GT-FACTS™ Version 2.5

Simple, Low-Cost, Off-Line
Gas Turbine Performance Monitoring Software

Background

Fern Engineering, Inc. has been developing software for monitoring the performance of gas turbines for more than 20 years. In 1982, under sponsorship from the Electric Power Research Institute (EPRI), Fern developed the first version of EfficiencyMap. This software is now in wide use throughout the electric power industry for on-line monitoring of gas turbine and combined cycle power plants.

In 1987, Fern demonstrated the capabilities of PC-based software in monitoring the performance of gas turbines and centrifugal compressors in pipeline operation with the emphasis on efficiency maintenance. Subsequently, the Gas Research Institute (GRI) funded the development of the PEGASYS™ software, which included beta tests on various simple and regenerative cycle engines.

Since 1987, Fern has continued to evolve the code, enhancing the robustness and versatility. The current version of PEGASYS™ is a set of generic modules for modeling, condition monitoring, and O&M cost optimization. To date, the software has been used for the on-line monitoring of over one hundred machines, including compressors, pumps, steam turbines, and gas turbines.

While on-line monitoring programs such as PEGASYS™ provide in-depth analysis of gas turbine performance on a component-by-component basis and can help an operator optimize maintenance activities, they are expensive to buy and expensive to implement in the field. For many gas turbine operators, such an investment cannot be justified, particularly if their turbines are being used for peak-load operation only.

GT-FACTS™ – A Low-Cost Alternative

Fern recognizes the need for low-cost, simple gas turbine performance monitoring software, and has developed an off-line product called GT-FACTS™. Using manufacturers' performance curves, GT-FACTS™ predicts the expected performance of a gas turbine as a function of barometric pressure, ambient relative humidity, ambient and inlet temperatures, and inlet and exhaust pressure drops. The expected performance is then compared to actual, as-measured performance of the turbine in terms of heat rate, air flow, and generator output. This data can be trended over time to detect deterioration in performance. A Microsoft® Excel™ spreadsheet with built-in plots and macros for importing the data produced by GT-FACTS™ is used for trending the data and producing reports that provide a "snapshot" of the turbine's performance at a given time.

Transpose to "Standard Day" Conditions

Because of the substantial effect that inlet temperature has on turbine performance, it is often difficult to determine if a drop in power output is due to a change in ambient temperature or to a deterioration in turbine performance. One way to overcome this is to correct or "transpose" actual operating performance back to "standard day" or "ISO" conditions. In this way, the effects of variations in ambient temperature are factored out. If no deterioration in machine

performance occurs, the transposed power should produce a trend plot that is a flat line. In reality, of course, factors such as compressor and inlet filter fouling or increased seal leakage cause the transposed power to drop over time. Figure 1 is a plot produced by the GT-FACTS™ 2.5 package using sample data that shows how trending the transposed power helps to clearly identify the magnitude of performance degradation that can be masked by changes in ambient temperature.

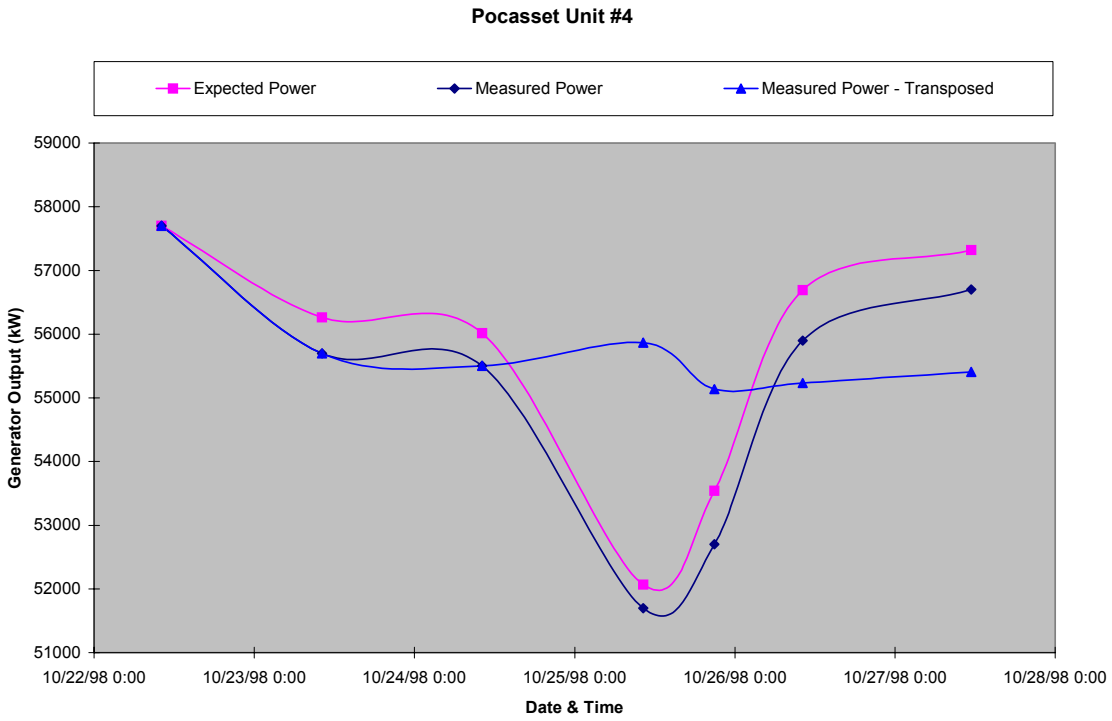

Figure 1 - Generator Power Trend Plot Produced by GT-FACTS™

Effect of Evaporative Cooling

Because inlet temperature has a strong effect on power output, many gas turbines are equipped with evaporative coolers to lower the inlet temperature on hot days. The same calculations used for transposing results back to ISO conditions (i.e., 59ºF) can also be used to evaluate the impact of evaporative cooling. For example, GT-FACTS™ also transposes the actual performance (heat rate, air flow, and power output) to the measured ambient temperature. If an evaporative cooler is used to reduce the inlet temperature to a given point below the ambient temperature, then the actual and transposed ambient results can be compared to see how much of a boost was provided by the evaporative cooling.

