Winyah Units 1 and 2 Heat Rejection Study

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Abstract

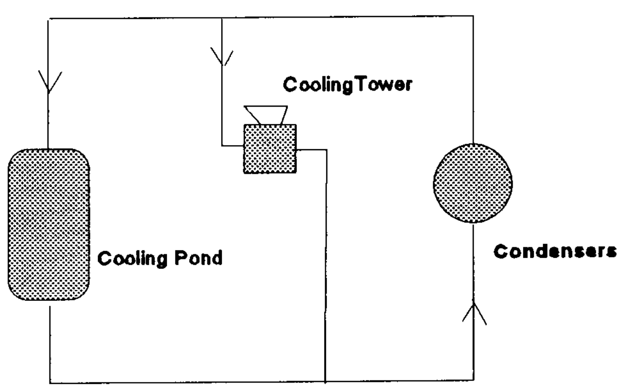
A study was requested on Santee Cooper's Winyah Generating Station on the heat rejection system for Units 1 and 2. This study uses the PEPSE software in a unique way that would give meaningful results. The heat rejection system includes the use of a cooling pond and cooling tower for the two generating units. Test data was collected on the cooling pond and cooling tower systems over three months of operation. The data was used to construct a working PEPSE model of this system. This data was then used to evaluate different heat rejection systems for the most efficient cooling pond and cooling tower setup.

Introduction

Winyah Units 1 and 2 are two of four 260 net MW generators at Santee Cooper's Winyah Generating Station in Georgetown, South Carolina.

The Units 1 and 2 cooling circuits are setup with an approximately 411 acre cooling pond and an eight-cell cooling tower in parallel with each other, Figure 1. The cooling pond is the primary heat rejection component and the cooling tower is used during the hotter months when both units

Figure 1- parallel tower



are online.

The goals for this study were:

1- To build a working model of the cooling system, and

2 - To determine the optimal placement for the cooling tower in relation with the cooling pond.

The result of this study was that the optimal tower placement is in series with the pond at the pond's outlet flow.

PEPSE Modeling

Design data was not available for the pond with information that the PEPSE model could use. Therefore, data was collected on the system over a period of two to four months, during the spring and summer. This data was then used to estimate the operating performance of the tower and pond. Data was collected with the cooling tower in and out of service.

Data was collected at 11 points on the heat rejection system. See Figure 2. Two different modes are used to collect the data. Manual collection was completed at points not monitored by the Performance Services data acquisition system. The DAS collected the remaining points required for the modeling.

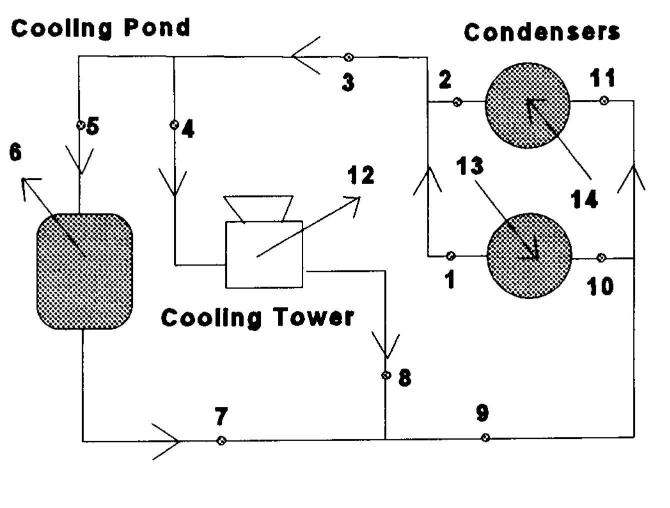


Figure 2 - Data collection points ∘

A summary of the data points collected are listed in Table 1 below.

