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Hybrid and LNG Systems for Turbine Inlet Cooling

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Hybrid and LNG TIC Systems

Presentation Outline

- System Descriptions & Characteristics
- Examples with Psychrometrics
- Benefits
- Limitations & Disadvantages
- Project Examples

Hybrid TIC Systems

Characteristics

- **Incorporate combinations of two or more technologies**
- **Allow simultaneous use of at least two technologies in sequential processing**
- **May offer the flexibility of using each technology individually**

Pseudo-Hybrid TIC Systems

Characteristics

- **Incorporate combinations of two or more technologies**
- **But permit the flexibility of using only one technology at a time (Do not do allow simultaneous use of both technologies in sequential processing as in the hybrid systems)**

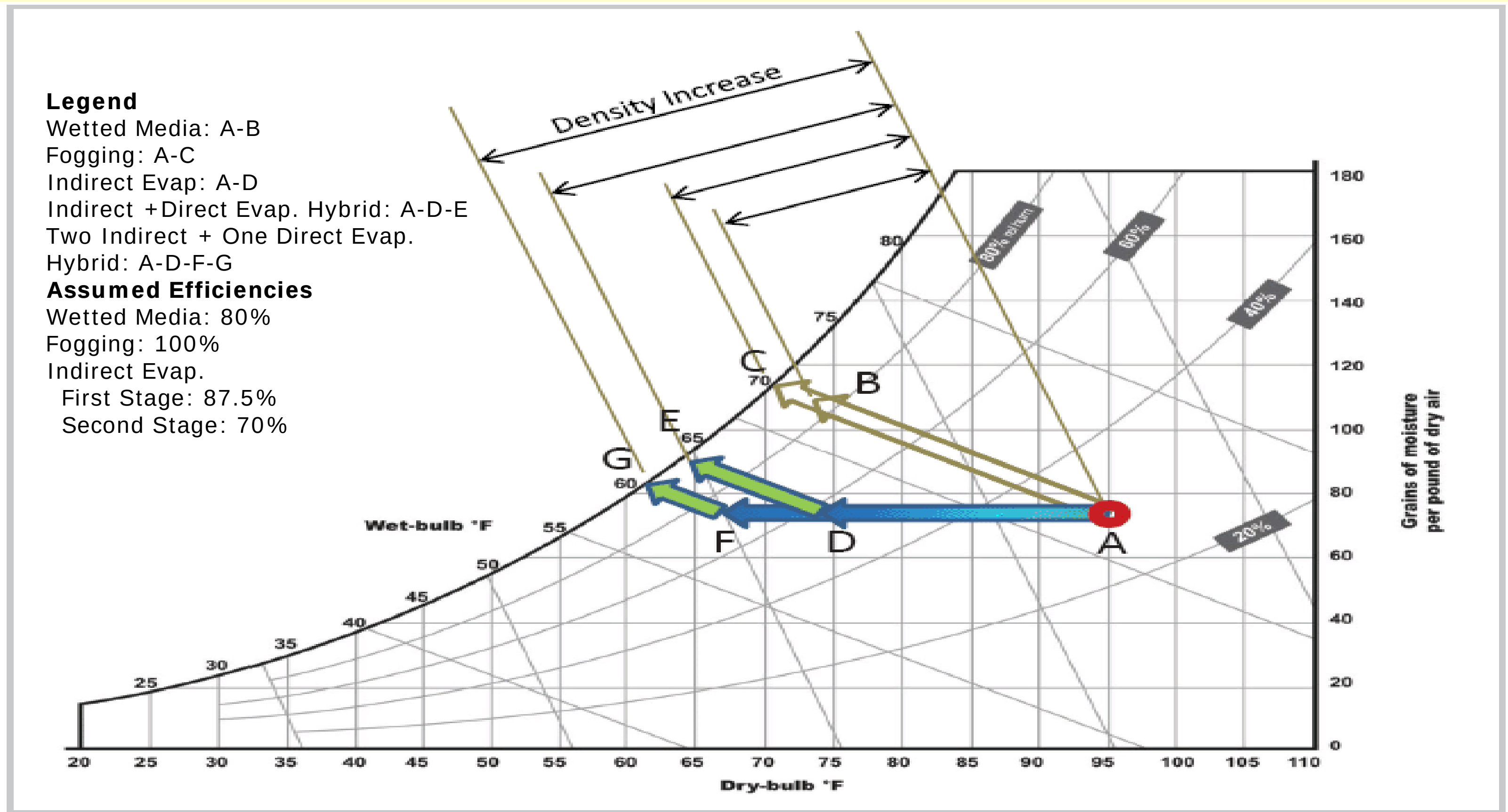
Hybrid TIC Systems

Examples

- **Chillers + Direct Evap (Fogging/Wetted Media)**
- **Chillers + Wet Compression**
- **Indirect Evap + Direct Evap**
- **Indirect Evap + Chiller**
- **Indirect Evap + Chiller + Direct Evap**
- **Absorption Chillers + Electric Chillers**

