Chilled Water Loop Optimization

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WHAT WE STARTED WITH:

LOOP OUTLINE:
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- Justification for the loop
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- Justification for the loop

Value of the loop piping, $10 Million Vs. Value of the chillers on the loop, $5 Million
WHAT WE STARTED WITH:

LOOP OUTLINE:

- The game changed after the introduction of variable speed chillers
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• There will probably be no further expansion of the loop.
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  • There will probably be no further expansion of the loop.

  • Modular variable speed chillers are the better way to go in our climate.
WHAT WE STARTED WITH:

ORIGINAL CONTROLS CONCEPT:
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• Focused mostly on functionality with not much concern given to efficiency issues.
WHAT WE STARTED WITH:

OVERALL LOOP ENERGY EFFICIENCY:
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OVERALL LOOP ENERGY EFFICIENCY:

• 0.85 kW/ton, 0.8 kW/ton after installation of the variable speed chiller.
SCOPE OF THE MBCx PROJECT:
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An MBCx project focused on improving existing hardware with better usage and controls (no capital costs).
SCOPE OF THE MBCx PROJECT:

FUNCTIONALITY:
SCOPE OF THE MBCx PROJECT:

FUNCTIONALITY:

• To automatically maintain a constant Differential Pressure, as well as staging the chillers off and on smoothly.
SCOPE OF THE MBCx PROJECT:

ENERGY EFFICIENCY:
SCOPE OF THE MBCx PROJECT:

ENERGY EFFICIENCY:

• Improve the efficiency of all chiller plants.
SCOPE OF THE MBCx PROJECT:

EXTRAS:
SCOPE OF THE MBCx PROJECT:

EXTRAS:

• Critical cooling
• Use loop thermal capacity for load shedding
• Leak detection and leak location.
STRATEGY:
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Hiring Consultants vs. Doing the work in House:
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• "Fits all" algorithm vs. "algorithm for a given situation"

• Intimate Knowledge of the plant
STRATEGY:

OTIMIZATION METHODOLOGY:
STRATEGY:

OTIMIZATION METHODOLOGY:

• Sacrifice slightly on the ideal mathematical optimum for a robust sustainable system.

• Take in to account temporal changes in the performance of the system components.
OPTIMIZATION ALGORITHM:
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Optimization of the Loop
Optimization Algorithm:

Optimization of the Loop

• Decide which chillers to run based on the capacity and efficiency of individual chillers.
OPTIMIZATION ALGORITHM:

Optimization of the Loop

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• Decide the Condenser Water temperature set point.
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• Decide the Differential Pressure set point (constant for now).
OPTIMIZATION ALGORITHM:

Optimization of the Loop

• Decide which chillers to run based on the capacity and efficiency of individual chillers.
• Decide the Condenser Water temperature set point.
• Decide the Differential Pressure set point (constant for now).
• Consider a needed cooling capacity of the loop in the immediate future (few hours), based on the time of day and the weather forecast.
Chiller Efficiencies at 74 F Condenser Temp and 42 F Supply Temp

- ESB
- CNSI
- Bren
- Library
- Chemistry, Broida
- ENG 1
- BIO 2
OPTIMIZATION ALGORITHM:

Optimization of individual chillers
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Optimization of individual chillers

- Balancing power for compressor, cooling tower fan, condenser pump. Use performance curves updated for the momentary changes (maintenance issues etc.)
ESB Condenser Problem, 8/26/2014

Approach = Tsat - Tchw [F]

Before Cleaning

After First Cleaning

After Second Cleaning

Ideal
Broida Cooling Tower Performance (BAC model)

100% Load = 8.2 kW / F
50% Load = 4.2 kW / F

1 HP = 0.84 kW (0.9 motor efficiency)

How many F App T can be increased at any fan power saving before compressor power increase becomes larger than fan power reduction.
For a given % load: \[ AT = (AT_{55\text{WB}} - AT_{70\text{WB}}) \times (70 - \text{WB}) / 15 \]

Add few F for a degraded cooling tower performance (determine experimentally)
MEASUREMENTS:
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- Uncertainty in a typical Btu measurement is in the range of improvements one is trying to achieve.
- Temperature measurements
- Flow rate measurements.
- Improving measurements may amount to a third of the total effort.
CONCLUSIONS:
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- 0.63 kW/ton a yearly average compared with 0.8 kW/ton baseline.
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- Additional energy savings thanks to the improved functionality (maintaining a desired chilled water temperature and pressure differential).
Loop Efficiency September 2014

- Measured: Average 0.64 kW/ton
- Baseline: 0.8 kW/ton
- Linear (Measured: Average 0.64 kW/ton)
Loop Efficiency June 2015

- Measured: Average 0.625 kW/ton
- Baseline: 0.8 kW/ton
- Linear (Measured): Average 0.625 kW/ton
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- About 70% of the expected total improvement in efficiency achieved, 30% remains to be done.
THANK YOU!