Use and Experience of Gas Turbine On-line Diagnostics

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Abstract

Ten years ago Gas Turbine (GT) Diagnostic Systems were ordered in less then 10 % of new units. Today this has changed dramatically; almost all newly ordered gas turbines are equipped with at least a basic Diagnostic System. A main reason is the constantly progressing gas turbine technology.

To minimize the risk for vendor and customer, diagnostic benefit starts from the beginning of gas turbine life time with product development and engineering, continues during plant shop test, commissioning, acceptance test and warranty period and closes the loop with maintenance and service.
The modular WIN_TS Diagnostic System connected to the I&C System has access to any of the sensors and obtains between 300 and 1000 signals. Additionally to these signals with the highest resolution of 1s, a high speed data acquisition for selected signals is included for analogue and for binary signal analysis down to milliseconds. Together with Database, Archive and Remote Access, these is the basic system frame, on top of which there are various technology modules.

There are for example thermodynamic, hot gas path, vibration and component life cycle modules available for analysis and diagnostics.

Through remote access, the system is connected to a Diagnostic Center from which it is commissioned and to where it sends data via a data container. By means of the Diagnostic Center, the experts have the possibility to support any critical situation during commissioning or service. Just some mouse clicks enable them to obtain data from gas turbines all over the world.

The operating data taken from the Win_TS system are also very important for generation of availability and reliability figures as well as fleet statistics.

Based on the evaluation of different vibration parameters out of Win_TS it is also possible to contact engineering for support and remedies. Examples show how engineering advises inspections and how the early knowledge of the unit condition can significantly help to improve the unit availability.

For the customer it is important to have access to the knowledge of the developers of his gas turbine in critical situations through a diagnostic platform.

For the supplier the highest value is live feedback from his own „running technological systems“ in order to to optimize learning.
1 Power Plant Market and Role of Advanced Monitoring and Diagnostics Systems

In all world regions, the power generation market has been characterized in recent years by its orientation towards utilization of gas turbines, both as simple cycle and combined cycle plant applications. In these plant configuration, both proven or advanced gas turbines represent the high tech piece of equipment at the core of the plant. Regardless of the overall plant configuration and other extended equipment installed, the Return on Investment ultimately hinges on the gas turbine. Hence it is essential to focus on this crucial core component.

One lever to do this is to employ advanced Monitoring and Diagnostics Technology. The approach presented in this paper was fully developed and implemented over recent years, including input and feedback both from customers and gas turbine development. The goal is to maximize investment security and returns throughout the complete plant life cycle. The critical plant scope for this includes besides the gas turbine the generator, the air intake/exhaust system and the corresponding auxiliary systems, as shown in Figure 1. (Siemens name for this product scope: Econopac™, derived from Economical Package)

![Figure 1: Monitoring and Diagnostics of GT Plant Key Components](image-url)
Presented here, Monitoring and Diagnostics applied to the Econopac is the tool to back the customer’s key generation technology and investment with matching state-of-the-art support technology and processes. In essence it is advanced life-time support based on a **high-tech platform for monitoring, diagnostics and service**, contributing to achieve high reliability.

**Fig. 2**

The underlying philosophy of the GT-Econopac Monitoring and Diagnostics concept is described within the triangle of Quality Management (**Figure 2**):

- focus on function : performance,
- time: response time, and
- value: reliability through prevention of forced outages.

Illustrated in the center of the triangle are the corresponding key elements of the concept and the benefits of the implementation of Monitoring and Diagnostics:  

- Diagnostics during all stages of turbine operation and life cycle  
  (also channelled into the feedback loop for new product development)
- Condition-based maintenance evaluated and directed by experts

- Detection and resolution of problems, more effective prevention of forced outages

In the recent years enormous advances were made in the fields of development of computer power, network technology, as well as specific diagnostic tools. This provided the information technology basis (IT) for advanced Monitoring and Diagnostics in an on-line mode, with remotely, centralized performed interrelated data analysis and diagnostics.

