacity from renewable energy sources as part of its NDC targets, with solar and wind energy expected to constitute the majority. These sources, categorized as non-dispatchable ("Must Run") and highly intermittent due to their dependence on weather conditions, pose significant challenges for grid integration. To accommodate such a large share of variable renewable energy (VRE), coal-based power plants must adopt flexible operational strategies. This flexibility will enable higher VRE absorption and contribute to reduced fuel costs and emissions by lowering coal-based generation. This paper examines the critical role of coal-based thermal power in meeting the grid's flexibility requirements, minimizing renewable energy curtailment, and maintaining grid stability. Additionally, it proposes a methodology for identifying the thermal coal-based units for prioritizing investments to reduce the Minimum Power Load (MPL), based on their anticipated operational performance.

Operational Flexibility of Thermal Power Plants: Insights from Ramagundam Unit 7 Low Load Tests

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This paper presents an in-depth analysis of two low-load operational tests conducted at Ramagundam Unit-7. The primary objectives were to assess the plant's capability to operate stably at 40% load, evaluate its ability to meet ramp rate requirements, and identify key areas for operational flexibility improvements. Significant challenges, including coal dust distribution issues, control loop inefficiencies, and low-load stability concerns, were identified and addressed. The results offer valuable insights and practical recommendations for enhancing the operational flexibility of thermal power plants, particularly in regions integrating renewable energy at scale.

The increasing penetration of renewable energy sources necessitates greater operational flexibility in thermal power plants. This is especially critical to balance grid stability amidst the variability of renewable energy supply. Low-load operation enables thermal power plants to act as flexible backup systems during periods of high renewable energy generation.

This study focuses on Ramagundam Unit 7, 500 MW coal-fired power plant, and its performance under low-load conditions without significant retrofitting. The findings address fundamental questions about maintaining efficiency and minimizing greenhouse gas emissions at partial loads. Additionally, operational challenges such as load ramping, flame stability, and equipment efficiency are explored, offering insights into maintaining plant viability within a dynamic energy landscape.

According to the phasing plan, the unit is expected to become fully flexible by 2030, following nearly three decades of commercial operation. This timeline emphasizes the importance of preparing existing assets for flexibility without compromising reliability and cost.

From Stability to Flexibility- Thermal Power Plant Adaptations for Renewable Integration

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India's Nationally Determined Contributions target a substantial RE capacity of 500 GW by 2030, constituting 45% of the total installed capacity. The same is projected to increase to 596 GW by 2032 dominating the installation of 304 GW from fossil-based sources. Although, this accelerated growth of RE is pivotal to India's energy transition, it poses operational challenges to thermal power plants. The intermittency & variability of RE generation calls for enhanced flexibility in TPP operations to ensure grid stability.

In FY 2023-24, India's thermal power plants average PLF remained at 69%, which is further expected to decrease with rising RE penetration. Moreover, advancements in technologies, like pumped storage and battery energy storage systems, are anticipated to further reduce PLFs, especially during nighttime.

In India, most of the plants are traditionally designed for a 55% MTL considering the base load operation but same must be lowered to 40% MTL to accommodate the growing generation from RE sources. Additionally, it is also required to have steeper ramp rates of up to 6% per minute and shortened startup/shutdown cycles for addressing variability & intermittency of RE. These adaptations strain equipment reliability and efficiency, escalating operational costs.

This paper includes outcomes from flexibility trials conducted at Indian TPPs, detailing key operational challenges and highlighting mitigation strategies. It further explores innovative solutions that can help enhance efficiency and reduce APC during part-load operations. Finally, a brief roadmap is presented to enable TPPs to adapt to India's dynamic energy ecosystem while maintaining grid stability and economic viability.

Boiler Flame Failures in Flexible Operating Regime - Operational optimization

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Pulverized fuel Boilers are critical components in thermal power generation where their reliability and efficiency directly influence operaϴonal performance. One of the significant challenges in boiler operations is the occurrence of flame failures, which can disrupt energy production, lead to downtime, and compromise safety.

Flame failure occurs when the combustion process within the boiler ceases unexpectedly. This can result from various factors, including fuel quality issues, inadequate air-fuel mixing, unstable combustion conditions, or faults in the burner management system. Flame failures are particularly concerning in flexible operating regimes, where boilers frequently adapt to fluctuating loads and fuel types to meet dynamic energy demands.

Flexible operation is need of the hour in our Indian power scenario and it is necessary for all thermal stations to do flexibilization. This operation potentially increases the complexity of maintaining stable combustion due to Rapid load changes, change in coal characteristics. These factors contribute to operational challenges and will lead to an environment where flame stability is harder to achieve. NTPC stations are operating with flexibilization from 100% to 55% and are facing so many challenges in this front. Addressing these challenges requires a combination of advanced operational strategies, robust maintenance practices, and the adoption of best practices

This paper deals with the study of last five years database of flame failures in NTPC stations, further digging into the flame failures root cause analysis, identifying the better operational strategies to prevent boiler flame failures, their impact on operations, and strategies for mitigating these issues through operational optimization and improved system management.

specific lean mixture operating conditions resulted due to liabilities and varying coal qualities need to be overcome through operational optimization at equipment level and also at process level. Strategies have been formulated for addressing the part load flame failure issues.

Complete Cycle Solution

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Complete cycling solution by Arnold offers following benefits:

- Emission Excellence
- High Performing Unit Reliability
- Power Black Agility
- Improved Cycle Efficiency
- Reduced Startup Costs

Good Insulation is an important component of warming system. Key Target areas are: -

1. HRSG Warming
   HRSG warming is required to offer Freeze protection, startup holds and mitigate HP Drum / Piping Fatigue. Heating blankets used for downcomers can help in faster startups, no cycle chemistry impact and can also help in eliminating air ingress.
2. Steam Turbine Warming
   3-dimensional shaped insulation blankets have advantage of perfect fit to Turbine surface and offer much better stability and higher manufacturing quality. They also retain their shape after years of use and have long term high-temperature resistance. Startup time can be reduced by up to 75% (from 6 hrs to ~2 hrs), helps in startup fuel savings and reduce stress on CT HGP / Exhaust area.
3. Steam Valve Maintenance
   Steam Valves are one of the most stressed components in Steam startup cycle and often a large source of online heat rate loss. Heat rate improvements can be carried out through specialized service of these valves.

Session - 11: Generator & Electrical Systems

Implementation of Remote Racking of MV Breakers by Integrated Motorized Mechanism

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Conventionally, the process of racking Medium Voltage (MV) circuit breakers is carried out manually from the breaker panel front through an external handle connected to the breaker spindle. The proximity to the MV panel exposes the Operator to unsafe zone of arc flash boundary during rack-in/out of the breaker from live bus arising out of any malfunction, wrong indication/identification of panel etc. Internal arcs and pressure waves generated due to faulty racking activity has catastrophic consequences to the personnel & equipment. The risk is higher if the original switchgear is not Internal Arc resistant and no gas ducts are installed.

The paper details the various perspectives of the hazard and elaborates mitigation strategy to enable remote racking of the breakers, thus keeping the operating personnel out of arc flash zone. The solution elaborates a pilot project implemented in one of the NTPC stations where 5 numbers of existing MV breaker panels have been upgraded with remote integrated motorized racking mechanism. The prime purpose of the remote racking implementation is to keep the operator out of the arc flash boundary and build-in additional safety interlock logic for ruling out common operator mistakes during racking operation by the use of remote-control panel. This Pilot project on upgradation of breaker panels with Motorised Rack-in & Rack-out will serve as a useful reference for emulating in other Medium/High Voltage breakers and enhance safety in switchgear operation.

Strategies to Achieve Zero Forced Outage of Kudgi Thermal Units due to Electrical System

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This paper explores the successful implementation of action plan for zero trippings in Kudgi Super Thermal Power Station on account of Electrical Systems for four consecutive years from F.Y 2020-21 to F.Y 2023-24, in contrast to the 418 trippings recorded across NTPC stations with a FO of 5151 MU during the same period. This achievement is attributed to targeted initiatives addressing engineering/ erection/ commissioning deficiencies in critical areas which can lead to Unit Outage such as Transformers, Actuators, HT & LT switchgear, HT & LT motors, Generator, Bus ducts and Switchyard. By systematically identifying and rectifying these shortcomings, we have enhanced the reliability and efficiency of our power plant operations. The paper details the specific measures undertaken, including attention to the minute details, advanced diagnostic techniques, proactive maintenance strategies, and the integration of state-of-the-art technologies. The results underscore the importance of a holistic approach to electrical engineering in achieving operational excellence and setting new benchmarks in the power industry.

Rectification of High Temperature Issue in Segmented Isolated Phase Bus Ducts - A Case Study of 2 X 800 MW Ultra Super Critical Thermal Power Plant

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In ultra supercritical Power Generation Units at APJL Godda, during routine inspection and thermography of IPBD, it was observed that the bottom segments equalizing link's temperature was observed @ 240°C at 750MW (full load was yet to be achieved). The hot Spots is observed in the IPBD segments from Generator terminal Box to Shunt in Phase and neutral side.

Following are the observation found.

Red-hot spot was observed in Y phase top side conical segment flange at neutral side IPBD.

Further it was observed that similar type of hot spot is observed at different locations even in phase side when unit is running in between 650 - 800 MW.

The observation was shared with EPC, and as per their recommendation additional earthing was provided at phase and neutral side shunts to ground. However, no improvement was observed.

This paper discusses ä problem of IPBD. The hot spots were specifically identified in the IPBD segments located between the Generator Terminal Box and the shunts on both the phase and neutral sides. No such temperature anomalies were detected in the IPBD beyond the shunt locations on the phase and neutral sides. The localized temperature rise in these areas suggests potential issues related to electrical resistance, contact anomalies, or other factors affecting the performance of the IPBD segments. However, since no temperature anomalies were observed beyond the shunts, the problem appears to be confined to the initial section of the IPBD system.

Generator Performance Under Flexibilization: Challenges and Mitigation Approaches

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Generator is one of the most critical equipment in any power station. Reliable operation and availability of the generator are of utmost important to any power generating utility. The growing demand for grid flexibility has led to the adoption of flexibilization strategies in thermal power plants, enabling rapid start-ups, shutdowns, and load-following operations to meet fluctuating grid demands. While these strategies enhance adaptability, they impose significant stresses on generator systems, resulting in challenges such as overheating of critical components, premature bearing wear, and excitation system malfunctions. Based on failures observed across NTPC's fleet, this study identifies inadequate design for flexible operations, insufficient maintenance protocols, and operational stress as key contributors to these issues. To mitigate these challenges, the paper proposes implementing advanced predictive maintenance techniques, redesigning components to withstand frequent cycling, and refining operational practices to reduce stress during flexible operations. These measures aim to enhance generator reliability and performance, ensuring the longevity of flexible-generation-capable power plants in the evolving energy landscape.

From Vibration Anomalies to Generator Integrity: A Methodical Approach to Troubleshooting

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Vibration measurement serves as the heartbeat of any rotating machine or equipment. Elevated vibration levels typically prompt operational personnel to take immediate remedial actions to reduce these levels. If left unchecked and allowed to exceed the trip threshold, vibrations can trigger automatic shutdowns, leading to forced outages. In situations where the operation and maintenance teams are unable to pinpoint the root cause, units are often re-synchronized, risking further trips.

This paper presents the case of a running power plant of 250 MW TG set, which encountered high exciter shaft vibrations. An investigation into this anomaly uncovered a potentially catastrophic underlying issue, demonstrating the significance of thorough diagnostics and innovative troubleshooting approaches in power plant operations.

Session - 12: Power Plant Chemistry

A Novel Approach to Managing Air Cooled Condenser Corrosion and Enhancing Reliability

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This session will focus on a novel approach to managing corrosion in air-cooled condensers (ACC) through targeted neutralizing amine injection. By directing the feed of ethanolamine specifically to areas of corrosion concern, operators may achieve more effective pH control, reducing corrosion and subsequent iron oxide transport. Minimizing ACC steam-side corrosion can significantly lower the risks of long-term reliability and performance losses caused by air in-leakage. Excessive iron oxide transport to the steam generator, a common issue in ACC systems, heightens the risk of tube failures. This discussion will highlight the potential benefits of ethanolamine injection downstream of the high-temperature superheater, offering ACC operators an innovative option for mitigating corrosion and improving system reliability.

Reverse Osmosis - A Proven Technology in Water Treatment Yet Intricacies in its Operation - Learnings of Revival of Ro Plant at NTPC Telangana

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In all the 800 MW units of its fleet, NTPC has switched over from conventional resin-based DM plants to more advanced membrane-based RO plants to meet its highly pure DM water requirements for boiler feed at competitive DM water production cost. Undoubtedly, membrane-based technology is having key advantages of its compact design, handling of less hazardous chemicals and lower capital costs but at the same time technical expertise in understanding the intricacies in its routine operation is the area which needs special attention. On one side conventional resin-based DM plant is old aged proven technology, which is not only rugged, but the technology is also much easier to understand, operate & handle in comparison to the membrane-based RO technology which has many interlinked performance affecting enablers contributing to system's overall production & efficiency capabilities.

This paper provides an insight into the "Head on comparison of conventional Resin based DM plant vis a vis Membrane based UF + RO Plant covering Intricacies involved in operation of UF + RO based DM plant with a Case Study of Learnings of revival of RO Plant at NTPC Telangana." The case study highlights the "Key factors influencing the UF + RO plant operational performances along with various trouble shoot methodologies to address the product quality issues". The key objective of documentation of this paper is to understand and dissemination of learnings achieved at NTPC Telangana plant in operating UF + RO based DM Plant to meet DM water requirements for Ultra super critical units.

Chemistry Management in Ultra Supercritical Boiler at Godda of Adani Power

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This is the first running ultra supercritical boiler in India having Super-heated temperature 605°C and Re Heat temperature 613°C. Along with FGD it is the first NOx control by SCR technology in India and with so many other areas in the technology front, it is the first export concept power station first in India and exporting power for more than one and half years. Now coming to the water chemistry of ultra supercritical once through boiler we have implemented Oxygenated Treatment (OT) within a short period from its continuous run. OT is considered today the best regime for chemistry management of supercritical boiler. Aim of OT is iron transport minimization to boiler water wall such that the boiler should run with a thin film of oxide protection which eases heat transfer along with metal protection for a very long period of time and can avoid chemical cleaning of boiler in near future.

To optimize water chemistry at Godda along with that Dissolved Oxygen (DO) monitored online ORP during transformation from so called magnetite layer to hematite layer. For iron level detection in feed water along with ICP-MS which is considered the right method for very low ppb level iron we have implemented shift wise monitoring of turbidity (NTU) which gives an encouraging output and used filter paper stain analysis to understand that our OT Programme is in line with the expectation.

By going through the main paper one can easily understand how the ORP behaves during the transformation from AVT(O) to OT regime. Turbidity trend will explain how it is an easier option to understand the iron transport in different samples.

Strategies to Maintain the Integrity of Boilers and Turbines by Preventing Corrosion and Deposition in Current Operational Scenarios

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Maintaining optimal cycle chemistry is crucial for ensuring the integrity and efficiency of boilers and turbines in thermal power plants. However, challenges such as corrosion and deposition, which compromise equipment performance and reliability, are common. Forced outages caused by deviations in cycle chemistry parameters further exacerbate these issues.

