PowerPlant (Thermal) OperatingPrinciples

ACTSYS
Process management consultants

about **ACTSYS** process management consultants pte ltd

ACTSYS focus on power plant performance monitoring (both at combined cycle plant and conventional thermal power plant) using thermodynamic simulation tool, GateCycle. ACTSYS also conducts training to operational engineers to familiarize the thermodynamic basics of power plant equipments and systems. Typical training methodology and contents are detailed in this document.

Objective

This course deals with the basics of various thermodynamic concepts related to conventional steam thermal power plant and heat balance analysis of various components and sections. Hence, this would enable engineers understand the importance of various operating parameters on plant performance and efficiency. Excel based exercises and GateCycle™ based exercises would be practiced during the training that would help engineers to have hands-on experience in computing efficiency and losses associated to different system.

Target **Audience**

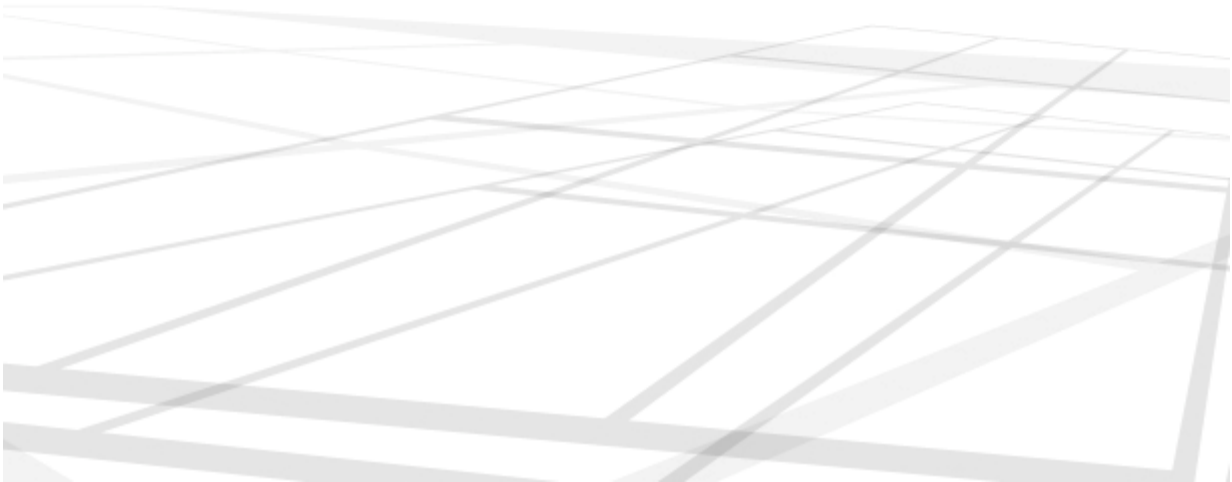
This course is customized to suit operational staff and support engineers.

duration

5 days

course schedule

	DAY 01	DAY 02	DAY 03	DAY 04	DAY 05
0830-0900	Introduction	Recap Day 1	Recap Day 2	Recap Day 3	Recap Day 4
0900-1000	Basics of Thermodynamics	Boilers - Components	Feedwater Heaters - Feedwater Heater Optimization	Steam Turbine - Performance Calculations	Auxiliary Equipment - BFP
1000-1015	***Coffee Break***				
1015-1115	Basics of Thermodynamics	Boilers - Components	Feedwater Heaters - Feedwater Heater Optimization	Condenser - Introduction Condenser - Factors influencing the efficiency	Auxiliary Equipment - Fans
1115-1215		Boilers - Efficiency	Steam Turbine - Introduction		
1215-1315	***Lunch Break***				
1315-1415	Basics of Thermodynamics Boilers - Fuels and Combustion	Boilers - Efficiency	Steam Turbine - Factors influencing the efficiency	Condenser - Performance Calculations	Plant Efficiency - Introduction
1415-1515					
1515-1530	***Tea Break***				
1530-1630	Boilers - Fuels and Combustion	Feedwater Heaters - Introduction Feedwater Heaters - Deaerator	Steam Turbine - Factors influencing the efficiency	Condenser - Performance Calculations	Plant Efficiency
1630-1730			Steam Turbine - Performance Calculations	Auxiliary Equipment - Introduction	Course Evaluation