Hybrid TIC Systems

Psychrometrics



Reference: L. A. Schlom and M. V. Bastianen, Energy-Tech, June 2009

Pseudo-Hybrid TIC Systems

Example

- Direct Evap Cooling or Direct Contact Cooling with Chilled water

Hybrid TIC Systems

Benefits

- **Maximize the net CT output by minimizing parasitic loads**

  - For example: When evap cooling alone can provide the desired power output, chiller parasitic load is reduced compared to a system only incorporating chillers

- **May* reduce the capital cost compared options**

  - For example: Evap cooling first can reduce the chiller capacity need that in turn reduces the installed cost a chiller system compared to a system using only chillers

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* Not always

Hybrid TIC Systems

Limitations & Disadvantages

- **Generally attractive in dry weather conditions**
- **Inlet pressure drop may be higher than that for a single technology option**

Hybrid TIC Systems

Example

Las Vegas Cogeneration Facility

Power System

- Four LM6000s (41 MW each)
- Two in cogen and two in combined-cycle

TIC System:

- Fogging followed by chillers to cool inlet air to 50^{o}F
- Only fogging when ambient <70^{o}F
- Chiller (absorption) alone when humidity is high

Hybrid TIC Systems

Example

A Food Processing Company, Bakersfield, CA (2007)

Power System

- One Allison 501 (5 MW) in Combined-Cycle Mode

TIC System

- Indirect evap followed by direct evap
- Replaced an existing direct evap system

Hybrid TIC Systems

Example

Sonoco (A Packaging Company)

Brantford, Ontario, Canada (2006)

Power System

- One Allison 501 (5 MW) in Combined-Cycle Mode

TIC System

- Indirect evap followed by a 150-ton electric chiller

Hybrid Systems

Example

Calpine Clear Lake Cogeneration, Pasadena, TX (1999*)

Power System

- Three W501D (106 MW each)

Hybrid System

- Absorption chillers followed by mechanical chillers
- Absorption chillers (8,300 tons operating on hot water heated by HRSG exhaust) produce chilled water at 41^{0}F and mechanical chillers (1,200 tons) operating in series further reduce the chilled water temperature to 38^{0}F for storage in a 107,000 Ton-hrs TES tank

•The plant was originally was constructed in 1982 with fogging; Chiller system was retrofitted in 1999

Pseudo-Hybrid TIC Systems

Example

Channel Island Power Station, Darwin, Australia (1995)

Power System

- Five GE Frame 6 (42.1 MW each):
  Two in combined-cycle and
  Three in simple-cycle configurations

Pseudo Hybrid System

- Allows either direct-evaporative cooling or direct-contact cooling using chilled water from mechanical chillers

LNG Systems

Background

- **Many countries (including U.S.) import LNG (Liquefied Natural Gas)**

- **LNG arrives at the terminals at -259ºF**

- **LNG must be vaporized before it can be used as a fuel at the terminal or transported to other locations by pipeline**

- **Traditional Heat supply options for vaporizing LNG:**
  1. Burn natural gas (~2% of the energy in LNG)
  2. Heat exchange with air at ambient temperature
  3. Heat exchange with ambient temperature water

LNG-TIC Systems

Characteristics

- **LNG is used to chill an anti-freeze solution, such as ethylene glycol and water**
- **Chilled anti-freeze solution is used to cool the inlet air**

LNG-TIC Systems

Benefits

- The power plant receives “free” source for cooling the inlet air
- LNG plant receives “free” source of heat for vaporization of LNG

LNG-TIC Systems

Limitation

- **Power plant has to be located near an LNG vaporization facility, which is generally located at or near an LNG import terminal**

LNG-TIC Systems

Example

Guayanilla Bay, Puerto Rico (2000)

- **507 MW Combined-Cycle Plant**
- **24 BCF/Yr. LNG Vaporization Facility***
- **Anti-freeze Solution: Ethylene Glycol-Water**

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* Only a fraction of the vaporized LNG is used by the Power plant at this location; Most of it is injected in pipeline for distribution to other locations.

LNG-TIC Systems

Example

Sparrows Point, Dominican Republic (2003)

- **319 MW Combined-Cycle Plant**
- **97 BCF/Yr. LNG Vaporization Facility***
- **Anti-freeze Solution: Ethylene Glycol-Water**

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Hybrid & LNG-TIC Systems

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