Adhering to standard startup guidelines is essential for safe and efficient operations. Key strategies include ensuring the availability of condensate polishers to control corrosion products and ionic impurities, utilizing SWAS for continuous cycle chemistry monitoring, and adopting innovative measures like installing pre-filters to reduce CRUD loading on condensate polishing units. These approaches enhance efficiency across all types of units and significantly reduce startup times, particularly in drum-less units.

Regular overhauls and inspections of critical components, including condensate polishing plants (CPP), SWAS, and condensers, demineralized (DM) plants, etc. are essential to maintaining optimal cycle chemistry during normal operations. Updated specifications for CPP, SWAS, and DM plants in upcoming supercritical water-cooled and air-cooled condenser units are designed to meet the demands of flexible operations and dynamic water chemistry conditions.

A comprehensive approach that incorporates asset management, adherence to operational guidelines, and the use of advanced monitoring tools ensures early detection and resolution of water chemistry deviations. These practices extend the lifespan of critical components, reduce downtime, and enhance operational reliability.

This paper outlines strategies to address these challenges, focusing on maintaining recommended cycle chemistry, improving asset management, and implementing design improvements to ensure efficient and reliable power generation.

A New Acid Cleaning Method for removal of Hard Silicate Scale deposit in Condenser tubes of U#2 of Dhariwal Infrastructure limited 2x300 MW plant

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Dhariwal Infrastructure Limited is a 2x300 MW thermal Power Station situated at Chandrapura Maharashtra. The Station draws water from the Wardah River. This is further used for plant operation and process requirements including condenser cooling in closed cycle. Average COC (Cycle of Concentration) of the Circulating water System is generally maintained at 6-7. However, since the area of Chandrapur is water scarcity zone, COC of circulating water system reduced up to 5 during the summer season. Moreover, the composition of the soil of the waterbed through the water flows is rich in Magnesium and Silicate. During summer season the Magnesium Hardness concentration becomes 800 ppm respectively and the Silica concentration goes to as high as 160 ppm in circulating water. Thus, the water scarcity coupled with very high salt concentrations makes it's a big challenge for the station to optimize the cooling water program. Historically the station faced huge difficulties to overcome these challenges. Over a period, it was observed that a Hard Silicate scale of about 0.5mm thickness was developed inside the Condenser tubes. The Silicate percentage in the scale deposit sample was found to be as high as 60%. Information collected for all power it was evident that no power stations across India have had such High level of Silicate scale. The Station thus carried out lot of research and analysis on the scale material and finally arrived at a suitable acid chemical cleaning composition to remove the hard silica scale.

The paper describes the research work done in detail and finally arriving at a suitable composition of different chemicals which was implemented recently in U#2 removing the Hard & 10-year-old silicate scale deposit material completely. The paper also describes the challenges faced in maintaining very High COC and its circulating water Chemical treatment.

Session - 13 : Control & Automation in Power Plant

Dry Ash Evacuation Process Improvement- "Advance Pulse Jet Timer System (A-PJT)"

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In India Coal is being used as main source of fuel for power generation in thermal power plants. Coal is fired in boilers for steam generation, as a resultant huge amount of Ash is also being produced in this process. The prime concern for coal-based power plants is the quality of Indian Coal, as Indian coal has low calorific value and Sulphur content but has a high ash content in the range of 30 - 45%due to which ash is being generated in abundance. As the Thermal Power Generation Capacity is increasing in the country thus the Fly ash generation is also increasing. In a Thermal Power Plant this Dry Fly Ash is convoyed from ESP to Silo via Transport Air. From Silo this Ash is being transported via Bulkers or BTAP Wagons to Cement and Ash Brick Plants where it serves as a raw material. Also100% Ash Utilization is a Statutory norm to which every Thermal Power Plant must comply. This paper discusses the problem being faced at SSTPS in conveying Dry Ash from ESP to Silo and how a New System "A-PJT" has been developed In-House as a tool to ensure Improvement in Dry Ash Evacuation Process.

Advanced Process Control Deployment with No Black Box Solution

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With the fast integration of renewable energy, coal-based stations are required to change the load with at least 3% to meet the grid requirements. In this scenario, with rapidly changing load schedules, critical steam parameters also fluctuate, increasing fatigue on high-pressure, capital-intensive equipment. Units are experiencing failures due to fatigue.

To control steam temperature and pressure, various strategies are being implemented by control system vendors. These strategies are often black-box type and are not yielding the desired results under Indian conditions, which involve high coal quality variations and dynamic plant conditions. Most of these solutions require continuous attention as equipment characteristics change with scheduled maintenance and overhaul.

The NTPC control system tuner group has implemented model-based control in NTPC Telangana with the help of EPRI/Provecta. This implementation is fully integrated into the existing DCS, does not involve black-box logic, and has repeatability across the NTPC fleet. Some of these algorithms are in various stages of implementation in different NTPC plants by the CST group.

In this paper we are presenting implementation of advanced model-based control strategies for Unit Load and steam temperature controls implemented in NTPC Telangana with the help EPRI/Provecta. With the series of test load variations data has been collected for boiler turbine response. Collected data has been put on System identification toolbox and analysed. PTx and Enthalpy control implemented for better steam temperature control. The design modifications and tuning applied to the steam temperature controls and separator outlet temperature controls have improved steam temperature control performance substantially.

Reduction in Rake Detention Time through Automation Control Techniques

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Efficient rake handling is not only a key performance indicator for any coal handling plant in terms of operational efficiency but also establishes a trustworthy relation with stakeholders like Indian railways, Coal India and others. With transition to ROM coal in FY20-21 Nabha Power Limited (NPL), faced a significant challenge with increasing rake detention time exceeding the allotted time of 05-hour window per rake by Indian railways.

This paper presents the implementation of two key automation control techniques at the NPL's coal handling plant, leading to significant improvements in rake detention time thereby improving overall operational efficiency.

Firstly, a real-time current monitoring system for vibrating grizzly feeders (VGF) and reversible belt feeders (RBF) was configured in PLC. This system, coupled with logic modifications for both VGFs and RBFs enabled managing feed rate on conveyors in sync with VGF/RBF currents and effectively addressed overloading and choking issues for VGF/RBF, ensuring smooth and uninterrupted coal unloading.

Secondly, a new Wagon Tippler (WT) operation mode was introduced, eliminating the need for frequent maintenance mode operation (manual intervention) and reducing unloading cycle time. This mode incorporates enhanced safety interlocks compared to that of maintenance mode.

The combined impact of these operational control techniques has resulted in a substantial reduction in rake detention time, from 06:10 hours in FY 21-22 to 04:31 hours in FY 24-25, translating to a remarkable 27% improvement.

Advanced slurry density measurement: Technology and techniques for industrial applications

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Slurry density measurement is a critical parameter in various thermal power plants. Accurate determination of slurry density is essential for optimizing process efficiency, controlling ash slurry flow and ensuring consistent lean ash to water mixture.

This paper explores various methods for measuring slurry density as well as advanced approaches like nuclear density gauges, differential pressure method. The advantages and limitations of each method are discussed in terms of accuracy, reliability, cost-effectiveness and suitability and ease of operation. Additionally, the impact of factors such as temperature, particle size, and concentration, density measurement is examined. The study also highlights recent technological advancements aimed at improving measurement precision and enabling real-time monitoring in dynamic slurry systems. The findings underscore the importance of selecting the appropriate measurement technique based on specific application requirements to achieve optimal process control and product consistency.

Non-nucleonic methods for slurry density measurement involve techniques that do not rely on nuclear radiation or isotopic sources. These methods are typically used for safety, environmental, and regulatory reasons. Below are some of the most common non-nucleonic methods for slurry density measurement:

(1) Ultrasonic Densitometry (2) Hydrostatic or Pressure-based Methods (3) Vibration-based Techniques (4) Optical Methods (5) Capacitive or Impedance-Based Sensors (6) Coriolis Mass Flow Meters (7) X-ray or Gamma Ray Transmission (without nucleonic sources)

Summary:

These non-nucleonic methods provide alternative ways of measuring slurry density without relying on radioactive sources. The choice of method depends on the specific application, accuracy requirements, and operational conditions, such as slurry composition, flow rate, and particle size.Use of strain gauges as load cell proves a very accurate analysis during the ash slurry density control mechanism by measuring density in real time format of the HCSD system their after providing feedback to the operators.

Upgradation of OWS/servers /NAS - Performance and availability by replacement of HDD with SSD

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All the OWS and Servers are Windows 7 Ultimate 64-bit OS based machine whose support has been stopped by Microsoft since 14th Jan 2020. Quotation and upgradation of HMI from the respective OEMs is still under discussion stage. To ensure 100% availability of Units, these OWS and Servers HDD plays the vital role. The HDD installed in these machines are manufactured between 2014-2017, there is frequent failure in OWS due to aging effect and several notifications were raised for non-availability of the OWS by operation department.

Given that SSD have better performance w.r.to HDD, the HDD were replaced with SSD with the help of an adaptor to ensure same Sata interface as well as the SSD is suitably placed in the existing slot of the HDD. It was first tested in Toshiba OWS and later same was implemented for Siemens OWS, SOS and NAS. Further to increase the storage space in the CCTV servers, additional SSD were installed with Adaptor.

Replacing HDDs with SSDs in OWS, servers, and NAS lead to substantial improvements in performance, reliability, and overall efficiency.

Session -14 : Fuel Management

Operation and Control Philosophy of Rapid Loading System in NTPC Pakri-Barwadih Coal Mines

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Pakri-Barwadih Coal Block (PB) was allotted to NTPC, under Government Dispensation Route, by the Ministry of Coal vide letter no: 13016/29/2003-CA dated: 11.10.2004. The block is located in the North Karanpura Coalfield in the Hazaribagh district of Jharkhand State. As per the approved Mining Plan, the entire block is divided into four parts- Western Quarry, Eastern Quarry, North-West area and area beyond 300m depth (Underground Area). The mining Plan (including the PBNW) for a rated capacity of 18 MTPA was approved by MoC vide letter 07.03.2016. The Mining Plan envisages a production capacity of 17 MTPA from PB - West & East Quarry and 3 MTPA from PB-A (North-West Quarry or NW Quarry). Currently it is the biggest mine of NML/ NTPC.

Rapid Loading system, the new philosophy in NML as well as in NTPC has been commissioned in NTPC. Two Rapid Loading system has been commissioned in Pakri site and as per capacity on an average around 12 rakes can be loaded directly conveyor to rakes. This is economical to NTPC as on average NTPC is saving Lakhs of Rupees on transportation cost. This is environment Friendly as no Hyva movement will be there in forest land.

This overview covers the coal weighing and loading system for wagons to be installed at PAKRI BARWADIH- The purpose of the project is to achieve efficient, fast. And Specified amount of loading Coal from Surge bunker into moving wagons at a speed of 0.8 to 1.2 Kmph. Coal from Mines are coming to Ground Bunker of 10000 Ton Capacity either direct feeding or from Reclaiming from stacked Coal. Coal from Ground Bunker are feed to Surge Bunker such that in one go of Wagon moving at the speed of 0.8 to 1.2 KMPH by running conveyor continuously and it takes about one hour for one rake loading.

In our paper it has been shown how major problems related to this type of Rapid Loading System has overcome. In NTPC we are sharing our experience with other plants where RLS is about to come. With the papers the same experience can be shared with other non NTPC Plants also. As a cost benefit analysis paper shows the benefit of Rs 10 Lakhs per rake to NTPC when compared to Road based transport System.

The Challenges at Ntpc- Mouda Attributable to High Demurrage on Account of Underutilization of Wagon Tippler#1: A Case Study

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The goal of this paper is to present the challenges faced and their resolution carried out to utilize WagonTippler(WT) #1 to its fullest capacity of tippling of wagons weighing up to 110 Tons.

NTPC Mouda STPP has installed capacity of 2320 MW (Stage I: 2 x 500 MW, Stage II: 2 x 660 MW).There are total of 6 nos. of Wagon Tipplers at Coal Handling Plant for coal rake unloading, 3 nos. eachof make M/s TRF and M/s Elecon and there is no provision of Track Hopper facility. NTPC Mouda wasreeling under huge demurrage because of miscellaneous reasons. Demurrage paid in FY-2023 isRs.5.74 Crore which is very high. Outage on account of unacceptable coal spillage and high equipmentbreakdown attributed to high demurrage at Wagon Tipplers. WT#1 system was identified with leastavailability among all Wagon Tipplers for unloading of wagons because of constraints from mechanicalside. Wagon Tippler#1 is installed in Stage#1 which is supplied and erected by M/s TRF and has beenoperational for more than 12 years.

Effective Coal Stockyard Management to meet Challenge of Handling Multiple Quality Coal

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Many Power stations are handling multiple source coal and even, quality of coal from individual sources /sidings are also varying. This uncertainty in coal quality is affecting stockyard management and consequently main plant operation with varying specific coal consumption (SCC). Even though average coal quality is maintained within range but inconsistency of quality in incoming coal resulting increase in specific coal consumption. Increased variability in specific coal consumption affects energy performance and reliability issues in boiler and auxiliary. In these cases, effective stockpile management is a necessity. The CSMS (Coal stockyard management system) is an in-house developed logic backed digital information system for coal handling plant operators and managers, which enable effective decision-making and process control. The developed system is useful for stations handling multiple siding coal with large volume and varying quality.

Best practices of CHP Maintenance to avert Monsoon challenges in the year 2024 'NTPC Ramagundam experience'

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NTPC Ramagundam CHP system of total 31 KM conveyor belt length is more than 40 years old and has faced many challenges in recent few years monsoon period during unloading and evacuation of coal. Continuous coal supplies to unit bunkers also interrupted resulted into DC & Generation loss for NTPC Ramagundam. In FY23 total 231 MU and in FY24 of 284 MU generation loss occurred at NTPC Ramagundam due to CHP monsoon related issues.

To avert this challenge in 2024 monsoon period multiple initiatives were taken by CHP Maintenance on war front basis in last one year. It started in Nov-23 with the comprehensive review of Ramagundam CHP monsoon preparedness along with CC-OS followed by action plan (as below) implemented at site by CHP-MM Ramagundam to actualize the target of no DC/generation loss on account of CHP issues at NTPC Ramagundam in 2024.

1. Major chute enlargement works in critical TPs like TP-2, TP-11 & TP-13.
2. Massive mother plate replacement of Approx. 300 MT w.r.t. 180 MT in year 2023 (20 & 25 MMSH material also arranged from various NTPC stations to meet the target before monsoon).
3. Higher no of full belt replacement of total 6 KM length w.r.t. 5.4 KM in year 2023.
4. Annual Overhauling as per CC-OS guidelines of critical equipment like Crushers 1&6, Paddle feeders 2&4, Stacker Reclaimer-1&2, Unit#4,5,6 & 7 tippers & bunker conveyors.
5. Reducing Belt mapping and PM schedule of critical conveyors and equipment

Additionally following long-term improvement/projects have been taken up by CHP-MM through innovative schemes and R&M proposals for making the Ramagundam CHP system more reliable and sustainable.