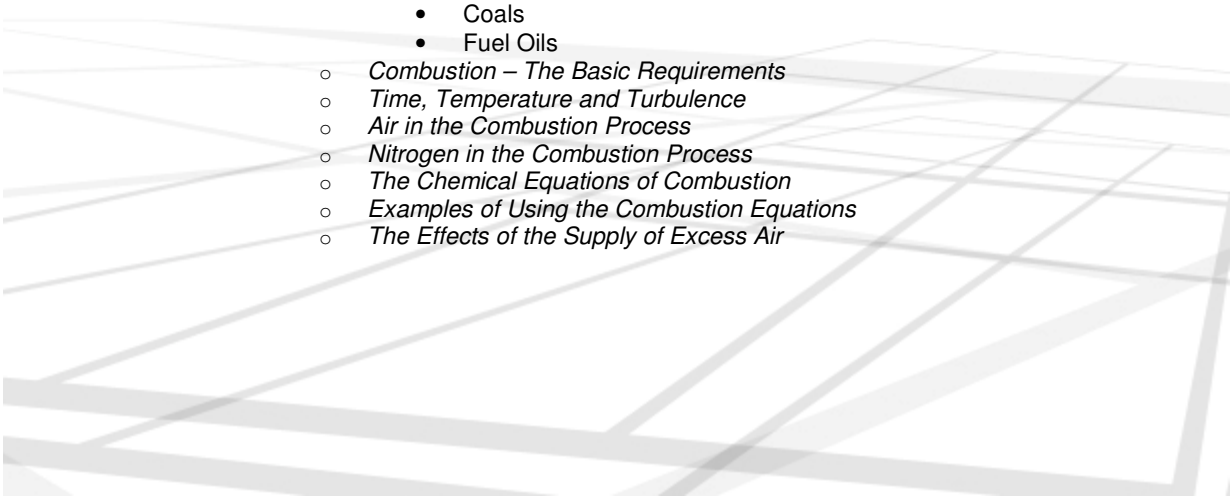
scope & **duration**

The course will include the following:

1. Basics of Thermodynamics (4 hrs): In this section, basics of thermodynamics that are relevant for the thermal power plant performance analysis are covered. Starting from the units of measurement, this section will include discussion on steam property, usage of steam tables & mollier diagram, concept of various thermodynamic cycles and relative advantages of different thermodynamic cycles and its applications. In addition, basic of heat transfer will also be covered. This section will help engineers to brush up the thermodynamic concepts that are relevant for thermal power plant. Excel & GateCycle based exercise on calculation of key steam properties such as specific heat capacity, enthalpy, internal energy, etc and cycle efficiency will be carried out.
    - *Units and Definitions*
        - Introduction
        - SI Units
        - The Unit of Force
        - The Unit of Pressure
        - Definitions
        - Practical use of the Units Described
    - *The Water to Steam Process*
        - Introduction
        - Sensible Heat
        - Latent Heat of Evaporation
        - Critical Point
        - Effect of Pressure Increase on Specific Enthalpy of Steam
    - *Steam Tables*
        - Introduction
        - Dry Steam
        - Wet Steam
        - Superheated Steam
        - Specific Volume
        - Entropy
        - Internal Energy
        - Layout of the Steam Table
        - Obtaining Information from the Steam Tables
        - Interpolation
        - The Mollier Diagram
    - *Heat Engine Cycles*
        - Background
        - Definitions
        - The Carnot Cycle
        - The Supercritical Cycle
        - Further Consideration of the Carnot Cycle
        - The Rankine Cycle
        - Efficiency of the Rankine Cycle
        - Improving the Rankine Cycle
        - The Simple Condensing Cycle
        - The Simple Feed Heating Cycle
        - Use of Heat Within a System
        - Maximum System Efficiency: the Carnot Cycle
        - Practical System Efficiency: the Rankine Cycle
        - Multi-stage Regenerative Feed Heating Cycle
        - Gains from Regenerative Feed Heating

- *Steam Throttling*
  - Effects of Throttling
- *Heat Energy Transfer*
  - Introduction
  - Conduction
  - Convection
  - Radiation
- *Heat Flow by Conduction*
  - Heat Transfer in Practice
  - Heat Energy Transfer in a Boiler Tube

2. Boilers: Thermodynamic performance of boiler will be discussed in this section.
   a. Fuels and combustion (2 hrs): This section helps get familiarized with fuel sourcing, characteristics of fuel, basics of combustion, combustion air calculation and estimation of heating value. Excel & GateCycle based exercise on combustion air calculation and heating value estimation would be carried out.
      - *Background*
      - *Forms of Energy*
      - *Types of Fuel*
      - *Heating Capabilities of Fuels*
      - *The Origins of Fuels*
        - Coal
        - Oil
        - Gas
      - *Chemical Composition and Calorific Value of Fuels*
        - Introduction
        - Calorific Values
        - Relative Heating Values of Coal and Oil
        - Estimation of Heating Value of a Fuel
      - *Main Fuel Types – Characteristics*
        - Coals
        - Fuel Oils
      - *Combustion – The Basic Requirements*
      - *Time, Temperature and Turbulence*
      - *Air in the Combustion Process*
      - *Nitrogen in the Combustion Process*
      - *The Chemical Equations of Combustion*
      - *Examples of Using the Combustion Equations*
      - *The Effects of the Supply of Excess Air*



