Power Plants and Personal Computers

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POWER PLANTS AND PERSONAL COMPUTERS

BY: Jack E. Steele, Jr., P.E.

Engineers at South Carolina Electric & Gas Company have reduced the time it takes to produce results of power plant testing from days to less than an hour by using personal computers.

Engineers can now quickly analyze data to help improve plant thermal efficiency and can solve power plant problems in a fraction of the time previously required.

Before the installation of the IBM-PCs, turbine efficiency data was collected by the results engineer and the test engineering group. This data was formatted and sent to a Control Data Corporation computer in Minneapolis for analysis in the Syntha program. With the introduction of the personal computer, it was immediately apparent that the logical place to use such a powerful electronic tool was the power plant. The PC has the software to run the turbine efficiency by stages at the plant and can provide vital information more quickly than the standard Syntha test. This does not, however, eliminate the need for the Syntha turbine test which analyzes the complete turbine cycle.

Boiler efficiency now can be calculated on the PC by entering data into a program written from the ASME heat loss method. The

results are readily available from a printout. Previous methods required manually calculating the numerous formulas required for the test and then transferring the results to a printed form.

With the installation of each IBM-PC, SCE&G plans to install a data acquisition unit and hard wire data points from the turbine and the water treatment area for continuous monitoring. Other major pieces of equipment will be wired for periodic monitoring.

Purchasing and installing a personal computer in each power plant required much planning and coordination between Production Operations and Computer Services. Selecting hardware was a major task, with care taken to choose reliable hardware that would not quickly become obsolete. Compatibility with the mainframe IBM computer was also a prime consideration. Hardware installed in each of the fossil plants included:

1 - IBM-PC Model 5150 with 256k and 2-320k disk drives
1 - Techmar memory expansion board with 256k
1 - Ast 6-PAK memory expansion board with 384k
1 - Sanyo monochrome monitor
1 - IBM color graphics adapter board
1 - Epson RX-80 graphics printer
1 - Hayes 1200 external "smart" modem
1 - Irmaprint 3278 printer adapter host/pc

SCE&G was one of the first utilities to test available power plant thermal performance software; little software had been tried in the field. Because of this, the selection of software became a time consuming task since each program required a thorough evaluation.

Two programs were developed for data entry and file transfer. The spreadsheet Lotus 1-2-3 and later Symphony were used for these programs. One program was for monthly power station reports, the second for daily plant heat rates. Each of these programs allowed a transfer of data to the host computer by way of the company-owned microwave communications system. Each IBM-PC is linked to the host by an Irma 3278 emulator interface board.

Data is transferred into a TSO (time sharing option) dataset on the mainframe computer. A program which calculates system heat rates as well as individual plant heat rates and statistics is run against this data. The Roscoe program for the monthly power station report produces individual plant data but does not compile data for the system. For easier entry and access of data, SCE&G engineers converted original programs to database programs.

The IBM-PC is menu-driven, making it easier to quickly perform a number of functions. Two of the most useful functions of the menu are to activate a file transfer program and to automatically link the PC to the mainframe computer. File transfer is done automatically from within the program by typing a code word. File transfer is now a common practice between the remote stations. This has eliminated the problems encountered by mailing diskettes containing programs and data.

Before the introduction of the IBM-PC into the power plant, all performance data was transmitted by telephone and by mail. Now this data is either transferred to the mainframe computer or is entered directly into a program that resides on the mainframe. This includes all fuel management and materials management data which is entered into database mainframe programs. Electronic mail is used on the computer to send messages to individuals or to a network. This allows a hard copy of important messages and reduces misunderstanding.

The microwave is used in most instances to communicate with the mainframe computer; however, each plant PC is capable of talking to the mainframe computer or from PC to PC by way of the Hayes smart modem and the local telephone system.

Engineers in the power plants can determine how the turbines are performing by using EX-PROP, an interactive program sold by Exergetic Systems, Inc. of Livermore, Calif. This is an excellent program for turbine performance and also contains the ASME steam tables. A program that deserves high merit is EX-FOSS for boiler efficiency. This program is interactive and is a product of Exergetic Systems, Inc.

Two other Exergetic Systems, Inc. programs, EX-AIR and EX-GAS, are also interactive and are used for cooling tower and fan efficiency, respectively. Other software programs purchased from Energy, Inc. are a part of the "BETH" library. These programs provide engineers with the ASME heat loss method of determining boiler efficiency, feedwater heater performance and condenser cleanliness. These programs are interactive and are called HTLOSS, FWHTR and CONDEN.

