SOLAR THERMAL POWER PLANTS (CSP)
Advanced training

INTRODUCTION

Current situation of CSP at world level (1 st Day)

- Brief history
- Current trends
- Projects overview (Spain, USA, MENA, South Africa, India, …)
- Who is who (Promoters, EPC companies, Manufactures, R&D centers, …)

I. ENGINEERING COURSE (40 hours)

1. GENERAL ASPECTS (1 st Day)

1.1 TYPOLOGIES

- Types of CSP plants
- General diagram of a CSP plant
- Hybridization Possibilities: Biomass, Combined Cycle (ISCC), etc.

1.2 DESIGN STEPS OF A CSP PLANT

- Conceptual Engineering
- Basic Engineering
- Detailed Engineering

1.3 DESIGN SOFTWARE

- Solar field calculation software
- Software for equipment dimensions
- 3D Software
- Software to calculate thermal stress of piping
- Software for the electrical design
- Software for Civil works and buildings

1.4 SOLAR RESOURCE

- Evaluation of solar radiation
- Measurement of solar radiation.
- Public data bases. Advantages and disadvantages

2. THE SOLAR FIELD IN PARABOLIC TROUGH PLANTS (2 nd Day)

2.1 MAIN CARACTERISTICS OF THE HTF SYSTEM

- General diagram of the HTF system
- Main pumping station and recirculation pumps
- Thermal stress of the pipes, reasons to be considered
- Calculation of the size of the expansion tanks
- Pipe insulation
- Auxiliaries (Filling, Filter & Cleaning, Ullage, Antifreezing, Nitrogen plant, …)
- Expansion & Overflow tanks
- Heat exchangers with the steam generation train
- Common problems of the HTF system
- Characteristics of thermal oil (data sheet)
- Environmental aspects (leakages, recycling)

2.2 ELEMENTS OF THE SOLAR FIELD

- Solar concentrator and absorber tube
- Design solar field: minimum number of loops
- Civil work of the solar field
- Optimum collector tilt
- Selection type of foundation
- Instrumentation and Control
- Protection against wind and storm

2.3 DESIGN OF THE SOLAR FIELD

- Design point requirements
- What is a loop
- Characteristic parameters of a loop
- Calculation of the thermal power of a loop
- Solar Field size and configuration

2.4 THERMAL STORAGE SYSTEM

2.5 PRECAUTIONS DURING CONSTRUCTION

- Tube alignment
- Flange plates and welded unions
- Pumps

3. THE HELIOSTAT FIELD AND RECEIVER SUBSYSTEMS IN TOWER PLANTS (3 rd Day)

3.1. OPTIMIZATION OF HELIOSTAT FIELD - TOWER - RECEIVER PARAMETERS

- Design point requirements
- Field layout (heliostat size, shape and quality)
- Tower high
- Receiver (configuration and dimensions)
- Influence of latitude, terrain, TMY, plant & storage sizes, heliostat characteristics, receiver type, maximum radiation allowance, aiming strategy, …

3.2 ELEMENTS OF THE SOLAR FIELD

- Heliostats
- Civil work of the solar field
- Selection type of foundation
- Instrumentation and Control
- Protection against wind and storm

3.3 THE RECEIVER SUBSYSTEM

- Tower (Single and multi-tower approaches)
- HTF alternatives (molten salt, steam, air, …)
- Receiver (type, tubes, headers, panel array, flow circulation …)
- Valves and Piping (Down comer issues)
- Ceramic protections
- Instrumentation and Control (Temperature, pressure, mass flow, radiation)
- Characteristics of molten salt (data sheet)

3.4 THE STORAGE SYSTEM

3.4 PRECAUTIONS DURING CONSTRUCTION

4. THE SOLAR FIELD IN LINEAR FRESNEL PLANTS (4 th Day: 3 hours)

4.1 MAIN CARACTERISTICS OF THE HTF SYSTEM
- HTF alternatives (Saturated/Superheated steam, molten salt, …)
- Pumps and valves
- Expansion pipes