Data Collection

Table 1

Location	Reading Type/Number	Collection Method		Calculated Data
		DAS	Manual	
1-W1 CW in	Temperature (F)	X		
2-W2 CW in	Temperature (F)	X		
3-Avg. CW in				X
4-Hot water Tower	Temperature (F)		X	
5-Hot water Pond	Temperature (F)		X	
6-Heat Rejection Pond	Btu/hour			X
7-Intake Canal to Plant	Temperature (F)		X	

Location	Reading Type/Number	Collection Method		Calculated Data
		DAS	Manual	
8-Cold Water Out of Tower	Temperature (F)		X	
10-W1 CW in	Temperature (F)	X		
11-W2 CW in	Temperature (F)	X		
13-Heat in from Turbine W1	Btu/hour			X
14-Heat in from Turbine W2	Btu/hour			X
wb	Temperature (F)		X	
db	Temperature (F)		X	
W1 Condenser Abs.	Inches Hg	X		
W2 Condenser Abs.	Inches Hg	X		
Ambient Pressure	Psia	X		
Steam Flow	lb/hour	X		X

This data was used to benchmark the four major components in the model. These components were the two condensers, cooling tower and cooling pond. This model incorporated two overall heat transfer coefficients, one for each of the two flows going through the pond. The cooling pond was modeled as a large 4,356,000 square foot surface area heat exchanger, with a temperature rise of 10°F. These heat transfer coefficients were calculated using the collected data and the above assumption of temperature rise and surface area.

The tower was modeled using the tower approach temperature, humidity and air flow. This data was used to calculate tower capability. For the outlet series tower, capability was used to calculate the tower approach by trial and error. This estimate was completed using a tower capability test spreadsheet developed in-house. The data was also given to a vendor for analysis. Our estimates were within 1.2 degrees F of the vendors predicted temperatures.

Condensers were modeled for the specified heat into the circulating water system at full load generation. Full load steam flow conditions were taken from the DAS to calculate condenser heat load for this system. Worst case heat loading of the pond and tower cooling system was the only concern for this study. Therefore the condensers were modeled as a constant heat source.

This produced a working PEPSE model of the current system for both tower on and tower off. From these results, a model could be produced for the other two systems in consideration. The cooling circuit was then modeled to accommodate these other systems. Figure 1 shows the current cooling circuit, Figures 3 and 4 show the other circuits modeled. The end result of these cooling circuits was a PEPSE schematic represented in figure 5. This was the model which was