Two other programs from Energy, Inc. of Idaho Falls, Idaho are APHTR and GASTUR. These programs are interactive and are used for air heater thermal performance and gas turbine efficiency. Another program which provides valuable information as well as pressure drops in piping is called PRESDROP. This is also an interactive program and is sold by Impulse Engineering of San Francisco, California. This company can provide an excellent interactive ASME steam table and turbine efficiency program

called IMP-STM/PC and a newer version called STEAM'85/PC. Programs from Exergetic Systems, Inc. and Impulse Engineering are compatible with Lotus 1-2-3 and have file write capabilities. They are also compatible with IBM "TOPVIEW" and Microsoft "WINDOWS" PC task integrating programs.

The total cost for hardware and software to support six installations is less than $70,000. Using the IBM-PC to improve efficiency in one plant saved approximately $250,000 the first year. The intangible savings have have not been determined; however, the IBM-PC enables the engineer to closely monitor equipment in the plant. This makes it easier to quickly correct problems and prevent failure and down time.

The potential of the IBM-PC to provide the engineer with the necessary solutions to improve power plant efficiency is limited only by the software available. SCE&G was fortunate to find the right programs to fit our needs. There is an abundance of software programs on the market; however, only a few are worth the investment.

Training is of the utmost importance in making a PC network successful. At South Carolina Electric & Gas Company, the Computer Services department provides an in-house training program for users and potential users. The training consists of

a course using a hands-on terminal tutorial method. A formal training program in Roscoe utilizes textbook instruction, videotape and personalized instruction on the terminal.

Courses are also available in TSO, Dynaplan, JCL, SAS and E-Mail. Engineers receive personalized training in using the IBM-PC at the site from software tutorials and instructions provided by the Engineering Support department.

SCEG PLANT PERFORMANCE MENU

1 - CE78 - ACT LIKE A TERMINAL
(TYPE 1 OR PRESS BOTH SHIFT KEYS)

2 - PC/COM FILE TRANSFER

3 - BASICA

4 - DW3

5 - SYMPHONY

6 - PRINTER UTILITIES

7 - ENGINEERING PROGRAMS

X - EXIT TO DISK OPERATING SYSTEM (DOS)

ENTER DESIRED SYSTEM

FILE TRANSFER MENU

0 - AUTOMATICALLY SEND daily DATA TO PLANT FILE

1 - AUTOMATICALLY SEND monthly DATA TO PLANT FILE

2 - GO TO PCCOM MANUAL MENU

3 - SEND WORKSHEET OR BASIC PROGRAM TO HOST

4 - RECEIVE WORKSHEET OR BASIC PROGRAM FROM HOST

5 - SEND A BATCH OF FILES

6 - RECEIVE A BATCH OF FILES

7 - SEND A FILE TO A HOST PRINTER

X - RETURN TO MAIN MENU

ENTER OPTION

SCEG PLANT PERFORMANCE UTILITY MENU

2 - RESET PRINTER (TO ROMAN, PICA, SINGLE-STRIKE)
3 - TURN ON ITALIC MODE
4 - TURN OFF ITALIC MODE
5 - TURN ON DOUBLE-STRIKE MODE
6 - TURN OFF DOUBLE-STRIKE MODE
7 - TURN ON EMPHASIZED MODE
8 - TURN OFF EMPHASIZED MODE
9 - PRINT A TEST SENTENCE ON THE PRINTER

10 - TURN ON PICA MODE (10 CHAR./INCH)
11 - TURN ON ELITE MODE (12 CHAR./INCH)
12 - TURN ON COMPRESSED MODE (17 CHAR./INCH)
13 - TURN OFF COMPRESSED MODE
14 - SWAP PRINTERS (IF YOU HAVE MORE THAN ONE)

X - EXIT TO MAIN MENU

ENTER DESIRED OPTION

ENGINEERING PROGRAMS

0 - EX-PROP - INTERACTIVE WATER/SYSTEM PROPERTIES
TURBINE, HEAT PUMP EFFICIENCY

1 - EX-AIR - INTERACTIVE AIR PROPERTIES

2 - EX-GAS - INTERACTIVE GAS AND HYDROCARBON PROP

3 - BETH SYSTEM MENU

4 - COMPILE, LINK & EXECUTE FORTRQN PROG PJF 112985

5 - CHECK VOLTAGES ON LAB MASTER
ONLY USE POWER SOURCES OF VOLTAGES -10 to +10 V

X - RETURN TO MAIN MENU

ENTER OPTION

BETH MENU

0 - ASPHTR		AIR PREHEATER THERMAL EFFICIENCY
1 - ATMOS	(N/A)	COMBUSTION CALCULATIONS
2 - BOGEY	(N/A)	BOGEY CURVE DATA ANALYSIS
3 - CONDEN		CONDENSER PERFORMANCE
4 - FWHTR		FEEDWATER HEATER PERFORMANCE
5 - GASPROP	(N/A)	THERMODYNAMIC GAS PROPERTIES
6 - GASTUR		GAS TURBINE PERFORMANCE
7 - HTLOSS		BOILER EFFICIENCY (HEAT LOSS METHOD)
8 - INOUT	(N/A)	BOILER EFFICIENCY (IN/OUT METHOD)
9 - PSYCHR	(N/A)	PSYCHROMETRIC TABLES
A - PUMP	(N/A)	PUMP PERFORMANCE
B - STMTUR	(N/A)	STEAM TURBINE PERFORMANCE
C - WATPROP	(N/A)	THERMODYNAMIC WATER PROPERTIES
D - XYPLOT		CARTESIAN GRAPHICS PROGRAM