![IT innovation supports Gasturbine Diagnostics](image)

**Fig. 3**

Hence, 10 years ago GT Diagnostics Systems were ordered in less than 10% of new units. Today this has changed dramatically; almost all newly ordered gas turbines are equipped with at least a basic Diagnostic System. A main reason is the constantly progressing gas turbine technology. Correspondingly, IT innovation keeps growing and supporting gas turbine diagnostics development. 1990 typically a PC runs with a Intel 486 / 33MHz while today the speed is increased over 3 GHz with a Pentium 4.
For example, in 1990 the transfer of 10 MB data with a 1200 Baud modem took one day, 2004 it only takes 14 minutes with a dual ISDN line and just 30 seconds with intranet/LAN connection. 10 MB is today a typical day file size for gas turbine data which is transferred between fields and offices.

**Figure 3** shows the increase of processor speed and Gas turbine Diagnostics installations in new units.

2 Diagnostic System Platform: Task and Concept

**Evolution Goal:** one common platform for GT, ST and GUD Data Acquisition & Diagnostics

**Past**

*Gas Turbine Diagnostic Calculators* and other diagnostic systems in the early 90th

**Today**

Modern PG Diagnostic Systems „WIN_TS” today

**Fig. 4**

In the early 90’s, a number of different hard- and software Systems were necessary to perform the diagnostics tasks in a plant. To reduce the complexity of those configurations the development goal was to achieve a common platform for data acquisition and diagnostics.

**Figure 4** shows in the upper section a typical example from the early 90’s with the high complexity of different hard- and software installations. These installations were more or less not compatible and used in separate and stand-alone mode. To do this, diagnostic capabilities
were limited, time consuming and required a high formal software and hardware competence. Shown in the lower section is the example for today, with the reached development goal, while profit could be taken from the information technology evolution. Through one common platform we can handle these different analysis and diagnostics tasks. In addition new diagnostic functions were incorporated in the same manner. One Windows-PC now exceeds the tasks which were then performed by a number of computer devices.

![Diagnostic System Platform](image)

**Fig. 5**

In addition to this development, the following goals were achieved *(Figure 5)*:

- **Central access to all analysis modules:**
  Depending on the gas turbine-technology requirements, the customer has access to more than twenty different analysis and diagnostic modules through Windows Look and Feel.

- **Integration of 3rd party products:**
  Market available technologies from different companies in combination with the competence of gas turbine producers should compliment the diagnostic platform.

- **Synergy and cost reduction of equipment and tools:**
Less hardware and software equipment, along with less administration effort provides synergy and cost reduction and prevent computer farms around a gas turbine.

- Combination of different data in one database:
  Combination of different data in one database allows more complex and interrelated data conditioning, analysis and diagnostics.

- One evaluation tool for technologists:
  There is a common tool used by the technologists for visual evaluation of different kinds of data. This allows easy handling and focus on the technological evaluation and interpretation.

Fig. 6

For example thermodynamic, hot gas path, vibrations and component life cycle modules for analysis and diagnostics are in use. Latest developments are acoustic analysis to detect foreign objects in the combustion chamber.

**Figure 6** shows the gas turbine monitoring and diagnostics with typical diagnostic tasks.
**Conceptional Goal:**
Integration of all Diagnostic Technologies

- GT experience reports
- Thermodynamic GT
- Operation logs
- Pre event recorder
- Operation hour counter
- max. OTC after ignition
- Temperature distribution
- Vibration Analysis
- Step change vibration
- Bearing temperature
- Coastdown time
- Acoustics Analysis
- Humming

**Platform for All Technology Modules**

**Gas Turbine Diagnostics**
WIN TS Diagnostic System

**System Functions Determined through Technology Modules**

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**Fig. 7**

Figure 7 shows the integration of all diagnostic technologies into one platform.

**Fig. 8**
Figure 8 shows the modular structure of the WIN_TS Diagnostic Platform. The system contains a basic system frame with the interface to Instrumentation and Control, to networks, to remote access, and the data base and archive infrastructure.