Figure 3 - inlet series tower

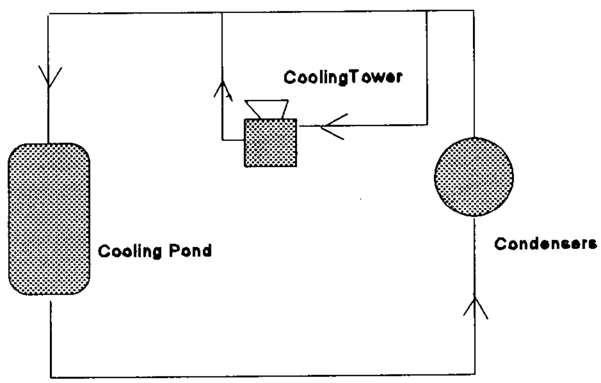
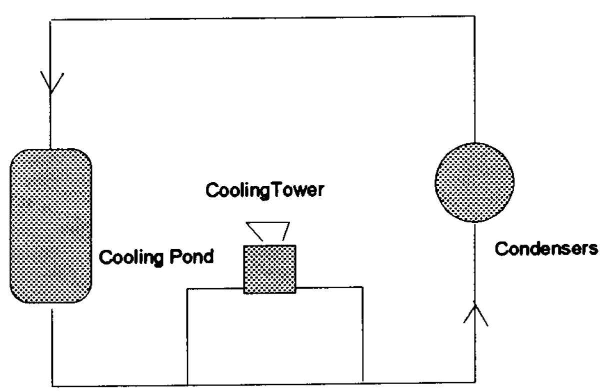
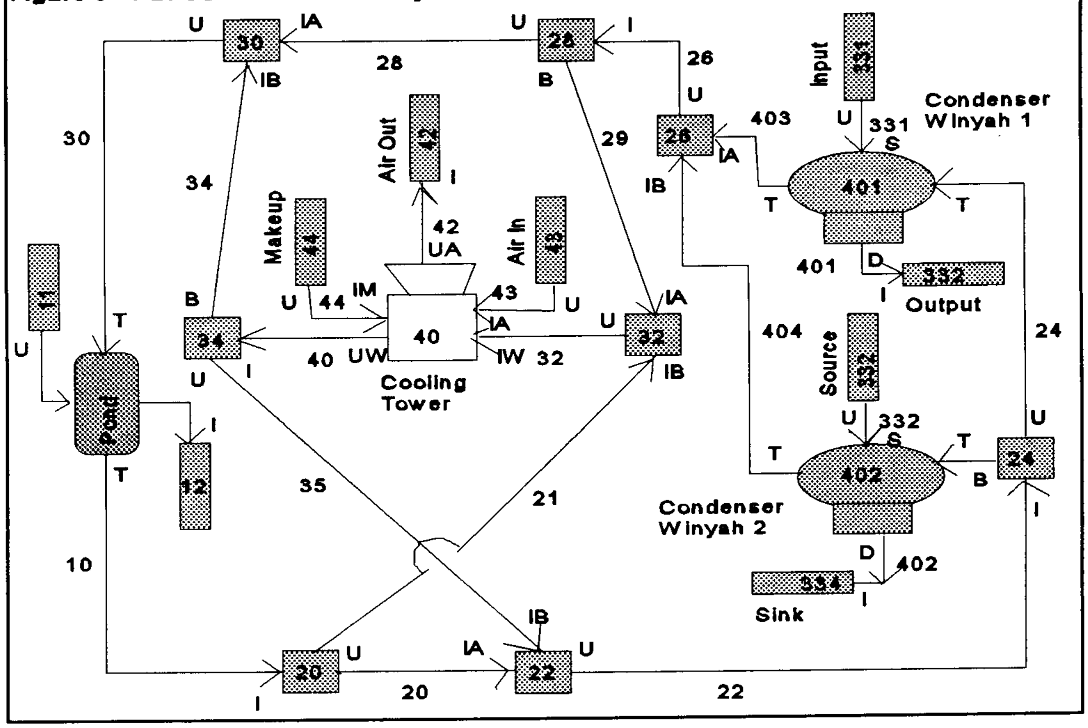


Figure 4 - outlet series tower



constructed and bench marked using the data collected. A PEPSE (card) deck of this model appears in Appendix I.

Figure 5 - PEPSE Schematic: Winyah 1 and 2 Cooling system



Results

There were four different PEPSE cases reviewed. Two cases were used for bench marking the model. The other were two possibilities for cooling systems.

Benchmark cases were modeled from data collected during the summer of 1996. The base case was run with the tower in a parallel flow circuit (Figure 1). The next case was for the tower off using only the pond for cooling. Data from the first case revealed an estimated tower capability of 65 percent. A two degree reduction in cold water temperature can be expected from a tower capability of 100 perccent. It is estimated that every two degrees in temperature reduction is approximately 3 to 21 Btu/kwh in heat rate improvement. This improvement is dependent upon what the starting inlet temperature is.

The other two cases used the tower as an inlet series pre-cooler and an outlet series post-cooler. Table 2 shows the final cold water temperature the condensers would see.

Table 2

Condenser cold water inlet temperatures	Performance Services Results (F)
Current circuit with 65% tower in parallel	92.0
Cooling circuit with 65% tower inlet series cooling	91.0
Cooling circuit with 65% tower outlet series cooling	90.0

The cases were then rerun to show what would happen if the tower capability was 100 percent. Table 3 below shows these results.