What Do You Need to Run GT-FACTS™?

If you have a Windows-based PC with a copy of Microsoft® Excel™ 97 or newer, you are ready to go. You need to have the following instrumentation on your gas turbine:

- Barometric pressure
- Ambient relative humidity
- Inlet temperature
- Ambient temperature (required only if evaporative cooling is used)

- Generator power output
- Heat rate
- Inlet pressure drop (can be estimated if it is not expected to vary significantly)
- Exhaust pressure drop (can be estimated if it is not expected to vary significantly)

Finally, you will need the following manufacturer's data for your gas turbine model(s):

- Site elevation
- Ambient temperature and relative humidity at rated conditions
- Inlet and exhaust pressure drops at rated conditions
- Rated performance in terms of power, heat rate, and air (or exhaust) flow on your fuel type
- Effect of additional inlet and exhaust pressure drop on heat rate and power
- Curves relating effect of inlet temperature on power, heat rate, and air (or exhaust) flow
- Curves relating effect of specific humidity on power and heat rate

This data will be used to produce the expected performance calculations for your turbine(s)[1].

How It Works

1. You start the GT-FACTS™ program by clicking on its icon.
2. On the opening screen, you choose the gas turbine model (e.g., GE PG7101E) that corresponds to the turbine you want to monitor.
3. Then you enter the measured data collected from the turbine at a given point in time.
4. As the data is entered, GT-FACTS™ automatically calculates the measured, expected, and transposed (to ISO and ambient temperature) performance of the turbine.
5. You can then export the results to a comma separated values file (*.CSV) which can be read by the Excel™ spreadsheet.[2] If this is the first time you are generating performance results for a given machine, you will want to start a new CSV results file. Otherwise, you will simply append the new results to an existing file. You can have as many different CSV results files as you wish. Typically, you would have one file for each machine you are monitoring.
6. Exit GT-FACTS™ and start Excel™.
7. Open the file GTFACTS.XLS (found in the GT-FACTS sub-directory).
8. In the Setup worksheet, click on the “Import Data” button. You will be prompted for a descriptive name for the turbine. Then use the familiar "File Open" window to find the CSV results file that you want. The data from the CSV file is automatically copied into the spreadsheet.
9. You can now look at the built-in charts that show trends of power, heat rate, and deviations between the measured and expected results. As with any Excel™ chart, the plots can be printed or copied into another document.
10. You can also look at a Gas Turbine Performance Analysis report that summarizes the performance results at a particular point in time. You can toggle through each result set that is in the CSV file by the click of a button. A "Print Report" button sends the report to your printer (if available).
11. When you are ready to look at results from a different machine, return to the Setup worksheet and again click the "Import Data" button. The previous results data will be cleared from the spreadsheet and a new CSV results file will be imported.

[1] In many cases, you may not need this data since GT-FACTS™ 2.5 comes with 39 gas turbine models already built-in. See the list at the end of this document.
[2] The version of GT-FACTS™ supplied with the demo package does not have the export capability. In addition, the demo version of the software does not allow the user to adjust the expected performance curves for a given gas turbine model to match the performance of a machine.

Price

The price for a site license of the GT-FACTS™ 2.5 package is only $495 USD. You may use this single copy to monitor all of the gas turbines at your site. GT-FACTS™ 2.5 comes with the expected performance curves of 39 gas turbine models already built in (see list below). If the gas turbines you are interested in monitoring are not included in this list, you can create your own using the model entry/modification capability of GT-FACTS™ 2.5. However, if you prefer, Fern Engineering, Inc. will do it for you. We charge a nominal set-up fee of $200 USD for each gas turbine model you would like added to the package.

The price includes any updates made to GT-FACTS™ within one year of your purchase.

Gas Turbine Models Currently Available in GT-FACTS™ 2.5

ABB GT11D-2
GE LM2500
GE LM6000
GE PG5211LA
GE PG5341N
GE PG5361P
GE PG6001B
GE PG6101FA
GE PG6521B
GE PG6541B
GE PG6551B
GE PG6561B
GE PG6581B
GE PG7101E
GE PG7111E
GE PG7111EA
GE PG7121EA
GE PG7211F
GE PG7221FA
GE PG7231FA
GE PG7781B
GE PG7821B
GE PG7931C
GE PG9171E
GE PG 9311FA
Mars T-12 000
Siemens V94.2
Taurus 70S-9000
Tornado-1S
UTC GG4A-7
Westinghouse W191G
Westinghouse W251B
Westinghouse W501AA-3
Westinghouse W501AB
Westinghouse W501B-6
Westinghouse W501D
Westinghouse W501D5A
Westinghouse W501F
Westinghouse W501G-CC

About Fern Engineering, Inc.

Fern Engineering, Inc. is an independent, employee-owned engineering consulting firm located on Cape Cod in Massachusetts. Since 1967, Fern has provided engineering services to gas turbine users and manufacturers throughout the world. A full list of our services and capabilities can be found at our award-winning Website: www.fernengineering.com