Closed-Loop, Evaporative Cooling Systems

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Agenda

• Closed-loop, evaporative cooling systems
  Wet Surface Air Coolers (WSAC)
• Technology comparison
• Applications
• Water and energy savings
• Summary/questions
What is a Wet Surface Air Cooler?

• Heat removal device
  – Cooling liquids
  – Condensing vapors
Wet Surface Air Cooler

• Where is it applicable?
  – Aux loop cooling
  – Direct vacuum steam condensing
  – Refrigerant condensing
  – Lowering discharge water temperature

• Where is it being used?
  – Numerous simple and combined cycle power plants worldwide
How Does the WSAC Work?

1.) Typical Shell & Tube Heat Exchanger

2.) Remove “Shell” Exposing Tubes

3.) Spray Water Directly Over the Exposed Tubes

4.) Air is Induced Over Tubes in the Same Direction as the Water

SENSIBLE

LATENT
How Does the WSAC Work?

1. Air is induced downward over tube bundles.
2. Water flows downward along with the air.
3. Heat from the process stream is released to the cascading water.
4. Heat is transferred from the cascading water to the air stream via vaporization.
5. Air stream forced to turn 180° providing maximum free water removal.
6. Fans discharge air vertically at a high velocity preventing recirculation.
Cooling Technology Options

Cooling Tower / Heat Exchanger  Dry / Air Cooled  Wet Surface Air Cooler (WSAC)
Equipment Configuration

**Factory Assembled**

**Field Erected**
General Specifications

Serpentine Coils or Bolted Straight Through Bundles
General Specifications for WSAC

• Spray Water Distribution System
  – Low-pressure / High-flow design
  – Full flooded spray pattern
  – No fill
Water Issues

**Evaporation (GPM)** = Heat Load (Btu/hr) / 570,000

**Makeup** = Evaporation + Blowdown + Drift

**Cycles of Concentration** = (Evaporation / Blowdown) + 1
Reducing Water Makeup in Existing Open-Loop Systems

SAVINGS: 525 MW plant → 60 million gal/yr
Aux Loop Cooler
Schematic of Dry/Wet Cooler

Cooling to 80°F at 95°F DB / 70°F WB
Water Savings Using
Niagara Dry/WSAC

WSAC SAVES OVER 50% OF ANNUAL WATER CONSUMPTION

% WATER USE

DRIY BULB TEMP (degF)
Wet / Dry Cooling in a Combined Cycle Power Plant
Comparison of Total Power Required vs. Approach Temp

(100 MM BTU/hr heat load)

System Power Requirements (MW)

Temp Approach (DegF)
WSAC Benefits

Pump less water

– Lower horsepower
  • Reduced installation costs
  • More available power for sale
  • Lower carbon footprint
WSAC Benefits

Can use poor quality water
- Reuse plant water
- Brackish water, seawater
- Agricultural runoff
- FGD water

Can run higher cycles of concentration
- Less water to purchase
- Less water to dispose of
WSAC Benefits

Cocurrent spray system design
  – Lower discharge height
  – Lower PM10
WSAC Benefits

Can cool plant discharge water
  – Reduced thermal effect
WSAC Benefits

Can evaporate blowdown
  – Smaller evaporation ponds
  – Less ZLD system capacity
  – Cost savings
    “Expensive to own and operate”
Small Packaged Fluid Cooler
Large Gas Turbine Packaged Fluid Cooler
Combined Cycle Plant – Aux Loop Cooler

1100 GPM, 160°F Inlet Temp., 120°F Outlet Temp., 80°F Wet Bulb
Steam Condenser
Steam Condenser
670,000 lb/hr Steam Condensers and Auxiliary Fluid Cooler
12,000 Ton Ammonia Condenser
Griffith, AZ
Summary

• More efficient cooling/condensing
• Improved heat rate
• Less HP
• Lower carbon footprint
• Less maintenance
• Water savings
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