1. Belt patch detection system for early detection of belt failure (implemented).
2. Motorized pulley in stacker reclaimers for improving system reliability (implemented in SR-3).
3. Additional stacking path from CH-2 to Stockpiles for improving system redundancy (under approval).
4. Scoop type fluid coupling to avoid frequent tripping of HT motors of 19 A/B conveyors

Reliability Centered Maintenance of Wagon Tippler System for enhanced availability of coal unloading System: "A case study of NTPC Kudgi"

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During the years' wise experience of 22-23 and 23-24 the major outages of wagon tipplers systems at NTPC Kudgi, were recorded against outages of Apron Feeder, SAC coupler problem, Wagon tippler wheel gripper, coal accumulation into cradle pit etc. To improve the rake unloading cycle time, the recurring problems needs to be corrected after proper RCA. After proper study and site-based initiatives like installation of Proximity Switches, ZSS, Air Blast cleaning, flexible sealing, installation of seal guard arrangement, usages of Grapholog H1 spray, Open Gear grease application, SAC coupler modifications, Wheel Gripper modifications etc., the availability of WT's system has improved a lot, and outages too gets reduces. The result too gets seen and NTPC Kudgi also clocked minimal demurrages charges in the month of Nov'2024 for both the financial year 2023-24 and 2024-25 with handling of 2nd highest numbers of rakes i.e. 189 (with DC charges of 7.4 Lakhs only) against highest no of 193 (with DC charges of Rs. 36.6 Lakhs).

The all the initiative taken at site has enhances reliability of Wagon Tippler#1, 3, 4 and 5 and same is being planned to incorporate in WT#2 too during its scheduled overhauling in Dec'2024.

The reliability cantered maintenance has not only enhanced the confidence of Operation people on wagon tippler's systems but also the extra burden of coal removal from hoppers, cradle pit too has eliminated, which same has also been recognized by our cross functional department like operation, Fuel Co-ordination group as well by housekeeping people.

Session - 15 : Energy Transition

Sustainable Biomass Supply Network Model: A Pathway to Efficient Energy Transition

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Biomass represents a promising renewable energy source with significant potential to reduce the carbon footprint of coal-fired thermal power plants and various industrial processes. Unlike other renewable energy sources such as wind power, biomass offers a reliable energy supply with minimal volatility. Despite these advantages, biomass remains underutilized as a renewable energy resource, largely due to constraints in supply chain systems. The primary barriers hindering the development of biomass and biofuel technologies include the high cost of feedstock, lack of consistent and reliable supply chains, and uncertainties in logistics and operational management. This study examines the main components of the biomass pellet supply chain, providing a comprehensive overview and classification of existing contributions in the overview of solid biofuel supply chains. This study of interface platforms highlights the interdependencies among logistics, supply-driven and demand-based collection models and underscores the importance of coordinated logistics to enhance the overall efficiency and sustainability of the biomass supply chain. To address current challenges, this paper focusses on holistic digital models that encompass all facilities within the entire biomass supply chain. Such models should incorporate strategic, tactical, and operational decision-making levels, enabling comprehensive solutions to address issues related to inventory control and real-time decision-making. Additionally, this study identifies state and district-level optimization as a critical area for future research, emphasizing the need for localized solutions to improve biomass utilization and supply chain performance. By addressing these multifaceted challenges, the study provides directions to enhance the viability of biomass as a renewable energy source, contributing to sustainable energy transitions and reducing the carbon footprints of industrial and power generated systems.

Municipal Solid Waste Co-firing in a Pulverized Fuel-fired Boiler

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A novel technique for converting Municipal Solid Waste (MSW) into torrefied pellets for co-firing in a conventional pulverized fuel-fired boiler has been studied. Torrefied MSW co-firing has been successfully demonstrated at NTPC Tanda Unit #4 (110 MW) - the first of its kind in a pulverized fuel-fired boiler globally. No major capital equipment installation or retrofits were required for this cofiring trial. External blending mechanism was employed in stockyard through payloader buckets while maintaining the blending ratio of torrefied MSW and coal up to 1:10 through the number of buckets.

Entire torrefied MSW co-firing demonstration at Tanda was conducted in several phases involving studies of combustion behaviour and chemical analyses at NETRA & site chemistry Labs, development of station specific operational procedure, C&I logics modification for mill firing mode switching (coal firing to MSW blended fuel firing) and mill steam inerting valves remote operation provision. Comparative assessment of boiler efficiency, auxiliary power consumption, emission tests during MSW co-firing were carried out. Emission of family of poisonous chemicals (that are envisaged to be generated on MSW burning in Boiler furnace) were stringently monitored.

Based on the trial findings, MSW pellets blending has been recommended as a safe and promising option in pulverized fuel-fired boilers. It provides additional benefits of fuel security while helping to manage wastes better. Due to its lower alkali and sulfur content and improved grindability, MSW torrefied charcoal outperforms biomass pellets for substituting fossil fuel and emission reduction.

Nuclear for Viksit Bharat @2047

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Viksit Bharat @2047: A Vision for India's Future envisions India as a developed nation by the centenary of its independence. At the heart this vision is India's energy transition with an objective to develop a resilient, diversified energy system that promotes economic growth while combating climate challenges. This transformative roadmap emphasizes inclusive development, sustainable progress, and effective governance, which can primarily be measured from Human Development Index (HDI). The relationship between HDI and energy consumption is significant and multifaceted as HDI is a composite index measuring average achievement in key dimensions of human development: health, education, and standard of living. There is a strong positive correlation between HDI and per capita energy consumption. Countries with higher energy consumption per capita generally have higher HDI scores, reflecting better health, education, and living standards. Energy can be met from various sources, fossil and non-fossil based. India's energy mix is diverse, comprising fossil (~76%) and non-fossil incl nuclear (24%). Under the Business-As-Usual (BAU) case, the energy mix shall lead to alarming levels of greenhouse gases, predominantly Carbon-dioxide. This indicated an increase of global mean temperature above 2oC above pre-industrial era. The Paris Agreement 2015 aims to limit global warming to well below 2°C above pre-industrial levels, with efforts to limit the increase to 1.5°C. India too has significant role in curtailing the global greenhouse gas emissions. India has committed to several ambitious targets like Panchamrit, to reduce its carbon footprint. All these demand for shifting the focus towards cleaner (Low or No carbon emissions) fuels to meet the energy needs. In comparison to renewables like solar/wind, Nuclear, with its added advantage of being able to provide round the clock dispatchable power, has a key role to play in this energy transition goals. The use of nuclear is not only limited to electric applications, but also to various hard to able energy sector applications. This cogeneration system of applications in electric and non-electric domain, improves its efficiency and makes it economically competitive with its counterpart energy sources. Out of such applications, district heating/cooling has been analyzed in detail (through software model internally developed on excel macros) and the results are attractive, both in terms of economics as well as environmental benefits. In this paper, efforts have been made to bring forth the irreplaceable benefits from nuclear energy, which can take India on its path towards sustainable development.

Optimizing Coal Fleet Performance to Accelerate the Energy Transition

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This session will explore a project focused on evaluating the full coal fleet performance in target countries to support a more strategic and impactful energy transition. By prioritizing actions across entire coal fleets rather than individual plants, this approach enables the potential early closure of the worst-performing plants while concentrating upgrades, repurposing, and retrofits on those that can deliver cleaner and more efficient power.

The session will highlight how this strategy can accelerate emissions reductions, avoiding gigatons of CO_2 and hundreds of tons of mercury emissions, while saving billions of dollars in health-related costs. This coordinated approach offers a practical glide path to transitioning from conventional coal to renewable, zero-emission energy systems.

Enabling a Reliable, Decarbonized Future in a Variable Renewable Energy World

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Energy storage is a critical enabler of the transition to a clean, affordable, and reliable energy future, supporting the rapid growth of variable renewable energy (VRE) like solar and wind. By storing excess energy and delivering it when needed, energy storage enhances grid stability, provides system inertia, and offers critical ancillary services such as frequency response and spinning reserves. As VRE deployment grows and displaces traditional thermal generation, the need for bulk energy storage capable of supporting hundreds of MWhs with durations beyond 6-48 hours-or even seasonal storage exceeding 500 hours-becomes imperative.

EPRI's Bulk Energy Storage program delivers actionable research on bulk energy storage technologies, providing detailed cost, performance, and operational insights to accelerate their adoption. It also evaluates integration strategies, performs cost-benefit analyses, and conducts field testing to help utilities plan for and deploy advanced storage solutions.

Session - 16 : Climate Change & Environment Management

Climate Change and Environment Management

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Around 500 million years ago atmospheric CO_2 concentration was around 3000 to 3500 ppm and through photosynthesis over the period, the concentration of CO_2 reduced to 280 ppm which continued for 33 million years till industrial evolution i.e. till end of 17th century.

Human activities mainly through emissions of greenhouse gases, have unequivocally caused global warming, with global surface temperature reaching 1.1°C in the 21st century. Global greenhouse gas emissions have continued to increase due to burning of fossil fuel, population explosion, unsustainable energy and land use pattern, forest fires, Industrialization, high energy intensive modern agriculture etc. The earth's climate is changing, and it is evident by changes in the weather pattern i.e. extreme weather events like frequent cyclones, typhoons, tornados, droughts & floods, rise in sea levels and melting of glaciers and sea ice.

A greenhouse is a house made of glass that can be used to grow plants in cold areas. Glass is transparent to lower wavelength UV rays but are opaque to higher wavelength infra-red rays (heat rays). This helps in warming of the glass house. Similarly, CO_2 & other GHG gases in the atmosphere acts as glass of the greenhouse allowing the lower wavelength UV rays to enter the earth's atmosphere but does not allow the higher wavelength Infra-Red rays to escape. This continuously builds up the earth's temperature leading to a phenomenon call global warming.

Atmospheric carbon dioxide concentrations have increased by more than 50 percent since pre-industrial times, from approximately 278 parts per million (ppm) in the late-18th century to 426 ppm as on date. Thus, there is 1.5-fold increase in atmospheric CO_2 in just 200 years which had remained stabilized for millions of years at 280 ppm.

Ensuring a Sustainable Coal Mining and Supply for Thermal Power Plants: Beyond Environmental Compliance

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Mining is one of the major contributors of the growth and sustenance of human civilization and development of nation. Coal plays a crucial role in the generation of electricity and considering the need for economic growth and limited viability of renewables at present, coal will continue to play a formidable role in India's energy scenario.

However, coal mining and allied activities adversely affects the overall environment in and around the coal mining areas. The adverse impacts include land degradation, air pollution, water pollution, ground water level declination, blast vibration, noise pollution, besides having impact on socio-economic status and flora & fauna in and around the area. The paper depicts various environmental impacts and its management due to coal mining and its evacuation.

Environmental Compliance is a continuous process, but it is dynamic and challenging due to changing environmental laws. While compliance is important, but it is not enough just to tick the boxes on a mandatory checklist. Thinking beyond compliance with a robust environmental management system is the need of the hour which can prove beneficial for society. Use of AI tools in monitoring and control of environmental parameters would drive a long way for sustainable environment management.

The environment clearance (EC) and forestry clearance (FC) provisions need strict implementation & monitoring and there is a need to do more and go beyond these provisions for better environmental sustainability. This paper also analyses the various delays in obtaining Environment and forest clearance in different projects and outlines detail analysis of various activities with a view to minimize timeline in other project specially for obtaining clearances for newly allotted coal blocks.

The paper also outlines various activities which would be taken beyond compliance for sustainable development and operation of coal blocks minimizing delay in supplying coal to thermal power plant and promoting environmentally sustainable coal mining.

Exploring Business Opportunities in Biomass & MSW Torrefied Pellets in NCR

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This research paper explores the business opportunities arising from the production and utilization of torrefied Agro residue & Municipal Solid Waste (MSW) charcoal pellets in India's National Capital Region (NCR). Biomass torrefaction, a thermal process that converts biomass into a coal-like material, enhances the biomass's energy density and hydrophobic properties, making it a more efficient and sustainable fuel alternative. The study identifies economically viable locations for setting-up of torrefaction units based on Raw material availability, focusing on selected districts in Haryana and Punjab. The paper examines potential industries for off-take, including high energy-intensive sectors such as steel manufacturing, pharmaceuticals, textiles, cement, paper and pulp, food processing, and metal smelting. Additionally, it highlights the role of thermal power plants in biomass co-firing and the establishment of Eco-Fuel Centres to distribute torrefied biomass pellets to small and micro businesses. A detailed cost analysis of torrefied biomass pellet production covers capital cost components, manufacturing costs, and vendor profit margins. The study proposes a DBFOT (Design-Build-Finance-Operate-Transfer) business model, where entrepreneurs design, construct, finance, and operate the torrefaction units, with the Investor, maintaining strategic oversight and off-take agreements. The paper concludes with a summary of Raw material assessments, prospects for the torrefied biomass pellet industry, and recommendations for stakeholders to capitalize on the identified business opportunities.

The National Capital Region (NCR) faces significant environmental challenges, primarily due to the high incidence of stubble burning, which contributes to severe air pollution and health hazards. Traditional disposal methods of MSW, such as open burning and land filling, exacerbate environmental degradation and greenhouse gas emissions. Biomass torrefaction is a thermal process that converts biomass into a coal-like material known as torrefied biomass. This process involves heating the biomass in an oxygen-deprived environment, enhancing its energy density, hydrophobic properties, and grindability. As a result, torrefied biomass can be used as a sustainable and efficient fuel alternative, offering significant environmental benefits by reducing carbon emissions and providing a renewable energy source.

Strategies for Smooth Commissioning and Stabilization of FGD Systems

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Flue Gas Desulfurization (FGD) systems have been newly installed at NTPC, and during the commissioning and stabilization phases, several operational challenges have emerged. This paper addresses the major issues encountered, such as high gypsum moisture content, vacuum belt filter choking, cracking of gypsum cakes, and inferior cake wash performance. The study integrates laboratory analysis results from the desulfurization system and the corrective actions taken to address these issues. Key factors influencing the gypsum dehydration process, including dust concentration at the system's entrance, disposal of desulfurization wastewater is analysed in detail.

Furthermore, the paper examines the impact of gypsum cyclone operation on the efficiency of gypsum slurry dehydration, highlighting the importance of maintaining optimal cyclone performance for effective moisture reduction. The analysis underscores the need for careful management of system parameters to ensure the efficient operation of FGD systems.

Based on the findings, the paper proposes a series of treatment measures and recommendations aimed at improving the commissioning and stabilization processes. These include optimizing operational conditions, enhancing system design, and ensuring proper maintenance of critical components. By implementing these measures, it is expected that the desulfurization system can achieve safe and efficient operation, leading to better control of gypsum moisture content and overall system performance.

The emissions from coal-based thermal power plants (TPPs) have long been recognized as a significant contributor to environmental degradation and public health challenges. The combustion of coal releases pollutants such as Sulphur dioxide (SO_2), nitrogen oxides (NO_2), carbon monoxide (CO), and particulate matter (PM), which can disperse over extensive areas and transform into secondary pollutants like sulphate (SO_2) in the atmosphere. Recognizing the pressing need to mitigate these impacts, the Ministry of Environment, Forest and Climate Change (MoEF&CC) introduced the "Environment (Protection) Amendment Rules, 2015," which revised and tightened the emission norms for $PM_{2.5}$, SO_2, NO_2, and mercury for TPPs. This regulatory advancement necessitates the installation of Flue Gas Desulfurization (FGD) systems in many power plants across the country to achieve compliance with the stipulated SO_2 emission limits.

Net Zero For Power : A Roadmap For Energy Utilities

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Power sector utilities have vital role in reducing greenhouse gas emissions for achieving net zero emissions in the global fight against climate change. Also, power sector companies are gradually transforming into integrated energy companies with foray into demand side management, EVs, Green Hydrogen and chemicals etc. This paper provides a practical guide for companies operating in energy sector to draft a net zero roadmap, drawing inspiration from different Net zero reports published by agencies like IEA, NITI Aayog, country targets and net zero target of companies and lay special emphasis on Indian context. The roadmap emphasizes setting clear targets, leveraging innovative technologies, and aligning with supportive policies to achieve measurable outcomes.