Table 3

Condenser cold water inlet temperatures	Performance Services Results (F)
Current circuit with 100% tower in parallel	90.0
Cooling circuit with 100% tower inlet series cooling	91.0
Cooling circuit with 100% tower outlet series cooling	88.0

Conclusion

This study shows the best position for a cooling tower is as an outlet series post-cooler. Also that improving the capability will gain greater improvement than changing the cooling system. Currently there are no plans for changing the system to a post-cooler arrangement, but there is work being completed on the tower to improve its performance capability.

APPENDIX A

```
010001 80  * 80 COLUMN OUTPUT SPECIFICATION FOR VERSION 55H
= Model for the winyah 1 and 2 cooling pond and cooling tower
* TOWER CAPABILITY SET AT 100 PERCENT
*
* TYPE: DESIGN MODEL
* PROJECT: EVALUATE the possible configurations of tower inlet and
* outlet for the most effective setup
* FILE NAME: PNDMODL3
* FILE CREATED: 09/25/96  LMS
************************************************************************
* GENERIC DATA
************************************************************************
010200  0
012000  15, 50.0,  100.0
012001  5, 2, 5, 2, 2, 1, 0, 3
************************************************************************
*  OUTPUT TABLE SUPRESSION
************************************************************************
020000  Noprnt
020001  PRINT  * FLAG SETTINGS AND DATA FOR SYSTEM
020003  PRINT  * COMPONENT PROPERTIES
020009  PRINT  * FEEDWATER PERFORMANCE -A-
020010  PRINT  * FEEDWATER PERFORMANCE -B-
020012  PRINT  * DETAILED HEAT EXCHANGER PERFORMANCE OUTPUT
020013  PRINT  * DETAILED SOURCE, SINK , AND VALVE PERFROMANCE OUTPUT
020020  PRINT  * FIRST LAW - SYSTEM
020025  PRINT  * FIRST LAW - ENVELOPE
020038  PRINT  * SPECIAL INPUT PARAMETERS
020042  PRINT  * OPERATION SET VALUES CALCULATED
020051  PRINT  * ENVELOPE PERFORMANCE
020061  PRINT  * ENVELOPE PERFORMANCE, HEAT RATE
************************************************************************
*  STREAM GEOMETRY
************************************************************************
500100  10,  T,  20,  I
500110  11,  U,  10,  S
500120  10,  D,  12,  I
500200  20,  U,  22,  IA
500210  20,  B,  32,  IB
500220  22,  U,  24,  I
500240  24,  U,  401,  T
500250  24,  B,  402,  T
500260  26,  U,  28,  I
500280  28,  U,  30,  IA
500290  28,  B,  32,  IA
```

```
500300  30,  U,  10,  T
500320  32,  U,  40,  IW
500340  34,  B,  30,  IB
500350  34,  U,  22,  IB
500400  40, UW,  34,  I
500420  40, UA,  42,  I
500430  43,  U,  40,  IA
500440  44,  U,  40  IM
503310 331,  U, 401,  S
503320 332,  U, 402,  S
504010 401,  D, 333,  I
504020 402,  D, 334,  I
504030 401,  T,  26,  IA
504040 402,  T,  26,  IB
**********************************************************************
*  STREAM FLOW STREAM TOTAL CIRC FLOW
**********************************************************************
* Special stream card for a closed circuit system
* It applies for the stream before the condenser inlet splitter
600220  6, 1, 1, 91.9, 14.7, 155148708.0
**********************************************************************
*  STREAM closures: set up for the as built cooling circuit
**********************************************************************
600216  CLOSE
600346  CLOSE
**********************************************************************
*  COMPONENT SPECIFICATIONS
* INPUT COMPONENT USED ON UNIT 1 CONDENSER STEAM IN
**********************************************************************
703310  33, 116.00, 1.512,  1339625.0,  0.0,  1112.0
**********************************************************************
* Simulated Pond component using HXCHGER
**********************************************************************
700100  20
700102  2,  -432986400.0,  99.44,  4356000.0
700109  0
**********************************************************************
* Cooling Tower
**********************************************************************
* Card order is #, CTYPE,IBLOWD,IDXCOO,APIOWI,TTUA