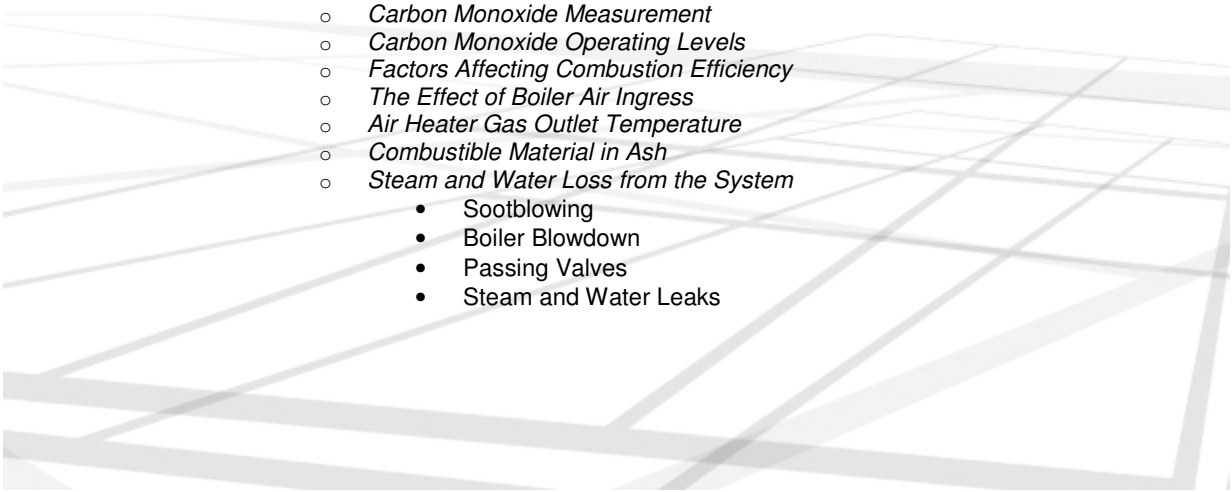
scope & **duration**

b. Boiler Components (2 hrs): Heat transfer behaviour of boiler at radiation zone and convection zone will be discussed. Performance of economiser and influence of air heater leakage on boiler performance will be discussed.

- *Radiant Zone*
- *Convection Zone*
- *Adjustment of reheater / primary superheater flue gas damper.*
- *Economizer*
  - Economizer flue gas outlet temperature
  - Economizer Pressure drop
- *Regenerative Air Preheater*
  - Leakage
  - Pressure drop
  - Cold end minimum metal temperatures

c. Boiler Efficiency (3 hrs): Various components calculation of boiler efficiency such as quantification of theoretical air requirement and excess air for complete and incomplete combustion, air heater leakage assessment, air heater leakage correction for flue gas temperature and quantification of components losses like dry flue gas loss, wet flue gas loss, unburnt carbon loss will be discussed. Also, the different methods of boiler efficiency computation like direct method and indirect method and its application would be discussed. Excel and GateCycle based exercise on the above mentioned calculation would be carried out.

- *Efficiency Calculations*
  - Heat Losses in the Boiler in Detail
  - Excess Air and Heat Energy Losses
- *Cost of Boiler Heat Energy Losses*
- *Measurement of Oxygen in Flue Gases*
- *Carbon Monoxide Measurement*
- *Carbon Monoxide Operating Levels*
- *Factors Affecting Combustion Efficiency*
- *The Effect of Boiler Air Ingress*
- *Air Heater Gas Outlet Temperature*
- *Combustible Material in Ash*
- *Steam and Water Loss from the System*
  - Sootblowing
  - Boiler Blowdown
  - Passing Valves
  - Steam and Water Leaks



