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# Electrical Energy – Daily Program

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## Day 1

### Welcome and Presentation of:

- Electrical Energy (present situation and expectations), demand, production and consumption all over the world.
- The Units and physical laws related to the generation of Electrical Energy.
- Conversions of the various energies i.e. Chemical Energy into Thermal Energy, Thermal Energy into Mechanical Energy, and Mechanical Energy into Electrical Energy.
- Various means for the production of Electrical Energy (production sources).

### Fossil Fuels

- a) Generalities
- b) Coal's origins
- c) Various Qualities of Coal
- d) Analysis of different types of coal
- e) Conclusions of the coal analysis's results
- f) Fuel Oil origins
- g) Fuel Oil Analysis
- h) Conclusions of the Fuel Oil analysis
- i) Natural Gas origins
- j) Natural Gas analysis
- k) Conclusions of the Natural Gas analysis

### Fossil Fuels Fired Power Plants

- a) Generalities
- b) Various types of Fossil Fuel Fired Power Plant
- c) Explanation of Elementary Systems in a Power Plant

## Day 2

### Coal-Fired Power Plant

#### Coal Handling

- a) Unloading
- b) Storage piling with problems of rain (moisture) and sun (fire)
- c) Fire Fighting System and water spraying on a coal storage place
- d) Coal Reclaim
- e) Coal Transport to Calibration, Crushing and iron free
- f) Coal Calibration, crushing and iron free
- g) Calibrated and Iron free Coal Transport to the coal bunker
- h) Analysis of the coal into bunker before burning



## ***Coal-Fired Steam Generator***

### ***Main Structure Construction***

### ***Feed water/Steam H.P Pipes Construction***

### ***Secondary Structure Construction***

### ***Casing and Furnace Construction***

### ***Coal and Air Cycle***

- a) Coal feeders from bunkers to Pulverizers
- b) Coal Pulverizers action
- c) Fire Protection of Pulverizers
- d) Co<sup>2</sup> storage for Co<sup>2</sup> injection into Pulverizers
- e) Pulverized Coal and Air Cycle on Steam Generator
- f) Forced Draft
- g) Rotary Air Heater
- h) Combustion Air to Wind boxes
- i) Primary Air Fan
- j) Temperature Control of the Primary Air
- k) Primary Air Inlet to Pulverizers
- l) Pulverized Coal going from Pulverizers to Coal Burners with forced primary air
- m) Auxiliary Air Heater for starting
- n) Induced Draft Fan
- o) Flue Gas stream route

### ***Feed Water/Steam cycle***

- a) Feed Water De-aerator tank
- b) Feed Water Pumps
- c) Low Pressure Heater of Feed Water
- d) High Pressure Heater of Feed Water
- e) Feed Water enters bottom header of the Economizer
- f) Feed Water from outlet Header of Economizer to Boiler Drum
- g) Feed Water from Boiler Drum to inlet Header of the Furnace Waterwall
- h) Mixture Steam-Water going from the Furnace to the Boiler Drum and Steam/Water separators
- i) Steam-free water going from the Steam/Water separators to the Primary Heater and after passing through the spray at temperature before entering to the secondary Super Heater
- j) High Pressure and Temperature Steam going directly from outlet Secondary Super Heater to the control Valve on the High Pressure Body of the Steam Turbine
- k) Low Pressure and Temperature Steam Outlet of the High Pressure Body going to the Re-heater Inlet
- l) Low Pressure and High Temperature outlet of the Re-heater going to inlet of the Intermediate Body of the Steam Turbine
- m) Control and regulation of the Coal-Fired Steam Generator
- n) Heat Balance of the Feed Water/Steam Cycle

### ***Ash Cycle***

- a) Slag collection on the Furnace bottom
- b) Slag Transport to storage
- c) Ash Precipitators functioning



- d) Field collecting coarse Ashes
- e) Field Collecting Fly Ashes
- f) Ash evacuation
- g) Ash Storage or recycling
- h) Quantity of Ashes going to stack
- i) Ash Environmental effects

#### ***Start up of a Coal-Fired Steam Generator***

- a) Start up with Auxiliary Steam Production
- b) Auxiliary Air Heater
- c) Start up System variable pressure furnace
- d) Start up System Constant pressure Furnace

#### ***Steam Generator Security***

- a) High Pressure By-Pass usefulness
- b) Safety Relief Valves
- c) Control and regulation of the boiler

