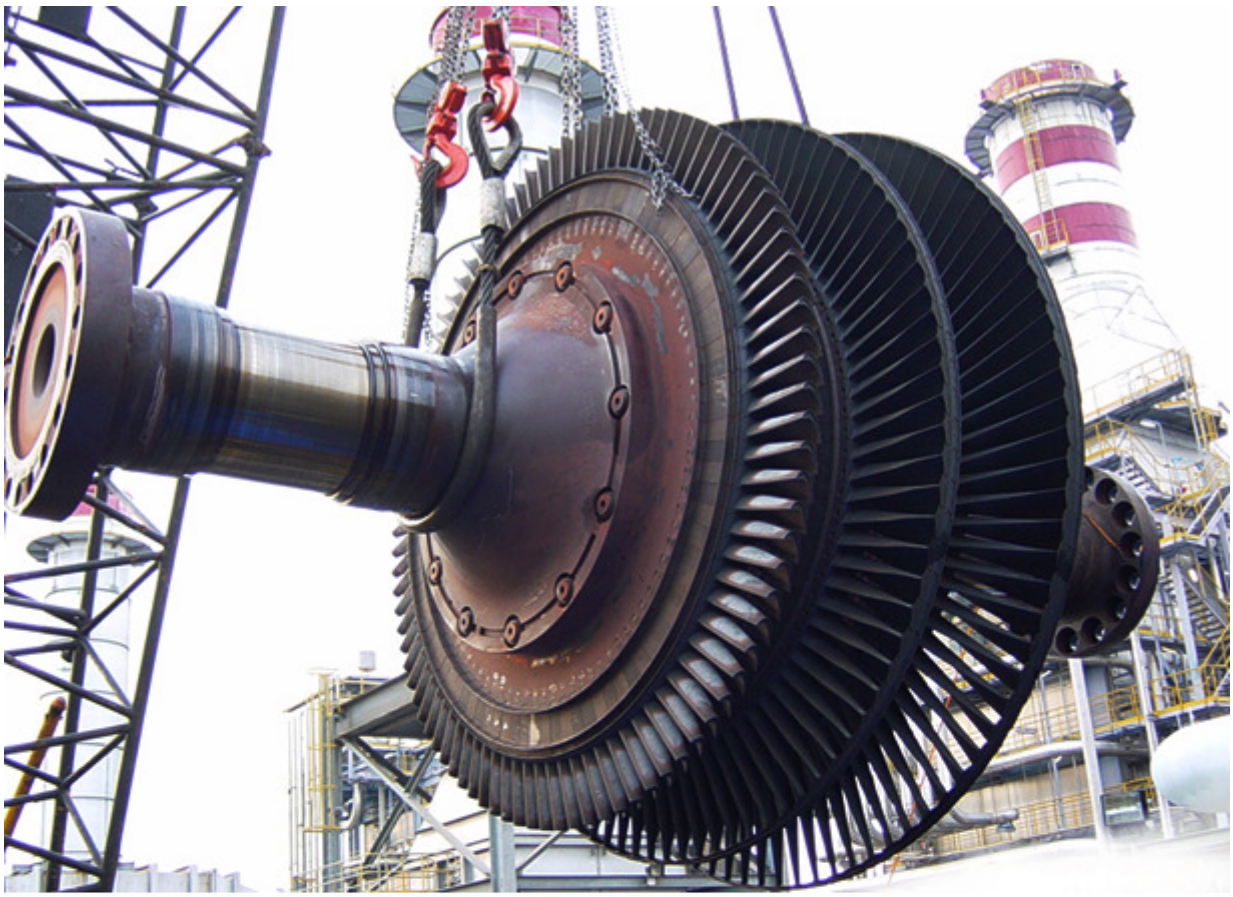


PowerPlant (CCP) OperatingPrinciples

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 combined cycle 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™ (Power plant thermodynamic modeling software - participants will be provided with a temporary Gatecycle™ license) based exercises would be practiced during the training that would help engineers to have hands-on experience in computing efficiency and losses associated with the different systems.

Target **Audience**

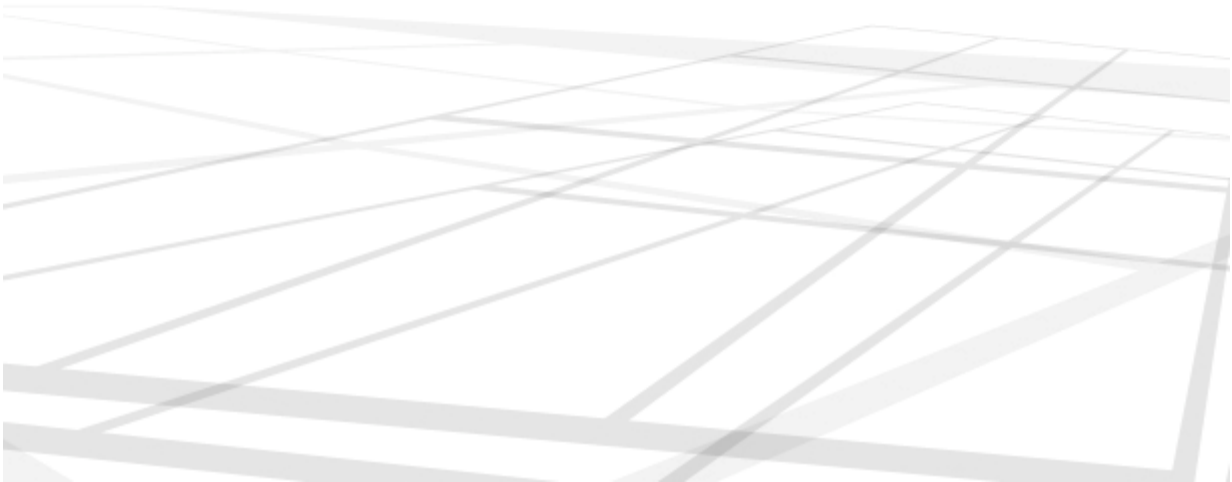
This course is customized to suit operational staff and support engineers.