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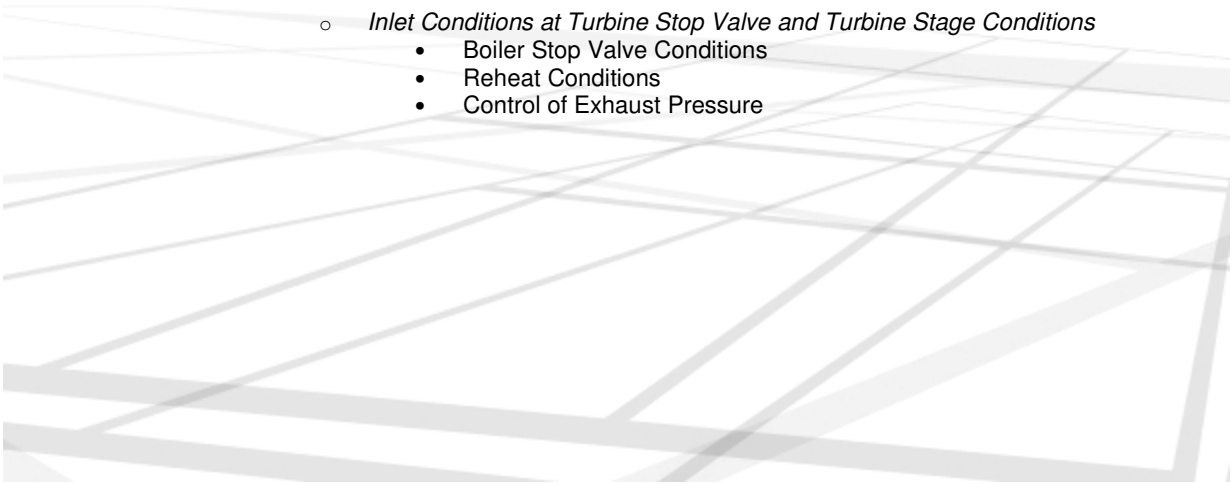
3. Feedwater Heaters (4 hrs): Performance of feedwater heater and importance of key performance indicators such as Terminal Temperature Difference (TTD) and Drain Cooler Approach (DCA) on heater performance will be discussed. Impact of heater bypass operation, fouled heater performance, tube leakage and drain bypass operation on plant performance will be discussed. Excel and GateCycle based exercise on heater performance quantification will be carried out.
    - *Feed Water Heaters*
        - Shell and Tube Heat Exchangers
    - *The Deaerator*
        - Introduction
        - Operating Principles
        - The Deaeration Process
        - The Deaeration Storage System
    - *Feed Heating*
        - Introduction
        - Feed Heater Optimisation
            - ❖ Feed water outlet temperature
            - ❖ Drain outlet temperature
            - ❖ Heater Bypass condition
            - ❖ Opening and closing of drain bypass valves to drain into condenser or deaerator directly.

4. Steam Turbine (6 hrs): Introduction to steam turbine performance, major loss components in steam turbine, factors contributing to the loss components and methods to quantify different efficiencies associated with the steam turbine would be discussed. Also, importance of seam inlet and extraction pressure on steam turbine performance and also for the performance monitoring will be discussed. Excel and GateCycle based exercise to quantify the steam turbine performance will be carried out.
    - *Inlet Conditions at Turbine Stop Valve and Turbine Stage Conditions*
        - Boiler Stop Valve Conditions
        - Reheat Conditions
        - Control of Exhaust Pressure



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6. Condenser Performance (4 hrs): Performance assessment of condenser at different operating condition and at different condenser operating load will be discussed. Factors influencing the condenser performance degradation such as air ingress, condenser fouling and reduction of condenser water flow will all be discussed. Excel and GateCycle based exercise to quantify the condenser performance at different operating condition will be included.
    - *Vacuum*
    - *Cooling Water Flow*
    - *Cooling Water Inlet Temperature*
    - *Air Leakage*
    - *Fouling*

7. Auxiliary Power (4 hrs): Performance assessment of auxiliary equipments like BFP, CWP and FD/ID fans will be discussed. Factors influencing the performance of pumps and fans at parallel operation will be elaborated. Performance of these equipments at partload and at reduced speed operation will also be discussed. Excel and GateCycle based to exercise to quantify the performance at different operating load and condition will be included.
    - *Introduction*
    - *Effect of Machine Loading on Works Power*
    - *Parallel Running of Auxiliaries*
    - *Variable Speed Drives*
    - *Other Auxiliary Equipment*
        - Boiler Feed Water Pumps
            - Internal recirculation
            - Pump efficiency
            - Turbine driven pump operation and motor driven pump operation
        - FD / ID / PA Fans
            - IGV flow control

8. Plant Efficiency (3 hrs): Plant performance factors such as net heat rate and gross heat rate, thermal efficiency will be discussed. Performance monitoring concept of total plant will also discussed.
    - *The Concept of Heat Rate*
    - *Turbine and Boiler Loading*
    - *Boiler Loading*
    - *Turbine Loading*
    - *Monitoring of Thermal Efficiency*