X - RETURN TO ENGINEERING MENU

ENTER OPTION

An example of how Ex-Prop may be used to monitor turbine performance is shown in the attached print-outs. Pressure and temperature readings are taken periodically while the turbine is operating at or near maximum capacity. The data points are selected as the inlet and outlet of the high pressure section, the intermediate pressure section, and the low pressure section of the turbine. The engineer enters the data into the steam table section of Ex-Prop and presses the control and F1 keys which initiate the calculation of all of the state values. The turbine efficiency mode is selected and the inlet and outlet state points of each section are entered. The turbine efficiency calculation is initiated by pressing the control and F5 keys and the results are displayed on the screen.

The pressure and temperature readings which are necessary to run the program are readily available. The collection of data and running the program can be completed in less than half an hour. This enable the engineer to closely monitor the turbine and establish a trend. If the efficiency begins to change at the same loads then this is an indication of a problem that needs further testing to determine the exact cause and location. This is where the Syntha program becomes an invaluable tool since it has the capability to pin-point the problem areas as in the case at Wateree Station with Unit No. 2 turbine.

The No. 2 turbine at Wateree Station was monitored for a six month period and it was evident the the efficiency was continuing to drop in the high pressure section of the turbine. Syntha testing confirmed that a problem existed in the first stage of the high pressure turbine and with the steam seals in other stages.

As a result of the testing, an outage was scheduled to correct the turbine problems. The repairs made to the turbine increased the high pressure turbine efficiency by 7% and the output at the generator by approximately 31 megawatts for an annual savings of $1,056,675.

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EX-PROP v.2.2          WATEREE UNIT NO. 2 HP TURBINE                86/07/14 09:48
---------------- S T A T E   P O I N T S   F O R   W A T E R -------------------
PROPERTIES   Point 1  Point 2  Point 3  Point 4  Point 5  Point 6
Channel No.   HP1       HP7
Press    psia>3480.500>600.9000
Temp    deg-F>1011.700>561.6000
EnthalBtu/lb 1430.931 1263.359
Qualty Fract 99.99990 1.162442
SpcVolft^3/# .2113828 .8902009
ExergyBtu/lb 704.7990 522.5185
EntrpyBtu/#R 1.476815 1.506730
IntEngBtu/lb 1294.787 1164.372
NozCon C=P/v
-------------------- T U R B I N E   E F F I C I E N C Y ---------------------
Turbine bowl state point 1
Turbine shell state point 2

Isentropic     HH(B)-HH(X)                  Exergy           HH(B)-HH(X)
Efficiency = ---------------- =.8483990   Effectiveness = ------------ =.9193071
( Fract)      HH(B)-HH(isen)               ( Fract)         GG(B)-GG(X)

Legend: HH=Enthalpy, GG=Exergy, B=Bowl(inlet), X=Shell(eXhaust)

EX-PROP v.2.2 Copyright (c) 1984 Exergetic Systems, Inc.
F1=State, F2=Energy Bal, F5=Turb Eff, F6=Pump Eff, F8=Save, F9=Config, F10=Help
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```
EX-PROP v.2.2          WATEREE UNIT NO. 2 IP TURBINE                86/07/14 09:54
----------------- S T A T E   P O I N T S   F O R   W A T E R -------------------
PROPERTIES    Point 1   Point 2   Point 3   Point 4   Point 5   Point 6
Channel No.   HP1       HP7       IP-IN     IP-OUT    LP-IN     LP-OUT
Press    psia>3480.500>600.9000>568.7000>99.72000>99.72000>.4150000
Temp    deg-F>1011.700>561.6000>1015.200>571.2000>569.1000 73.94083
EnthalBtu/lb 1430.931  1263.359  1526.960  1314.874  1313.824>985.2569
Qualty Fract 99.99990  1.162442  1.875147  1.363180  1.360201  .8968287
SpcVolft^3/# .2113828  .8902009  1.507958  6.053291  6.040105  686.0287
ExergyBtu/lb 704.7990  522.5185  677.5700  457.0090  456.4602  75.89529
EntrpyBtu/#R 1.476815  1.506730  1.727499  1.744735  1.743715  1.849469
IntEngBtu/lb 1294.787  1164.372  1368.266  1203.172  1202.364  932.5728
NozCon C=P/v
--------------------- T U R B I N E   E F F I C I E N C Y ----------------------
Turbine bowl state point 3
Turbine shell state point 4