Researched Net Zero frameworks involves setting ambitious long-term goals, conducting emissions audits across Scope 1, 2, and 3 categories, and implementing targeted reduction strategies. Case studies of global energy utilities like Enel, EDF and Iberdrola highlights intense renewable diversification plans with plans to mitigate Scope 3 emissions in value chain. Technological innovations, such as green hydrogen and carbon capture and storage (CCUS), are key enablers, with CCUS projected to store 7.6 billion tons of CO_2 annually by 2050. Financial incentives, including tax breaks and subsidies, provide critical support for businesses. Collaborative partnerships and phased investments can help overcome challenges like high costs and supply chain complexities. The benefits of a net zero roadmap include regulatory compliance, enhanced brand value, cost savings, and increased investor confidence. By setting actionable strategies and leveraging supportive policies, companies can lead the transition to a sustainable future while securing long-term economic and environmental benefits.

Session -17 : Ash Handling & Utilization

Optimizing Ash Handling Plant Operation from Ash Characteristics Measurable at Power Plant

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Pneumatic fly ash conveying systems in thermal power plants are often not able to transport ash as per their expected duty due to either variability of ash characteristics and/or inadequate system sizing resulting in generation loss and reduced ash utilization. However, even within the practical constraints in an already installed system, there is a scope of optimizing the plant operation (using the existing system/equipment) to achieve reliable ash conveying including controlled ash flow through the ESP hoppers and pipelines. Such optimization is possible by ash properties which can be easily measured by the power plant operating personnel. This paper results from an investigation into the relationship between the physical characteristics of ash to its convey ability and flowability. Based on a test program including the pneumatic conveying (in a pilot plant) and flow property measurement of 23 ash samples obtained from five different power stations of NTPC (Dadri, Mauda, Kaniha, Sipat, Rihand), predictions for convey ability and flowability have been made using angle of repose, particle size distribution and bulk density. The developed guideline will assist operational engineers to predict the flow condition and appropriately control the operating parameters for optimizing the ash disposal rate.

A Novel Approach in Operation and Maintenance Practices Ash Handling Plant (AHP)

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Operation & Maintenance of Compressors, Trouble free operation of Bottom Ash hopper Equipment Clinker Grinder and Lifecycle enhancement of ash slurry disposal pipelines has always remained a matter of concern for ash handling plant. This paper will illustrate a novel approach introduced in mentioned three critical areas. The geography of topics is as under:

(A) Trouble free operation of Bottom Ash hopper Equipment Clinker Grinder: Clinker grinder having frequent gland leakages and gland packing is not sustaining for more than 8-10 days subsequently shaft sleeve life is 3-4 months. To address this failure, an out of the box approach was devised for reasonable modifications in existing design of OEM. This improvement involved challenging and refining the original design of OEM, ultimately enhancing its functionality and ensuring better performance.

(B) Lifecycle enhancement of ash slurry disposal pipelines: ADL includes data oriented predictive maintenance with automated timely alerts. Exhaustive case studies carried out for approx. 20KM of 400NB Pipeline & operational life of pipe gets improved. It helps in uninterrupted ADL functioning, strategic inventory planning & cost saving.

(C) Energy optimization based on centralized data analysis of TAC: Efficient operation of 14Nos. screw compressors based on data, algorithms using energy optimizer developed by OEM & will be 1st of its kind to be introduced in low pressure compressors. Readily available dashboards for all types of alarms like operating parameters, service requirements, communications, trends, process makes control room to get hands on useful data and increase the availability, reliability and energy efficient.

Rare earth and critical elements in coal ash from various Indian power plants

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The recovery of critical minerals from fly ash represents a promising avenue for enhancing resource sustainability and reducing environmental impact. Recent studies indicate significant variations in the concentration of these critical minerals across different power plants, influenced by factors such as coal type and combustion conditions. The total rare earth element (REE) contents in the fly ash were categorized into critical (Nd, Eu, Tb, Dy, Y, and Er), uncritical (La, Pr, Sm, and Gd), and excessive (Ce, Ho, Tm, Yb, and Lu) elements. The outlook coefficient was calculated as a ratio between critical and excessive elements. An Outlook coefficient > 0.7 was considered economically viable ash for REE recovery. In coal ash, the total REE varied from 354 to 569 mg/k; lignite ash, 451 to 2939 mg/kg; biomass and incinerator ash, 147 to 332 mg/kg. Generally, the REE content was significantly less in the bottom ash. However, most fly ash had an outlook coefficient > 0.7, indicating their suitability for the economic recovery of REEs. Data collected from various plants illustrate the potential for fly ash to serve as a secondary source of these minerals, helping to mitigate supply chain vulnerabilities that arise from over-reliance on primary mineral extraction. Despite encouraging findings, significant research gaps remain. There is a need for processing technologies that can efficiently extract these minerals. Addressing challenges, such as the environmental implications of mineral recovery and the economic feasibility of such processes, is essential for practical implementation.

Digital Transformation in Logistics Management for Ash Disposal in Coal Based Thermal Power Plant

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Efficient and eco-friendly disposal of ash remains a critical challenge for coal-based thermal power plants in India. While 100% ash utilization has long been a regulatory mandate for all thermal power plants, the Ministry of Environment, Forest and Climate Change (MoEF&CC) in May 2020 allowed the transport of coal with higher ash content for non-pithead plants, subject to compliance with stringent emission norms. This regulatory change has posed greater challenges for non-pithead plants like Nabha Power Limited (NPL), where higher ash generation necessitates enhanced disposal mechanisms to meet utilization targets.

NPL, a 1400 MW supercritical thermal power plant in Punjab, manages the disposal of ~22 lakh MT of ash annually, dispatching it to cement plants, ready-mix concrete (RMC) units, and other end-users. This paper details the optimization of logistics management for inbound and outbound vehicles involved in ash management, focusing on the digitalized initiative that transitions from manual operations to an automated and digitalized workflow. Key interventions include RFID-based vehicle tracking, real-time monitoring, automated weighbridge systems, and integrated invoice generation.

The implementation of these systems has significantly reduced vehicle turnaround time (TAT), minimized traffic congestion, improved safety. Additionally, the paper addresses the specific challenges posed by higher ash generation at non-pithead plants and provides a roadmap for replicating these solutions across similar facilities in the country.

Strengthening the ash dyke top road using geosynthetic materials for enhancing the ash utilization

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The Ministry of Environment, Forest and Climate Change (MoEFCC) mandates 100% utilization of fly ash and bottom ash by coal-based thermal power plants (TPPs). Major contribution to Ash Utilization currently involves transporting ash to road projects, but movement of Ash Utilization vehicles over ash dyke top is restricted and only crossing of dyke is allowed. This paper explores strengthening ash dyke top roads using geosynthetic materials to enhance ash utilization.

Geosynthetic materials, including Geogrids, Geotextiles, and Geocells, offer a promising solution to these challenges. These polymeric materials enhance road reinforcement, separation, filtration, and drainage, thereby improving load-bearing capacity and road longevity. Geogrids provide lateral restraint and tensioned membrane effects, while Geocells offer stabilization through lateral confinement. Geotextiles act as separators and filters, preventing aggregate penetration and maintaining road integrity.

Strengthening dyke top roads with Geosynthetics can significantly improve ash utilization rates. For existing roads, a combination of Geotextiles and Geogrids can be used to reinforce the subgrade and aggregate layers, reducing maintenance costs, and enhancing road durability. For future dyke raisings, incorporating Geosynthetics in the embankment wherever required during construction can facilitate ash utilization without compromising dyke stability.

A case study demonstrates the cost-effectiveness of using Geosynthetics. Strengthening a 100m stretch of road with Geosynthetics costs approximately Rs. 2.9 lakh, compared to Rs. 6.6 lakh for traditional repairs. This approach not only meets regulatory requirements but also promotes environmental sustainability by reducing legacy ash and conserving natural resourcpes.

Session - 18 : Renewable Energy & Energy Storage

Performance Ratio Improvement of Solar Power Plant Using Re-Binning Technique

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One of the reliability indicators of solar power plant is performance ratio which indicates operating efficiency of the plant. In the present paper performance of the 50 MWp Rajgarh solar power plant modules performance was analyzed with different methodologies like thermography and IV curve testing. IV testing measures the current and voltage characteristics to generate an IV curve of module/ string, identifying issues like shading, soiling, or degradation. IV testing of Rajgarh plant was performed at SMB level, inverter level than plant level. Based on the outcomes of the analysis defective modules were replaced with new one in one inverter block and extracted modules from that block were relocated in other inverter blocks using re-binning technique to maximize the output and minimize the mis-match losses. Comparison of Performance ratio has done on SMB level as well as inverter level and significant improvement has observed after module re-binning & reshuffling process. Year wise performance ratio of station also compared for visualizing the overall impact of process on station.

Transforming India's energy landscape: Role of energy storage in renewable energy integration

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India is the fastest-growing economy in the world and has the second-largest population. This expanding economy demands significant energy and resources. Despite being a developing nation, India has made substantial investments to reduce carbon emissions across all sectors. The country has committed to becoming a net-zero emissions nation by 2070. By 2030, India aims to achieve 500 GW of non-fossil fuel energy capacity, with 50% of its energy generation coming from renewable sources. Of this 500 GW target, 400 GW will be derived from solar and wind energy.

However, achieving these ambitious capacity addition targets in renewable energy poses challenges. According to a report published by Berkeley in July 2024, India is projected to face a power shortage of 20-40 GW by 2027, even if all planned thermal and hydro capacity comes online as scheduled. This shortage is primarily during evening peak hours when solar generation ceases, and wind generation remains highly unpredictable. Consequently, despite having sufficient installed capacity, India could experience power deficits during peak demand periods, presenting a major obstacle to its energy transition strategy.

The solution lies in energy storage. By storing energy during periods of low demand and releasing it during peak demand, energy storage systems can address these deficits. Renewable energy plants equipped with 4-6 hours of storage offer numerous benefits, including frequency regulation, load smoothing, improved utilization of solar and wind capacities, and enhanced grid stability.

Various energy storage options are available, each with distinct applications, capital investment requirements, lifecycle durations, and response characteristics. This paper explores these energy storage solutions, their technical and financial characteristics, and the necessity of energy storage through case studies on grid disturbances. Recommendations are provided to support the development and adoption of energy storage in India.

Las Vegas to Leh - A holistic development approach of Ladakh through Renewable Energy, Agrivoltaic, Green Hydrogen & Energy Storage

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Ladakh was established as a union territory of India on 31 October 2019, following the passage of the Jammu and Kashmir Re-organisation Act. Prior to that, it was part of the Jammu and Kashmir state. Ladakh is both the largest and the second least populous union territory of India. Ladakh is the highest plateau in India with most of it being over 3,000 m (9,800 ft).

Ladakh is a cold desert area and a less developed region of India and it deserves to be given special treatment with regards to allocation of funds and developmental projects. To discuss further on this issue, let's have its comparison or interesting analogy with a similar desert located but a highly developed city i.e. Las Vegas.

Las Vegas was quickly growing and officially was founded as a city and till Oct 1910, strict anti-gambling law was effective in Nevada. Jul 1930, President signed bill for the Boulder/ Hoover dam. Due to dam construction, Las Vegas population swelled from 5000 to 25000 & first gambling license issued in 1931. In 1937, Southern Nevada Power became the first utility to supply power from the Hoover dam. Availability of electricity, dam and lake make it a tourist attraction resulted in growing hotel, resort & casino industry. Atomic explosions at Nevada portray as tourist attraction and later it was the 28th largest city in the U.S., with a population of 661,000.

The tourism industry is a major contributor to Ladakh's economic growth and development, accounting for over 60% of the total revenue generated in the region. Just like its diverse and distinct flora and fauna of Ladakh Region, development of Ladakh also needs diverse ways.

If a dam construction and a casino & entertainment industry can convert a desert like village to a most famous city of world, then Ladakh can also be developed into a peaceful & developed oasis via above ways and means and can lead to multiple ways of revenue generation territory and not instead of only depending on tourism.

During these developments, great care to be taken to preserve the delicate ecology and culture. This can be achieved through the involvement of local population in these developments. In turn this will also bring greater opportunities of education and employment to local youth and bring them in mainstream of country development as whole.

Methanol Firing in Gas Turbines: A Sustainable Pathway for Renewable Energy Integration and Utilization of Gas Asset

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India's target of 500 GW of non-fossil fuel capacity by 2030 emphasizes the critical need for efficient renewable energy (RE) integration. However, the variability and intermittency of RE sources pose significant challenges for grid stability. Gas turbines, with their fast start-up and ramping abilities, can play an important role in energy transition and support expanded RE deployment. Despite this potential, India's 25 GW of gas-based power capacity remains under-utilized due to high costs and limited availability of conventional fuels, such as gas and naphtha.

To overcome these issues, alternative fuels such as hydrogen, methanol, ammonia, and syngas present potential solutions for efficient utilization of gas assets while enabling large-scale RE integration. NTPC's initiatives in carbon capture from flue gases to synthesize methanol highlight its potential as a fuel for gas turbines. Methanol firing can promote a circular carbon economy while advancing decarbonization efforts. Compared to conventional fuels, methanol offers advantages such as lower CO_2, NOx, particulate emissions, along with absence of SO_2.

This paper examines methanol firing in Kayamkulam Gas Turbine, covering system modifications, safety measures, and integration with existing infrastructure. It analyses the current and projected Energy Charge Rate (ECR) of methanol, the potential cost reduction from declining hydrogen prices, and emissions benefits. A phased demonstration approach is proposed, with Phase-I focusing on partial-load trials and Phase-II targeting full-load operation. The study highlights challenges, solutions, and scalability, emphasizing methanol's role in decarbonization, energy transition, and the revival of idle gas assets, setting a benchmark for its adoption across India.

Zerowatt Energy Intelligence system - An IoT & AI solution for increasing energy efficiency, reducing Auxiliary Energy Consumption, increasing profitability, and a sustainable future

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Reducing Auxiliary power consumption is critical for any power plant - Not just for making more power available ex-bus, but also for sustainable planet. Its cardinal for any thermal power plant to maximize the energy sold per unit of coal burnt. While thermal plants adhere to the norms for APC prescribed in the tariff regulations, opportunities for savings remain hidden - due to complex nature of large systems, non-availability of energy consumption data, lack of user-friendly IT systems etc. Some plants have dedicated team (OS / EEMG at NTPC) to critically analyze the opportunities for energy saving. Using the right tools will enhance the efficiency of these teams and helps them to drive the organization towards higher profits and a greener planet.

The intersection of thermal power plant operations and digital solutions requires deep domain expertise rarely found in traditional IT teams. Alphageek bridges this gap by combining six decades of power sector experience-spanning projects, management, commissioning, and operations-with advanced AI expertise led by a computer science PhD. This unique blend of industry knowledge and technical innovation has produced Zerowatt: a pioneering AI-powered platform delivering real-time energy intelligence and optimization insights.