* CTYPE=75 for cooling tower,IBLOWD=0 for no blowdown flow,
* APTOWI=9.4 is the tower approach temperature.= Tc-Twb
* TTUA=100 Tower exit air temperature this was a educated guess.
700400  75, 0, 44,  9.4, 100.0
**********************************************************************
```

```
* SPLITTERS
**************************************************************************
700200 63, 0.0, 0.401284109
700240 63, 0.0, 0.36918138
700280 63, 0.0, 0.401284109
700340 60, 0.0, 62278353.0
**************************************************************************
* CONDENSER Winyah 1
704010 10, 0, 2, 0.0, -3.08
* CONDENSER Winyah 2
704020 10, 0, 2, 0.0, -3.60
**************************************************************************
* MIXERS
**************************************************************************
700220 50, 1
700260 50, 1
700300 50, 1
700320 50, 1
**************************************************************************
* OUTPUT
**************************************************************************
703330 32
**************************************************************************
*Sources and Sinks
**************************************************************************
700120 30
700420 30
703340 30
700110 31,  90.0, 14.7, 170660976.
700430 31,  90.0, 14.7, 110000000.
700430 31,  90.0, 14.7,  52000000.
700433 AIR, .62
700440 31,  90.0, 30.0, 1000.0
* Input for steam from Unit 2 into the condenser.
703320 31, 121.58, 1.76832, 1361350.0, 0.0, 1114.0
/
= Tower out of Service
**************************************************************************
* STREAM FLOW STREAM TOTAL CIRC FLOW
**************************************************************************
700340 60, 0.0, 0.0
700102 2, -726711480.0, 166.83, 4356000.0
700110 31,  90.0, 14.7, 272364693.
**************************************************************************
* STREAM closures: for tower out of service
```

```
*****************************************************************************
600296  OPEN
600346  OPEN
600216  OPEN
600356  OPEN
600296  CLOSE
600346  CLOSE
600216  CLOSE
600356  CLOSE
/
= stream cooling series at inlet
*****************************************************************************
*  STREAM FLOW STREAM TOTAL CIRC FLOW
*****************************************************************************
703310  33, 116.00, 1.512,  1339625.0,  0.0,  1112.0
703320  31, 121.58,  1.76832, 1361350.0,  0.0,  1114.0
700340  60,  0.0,  0.0
700102  2,  -726711480.0, 166.83,  4356000.0
700110  31,   90.0,  14.7,  272364693.
*****************************************************************************
*  STREAM closures pond adjusted for flow chg.
*        and cooling in series at the inlet of the pond.
*****************************************************************************
600296  OPEN
600346  OPEN
600216  OPEN
600356  OPEN
600216  CLOSE
600356  CLOSE
/
= stream cooling series at outlet
*****************************************************************************
*  STREAM FLOW STREAM TOTAL CIRC FLOW
*****************************************************************************
*  Tower card was updated to account for the different
*  approach temperature due different inlet water temperature.
700400  75, 0, 44,  4.4,  98.0
*****************************************************************************
*  STREAM closures : for cooling series at the outlet of the pond.
*****************************************************************************
600296  OPEN
600346  OPEN
600216  OPEN
600356  OPEN
600296  CLOSE
```

600346 CLOSE

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References

The following references were used during the course of analysis and in preparation of this paper.

1- PEPSE computer code, SCIENTECH Inc., 440 West Broadway, Idaho Falls, Idaho

2- PEPSE Manual: volumes I, II, III, IV, SCIENTECH Inc., 440 West Broadway, Idaho Falls, Idaho