4.2 ELEMENTS OF THE SOLAR FIELD
- Linear mirror array and tracking system
- Absorber tube (reconcentrator, tube array, tube types, …)
- Design solar field: minimum number of loops
- Civil work of the solar field
- Instrumentation and Control

5. WATER STEAM CYCLE AND BOP SYSTEMS (4 th and 5 th Days: 8 hours

5.1 THE STEAM GENERATION SYSTEM AND OVERALL THERMAL BALANCE
- Basic parameters
- Differences between solar thermal and conventional plants
- Basic issues of the steam generation
- Process diagram in solar thermal plants

5.2 MAIN COMPONENTS
- Economizer
- Evaporator
- Super heater
- Degasser tank
- Main condenser and condenser for sealing steam
- Feed-water cycle
- Control system

5.3 POWER BLOCK LAY OUT
- General aspects about the equipment location and Layout optimization

5.4 THE STEAM GENERATION TRAIN
- Selection of the equipment
- Common problems of the Steam generation cycle
- Commercial options

5.5 WATER STEAM CYCLE
- Energy balances
- Water feeding pumps: options
- Steam traps, Bypass valve, …
- Condenser (Cleaning and vacuum systems)
- Cooling options (wet, dry, hybrid, …)

5.7 THE STEAM TURBINE
- Selection Criteria

5.8 OPTIMIZATION CHOICES
- Costs, Quality, execution and O&M Optimization

6. PRACTICES WITH THE CSP SIMULATOR RENOVETEC (P.TROUGH, 50 MW) (5 th Day: 5 hours)

II. COMMISSIONING AND O&M COURSE (40 hours)

1 st DAY:

COMMISSIONING PHASES

- Test before acceptation
- Reception of the systems
- Precommissioning or cold commissioning
- Hot commissioning
- Acceptation test
- PAC: Provisional Acceptance Certificate
- Time for optimization and guarantees
- FAC: Final Acceptance Certificate

COMMISSIONING STAFF

COMMISSIONING OF MAIN SYSTEMS

- Energization of the plant
- Connecting to gas
- Connection with feed-water
- Commissioning refrigeration system
- Commissioning auxiliary boiler
- Compressed air system
- Anti fire system

2 nd DAY:

COMMISSIONING SOLAR FIELD

COMMISSIONING HTF SYSTEM

COMMISSIONING MOLTEN SALT SYSTEM

COMMISSIONING WATER STEAM CYCLE

COMMISSIONING STEAM TURBINE

TESTS

- Performance test
- Test of fiability
- Annual guarantee
- Periodical tests
- PTC according ASME

FINAL RECEPTION

COMMON PROBLEMS DURING COMMISSIONING

3 rd DAY:

OPERATION OF CSP PLANTS

- Efficient operation
- Operating staff

- Responsibility of the operator
- Operation modes in CSP plants
- Energy balances as a tool
- Practices with simulator

4 th DAY:

PROGRAMMED MAINTENANCE

- Maintenance strategies in power plants
- Maintenance staff
- Maintenance plan

PREDICTIVE MAINTENANCE

- Analysis of vibrations of following equipments
  - Analysis pumps
  - Analysis steam turbine
  - Analysis electric generator
- Thermograph of following equipments
  - Thermograph electric system (cells, transformer, cables)
  - Thermograph soalr field
  - Thermograph HFT system
  - Thermograph water steam cycle
  - Thermograph steam generation train
  - Thermograph turbine
- Boroscopy of following equipments
  - Boroscopy steam generation train
  - Boroscopy HTF pumping station
  - Boroscopy steam turbine
- High frequency tests of following equipments
  - Leck detection
  - Analysis bearings
  - Analysis thicknesses
- Analysis thermal fluid in following equipments
  - Analysis HTF
  - Analysis lubrification oil
  - Analysis oil transformer

LEGAL MAINTENANCE

5 th DAY:

USUAL FAILURES

- HTF system
- Steam generation train
- Steam turbine
- Electric system and grid connection
- BOP
- High tension system
- Analysis of failures

SPARE PARTS AND TOOLS

TECHNICAL TOOLS

INFORMATION POLICY

- CMMS
- Periodically reports
- Indicators and guaranteed parameters
- Availability, power, specific consumes
- Other indicators