Abstracts of NTPC Papers Selected for Publication in e-compendium

Industrial Augmented Reality for Power Plant

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With applications of transforming digital technologies across all sectors in the world, power sector is continuously engaging in adapting to new technology which optimizes man power and user friendly. Augmented Reality(AR) is one which helps to unlock details about any equipment or standard operation procedure with just one click. It is an interactive experience that combines the real world with computer-generated 3D content .It helps to improve safety standards of an organization with its equipment and job specified procedures onsite with a mobile in hand avoiding human error . This paper includes two projects which use image triggering and location based triggering AR techniques to specify the information and procedures about equipment . Augmented reality demand is in rising trend from past ten years, numerous software platforms are providing various tools and 3D models as per requirement. WEB AR platform is being used for both projects. Equipment cooling water pump's details and procedure for Isolation/Normalization has been fed into AR software and tested at site using Image triggering, Telangana Water treatment plant pump house area used for location based triggering AR, results are satisfactory. Any newly joined or transferred executive could able to trace the line scheme, details of any pipe rack or equipment and could able to understand standard procedures for each job at site itself. Study is going to explore other AR platforms for more user friendly techniques for object based triggering and to monitor Real time parameters using AR facility.

A Novel Approach for Improving Ramp Rate of Supercritical Units by Using Thermal Storage System (TSS)

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This paper presents a solution for improving the ramp capability of a Thermal power plant (TPP). The increasing penetration of high-volatility renewable energy sources in the power system presents higher demands for flexibility from TPP. The study shows the improved capability of the plant flexible operation in supporting the responses to the grid load demand changes in view of the new regulations by CEA to achieve 40% technical minimum load. We are proposing the integration of external energy storage source such as thermal storage system (TSS) into the water-steam cycle which can provide an efficient approach to increase the plant flexibility during peak hours. The use of TSS to the super critical thermal power plant can improve unit stability during ramp up/down, provide better grid stability and reduce DSM charges. The TSS is charged with steam from the CRH, IPT inlet or even from LPT inlet during ramp down and discharge from TSS to CRH, LPT inlet or extractions while ramp up leading to quick response to ramp commands. Currently, the unit's load increase rate under coordinated control mode (CMC) is nearly 1% Po/min, which can now be enhanced to more than current ramp rate using the proposed TSS without revising the original controls. Similarly, the load decrease rate can also be achieved at a higher rate. Three TSS charging and discharging strategies are proposed and analyzed in this paper. Load increase rate is limited by the inertia of the combustion and heat transfer process. Therefore TSS can provide faster response in a range of seconds, thus resulting in instant load response. The proposed control method assists the load increase operations by responding to the load deviation.

Novel Reinforcing and Expanding Technology for Raising Existing Ash Dykes Beyond Ultimate Height

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The ash-dykes are typically conceived with maximum four upstream raisings due to inadequate factor of safety beyond that. In present-day practice, various challenges are being faced in capacity augmentation beyond ultimate height. The existing Buttressing technology has limited capacity enhancement due to use of conventional construction materials and techniques. This necessitates an alternative technology of ash-dyke design beyond ultimate height to sustain power plant generation.

With the various alternatives explored by NTPC, it is now established that existing Ash dykes constructed upto ultimate height can be augmented by novel reinforcing and expanding technology using geosynthetics materials. The feasibility of subsequent raisings of the existing ash dyke beyond ultimate height is explored using reinforcing and expanding technology for constructing Geosynthetic Reinforced Ash Dyke.

The results of assessment of feasibility with proposed technology indicates that additional capacity can be safely created in existing ash-dykes beyond ultimate height using above novel technology. The 5th and 6th raising of the existing ash-dykes beyond ultimate 4th raising is now technically feasible, which without reinforcement was not feasible with steep slope of 1:1.

Unlike the conventional ash dyke, the geosynthetic reinforced ash dyke is constructed with steep side-slopes for higher heights resulting enhanced ash storage area, reduced construction time and economical too, with respect to additional created capacity and time of construction. Through above novel technology, the evolved 'Geosynthetic Reinforced Ash dyke' provides a solution to augment the capacity of existing ash-dykes beyond ultimate raising for upcoming expansion of thermal power plants.

Keywords: Ash dykes, Raising, Geosynthetics, Reinforcing and expanding technology.

Quantum leaps in Wet ash evacuations system to enhance wet ash evacuation capacity - An NTPC Darlipali Experience

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Darlipali Super Thermal Power Station at Darlipali village in Sundargarh district in the state of Odisha. The power plant is one of the coal-based power plants of NTPC Limited. Coal is obtained from Dulanga Coal Block and water supply is sourced from the Hirakud Reservoir on the Mahanadi River through a pipeline at over a distance of about 30.0 km from plant site. The Station is consisting of 2x800 MW (Stage-I) Supercritical Coal Based Thermal Power Plant. Land area is Approx. 2002.66 acres out of which plant area is 996.90 acres.

Day by day coal quality is deteriorating and ash content in coal is increasing, even increasing beyond design parameters of ash evacuation system. In this ever-changing scenario running wet ash evacuation system efficiently in thermal powerplants is a huge challenge. Evacuation capacity enhancement in wet ash evacuation system can be achieved through making quantum improvements in the system. Root cause analysis must be done and suitable efforts to be made to avoid frequent damage to various components of wet ash evacuation system as each component plays an important role.

Micro Blades for Small Centrifugal Pump and Option for Aux. Power Saving in Thermal Power Plant

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This paper focuses the impact of micro blades on performance factors of centrifugal pump impeller, mainly due to slipping between the skin and fluid inside the impeller. The angle of leaving out fluid from the impeller is not similar as compared to the outlet blade angle of the impeller, which results in decreases in the whirl velocity (component) at the outlet and affect it's performance. To overcome this slipping problem the micro blades are introduced on the wall of the impeller and performed a CFD analysis between smooth impeller and impeller with micro blades to compare the obtained results(i.e. head and efficiency). Further, the results shows that the micro blades also reduced the circulation of fluid around the regular blades of the impeller and provides better distribution of velocity. To compensate the work structural analysis has been carried out using FEA for weight optimization with different materials and results are highlighted.

Keywords: Micro Blades, CFD, Centrifugal Pump, ANSYS, Impeller.

Supervised Learning AI integrated centralized data center for power plants

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Generally power plants operators would get alarms when one of the parameters goes beyond alarm level either on the lower side or on the upper side. It does not guide the operator in finding out the root cause of the parameter variation. There are multiple reasons for deviation of a parameter from its normal range, by eliminating those invalid reasons, the operator can zero in on the root cause.

NTPC operates a fleet of power plants ranging from steam turbines to gas turbines of different make and technologies. In the proposed model all data from these power plants will be available at a centralised data centre through a high-speed network (rather than traditionally used measures -PI system). If some critical issue happens then, using supervised learning AI based tools, root cause can be found if the required parameters are available. In some cases, all required parameters for RCA (Root Cause Analysis) may not be available, the AI based system can generate what checks need to be done at site to find out the root cause, which can be validated by first level engineer at centralised data centre. The results of the analysis would be shared with site engineers and control room through mail for corrective actions. This model will reduce the time taken for root cause analysis at site level when they are too busy say for the revival of the unit etc. Moreover, it will give advance information about a system which is going to fail and can suggest for corrective actions in advance.The advantages of this model are

1) It reduces the time taken for root cause analysis in an emergent situation.
2) The learned knowledge can be applied to similar make machines across NTPC
3) Predictive maintenance can be done taken up based on warning from the AI model, thereby machine availability can be improved
4) Operational manpower optimization
5) Equipment safety monitoring and warning at second level (Centralised data centre)
6) Environmental Monitoring and warning at second level (Centralised data centre)
7) Relatively less competent engineers can be deployed for plant operation at site.

Implementation of Integrated Coal Management System at NTPC's all Operating Coal Mining Projects

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In coal mining projects, the transportation of coal from the mine mouth to the railway siding is a critical operational activity. Traditionally, coal transportation relies heavily on manual processes, resulting in inefficiencies, errors, and delays. The Integrated Coal Management System (ICMS) represents a digital initiative by NTPC, to enhance the efficiency and transparency of coal transportation across its coal mining projects.

ICMS is a comprehensive, technology-driven solution integrating RFID-based vehicle access control, GPS-enabled tracking, automated weighbridge systems, CCTV monitoring, centralized data management, and real-time monitoring. Key features include automated vehicle identification, face recognition for drivers, weighbridge automation, GPS based tracking, Multiple geofencing, QR-coded slips for data integrity, and web-based applications with executive dashboards. The system is supported by industrial-grade hardware and onsite maintenance, ensuring over 95% uptime. With due study of latest technologies and available vendors in Indian scenario, ICMS was envisaged and planned for implementation as per site condition, and finally implemented in NTPC's all operating coal mines. While implementing ICMS, the challenges compounded by fragmented data management, security concerns, and safety risks and were addressed in a best possible manner, leading to smooth functioning of the system in NTPC's all operating coal mines, in a large scale and comprehensive manner.

This report covers a brief about coal transportation process from mine end to railway siding, challenges encountered in existing process, and solution offered, i.e. implementation of ICMS by addressing all challenges in a best possible way.

Dam Safety: A New Dimension in Hydro Power: Statistical Analysis of Compliances at Koldam HPS

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Dam Safety has been a domain of universal interest with multi-disciplinary expertise and recent revised and stringent regulations with multi-level monitoring has further highlighted its importance. This paper summarizes comparative statistical analysis of dam failure data across the globe. The failure phenomenon recorded in the historical data were compared with the parameters prevailing at Kodam e.g. most of the dam failures had occurred in the first two years after construction. Koldam is on the safer side as it is approaching about 10 years of age. Several such comparisons were performed with the statistical data regarding type of dam, age of dam, height and storage capacity of dam, Spillway capacity and modernization in dam design philosophy etc.

In recent past, the frequency of dam failure related incidents due to inadequate spillway capacity and mal-functioning of hydro-mechanical equipment has been reported from across the world. At Koldam, due care has been taken in designing spillway capacity after detailed hydraulic and hydrological studies. Scheduled maintenance and testing of HM equipment is ensured to avoid any such untoward event. Effect of GLOF is also analyzed and it was observed that due to sufficient distance of dam from nearest glaciers and in between dam projects, the spillway is safe from GLOF considerations.

Koldam Hydro Power Station is NTPC's flagship installation in the hydro sector situated on river Satluj in district Bilaspur, Himachal Pradesh, India. The dam safety compliances being followed rigorously at Koldam HPS are also elaborated in the paper. It concludes safe dam condition from the analysis of previous dam failure data.

Koldam HPS (2x 400MW) is managing its operation and maintenance activities along with the compliances of Dam Safety Act 2021 with optimal man megawatt ratio. In fulfilment of provisions of Dam Safety Act 2021, Dam safety unit at Kodam HPS is implementing the dam safety related assignment in true sense. A muti-disciplinary dam safety committee with diversified experienced minds has been set up for holistic examination and resolution of dam safety related issues at site level. Detailed Pre and Post monsoon inspections are being carried out with a systematic approach in a time bound manner and as per CWC guidelines.

Replacement/Repair of Power intake gate seal.

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A power intake gate in a hydropower plant is a controllable barrier located at the entry point of the water flow from a reservoir into the penstock, essentially acting as a valve to regulate the amount of water entering the turbine by opening or closing to control the power generation output; it is the primary mechanism to manage water flow into the power plant. To prevent flow of water past a closed gate, seals are provided either on the gate or on the metal frame in the gate slot. Rubber is the most commonly used material for seals, as it is elastic, deforms readily and regains its original shape on removal of load. There are 04 Nos 6.45mX6.5 m vertical intake gates (hydraulically operated) at NTPC Koldam. There is specified permissible water leakage past a closed gate and at NTPC Koldam it is 250 LPM approx as per design. For past few years, it was observed that leakage in intake gate#3 was way beyong permissible and was unmeasurable at penstock drain collected at dewatering pit. Therefore seal inspection/replacement was planned in September 2024 along with unit shutdown. First stop logs were installed in upstream of intake gates to isolate the gate from the reservoir. Then water tight door (bolted) was opened and access to penstock at downstream of gate was made. On inspection of gate it was found that bottom clamp plate along with bottom seal was torn/damaged in the middle section. Then new clamp plate (6600mm X 105mm) with 18mm dia holes was fabricated at site. It was also observed that holes thread for clamping screws in gate structures were damaged and the split head screws thread were not getting locked and remained loose. Then M18 dia holes were tapped in gate structure(bottom part). Split head screws were replaced with counter sunk screws with allen head to ensure proper tightening of the clamp plate, new bottom rubber seal and the gate structure. Gap measurement in bottom seal and sill beam of the gate was done through feeler gauges and feeler gauge of thickness 0.1 mm was no-go. Replacement of damaged bottom seal/clamp plate with new was completed. After that side seals were inspected and found to be intact. For accesing top seal of the gate, bonnet cover manhole was opened and access was done for gate top seal/associated parts inspection. The seal condition was intact. Hydraulic cylinder piston pin connected to gate was cleaned, lubricate and painted to avoid rusting. All the seals were lubricated. Water tight door was closed with bolts and tightened with 2T chain pulley to ensure water tightness.

Enhancing Solar PV Performance through Radiative Cooling

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Solar photovoltaic (PV) technology offers a promising solution to the world's growing energy demands. However, the efficiency of solar panels is negatively impacted by rising temperatures, which can lead to decreased power output and accelerated degradation. Radiative cooling, a passive cooling technique that exploits the "coldness" of outer space, has emerged as a viable method for enhancing the performance and longevity of PV systems. This paper explores the current state-of-the-art in radiative cooling for solar PV applications, examining various techniques, including selective emitters, planar structures, aerogels, and hybrid cooling systems, along with their effectiveness and associated challenges. Furthermore, it proposes potential solutions and novel approaches to overcome these limitations and discusses the potential benefits of integrating radiative cooling into solar PV systems.

Radiative cooling operates on the principle that any object with a temperature above absolute zero emits thermal radiation. However, for effective radiative cooling, it is essential to have selective emission in the atmospheric window (8-13 µm), where the atmosphere is transparent to allow heat to radiate directly into outer space [3]. This approach has gained significant attention in recent years due to its potential to enhance the performance and longevity of solar PV systems without the need for external energy input.

Unleash The Power: Improving Compressed Air System Efficiency by Reducing Ambient Temperature (Case Study & Implementable Ideas)

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Operation of ageing units at optimized heat rates and rated capacity is challenging under the present power sector scenario with stringent operating norms. Compressed air system is a vital component of power plant immensely affecting their profitability. Significant, yet often hidden thermal performance losses occur in compressed air systems. Compressed air system which does not perform as specified leads to higher overall coal consumption than expected. This in turn leads to lower plant output and higher plant heat rates.

The compressed air system is not only an energy intensive utility but also one of the least energy efficient. Over a period, performance of compressed air system reduces drastically. Capacity of a compressor is the full rated volume of flow of gas compressed and delivered at conditions of total temperature, total pressure and composition prevailing at the compressor inlet termed as FAD.

The objective of this paper is to present a case study and relevant ideas for improvement of efficiency of compressed air system. Theoretically, each 4 degree C decrease in intake temperature of compressor results in 1% increase in efficiency of compressed air system. For reducing the inlet air temperature, chilled water can be used from the existing HVAC system. The chilled water is to be circulated through coils at the openings from where the atmospheric air enters compressor house. The air will pass through these coils and by losing heat, the air will be comparatively colder. FAD of compressor will increase due to increased density of intake air.