Isentropic     HH(B)-HH(X)                    Exergy           HH(B)-HH(X)
Efficiency = ---------------- =.9238616   Effectiveness = ------------ =.9615767
( Fract)     HH(B)-HH(isen)                 ( Fract)        GG(B)-GG(X)

Legend: HH=Enthalpy, GG=Exergy, B=Bowl(inlet), X=Shell(eXhaust)

EX-PROP v.2.2 Copyright (c) 1984 Exergetic Systems, Inc.
F1=State, F2=Energy Bal, F5=Turb Eff, F6=Pump Eff, F8=Save, F9=Config, F10=Help
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```
EX-PROP v.2.2          WATEREE UNIT NO. 2 LP TURBINE                86/07/14 09:54
----------------- S T A T E   P O I N T S   F O R   W A T E R --------------------
PROPERTIES   Point 1  Point 2  Point 3  Point 4  Point 5  Point 6
Channel No.  HP1       HP7       IP-IN     IP-OUT    LP-IN     LP-OUT
Press    psia>3480.500>600.9000>568.7000>99.72000>99.72000>.4150000
Temp    deg-F>1011.700>561.6000>1015.200>571.2000>569.1000 73.94083
EnthalBtu/lb 1430.931 1263.359 1526.960 1314.874 1313.824>985.2569
Qualty Fract 99.99990 1.162442 1.875147 1.363180 1.360201 .8968287
SpcVolft^3/# .2113828 .8902009 1.507958 6.053291 6.040105 686.0287
ExergyBtu/lb 704.7990 522.5185 677.5700 457.0090 456.4602 75.89529
EntrpyBtu/#R 1.476815 1.506730 1.727499 1.744735 1.743715 1.849469
IntEngBtu/lb 1294.787 1164.372 1368.266 1203.172 1202.364 932.5728
NozCon C=P/v
--------------------- T U R B I N E   E F F I C I E N C Y ----------------------
Turbine bowl state point 5
Turbine shell state point 6

Isentropic     HH(B)-HH(X)                    Exergy           HH(B)-HH(X)
Efficiency = ---------------- =.8534099   Effectiveness = ------------ =.8633660
( Fract)      HH(B)-HH(isen)               ( Fract)         GG(B)-GG(X)

Legend: HH=Enthalpy, GG=Exergy, B=Bowl(inlet), X=Shell(eXhaust)

EX-PROP v.2.2 Copyright (c) 1984 Exergetic Systems, Inc.
F1=State, F2=Energy Bal, F5=Turb Eff, F6=Pump Eff, F8=Save, F9=Config, F10=Help
```

```
EX-PROP v.2.2          WATEREE UNIT NO. 2 TURBINE                    86/07/14 09:55
---------------- S T A T E   P O I N T S   F O R   W A T E R -------------------
PROPERTIES   Point 1  Point 2  Point 3  Point 4  Point 5  Point 6
Channel No.  HP1      HP7      IP-IN    IP-OUT   LP-IN    LP-OUT
Press   psia>3480.500>600.9000>568.7000>99.72000>99.72000>.4150000
Temp    deg-F>1011.700>561.6000>1015.200>571.2000>569.1000 73.94083
EnthalBtu/lb 1430.931 1263.359 1526.960 1314.874 1313.824>985.2569
Qualty Fract 99.99990 1.162442 1.875147 1.363180 1.360201 .8968287
SpcVolft^3/# .2113828 .8902009 1.507958 6.053291 6.040105 686.0287
ExergyBtu/lb 704.7990 522.5185 677.5700 457.0090 456.4602 75.89529
EntrpyBtu/#R 1.476815 1.506730 1.727499 1.744735 1.743715 1.849469
IntEngBtu/lb 1294.787 1164.372 1368.266 1203.172 1202.364 932.5728
NozCon C=P/v
-------------------- T U R B I N E   E F F I C I E N C Y ----------------------
Turbine bowl state point 1
Turbine shell state point 6

Isentropic     HH(B)-HH(X)                  Exergy          HH(B)-HH(X)
Efficiency = ------------- =.6914520   Effectiveness = ----------- =.7086527
( Fract)     HH(B)-HH(isen)             ( Fract)        GG(B)-GG(X)

Legend: HH=Enthalpy, GG=Exergy, B=Bowl(inlet), X=Shell(eXhaust)

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F1=State, F2=Energy Bal, F5=Turb Eff, F6=Pump Eff, F8=Save, F9=Config, F10=Help
```