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	GT - Gas Turbine	HRSG - Evaporator	Steam Turbine - Performance Calculations	Auxiliary Equipment - BFP
1000-1015	***Coffee Break***				
1015-1115	Basics of Thermodynamics	GT - Inlet Air Filters	HRSG - Other Key Performance Factors	Condenser - Introduction	Auxiliary Equipment - Compressors
1115-1215		GT - Overall Gas Turbine Performance	Steam Turbine - Introduction	Condenser - Factors influencing the efficiency	
1215-1315	***Lunch Break***				
1315-1415	Basics of Thermodynamics	HRSG - Basics of Heat Exchangers	Steam Turbine - Factors influencing the efficiency	Condenser - Performance Calculations	Plant Efficiency - Introduction
1415-1515	Gas Turbine - GT Compressor				
1515-1530	***Tea Break***				
1530-1630	Gas Turbine - GT Compressor	HRSG - Economiser	Steam Turbine - Factors influencing the efficiency	Condenser - Performance Calculations	Plant Efficiency
1630-1730	Gas Turbine - Combustor	HRSG - Superheater / Reheater	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 Combined Cycle 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 combined cycle 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
        - Brayton Cycle
        - The Rankine Cycle
        - Combined Cycle
        - Efficiency of the combined Cycle
        - Improving the Combined Cycle
        - The Simple Condensing Cycle
        - Maximum System Efficiency: the Carnot Cycle
    - *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. Gas Turbine: Thermodynamic performance of gas turbine will be discussed in this section.
   a. Gas Turbine (6 hrs): Individual component performance details and the overall gas turbine performance details will be discussed with suitable case example illustrations. Various performance indicators of the individual gas turbine components and its significance will be included with excel based & GateCycle™ exercises.
      - *GT Compressor*
        - Introduction to GT Compressor
          - Multi Stage Compression
        - GT compressor performance evaluation
          - GT Compressor performance at part-load
          - IGV flow control and GT Compressor Mapping
          - Parameter influencing the GT compressor performance
      - *Combustor*
        - Basic function of combustion chamber
          - NOx control techniques and its impact on performance
      - *GT Turbine*
        - Introduction to Gas Turbine
          - Gas Turbine features
          - Nozzle air cooling
        - Gas Turbine performance evaluation
          - Importance of Turbine inlet temperature
          - Isentropic efficiency of gas turbine and its importance
          - Parameter influencing the gas turbine performance
      - *Inlet Air Filters*
        - Filter classes and its performance differences
        - Importance of Performance factors such as arrestance capacity/efficiency, pressure drop, etc.
      - *Overall Gas Turbine Performance*
        - Gas turbine control
        - Parameters influencing the gas turbine performance and correction curves
        - Various Gas Turbine configurations and its implications on Performance
          - Reheat Gas Turbine
          - Nozzle air cooling

scope & **duration**

3. Heat Recovery Steam Generator (6 hrs): Performance of evaporator eonomiser, superheater/reheater and preheater at different operating conditions will be discussed. Real time case illustrations of good and poor performance of HRSG and its impact on steam generation will be discussed.
    - *HRSG*
        - Basics of heat exchangers
            - Introduction
            - Heat exchanger configuration
                - Parallel flow, counter flow and cross flow
                - Shell and tube heat exchangers
            - Heat exchanger performance factors
                - Effectiveness method
                - Concept of Number of Transfer Units (NTU)
                - LMTD correction factors and its applications
        - Performance evaluation of HRSG Components
            - Economiser
            - Superheaters/Reheaters
                - Performance evaluation
                - Temperature Control
            - Evaporators
                - Performance evaluation
                - Boiling heat transfer
                - Impact of circulation of water (Natural and Forced) on evaporation
        - Other key performance factors
            - Drum and Deaerator performance factors
            - Factors influencing the steam generation
            - Stack temperature and significance of dewpoint temperature

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 steam 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

scope & **duration**

5. 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*

6. Auxiliary Power (4 hrs): Performance assessment of auxiliary equipments like BFP, CWP and Compressors will be discussed. Factors influencing the performance of pumps and compressors 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
        - Compressors
            - IGV Control

7. 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*
    - *Overall Plant performance correction curves*
    - *Monitoring of Thermal Efficiency*