Optimizing Chimney & Canal Infrastructures of Thermal Plants for Energy Storage With Eco-Friendly Power

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In the future, there will be number of abandoned oil-gas wells, coal mines with the exploitation of onshore fossil resources. However, the similarity of large height difference between Chimneys of thermal plants within oil-gas wells, mines can be used as a building block for gravity power generation, thus maximizing the economic value of abandoned oil-gas wells, mines which can also be adopted for high rise chimney stacks in thermal plants. In this study, a scheme of gravity power generation by spud-in casing depth of oil-gas wells is proposed, and a gravity power generation model based on high rise structure is established. The parameters and economic benefits of gravity energy storage are calculated for Chimney Stack as well as for oilfields in case Study. It is shown that the power density and discharge time of the gravity energy storage system in Chimney Stack & abandoned oil-gas wells are suitable for distributed power generation. In addition, to the fast response characteristics of energy storage in Chimney Stacks along with specialized river turbine technology capable of providing steady state power, this hybrid system is suitable for providing continuous and sudden frequency and voltage changes in the power grid. Furthermore, the leveling cost of storage of the gravity system in Chimney Stack & abandoned oil-gas wells with river turbine technology is more economical with a high number of annual cycles.

Latent Heat Based Solar Energy Storage System

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Today 82% of energy demand is met by fossil fuels. India's electricity consumption is third of global average, and as per NITI Aayog India's energy consumption in 2020 was 6200TWhr which is set to triple by 2050 and minimum demand for electricity as 21000 TWhr by 2070. Increased emission has led to rise in global temperatures, and to contain this within 1.5°C of pre-industrial levels many countries have pledged their commitments to meet them. India's stand at COP26 is to have 50% of its energy met by renewable energy sources by 2030 and net zero emissions by 2070. India receives good amount of sunlight and has tremendous potential. Solar energy generates power during the sunshine hours. This paper focuses on Latent Heat based Solar Energy Storage System, a suitable solution for ensuring continuous supply of energy through renewables during non-sunshine hours to the grid. Thermal Energy storage system use a medium either its sensible heat, or latent heat, or thermochemical heat or combination of these to store solar energy. Concentrated Solar uses a combination of mirrors or similar reflective surfaces to focus the beam radiation onto a receiver. This receiver houses Thermal Energy Storage (TES) medium to capture and store the heat and exchanges its heat with water to generate steam which eventually drives the turbine. This paper also highlights the problems faced by Latent Heat Energy Storage Systems and suggests solutions, ensuring that our climate goals are met.

Optimization of ESP Performance: A Multi-Dimensional Approach Followed to Reduce Stack Particulate Emission Levels

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As per the latest environmental norms for TPPs, the limit of suspended particulate matter (SPM) emission for 500 MW units installed before 31st Dec 2003 is 100 mg/Nm³. The SPM emission levels of 500 MW units of Singrauli Super thermal power station (SSTPS) were quite high and was beyond acceptable limits. Hence, investigations were carried out to analyze the poor performance of ESP based on a multi-dimensional approach i.e. problem identification in mechanical, electrical and electronic aspects. Comparison of all the parameters related to ESP were also done with VSTPS 500 MW units. This helped with better understanding of the problems related to our ESPs. A study was conducted regarding similar problems and action plans in other plants.

In this paper, we have discussed various problems that were identified after extensive investigation of the ESPs at NTPC Singrauli. The action plan was then formulated to mitigate those problems and has been discussed in detail in this paper. With the proper execution of the same, a marked improvement in the performance of ESPs of both unit 6 & unit 7 were observed and emission levels as a result were reduced by around 200% & it came down to less than 70 mg/Nm³ (i.e. within prescribed acceptable levels). The results were noted on a daily basis by operation engineers to determine the improvement in the parameters related to the ESP.

This paper also suggests that similar methods can be applied to other thermal power plants as poor performance of ESP is a common problem. This technique of problem solving can go a long way in solving ESP issues and may also contribute to making thermal power plants sustainable for longer durations.

Flexible Operation of Thermal Power Plants through BESS

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India's transition to a sustainable energy landscape requires significant changes in the operation of thermal power plants (TPPs) to integrate variable renewable energy (VRE) sources like solar and wind. This paper explores the flexibilization of TPPs to operate efficiently at lower minimum technical loads and respond rapidly to fluctuating grid demands, ensuring grid stability and optimizing renewable resource utilization. The challenges of retrofitting TPPs for flexibility, such as technical, economic, and regulatory hurdles, are examined.

Battery Energy Storage Systems (BESS) are proposed as a solution to enable flexible operation of TPPs. BESS can store surplus energy during low-demand periods and release it during peak hours, reducing strain on thermal units, enhancing grid stability, and ensuring compliance with new operational norms. Case studies of NTPC units and projections for future energy demand highlight the potential of BESS to mitigate the technical challenges of flexibilization, such as ramp rate enhancements and lower minimum technical loads.

Despite challenges like high costs, limited battery durability, and safety concerns, advancements in battery technology and government incentives are expected to improve BESS adoption. By 2030, the levelized cost of storage is projected to decrease significantly, making BESS a viable option for India's power sector. This study emphasizes the critical role of BESS in balancing India's energy transition while safeguarding the economic viability and functionality of TPPs.

APC saving Through CEP VFD- An NTPC Dadri Experience

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A more specific definition was put forward in IEA (2011): "Flexibility expresses the extent to whicha power system can modify electricity production or consumption in response to variability, expected or otherwise." IEA (2014) introduced a distinction between a broader concept of flexibility and a narrower concept of ramping flexibility: "In a narrower sense, the flexibility of a power system refers to the extent to which generation or demand can be increased or reduced over a timescale ranging from a few minutes to several hours."

So, during these operations, it is also important to optimize auxiliary power consumption of all equipment which can be run at low power. Condensate extraction pumps are running at full speed at all load conditions and differential pressure is taken care by deaerator level control valve opening. Instead of keeping CEP pumps running at full load, It is better to run CEP through VFD control at different speed as per system requirement, which not only will save power but also increase equipment life.

NTPC Dadri demonstrated that 40 per cent minimum load operation at the 490 MW Unit 6 of the Dadri Thermal Power Station requires a capital expenditure of around Rs 200 million. However, no major retrofit is required if the unit were to operate at 55 per cent load. Modifications in operational procedures and control system tuning will be sufficient to operate the unit at 55 per cent load. There would be an increase in the O&M cost, decrease in efficiency due to increase in heat rate, increase in auxiliary power consumption, and increased oil consumption due to frequent start/stops and faster deterioration of power plant equipment. the increase in operational costs is estimated to be in the range of Rs 0.05-Rs 5.64 per kWh for a typical 200 MW/210 MW unit and Rs 0.01-Rs 6.18 per kWh for a 500 MW unit. For improving flexibility and not to lose in APC front, it was decided for installation of CEP VFD in Stage-2. Cost of installation of VFD in CEPs for Dadri Stage-2 is Rs 4.5 crores approx. At present at full load of a 490 MW unit, power saving of Approx 300 KW for each Unit and 600 KW in both units is being achieved amounting to saving of approximately Rs. 2,65,23,000 at full load operation (considering Rs. 4.50 per KWh).Payback period comes out to be less than 2 years, so it is win-win situation for Dadri and new technology implementation.

Artificial Intelligence/Machine Learning-Based Condition Monitoring and Predictive Maintenance pilot project at NTPC Kahalgaon

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The first of a kind pilot project in NTPC limited aims to leverage Artificial Intelligence (AI) and Machine Learning technologies in condition monitoring to radically transform the way predictive maintenance is done at power plants. Currently, predictive maintenance in NTPC Ltd. is carried out with scheduled vibration data collection by data collectors which are processed by software and analysed by a vibration analyst, whose recommendations form the basis for predictive maintenance decisions. With the implementation of artificial intelligence, recommendations can be generated in real-time, allowing for immediate equipment diagnostic. Additionally, the pilot project utilized cloud computing and edge computing technologies to deliver reports to users via desktop or handheld devices.

Data acquisition is achieved using sensors mounted on equipment. The data collected is transmitted wirelessly to the cloud, where it is processed using AI software. The processed reports are then sent to a configured platform accessible from desktops and handheld devices.

The pilot project was conducted in phases. Four equipment were selected based on equipment criticality and accessibility in the first phase. Sensors and junction boxes were installed in the second phase. In the third phase, equipment-specific data was input into the AI software, and user accounts were created in the data analytics platform to enable access to machine conditions and trends. The dashboard offers display such as machine learning status, instantaneous parameters, and frequency spectrum. The system is generating automated alerts based on the equipment condition and saving potential downtime.

AI based safety enhancement at Wagon tippler

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The implementation of an AI-based camera system at Wagon Tippler No. 6 in Mouda represents a significant advancement in operational safety within the industrial sector. This initiative, developed in collaboration with corporate safety and planning teams, aims to address existing safety hazards associated with the proximity of workers to moving machinery, particularly in high-risk areas such as near the Side Arm Charger and Wagon Tippler cradles.

Current Safety Concerns. The primary safety risks identified include:

Worker Entrapment: Employees are at risk of being trapped by moving machines such as side arm chargers and wagons.

Accidents During Operations: The in-haul and out-haul activities pose potential dangers to workers in the WT cradle area.

Lack of Immediate Alerts: The current system lacks timely notifications for safety violations, increasing the likelihood of accidents.

PPE: PPE compliance for workers, working near the vicinity of Wagon tippler is done by manual checking.

System Overview

To mitigate these risks, 08 AI based cameras have been strategically installed to monitor compliance and enhance safety protocols. The system's features include:

Detection Capabilities: The cameras utilize advanced algorithms to identify personnel and machinery within predefined zones (In-haul, Out-haul, Hopper), ensuring compliance with personal protective equipment (Safety Helmet, Safety Jacket and shoes) standards.

Response Mechanism: Upon detecting any violations, the system can trigger alarms in control room, one hooter near in haul side, WhatsApp and email notifications and Stop operations of Wagon tippler and SAC, thereby reducing risks effectively.

Identification of Causes of Shortfall in Unit Heat Rate and through Planning & Execution, Completing Modification Work in 54 Days against Scheduled 60

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NTPC Mouda Super thermal powers station Stage-2 had 2X 660 MW units which was erected at NTPC Mouda by M/S BHEL with technical collaboration with M/S G.E. Power, the erstwhile Alstom Power.

Since Commissioning there was a Heavy shortfall of HRH temperature by almost 45-50°C i.e Actual HRH Temperature which we are getting is 541°C to 555°C Against a design pressure of 596°C and also Boiler Flue Gas Exit temperature was Maintaining High by 20°C i.e Actual Flue gas Exit temperature was 148°C against a design temp of 125°C which resulted in a Heavy loss of heat rate by almost 30-45 Kcal/ KWH, nullifying any benefit of higher efficiency of supercritical Units. This Issue was taken up with M/S BHEL repeatedly and for complying with PG test requirement, it was decided to carryout Few modifications in the boiler to meet the design specifications.

Also, there were some other issues like.

1. High SH Spray of 76 TPH observed during Full Load Operation & 46TPH at Low Load operation observed (Indicates Design value of SH Spray Flow is High & also a high surface area margin was there in SH circuit).
2. High vibration of back pass bottom and huge ash accumulation over the extended floor panel.
3. Separator Safety valve passing issue due to under design for 8 No.
4. Huge Ash Accumulation was observed on Boiler Extended Floor Panel
5. The APH soot blowing pressure was maintaining less only 8 to 12 Ksc.

The present study was aimed at identifying the causes of the Heavy Heat rate loss and through planning, engineering and finalizing and execution of proposed RH Modification work in Boiler for Improving Unit Heat rate within Shortest possible time.

Emerging Dimensions for Seismic Upgradation Of Thermal Power Plants

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Several infrastructure development projects were undertaken in the country in early 1980s and 90s particularly for large capacity thermal power addition and majority of plants commissioned earlier are still operating. Indian Seismic design code was first released in 1962 and current revision is 2016. The proposed next revision of the seismic code for new constructions is in advance stage of finalization by BIS and expected shortly. A separate draft Code on earthquake safety assessment and retrofit of structures has also gone for country wide circulation and is in process of up-dation. Once released, existing structures will be required to be assessed and retrofitted. This paper focuses on seismic upgradation requirements for thermal power plants which may arise in future in view of above developments.

About 150 Thermal power stations with capacity more than 200 MW constructed in last 30 years have been studied as per current and proposed seismic codes. The plants have been segmented in <10, 10-20 and >20 years age group. It is seen that many stations have been updated to higher seismic zone in the proposed revision. For such projects, there is significant gap in existing capacity to withstand upcoming requirements and need for seismic retrofitting would be an emerging dimension in the days to come.

Paper discusses a few technological developments related to retrofitting of power plants. Being emerging field, considerable research and development efforts would be required for development of indigenous technology. Policy framework would be needed to consider seismic retrofitting expenditure in tariff determination.

Advanced Methodologies for Precision Measurement of Pin Rack Assemblies in Air Preheaters of Thermal Power Plants

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Air preheaters (APH) are critical components in power plants, enhancing thermal efficiency by recovering waste heat from flue gases. The precise alignment of mechanical components, particularly the pin rack assembly, significantly influences the performance and reliability of APHs. The pin rack assembly enables the rotor's smooth rotation, but improper measurement or misalignment can lead to excessive vibration, wear, and mechanical failures. Replacing a damaged pin rack assembly demands meticulous precision, considerable time, and expertise, resulting in prolonged downtime and costly generation losses for the power station.

Conventional methods for measuring radial and axial runouts in pin rack assemblies often rely on manual processes involving dial gauges. These approaches are prone to inaccuracies due to setup disturbances, coordination issues, and potential damage to instruments during air preheater rotation. Such challenges underscore the need for more reliable, precise, and efficient measurement techniques.

This paper proposes a comprehensive methodology for accurate measurement and inspection of pin rack assemblies using specialized tools and advanced technologies. By incorporating modifications such as circular-tipped fixture for dial gauges and innovative solutions like laser displacement sensors, the process becomes more reliable and less labour-intensive. The methodology ensures optimal alignment, reduces maintenance downtime, and enhances the operational lifespan of APHs.

Additionally, integrating technologies like IoT-enabled sensors, AI-based predictive maintenance, and robotic measurement systems further improves accuracy and efficiency. This approach offers a practical solution to minimize operational disruptions, ensuring long-term reliability and performance of air preheaters in power plants.

Unified DSM System at NCPS-Dadri-Thermal (a pilot project).

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Effort to bring discipline in the grid operations started with the introduction of Availability Based Tariff (ABT) by the Central Electricity Regulatory Commission (CERC) in 2002-03, to control grid frequency, prior to which the regional grids faced large frequency fluctuations, ABT introduced the concept of generation and drawl schedule to be given by the generators and the beneficiaries on a day-ahead basis. Any deviation from the scheduled generation and drawl on the day of operation is settled through Unscheduled Interchange (UI)/Deviation settlement Mechanism (DSM)- under which the prices for settlement of deviation are linked with grid frequency. Grid Regulator provides scheduled generation (SG) to power generators according to which power is to be generated. Power generation schedule for the day is provided in 96 blocks & each lasting 15 minutes. The average power generated by generators in 15 minutes block is termed as Average Generation (AG). AG should align with the SG to maintain grid stability. Any deviation between the SG and AG is termed as Deviation or Unscheduled Interchange (UI), which can significantly impact the stability of the grid.

To manage generation as per the SG for incentivizing Deviation/UI supporting grid stability or avoiding - penalizing Deviation/UI, which is de-stabilizing grid frequency, an ABT/DSM application is developed & installed across the generating stations through different vendors, which provides details of SG, AG, and UI to operators in power stations so that they can manage generation in accordance with the grid regulations, recent regulations on Ramping, AGC, DSM & other issues with vendor based ABT/DSM system, necessitated a revised ABT/DSM system for efficient commercial operation of units .