#### ***Steam Turbine Principle***

- a) Lubrication System (lift up, turn gear)
- b) Lubrication Oil Treatment
- c) Control Fluid System
- d) Steam Inlet at High Pressure Body
- e) Steam Reheating System
- f) Steam inlet at Intermediate Pressure Body
- g) Steam Inlet at Low Pressure Body
- h) Condenser of Steam Turbine Exhaust
- i) Condenser Vacuum System
- j) Condenser's Make Up and discharge system
- k) Condensing Water Extraction Pumps
- l) Condensing water going from the Condenser bottom to the Feed water de-aerator tank
- m) Main water cooling System of the Condenser
- n) Condenser Tube Cleaning System
- o) Turbine Steam Drains System
- p) Closed Water Cooling System
- q) Turbine Governing System
- r) Turbine Security Systems
- s) Turbine fast cooling

### **Efficiency of a Coal-Fired Power Plant**

### **Auxiliary Utilities Consumption**

### **Availability of the Power Plant**

## **Day 3**

### **Generator Principle**

- a) Lubrication
- b) Excitation



- c) Outlet Voltage from the Generator
- d) Stator Cooling System ( $H_2$  or  $H_2O$ )
- e) Bus Ducts
- f) Coupling Breaker
- g) Net work Synchronization
- h) Generator Protections
- i) AVR Automatic Voltage Regulation

### **Electrical Part into a Power Plant**

- a) Transformer Area
- b) Transformer Principle
- c) Usefulness of the various transformers
- d) High voltage Connection to the grid
- e) Transport of the Electricity
- f) Middle Voltage Generation and Distribution
- g) Low Voltage Generation and distribution
- h) DC generation and distribution
- i) UPS (Uninterruptible Power System) Generation and Distribution
- j) Centralized Control System or Control Data System
- k) Control Room
- l) Metering
- m) Lighting (inside and outside)
- n) Telecommunications (Telephone, Interphone, Radio contact, HF link)
- o) Electrical Power disposal for starting the Power Plant

### **Balance of Plant (BOP)**

- a) Auxiliary Buildings (Admin. Building, Ware House, Workshop, Garage)
- b) Various Tanks (Diesel oil, Fuel oil, Raw Water, Fire Fighting Water reserve, Demineralized Water, Potable Water)
- c) Water Treatment (Demineralization, Drinkability, Waste Water Treatment, Effluents Treatment)
- d) Raw water Distribution
- e) Drinking Water Distribution
- f) Demin. Water Feeding
- g) Fire Detection System
- h) Fire Fighting System
- i) Compressed Air Generation Systems (Service Air, Regulation air)
- j) Compressed Air Distribution System
- k) HVAC (Heat, Ventilation, Air conditioning) System
- l) Auxiliary Steam generation
- m) Auxiliary Steam Distribution
- n) Lightning Protection
- o) Emergency Diesel Generator



## Day 4

### Gas/Fuel oil-Fired Steam Turbine Power Plant

#### *Coal Handling (Not Applicable)*

#### *Fuel Oil Handling*

- a) Fuel Oil Unloading
- b) Fuel Oil Storage
- c) Fuel Oil Heating System
- d) Fuel Oil Transfer
- e) Fuel Oil Conditioning Skid

#### *Gas Feeding*

- a) Gas Conditioning Station

#### *Steam Generator*

#### *Coal Cycle (Not Applicable)*

#### *Air Cycle*

- a) Forced Draft Fan
- b) Air Heater
- c) Combustion Air Route to Wind Boxes
- d) Induced Draft Fan
- e) Flue Gas Route

#### *Fuel oil Cycle*

- a) Fuel Oil piping feeding from the Conditioning Skid to the Oil Burners

#### *Gas Cycle*

- a) Gas Piping Feeding from the Gas Station to the Gas Burners

#### *Feed Water/Steam Cycle*

- a) Same as Coal-Fired Power Plant

#### *Ashes Cycle (Not Applicable)*

#### *Steam Turbine principle*

- a) Same as Coal-Fired Power Plant

#### *Generator Principle*

- a) Same as Coal-Fired Power Plant

#### *Electrical Part into the Power Plant*

- a) Same as Coal-Fired Power Plant without the utilities for the Coal Handling and the Pulverized coal Cycle