The modular WIN_TS Diagnostic System connected to the I&C System has access to many of the operational installed sensors and obtains between 300 and 1000 signals. Additionally to these signals with the highest resolution of 1s, a high speed data acquisition for selected signals is included for analog and binary signal analysis down to milliseconds. Together with Database, Archive and Remote Access, this is the basic system frame. The valuables in the center of the system are the technology modules which can be selected according to the units task specific requirements.
3. Diagnostic Network Operation: Configuration and Implementation of the Feedback Cycle

**Fig. 9**

*Figure 9* shows the integrated technology platform at the plant site. An efficient and safe network configuration is the key for reliable remote data acquisition and diagnostics. Local acquisition, archive and diagnostics combined with periodic and event based data transfer are the onsite tasks. It continues in the Diagnostics Center with a centralized data base. Last but not least, it runs into advanced diagnostics in combination with technical experts knowledge.
Fig. 10

The shown global network configuration (Figure 10) gives an idea about the performance of plant diagnostics integrated into Siemens intranet. In the middle the PG Power Diagnostic Center is located. Via worldwide safe modem connection the data links to individual plants and their WIN_TS installations are established. For the qualified assessment of diagnostic findings the link to the different center of knowledge (competence) like steam turbine, gas turbine, generator and Balance of plant is established via internal Intranet.
Fig. 11

**Figure 11** shows the worldwide installation status of the WIN_TS diagnostic systems.

For gas turbines more than 120 installations are in operation in the 60 Hz-region, and over 130 installations in the 50 Hz-region.
It is important to receive at early stage continuous life data feedback from „running technological systems“ both for
- immediate Customer support
- product feedback

Fig. 12

Live data from a running technology system for immediate customer support and product life cycle feedback is a significant benefit for operation, research and development. As Figure 12 shows, the remote online diagnostic is the feedback loop into customer service, engineering and research & development after erection and commissioning.
4. Use and Experience of On-line Diagnostics along the Project Stages

Fig. 13

Through remote access, the local diagnostic systems are connected to Diagnostic Centers in Orlando and Erlangen, to where they send data via data containers. By means of the Diagnostic Centers, the experts have the possibility to support any situation during commissioning or service which needs their immediate attention. Just some mouse clicks enable them to obtain data from gas turbines all over the world (Figure 13).
Fig. 14

In Figure 14 advantages of diagnostics in phases are shown.

To minimize the risk for supplier and customer, diagnostic benefit starts from the beginning of gas turbine life time with product development and engineering, continues by diagnostic care during plant shop test, commissioning, acceptance test and warranty period and closes the loop over the entire life cycle with improved maintenance and service.

Further operating data taken from the WIN_TS system are important for generation of reliability and availability figures as well as fleet statistics.
**Fig. 15**

**Figure 15** shows an example for evaluation of different vibration parameters out of WIN_TS on basis of which vibration experts in the competence center advise inspections. Thus direct online knowledge of the unit condition can significantly help to improve the unit reliability.
Fig. 16

**Figure 16** shows the gas turbine Experience Report (GEB), basis for consistent reliability and availability evaluations, which was earlier manually generated by hand and is today performed as an automatic module through the system. It contains detailed information about availability, status and performance over rolling time periods.

5. **Summary, Outlook**

Monitoring and Diagnostics is a rapidly evolving field in power generation. The combination of available IT-technology and on-line ‘expert’-expertise provide cost-efficient service and benefits to the customer.

Thus it can be summarized:

- **More and more specific analysis and diagnostic technology available**

- **To maximise benefit for power plants, the challenge is to employ all technologies needed via one platform**
• Global network to a running fleet allows OEM experts fast data analysis and quick response to customer requirements

• On-line diagnostics - in combination with remote expert knowledge - is the key to future condition based maintenance and provides cost efficient service to reliable plant operation.

For the customer it is important to have access to the knowledge of the developer of his gas turbine in any situation at hand through a diagnostic platform.

For the equipment supplier it is strong value to have live feedback from his own “running technological systems” to optimize learning.

And last but not least online diagnostics opens the path from Scheduled Maintenance to Condition based Maintenance thus contributing to customers unit operation for highest profit.
Literature