The ABT system in use, prior to the implementation of " Unified DSM system" at NTPC Dadri was a PI based-"Unified ABT system" developed by NTPC-COS & site IT, that was utilizing ABT system data, through PI interface & PI tags to derive- AG, Unit loads, Frequency & other parameters-like AGC data from DCS LAN through the PI interface, but owing to the limitation on accuracy & speed of PI-based system & presence of multiple system interfaces - using IT-LAN , the system availability & the data acquisition was not as accurate and fast as per the requirement of the ABT/DSM to optimized the plant generation & sometimes it led to commercial losses .

Managing the Coal Show at NTPC North Karanpura with Trucks: A Case Study

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A 3X660 MW base load supercritical thermal power station like NTPC North Karanpura annually consumes about 100 LMT of coal at a nominal PLF of 85%. Such huge quantities of coal are usually sourced through railway wagons either through MGR networks or using that of Railways. In case of mines located very close to the plants, as is the case for North Karanpura, conveyors are an economic alternative for coal transport.

A 7.5 km long pipe conveyor is in the works for quite some time and as it sometimes happens with large projects, the units became ready for commissioning well before the pipe conveyor. Faced with a proposition of losing out commercially on account of foregone Fixed Charges, a contingency arrangement was made by shifting some of the coal unloading infrastructure from mine end to plant end and run the units by sourcing coal through trucks. Feeding two units with trucks has been extremely challenging yet a professionally satisfying experience, as the station rose up to the challenge and managed to recover full fixed charges for the first two years through this contingency arrangement. The pipe conveyor still appears some time away and preparations are on to run the third unit as well in the same fashion.

This is a case study not only about operating a super thermal power plant through coal trucks but also about continuing the legacy of the famed "Can do!" spirit of NTPC and never backing down in the face of a challenge. It details the several measures that were undertaken to make this contingency arrangement successful, viz. making elaborate road traffic safety arrangements; removing the bottlenecks in coal unloading; expanding the temporary storage capacity; increasing coal rehandling capabilities; deploying a mobile crusher; and many more. This case study can also be a ready reckoner for any power station that suffers any force majeure disruption in its rail system threatening to disrupt coal supply for a long time. Building upon this long-term experience and customizing it to their site conditions, a similar contingency arrangement may be put in place without compromising on the station's generation.

Design Matrices for a Cyber Resilient OT (Operational Technology) Infrastructure

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Safety of personnel along with hardware and software components of an industrial process from unauthorized access or attack, leading to disclosure/destruction of physical and financial indices of a system, should be the aim of cybersecurity of OT (Operational technology). The easy availability of services in the form of hacking/fraud, the threat landscape of OT has increased manifold. Air gapped control, no connection to internet, perception of limited knowledge of hackers in safety systems and OT are now considered a myth. Aligning the priorities of CIA triad with health, safety and environment will ensure conformance of scripting a true cyber secured architecture for OT vis-a-vis IT security requirement. Availability of time critical OT processes having special applications should be of highest priority with paramount importance to risk management goals of minimum risk impact to life, process and business.

Defense in depth architecture comprising of multiple zones and conduits along with detection, accountability and timely incident response should be considered in design, engineering, commissioning, operation and maintenance of OT. Adherence to NIST framework while framing the cybersecurity policy, baseline, guidelines and procedures with due care and due diligence w.r.t. business continuity plan and mandatory compliance to government regulations is essential.

Drawing parallel from ISMS (Information security management system), a CSMS (cyber security management system) is to be formulated with periodic audits and compliances. The basic life cycle comprises of identifying individual OT assets, allocating them into zones and conduits, performing risk assessment, applying countermeasures based on target security level to be achieved and maintaining with change management and incident response and recovery. It is important to balance the benefits of risk reduction against the cost of security measures to mitigate the risk while achieving a certain security level.

Considering security right from the product lifecycle, development lifecycle using a capability maturity model for OT controllers, HMI, network and software application ensure security of OT components. Cryptography, blockchain technology, use of digital verification and testing/blanket compliance against backdoor are key measures to prevent malware/trojan intrusion in supply chain management (SCM). Concept of hardware security to obfuscate IC layout, countermeasures against side channel attacks is to be introduced.

Absolute Block Working Through Radio Link: Improving Safety & Reliability in MGR Operation

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NTPC is largest power producer in India with installed capacity of the NTPC group is 76,598 MW & generating about 25% of total electrical power requirement of the country. NTPC has 36 Nos of Coal based thermal power plants having capacity of 62,194 MW. Most of these plants are getting Coal through rail network and number of plants are situated near Coal mines (pit head) having captive Rail Network (Merry Go Round System) for transportation of Coal from linked mines. Timely & continuous supply of Coal is vital for running these plants, which requires healthy transportation system (MGR). Signalling & Telecommunication (S&T) ensure safe movements of rakes through proper interlocking of points/signals etc. and efficient utilization of Rail Track.

To run coal rakes safely & efficiently, proper functioning of Signalling & Telecommunication (S&T) is most essential. Absolute Block Working (ABW) is core principle of S&T to run rake safely between stations. ABW is a system which ensures one train in one section of Track at a time.

Earlier, Copper cables has been used, in NTPC stations, as communication media which are laid along the track between stations which are around 10 to 20 kms apart and outside plant boundary. Copper is a costly material hence it is prone to thefts/sabotages. As of today, most of NTPC Stations are suffering from similar problem with Cu cable because of which Absolute Block Working is not functioning, which has compromised safety in rake movement.

Proper functioning of ABW is essential to ensure safe movement of rakes.

Telecommunication is a field where change is constant, probably no other field will be going through such changes so rapidly & to be relevant, the equipment/system needs to adapt such changes quickly. Time has come now to change to better media to replace Cu cable for above requirement.

Use of wireless technology (Radio Link) in S&T System for inter station communication, with latest available equipment, aimed at overcoming the shortages of conventional Copper Cables, is brought forward. With the rapid development in communication technologies, it offers many advantages over the conventional system.

Enhancing reliability of Plant critical equipment by Predictive maintenance (Condition monitoring) using Vibration spectrum analysis

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Predictive maintenance of Plant equipment is a power full tool which empower us for reliable & sustainable generation without any major breakdown as well keep our critical equipment healthy which is important part of plant equipment asset management. Condition monitoring is a management technique that uses regular evaluation of the actual operating condition of plant equipment and systems with the objective of optimizing plant operation cost. Most failures in rotating equipment develop progressively rather than arising suddenly. Most incipient failures cause changes in the vibration characteristics or vibration signature of a machine and these changes can be detected as the condition of a machine deteriorates. Vibration monitoring and analysis is the single most reliable technique responsible for Rotary Machines Diagnostics. Spectrum analysis is a vital part of Vibration Analysis. Vibration spectrum analysis is a method of measuring and displaying the vibration signals of a rotating machine.

GREEN AMMONIA CO-FIRING: Pathway to Decarbonize Thermal Power Generation

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This paper explores the implementation of green ammonia co-firing in Thermal Power plants, focusing on its feasibility, benefits, and roadmap. Green ammonia is an innovative solution for decarbonizing thermal power plants by reducing greenhouse gas (GHG) emissions and promoting renewable energy integration. This study aligns with India's commitment to achieving net-zero emissions by 2070 and highlights the technological, economic, and environmental dimensions of the proposed pilot project.

Impact of Ground Potential Rise (GPR) on Turbogenerator Shaft Vibration Monitoring System During External Grid Faults-A Case Study

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Grounding system is an essential part of electrical and C&I installation as it helps in eliminating electrical shock hazards and provide zero voltage reference point for the equipment. Ground Potential Rise (GPR) or Earth Potential Rise is a phenomenon that occurs when large amounts of electricity enter the earth. When currents of large magnitude enter the earth, electrical potential of grounding system increases. This rise in potential of ground caused by fault in the system is potential hazard for the equipment including monitoring devices. When grounding system is not as per standards, the GPR may influence the protection and monitoring of operating system and cause undesirable tripping. This case study will provide the details on impact of GPR on turbogenerator bearing / shaft vibration monitoring system and methods to manage GPR without sacrificing our machines.

Liquid Air Energy Storage - The Missing Link in Energy Sustainability

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Liquid Air Energy Storage (LAES) is a breakthrough technology addressing the challenges of renewable energy integration and grid stability. By utilizing liquid air as a storage medium, LAES provides a scalable, environmentally friendly, and efficient energy storage solution. The technology operates through air liquefaction, storage in insulated tanks, and re-gasification to generate electricity on demand. Unlike conventional batteries, LAES does not rely on rare materials, making it a sustainable alternative for long-term use.

This paper explores the technical, economic, and environmental benefits of LAES, with a specific focus on its integration into NTPC's operational framework. A case study on NTPC's planned 200 MW LAES facility at Tanda highlights its potential to enhance grid reliability, provide peak load support, and achieve significant economic returns with an estimated payback period of four years. By leveraging waste heat recovery and modular deployment, LAES offers high round-trip efficiency (~70%) and flexibility in site selection. Paper has proposed 'Four implementation strategies' by which LAES can be integrated into NTPC thermal and renewable portfolio.

As renewable energy continues to expand, LAES emerges as a critical enabler for achieving sustainability goals. Its ability to provide ancillary services such as grid inertia and reactive power compensation further underscores its value in modern energy systems. NTPC's adoption of LAES exemplifies its commitment to innovation and sustainability, paving the way for broader implementation of this transformative technology.

Development of Sustainable and Cost-Effective Strategy for Corrosion Mitigation.

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Simhadri being near to coastline faces a chronic problem of corrosion. This problem is exacerbated by the drafts from NDCT Stage 1 and 2 and ash Water sump, moisture laden air from forebay, and fumes of DM plant. Severe deterioration in Trestles, steel structures, pipelines is observed due to corrosion. Corrosion causes the progressive deterioration of material properties, resulting in the destruction of the structure. Hence, for improving lifespan and performance of Steel structures it is very important to implement a corrosion management strategy. Devising proper preventative corrosion management and reduction measures is important for plant sustainability, efficiency, cost management and improved safety of personnel. Actions taken for corrosion management are

1. 3 coat Painting of steel structures, pipelines, trestles as per rolling plan (devised based on site conditions). Annually 6-7 Lakh square meter area is being painted as per rolling plan.
2. Application of Marine grade painting (Norshok-M501 standard) in area susceptible to high corrosion.
3. Sea water jetty pipelines painting by slag blasting with SA 2.5 surface cleaning & 450-micron DFT coating.
4. Corrosion Management study for
    a. Using scientific approach for Estimation of rate of corrosion at NTPC Simhadri to determine different zones of corrosion based on environmental conditions. Development of mathematical model for different zones using CFD modelling to estimate futuristic corrosion rates & refining painting rolling plan.
    b. Establish the optimum painting formulation through fundamental investigation and characterization suitable for NTPC, Simhadri and Identify suitable advanced coating techniques to minimize the corrosion specific.

Reliable & Sustainable Generation, Asset Management and Energy Transition

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As renewable energy integration continues to expand, many steam turbines are increasingly required to operate at partial or technical minimum loads, deviating from their original design parameters and performance expectations. This operational shift places additional strain on turbines, leading to increased stress and erosion, particularly in the last-stage buckets, which are critical components in the turbine's efficiency and longevity. Recent failures of last-stage turbine buckets in power plants have resulted in major outages, significant generation losses, and high repair costs, underscoring the critical need for improved monitoring systems. Ensuring the reliable performance of steam turbines is therefore essential for maintaining the continuous and efficient operation of power plants, especially in the context of evolving grid demands.

The last-stage turbine blades (buckets) are particularly vulnerable to a range of failure modes, including erosion from steam flow, fatigue cracking due to cyclical stresses, and material degradation from prolonged exposure to high temperatures and pressures. If undetected, these issues can lead to catastrophic turbine failures with severe operational consequences. Traditional monitoring systems typically rely on periodic inspections, which often miss early-stage damage, increasing the risk of unexpected failures.

In response to these challenges, this paper presents an advanced version of the Blade Health Monitoring (BHM) system, initially developed for gas turbine compressors, now adapted for real-time monitoring of last-stage turbine buckets in steam turbines. The enhanced BHM system combines a comprehensive array of sensors, including strain gauges, acoustic emission sensors, and vibration monitors, to provide continuous condition monitoring. These sensors feed data into a sophisticated signal processing framework that detects early indicators of potential damage, such as changes in vibration patterns or unusual strain distributions.

Furthermore, the system incorporates machine learning-based anomaly detection models, which analyze sensor data to identify deviations from normal operating conditions, enabling the prediction of potential failures before they occur. This predictive maintenance approach helps to extend the operational life of turbines, reduce the risk of catastrophic failures, and minimize costly unscheduled downtimes.

Performance improvement of HVAC system

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Today, HVAC (heating, ventilation, and air conditioning) systems have become an integral part of modern buildings and are designed to provide comfortable indoor environments while conserving energy and reducing carbon emissions.

At NTPC Kudgi heart of HVAC system for main plant is 3 working and 2 standby Chillers.

They cater the requirement of HVAC for all 3 control/panel rooms and UPS battery room (with temperature less than 24 °C).

The system was running with all working and standby chillers to maintain the temperature parameters. The root cause was fouling of the Heat exchangers

With the Automatic Tube Cleaning System implementation in HVAC system, the number of chillers required to keep in service is reduced. The power consumption is reduced. The electricity cost savings are approx. 1.54 Cr per year. The operation is fully automatic, and it keeps chiller condenser clean and increases effectiveness of the chillers (verified from CER Temp / Power Consumption / Cond. Approach / no. of Chillers in service). The overall maintenance required is also reduced.

The system is now running with higher performance and lesser number of chillers than design i.e. 1-2 chiller in place of 3 nos. This results in power saving of 3.32 mu/year before ATCS installation and 1.04 mu/year from designed system.

ATCS has great potential to replicate in other NTPC plants where, shell and tube coolers where water quality is poor and requires manual cleaning repeatedly.

A Case study on improvement in Cooling Tower performance by installing Helper cell

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Cooling tower is vital component of any Thermal Power plant. The primary task of a cooling tower is to reject heat into the atmosphere. About 55 % of total heat input to the plant is finally dissipated as waste heat. In a steam power plant, due to increase in cold water inlet temperature to condenser the performance deteriorates, and the heat rate increases to a considerable amount which causes financial losses and in adverse situation it affects capability i.e plant generation. In Rihand Stage-3, Induced draft counter flow cooling tower is having 36 nos Cells (18 CT fans in each unit). Helper cell cooling Towers (CT) for Unit # 5 & 6 at NTPC Rihand were constructed to augment the performance of Stage III Cooling towers (5.29 C shortfall in cold water temperature). FRP (Fiber Reinforced Plastic) based Cooling tower (CT) of helper cell has been constructed for stage III at NTPC Rihand. The helper cell cooling tower was designed to handle a water flow of 40,000 m^3/hr 20,000 m^3 from each units 5 & 6 thereby improving condenser performance by reducing cold water temperature by 5.29 °C. Heat rate improvement of 27 kCal/kWh and 9.3 Cr per year net saving will be achieved after installation of Helper Cell.

Telangana 800MW experience sharing

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This paper provides a comprehensive overview of the commissioning and operational experiences from the supercritical units at Telangana. It covers the challenges faced during various phases of commissioning, including initiatives taken during process commissioning for DM, LDO, and time reduction, and further explores the issues encountered during full-load and trial operations. The paper also highlights the post-commissioning modifications and operational experiences that were learned from the supercritical units.