#### *Balance of Plant (BOP)*

- a) Same as Coal-Fired Power Plant



### *Efficiency of a Gas/Fuel Oil-Fired Steam Turbine Power Plant*

### *Auxiliary Utilities Consumption of a Gas/Fuel Oil-Fired Steam Turbine Power Plant*

### *Availability of the Gas/Fuel oil-Fired Steam Turbine Power Plant*

## **Gas/Fuel oil Turbine Single Cycle Power Plant**

### ***Fuel Oil Handling***

- a) Fuel Oil Unloading
- b) Fuel Oil Storage
- c) Fuel Oil Heating System
- d) Fuel Oil Transfer
- e) Fuel Oil Conditioning Skid

### ***Gas Feeding***

- b) Gas Conditioning Station

### ***How a Gas/Fuel oil Turbine Works***

### ***Generator Principle***

- a) Same as Coal-Fired Power Plant

### ***Electrical Part into the Power Plant***

- a) Transformer Area Simplified
- b) High voltage Connection to the grid
- c) Transport of the Electricity
- d) Middle Voltage Simplified Generation and Distribution
- e) Low Voltage Generation and distribution
- f) DC generation and distribution
- g) UPS (Uninterruptible Power System) Generation and Distribution
- h) Centralized Control System or Control Data System
- i) Control Room
- j) Metering
- k) Lighting (inside and outside)
- l) Telecommunications (Telephone, Interphone, Radio contact, HF link)
- m) Electrical Power disposal for starting the Power Plant

### ***Balance of Plant BOP (adapted to a single Cycle)***

- a) Auxiliary Buildings (Admin. Building, Ware House, Workshop, Garage)
- b) Various Tanks (Diesel oil, Fuel oil, Raw Water, Fire Fighting Water reserve, Potable Water)
- c) Water Treatment Drinkability, Waste Water Treatment, Effluents Treatment)
- d) Raw water Distribution
- e) Drinking Water Distribution
- f) Fire Detection System
- g) Fire Fighting System
- h) Compressed Air Generation Systems (Service Air, Regulation air)
- i) Compressed Air Distribution System
- j) HVAC (Heat, Ventilation, Air conditioning) System
- k) Lightning Protection
- l) Emergency Diesel Generator
- m) Black Start System



### *Environmental effects of a Gas/Fuel Oil Turbine Single Cycle Power Plant*

### *Efficiency of a Gas/Fuel Oil Turbine Single Cycle Power Plant*

### *Auxiliary Utilities Consumption of a Gas/Fuel Oil Turbine Single Cycle Power Plant*

### *Availability of a Gas/Fuel Oil Turbine Single Cycle Power Plant*

## **Gas/Fuel oil Turbine Combined Cycle (GTCC One Shaft)**

### ***Fuel Oil Handling***

- a) Fuel Oil Unloading
- b) Fuel Oil Storage
- c) Fuel Oil Heating System
- d) Fuel Oil Transfer
- e) Fuel Oil Conditioning Skid

### ***Gas Feeding***

- c) Gas Conditioning Station

### ***How a Gas/Fuel oil Turbine Works***

- a) Same as the Single Cycle
- b) Fuel Oil/Gas System Same as Single Cycle

### ***HRSR Heat Recovery Steam Generation***

- a) Gas Turbine Exhaust
- b) Supplemental Duct Burners (if any)
- c) Economizer Surface
- d) Evaporator surface
- e) Super heater Surface
- f) Steam Drum

### ***Feed Water/Steam Cycle***

- a) De-aerator Feed Water Tank
- b) Low pressure feed Water Heater
- c) Feed Water Pumps
- d) High Pressure Feed Water Heater
- e) Feed water Inlet Economizer
- f) Feed Water Outlet Economizer to Drum
- g) Feed Water From Drum to Evaporator
- h) Mixture Steam/Water From Evaporator to drum
- i) Steam from drum to Super Heater
- j) Steam from Super Heater to control Valve of Steam Turbine High Pressure Body

### ***Steam Turbine principle***

- a) Same as Coal-Fired Power Plant

### ***Condensing System***

- a) Same as Coal-Fired Power Plant



## ***Generator Principle***

### ***Same as Coal-Fired Power Plant***

#### ***Electrical Part into the Power Plant***

- a) Transformer Area
- b) High voltage Connection to the grid
- c) Transport of the Electricity
- d) Middle Voltage Generation and Distribution
- e) Low Voltage Generation and distribution
- f) DC generation and distribution
- g) UPS (Uninterruptible Power System) Generation and Distribution
- h) Centralized Control System or Control Data System
- i) Control Room
- j) Metering
- k) Lighting (inside and outside)
- l) Telecommunications (Telephone, Interphone, Radio contact, HF link)
- m) Electrical Power disposal for starting the Power Plant

