

Preface

Conversion of thermal energy to electricity is not a high-efficiency process. As the conversion temperature approaches the characteristic temperature of the fuel (for coal this is approximately 3000 °C), the efficiency of conversion increases. However, metallurgic constraints restrict the conversion temperature to a much lower value (approximately 600 °C). Research is ongoing for achieving temperatures near 700 °C. Furthermore, derating of thermal power generators due to various reasons poses problems to the power industry, as the available capacity becomes reduced. Thermal power generation is a highly capital-intensive industry, an environment polluter by default, and a large consumer of primary resources such as land, water, and fuel. Therefore, the operating availability of the installed capacity, design efficiency, and longer life spans are a serious concern. Undoubtedly, the ability to run beyond the regulatory period with high loading factors and high efficiencies gives thermal power plants a cutting-edge advantage of commercial superiority.

Various subsystems of a thermal power generator are built upon integrating many types of equipment. The subsystems operate in coordination to generate power with sustained reliability. Extensive research and development by the manufacturers of such equipment has improved the efficiency of individual pieces of equipment to a great extent. However, the overall operating efficiency of any subsystem depends on the optimum design of the subsystem and the operating practices. Therefore, operating and maintaining a thermal power generator requires understanding of system-level dynamics, which is different from the equipment-level operating and maintenance procedures.

Approximately 42 % of the total electricity produced globally is generated from coal. Burning of coal in these plants is responsible for almost 28 % of the global carbon dioxide (CO₂) emission. 1 % reduction in turbine efficiency in a 500 MW unit leads to reduction of heat rate by 4.5 kcal/kWh. This leads to reduction of 4 million tons of CO₂, reduction of 0.03 million tons of sulfur dioxide (SO_x), reduction of 4000 tons of nitrogen dioxide (NO_x), reduction of 500 tons of soot, reduction of 10,000 tons of Suspended Particulate matter (SPM), a savings of 2

million tons of coal and, finally, savings of Indian Rupee (INR) 220 crore (approximately 32 million USD).

Residual life assessment of plant components hover around two different approaches, one using data analysis based on operational history and the other based on a periodic examination of critical components. Operation beyond the limiting range can cause fatigue to the equipment and reduce its effective lifespan. Creep damage occurs when the component is operated above the grain recovery temperature characteristic of a material. Creep fatigue results in plastic deformation of the material. Low-cycle fatigue is the fatigue of a component as a result of cyclic loading beyond the strain limit. Each cycle in the resulting stress (load cycle) leads to utilization of the low-cycle fatigue resistance (low-cycle fatigue) and thus finally to stress cracking at the most highly loaded point.

Since 2001, the EN12952 code is being followed in many countries for design service loading combination. A boiler manufacturer will generally design the boiler so that there is some reserve with regard to the design service loading combination. It is a reality that a power plant is initially operated in base load operation due to its favorable efficiency compared with other available power plants. With increasing age, it will be deployed more and more in cycling duty or as a peaking plant. This different operating mode compared with the design of the components results in a different anticipated service life for the power plant equipment.

A load cycle is a closed hysteresis loop in the stress/strain diagram. The stress in the material is calculated from the pressure and temperature gradient, while the numbers of cycles to crack initiation are material properties. Continuous fatigue monitoring is the responsibility of the power plant operator (not the manufacturer) and to be performed for the most highly-loaded components.

Strong corrosion occurs at the furnace wall of coal-fired boilers by flame impingement. When coal containing a lot of sulfur content is used as fuel, the area in the neighborhood of the burner zone becomes an atmosphere of low oxygen partial pressure containing hydrogen sulfide (H_2S), creating a severe corrosive environment. Increase in the oxygen partial pressure on the piping surface by filling boundary air (to create an air curtain along the water wall piping) over the water wall piping surface, is considered effective.

Water is a major component used as a working fluid as well as a cooling medium. At high pressure, the solubility of water comes down and chemicals get deposited inside the vessel. Boiler tube failure due to corrosion and chemical deposition is a common phenomenon and a nightmare for all thermal plant operators. Due to bad management of water chemistry, carry-over silica at the low pressure (LP) stage of a turbine may disturb the dynamic balance of the turbine blade, cause rise in vibration, and finally, failure of the blades. More than 45 % of the energy input into turbine gets lost in the condenser. Untreated cooling water produces scaling and algae inside the condenser tube, causing heat transfer and thereby reducing turbine output and cycle efficiency. Therefore, managing water chemistry for cycle water as well as cooling water is a major challenge to power station managers. In addition to water, the chemical analysis of lubricating oil, transformer oil, etc. predicts the condition of different equipment. Chemical

analysis of flue gas predicts the efficiency of combustion. Considering all these facts, this book makes a special emphasis on thermal power plant chemistry.

The task and timing of major equipment maintenance is determined by predictive maintenance or reliability-centered maintenance focused on the engineering side of maintenance. As financial constraints are placed on maintenance resources, there is an increasing need for determining the timing of maintenance taking into consideration the financial expenditure and impacts. Risk Evaluation and Prioritization (REAP) provides the plant management quantified assessments of financial investment decisions of maintenance. Different maintenance strategies are deployed to avoid breakdowns, premature equipment malfunctions, and to increase response times to recover from failure, in order to effect improvements in overall plant availability. This book also covers details on the planning part of maintenance.

A large number of forced outages occur per year due to human error which not only affects the industry in terms of financial losses, but also in terms of its reputation among its customers as a reliable power producer. The root causes of these human errors have been discussed in detail for better outage management.

Best practices are not just benchmarking parameters. Implementation of these practices creates long-term sustainability. Best practices have many dimensions starting from maximizing efficiency to maximizing life span. The chapter dedicated to best practices in this book has covered many dimensions of good practices to minimize resource utilization, better environment management, knowledge management with maximizing growth, and life span.

The huge operating experience of National Thermal Power Corporation (NTPC) shared in a different forum has made it possible for me to write this book. Borrowed from erstwhile Central Electricity Generation Board (CEGB), different operating and management practices have been indigenized by NTPC to suit the weather and ambience of the country the plant belongs to. Many operating practices over time have been documented through instruction and directives, but many are still a tacit knowledge. Moreover, the instructions and directives do not speak about the knowledge and reasoning. Through this book I try to bare the knowledge of the different processes involved in thermal power plant operation and maintenance so that future engineers are not mandated to follow the instructions blindly, but are able to upgrade and make independent decisions for managing a power station.

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Best Practices and Health Monitoring

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