Key points discussed include:

1. Commissioning Challenges: The paper elaborates on the difficulties faced during the commissioning phase, specifically in areas like Boiler, Turbine, and Balance of Plant (BOP), and the strategies used to address them through resource planning and on-site modifications.
2. Systems Addressed: Apart from the main plant commissioning, challenges in Ash Handling Plant (AHP), Water Treatment Plant (WTP), and Control and Instrumentation (C&I) systems were also discussed.
3. Key Milestones Achieved: Despite the difficulties encountered, significant milestones such as steam blowing, synchronization, full-load operation, trial operation, and Commercial Operation Date (COD) were successfully achieved.
4. Problem-Solving Approach: The paper emphasizes the use of in-house developed solutions to resolve the various challenges faced during commissioning. This includes the effective application of operational excellence and project management during the transition to the Operations and Maintenance (O&M) phase.
5. Operational Excellence: Telangana's operational excellence is underscored, with a focus on how the plant continues to raise the bar in its pursuit of improving operational performance.

Through this paper, the authors share insights into unique problems faced during the commissioning and operational phases at Telangana and the successful strategies employed to overcome them, highlighting both technical solutions and project management approaches that contributed to the plant's overall success.

Energy Transition through Gas turbines: Technical Assessment and Implementation Challenges

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This paper examines the potential of utilizing hydrogen and carbon-captured methanol in gas turbines to drive energy transition, particularly in regions like India. Hydrogen's clean combustion and methanol produced from captured CO_2 significantly reduce greenhouse gas emissions, supporting a low-carbon future. The adoption of these fuels can also generate carbon credits, providing financial incentives for emission reductions. Additionally, existing stranded gas turbines, currently underutilized due to a lack of natural gas supply, can be repurposed with necessary technical modifications, such as updates to combustion systems, fuel injection, and materials. This approach not only addresses the challenges of fuel availability but also accelerates India's energy transition, contributing to global decarbonization goals while making efficient use of existing infrastructure.

Flexible Operation: Future of power generation in Indian scenario

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India's power sector is well diversified and evolving with changes in market dynamics. The demand for electricity in the country has increased rapidly and is expected to increase further in the coming years. In order to meet the increasing demand for electricity, the electricity supply chain has undergone a phase of transformation to competitiveness. The sources of electricity generation in India can be broadly classified into conventional (thermal) and non-conventional (renewable). Integration of Renewable generation into the Indian electricity grid is a challenge as well as an opportunity. In anticipation of the changing role of thermal power in the Indian power sector and its crucial role in making best use of renewable sources, this report has been brought out. Here in, an attempt has been made to capture the gravity of the situation by analyzing the generation trends and measures required for flexibilization as discovered in low load pilot tests and studies of thermal units.

Gas Turbine Lube Oil Varnishing

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Mineral based Lube Oil is used for Bearing Lubrication in Gas Turbines installed at RGPPL. M/s Indian Oil Corporation (IOCL) make Servo Prime 32G oil is used for bearing lubrication and same oil is used for hydraulic valves (IGV & Gas Module Valves) operation.

RGPPL was facing issues of oil varnishing in Gas Turbine#3A main oil tanks including frequent lube oil filter cartridges choking. Varnish formation in lubricating oil and hydraulic systems has been present for many years in the power generation industry. This article discusses about the investigation of the issue in oil quality and process for reducing varnish from the MOT oil and aiming to enhance the overall availability and sustainability of the power plant. This reduction reflects a substantial step toward sustainable oil consumption/ replacement intervals, aligning with environmental stewardship goals and ensuring a more resilient and responsible approach to power generation.

Best practices in unit commissioning in boiler chemical cleaning, steam blowing & boiler headers inspection

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Patratu Super Thermal Power Project (PSTPP), Stage-1 (3X800 MW) units are under construction. Stage-2 (2X800 MW) units approval is in progress. Stage-1, Boiler (800 MW) is of Once through, sliding pressure, supercritical steam generator with two pass, Spiral wall & Vertical Wall in 1st Pass, Dry Bottom, Dry fly ash, Balanced draft type, two level air staging in Furnace to minimize NOx formation. Boiler chemical cleaning procedure was initially approved with Main Boiler light up condition. But due to delay in readiness of Main boiler for light up, it was decided to carryout chemical cleaning of boiler with auxiliary boiler. As per requirement, Boiler chemical cleaning procedure with Auxiliary boiler light up was approved by OS. But the challenge was to achieve the required temperature for the process with auxiliary boiler. Because this was Unit-1 Boiler Chemical cleaning completed on 29.08.2024.

Safety in Fly Ash Silo area at NTPC Mouda

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Ensuring safety within power plant areas is of paramount importance due to the high-risk environment characterized by heavy machinery, hazardous materials, and complex operational processes. This paper proposes an AI-enabled surveillance system to address safety challenges and enhance operational efficiency in critical zones of power plant.

One particularly critical area is the Fly Ash Silo zone. The ambitious goal of achieving 100% ash utilization has made this area a hub of continuous activity, with trucks and bulkers transporting fly ash round the clock to destinations such as cement factories, National Highway Authority of India (NHAI) road construction projects, ash brick manufacturing units, and mine-filling sites. The transportation process involves moving ash in covered trucks and closed bulkers, following proper cleaning and handling protocols at the silo.

Handling fly ash presents significant safety risks due to its hazardous nature, potential exposure to harmful dust, and the operational complexities of loading, covering, and cleaning. These activities, if not managed effectively, can lead to accidents, health issues, and operational inefficiencies.

The proposed AI solutions aim to mitigate these risks by optimizing truck movement, predicting safety hazards, identifying blind spots, and issuing real-time alerts for compliance with Personal Protective Equipment (PPE) and safety protocols. Key focus areas include ensuring the use of safety belts during fly ash loading, monitoring the proper covering of ash-filled trucks, and overseeing cleaning activities to prevent exposure to harmful materials.

By leveraging advanced machine learning algorithms and computer vision techniques, the AI system monitors and analyzes traffic patterns, detects potential hazards in real-time, and integrates seamlessly with existing infrastructure. This integration provides actionable insights and timely alerts to both drivers and safety personnel, significantly reducing the likelihood of accidents and ensuring a safer working environment.

Provision of new manholes at Lower elevation of 210 MW Russian Boilers for improving safety and reducing downtime during tube leakages & Overhauling

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This process improvement project deals with inhouse and low-cost fabrication of new manholes at lower elevation of 1st pass of 210MW Russian boilers at stage#1 at NTPC Vindhyachal. This has already been implemented in two units of stage#1 Boilers and being implemented in balance 4 units during their respective scheduled overhauling.

As 210 MW stage#1 boiler are one of oldest units and due to unavailability of manhole at the height of bottom ash hopper sealing, during maintenance activities i.e. tube leakages and overhauling activities, shifting of Sky climber/scaffolding materials was very risky, difficult and time consuming. This in house project involves taking approvals from concerned authorities, designing of manhole bends, prefabrication of door & manhole box and finally fabrication of manhole at 8.5-meter height in the furnace zone of boiler 1st pass.

With the provision of new manhole at 8.5-meter height of boiler, shifting of materials has become easy and safe. Also, down time of shutdown unit has been reduced significantly.

As maintenance activities in boiler tube leakages & overhauling, downtime has been reduced significantly, which has resulted in savings of revenues as units could be revived early.

During overhauling approx. 36 hours of time saving could result in approx. 1.1 crore revenue saving and during boiler tube leakage approx. 4-5 hours saving could result in approx. 12-15 lakhs of revenue saving. This project can be replicated in similar design boilers which are facing same issues.

Implementation of Failsafe Logic to Avoid Table Tippling of Wagon Tippler in Case of Total PLC Power Failure

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NTPC TSTPS Coal feeding for stage-1 is done through TH-1 and Wagon Tippler (WT) 1&2. WT1&2 comprises of hydraulic based coal unloading system. System runs by automated logic developed on Emerson PLC platform.

Brief History of Incident

On 23rd Sep 2024 08:20 Hours, WT-2 Table got tippled up to 76 Deg without any command. This incident tagged highly unsafe as it may lead to accident, in worst case FATAL. A thorough analysis being done to investigate the root cause of Tipping of WT Table. The detail system and incident analysis being described in this paper.

Existing Scheme: In Brief Below 2 solenoids are exclusively used for Tippling.

S1: Proportional Directional control Valve. S2: Brake

Whenever Fwd./Rev. Command is provided, the Brake is energized. The S1 Solenoid is Current (ma) based with 24V DC Supply provided for the Integrated Control Electronics. Proportional Directional Valve command: 4 - 20Ma.Forward Tippling: Command :12 to 4mA, Reverse Tippling:12 to 20mA

Root causes:

1. Accidental Switching OFF the SFU of UPS ACDB of PLC Panel resulted in total power failure to both PLC.
2. Power failure lead to AO card output driven to 0mA and since 24Vdc is already available at local, the Solenoid S1 is acted there by tippling of Table happened

Modified scheme:

1. 1.Removal of SFU in UPS ACFB for PLC Panel (immediately implemented) - To AVOID mishandling while maintenance.
2. Cutoff 24 V Supply to S1 solenoid through Digital output from PLC logic

Secure Time Synchronization and Event Analysis of Various Different DCS Systems

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Secure Time Synchronization of OT Network is Very critical for better Event analysis like Trip, SOE(Sequence of Events) and alarm logs, Specially in modern environment where different DCS/SCADA/PLC Systems are used for Process. One of such technique for event analysis can be by taking some critical Hardwired signals from various DCS Systems to a common platform and creating a Firstout Logic for analysis of Root cause of Events, other technique can be synchronized time with vendor provided Time source but since it is a proprietary system it cannot be used for other different DCS System. In this paper phasing out of Obsolete Siclock 400 Siemens Time sync system used in Siemens TG DCS due to Cyber security vulnerabilities has been discussed. Further innovative technique of Time synchronization of Siemens TG DCS has been implemented using Secure Universal Network Time Protocol (NTP), Further creative way of Time synchronization has been proposed using IRIG to NTP Conversion and Time synchronization for various different systems has been unified. This will not only reduce the cost of purchasing various proprietary system for Time synchronization but also provide better cyber secure environment for OT Network.

Comprehensive Cyber Risk Assessment for Power Plant OT Systems: A Case Study on DDCMIS system in NTPC Vindhyachal

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As power plants are increasingly integrating Information Technology (IT) with Operational Technology (OT) systems, the need for robust cyber security measures becomes crucial. This convergence undoubtedly enhances operational efficiency but also introduces significant vulnerabilities in OT systems. In this context, cyber security risk assessment provides a more realistic and comprehensive methodology for evaluating and mitigating risks associated with cyber threats to OT systems.

Quantitative risk assessment differs from the qualitative methods, it assesses the magnitude of both the likelihood and impact of risks in terms of actual values, thus resulting more objective and in-depth evaluation. While qualitative assessments classify risks into categories, quantitative assessments calculate specific risk scores based on predefined formulas that incorporate asset value, threat probability, and impact severity.

Quantitative risk assessment in power plants support real-life data-driven decision-making, optimize resource allocation, and enhance transparency in risk management processes. Regulatory frameworks from the Central Electricity Authority (CEA), mandate annual risk assessments, ensuring that risk evaluation is aligned with industry standards and compliance requirements.

Incorporating quantitative risk assessments with present qualitative assessment, power plants can implement tailored security measures, such as advanced threat detection, enhanced network segmentation, and real-time monitoring, to safeguard critical OT infrastructure against emerging cyber threats. This study aims to conduct a hybrid risk assessment model on the DDCMIS supplied to NTPC, focusing on identifying and quantifying the risks associated with case study on supplied DDCMIS architecture, in line with the statutory regulations, and proposing effective security upgrades based on the findings.

Challenges and Methodology adopted in rectification of Liquid Fuel Handling System at NTPC Kawas

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Naphtha is a highly volatile fuel, with a low flash point, requiring careful handling to prevent fire or explosion hazards. Being heavier than air, naphtha vapors travel along the ground and provokes distant ignition as well as spreading fire in large areas. Naphtha fuel handling requires strict safety measures due to its high flammability and toxicity. Carrying out any maintenance work, specifically hot work, in the naphtha system is quite difficult and challenging from a fire safety point of view. In spite of being a secondary fuel for NTPC's various Gas stations, there is very less experience of carrying out such critical works in naphtha area. However challenging, but NTPC Kawas have carried out critical tasks of repair and revival of out of service 2000KL naphtha storage tank with tilted floating roof and replacement of Naphtha and HSD pipelines of the quantum of 2 Kms. This paper addresses the challenges faced, its solutions derived, and safety measures and methodologies adopted. Maintenance strategies implemented include advanced inspection techniques, repair methodologies and safety isolations to rule out associated risks. Results demonstrate significant improvements in operational reliability, cost savings, and safety standards enhancement, offering valuable insights into NTPC's operations and maintenance practices.

Dashboard for Realtime Heat Rate Monitoring and Predictive Analytics based on Artificial Intelligence and Machine Learning

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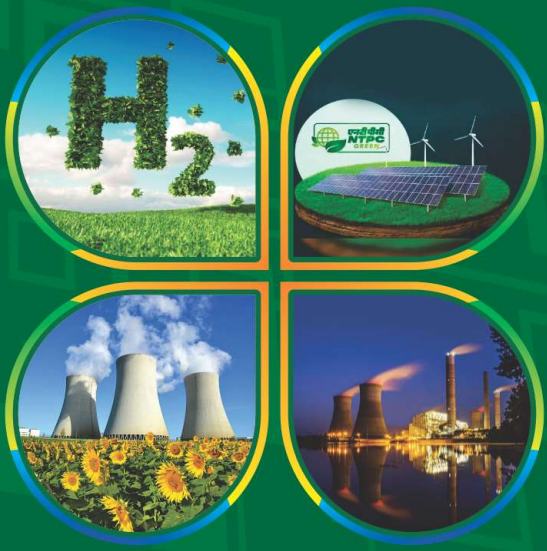
India's energy landscape is rapidly transitioning towards a higher percentage of renewable energy generation, such as solar and wind. While this shift is crucial for reducing carbon emissions, it also increases the importance of heat rate monitoring in thermal power plants for several reasons such as Grid Stability, Reduced Load Factors, Cost Competitiveness and Environmental Compliance.

Heat Rate is a key performance indicator (KPI) that measures the efficiency of a power plant in converting fuel into electricity. Monitoring and optimizing heat rate is essential for ensuring operational efficiency, minimizing costs, and reducing environmental impact. Also, Artificial intelligence (AI) has vast possibilities in revolutionizing heat rate monitoring in power plants by providing advanced tools and capabilities for efficiency optimization, such as Predictive Analytics, Pattern Recognition, Optimization of Operations and Automated Reporting.

This paper presents a case study where AvevaPiVision system has been utilized in-house to design a real time Heat Rate Monitoring dashboard for NTPC Khargone (2 x 660MW), Lara (2 x 800MW) and Gadarwar (2 x 800MW) units. Each unit dashboard utilizes 34 input parameters such as load, steam temperature, steam pressure etc. with 30 second sampling frequency, to compute real time heat rate.

The historical data generated from the dashboard is further utilized to train AI based model for providing actionable recommendations tailored to the unique characteristics of each unit. AI systems can identify and diagnose faults in equipment or processes that may be contributing to heat rate degradation, providing actionable recommendations for repair



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