#### ***Balance of Plant (BOP)***

- a) Auxiliary Buildings (Admin. Building, Ware House, Workshop, Garage)
- b) Various Tanks (Diesel oil, Fuel oil, Raw Water, Fire Fighting Water reserve, Demineralized Water, Potable Water)
- c) Water Treatment (Demineralization,rinkability, Waste Water Treatment, Effluents Treatment)
- d) Raw water Distribution
- e) Drinking Water Distribution
- f) Demin. Water Feeding
- g) Fire Detection System
- h) Fire Fighting System
- i) Compressed Air Generation Systems (Service Air, Regulation air)
- j) Compressed Air Distribution System
- k) HVAC (Heat, Ventilation, Air conditioning) System
- l) Auxiliary Steam generation
- m) Auxiliary Steam Distribution
- n) Lightning Protection
- o) Emergency Diesel Generator
- p) Black Start System



*Environmental effects of a Gas/Fuel Oil Turbine GTCC One Shaft Power Plant*

*Efficiency of a Gas/Fuel Oil Turbine GTCC One Shaft Power Plant*

*Auxiliary Utilities Consumption of a Gas/Fuel Oil Turbine GTCC One Shaft Power Plant*

*Availability of a Gas/Fuel Oil Turbine GTCC One Shaft Power Plant*

*Gas/Fuel Oil Turbine GTCC One Shaft Power Plant means that Gas Turbine, Steam Turbine and the Electric Generator are on the same shaft*

## **Gas/oil Turbine Combined Cycle (double shaft)**

*The difference between a GTCC One-Shaft and a Two-shaft is that each turbine is coupled separately with its own generator*

*This mean more equipment and more investment than for a one shaft GTCC. We can consider that this kind of power Plant has been abandoned*

*Diesel Oil Power Plant*

*Fuel Oil Handling*

- a) Diesel Oil Unloading
- b) Diesel Oil Storage
- c) Diesel Oil Transfer

*Diesel Engine Generator*

- a) Starting System

*Electrical Part into the Power Plant*

- a) Middle or Low Voltage to the grid
- b) Low Voltage Generation and distribution
- c) DC generation and distribution
- d) AVR
- e) Metering
- f) Lighting
- g) telecommunication

## **Nuclear Power Plant**

*Fission Principle*

*Reactor Containment*

*Reactor Vessel*

*Fuel*

*Rod Control*

- a) Full Length Rod control System
- b) Part length Rod Control System
- c) Air Cooling of Rod Control System



### **Primary loop**

- a) Charging Pump
- b) Pressurizer
- c) Steam Generator (155 bars, Inlet 296 °C outlet 327 °C, 60 000 to/h)

### **Secondary Loop**

- a) Low pressure Heater System
- b) Feed Water Motor-Pump
- c) Feed Water Steam Turbine-Pump
- d) High Pressure Heater System
- e) Steam Generator (55 bars, 270 °C, 7000 to/h)
- f) Turbine
- g) Condenser
- h) Main Water Cooling (Sea, River, Cooling Tower)
- i) Electric Generator

## **Day 5**

### **Environmental effects of a Nuclear Power Plant**

### **Efficiency of a Nuclear Power Plant**

### **Auxiliary Utilities Consumption of a Nuclear Power Plant**

### **Availability of a Nuclear Power Plant**

### **Comparing Elementary Systems between the different Power Plant processes:**

Coal-Fired Power Plant 146 Elementary Systems

GTCC One Shaft 189 Elementary Systems

Nuclear Power Plant 197 Elementary Systems

### **Renewable Energies**

#### **Hydroelectric Energy**

- a) Hydroelectric Energy from Falling Water (Dam, Pressure Pipeline)
- b) Hydroelectric Energy from the River Stream
- c) Pumped Storage reservoirs
- d) Maritime Wave Electrical Energy
- e) Maritime Tidal Electrical Energy

#### **Solar Energy**

- a) Solar Resources
- b) Passive Solar Energy (Water Heating)
- c) Photovoltaic Solar Energy
- d) Thermal Solar Energy (Solar Furnace)

#### **Aeolian Energy**

- a) How it Works
- b) Wind Turbine Farm on Shore
- c) Wind Farm Turbine of shore



- d) Wind Turbine on Building

### ***Geothermal***

- a) How it Works
- b) Pumping Depth Hot Water
- c) Heat Pump

### ***Biomass***

- a) How it Works
- b) Biomass Power Plant

## **How to store Electric Energy**

## **Conclusion, Questions and Answers session**