Power Generation

Application of Gas PTi & VE Technology

Background

This note has been prepared for the purpose of illustrating the effects which variations in the quality of natural gas can have on power generation equipment performance and emissions. In particular we study the impact of changes to Calorific Value (heat content) and Wobbe Index (combustion performance) on large gas turbines and gas engines used for power generation.

In many countries in recent times there has been a significant shift from a single source of indigenous natural gas towards multiple sources of gas from new interconnector pipelines and shipped LNG. Unconventional and variable quality gas sources such as shale gas and biomethane are also injected into national transmission systems. Many countries are now net importers of natural gas and this results in greater variation in gas quality for downstream users.

GasPTi has been developed to provide accurate and rapid measurement of gas properties so that users can monitor and compensate for variations.

Issues

Most gas turbine manufacturers provide contractual guarantees on equipment performance within certain limits of supply gas quality – this is usually in the form of a maximum change in Wobbe or CV over a short time period. The power generation operator has no control over supply gas quality and so can only monitor the position and adjust air/fuel ratio.

Modern large gas turbines typically operate with several stages of combustion and very precise air/fuel ratio to ensure minimum CO2 and NOx emissions and optimum turbine efficiency. If the CV of the fuel gas changes then the optimal efficiency of the turbine will be lost and this could cause problems with power production, burner combustion instability and increased emissions. On large gas engines, optimal settings for ignition timing and air/fuel ratio will change with variations in gas quality and significant engine damage can occur due to engine 'knock' and wear if control parameters are not adjusted. Emissions and combustion performance on conventional thermal plants will be adversely affected by gas quality changes.

Ideally what is required is a low-cost, fast and accurate instrument to detect any gas quality changes, with flexible communications options for process control.

Solution

GasPTi is a unique integration of gas sampling, gas conditioning and gas analysis which provides rapid and accurate monitoring of gas quality in a pipeline, with T90 response time less than 10 seconds and to a CV error less than ±0.5%. The system mounts directly onto a pipeline or can be post-mounted nearby with a short gas sample line. Best response and accuracy is gained from pipeline mounted systems with short sample line, electropolished internal surfaces.

Depending on the application, GasPTi signal outputs can be either serial, Ethernet or analogue interfaces. Rather than using a gas chromatograph for accuracy and a calorimeter for speed of response, the GasPTi can be used for both requirements.

Calorific Value (Gross and Net), RD, Wobbe, Compressibility, Methane Number, Motor Octane Number are standard physical properties which are output from GasPTi. A communications interface controller has been used in some applications to provide extra calculated parameters such as Modified Wobbe Index, Specific Heat Ratio and Molar Mass.

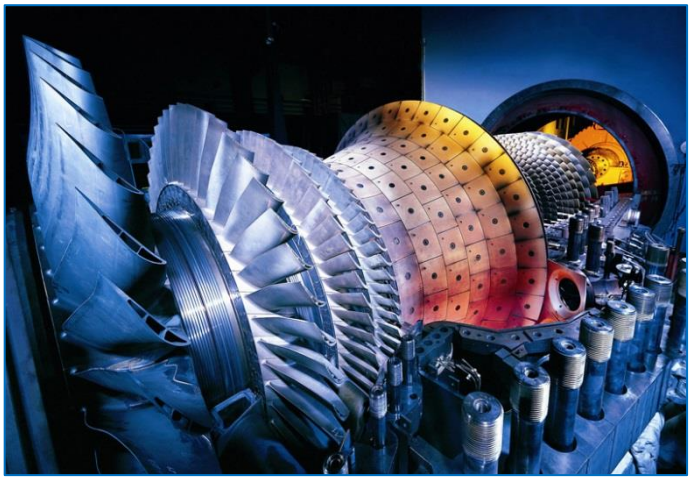

Figure1 – Gas PTi – Real time monitoring the power turbine for optimum lean burn operation.

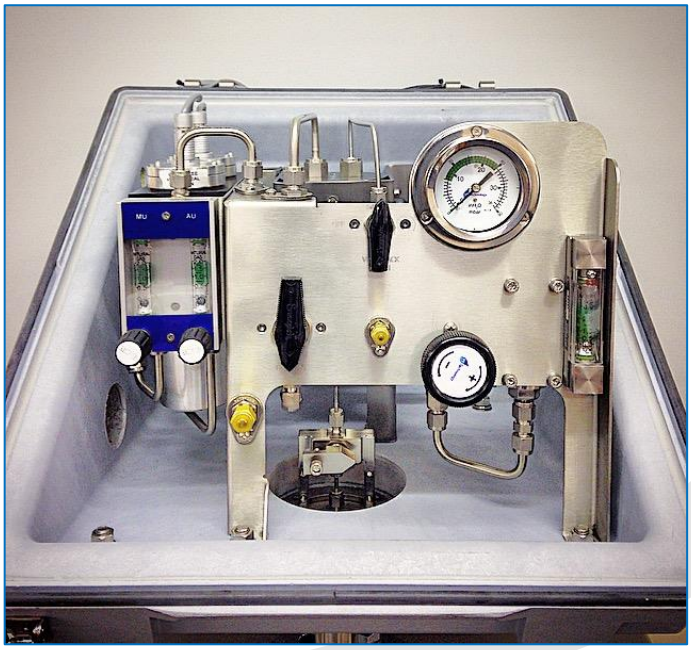

Figure 2 – Gas PTi – Real time - Sampling, Conditioning & Analysis.

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Conclusions

1. All power generation plant, whether gas turbines or gas engines, will be affected by variations in the Wobbe and Calorific Value of the natural gas supplied.
2. The effects of gas quality variation will be on power plant efficiency, power output and emissions of CO2 and NOx.
3. GasPTi provides rapid and accurate CV data which can be used for process control in near real-time replacing the need for more than one instrument.

Example Power Plant Applications

Location	Application	Gas Analytics
Italy & US	Gas turbine	Modified Wobbe Index
UK	Combined heat & power	CV
Japan	Gas engine & turbine tuning	CV & Wobbe
Japan	Gas engine tuning	Methane number
Japan	Gas engine heat pump	CV & Wobbe
Japan	Gas engine tuning	CV & Wobbe
Nethlands	Gas Turbine	CV & Wobbe

Publications:

Development and Testing of a New Gas Properties Transmitter INGAS International Gas Conference, Istanbul, 2013.

Development of Real-time Gas Quality Measurement International Gas Union Research Conference, Copenhagen, 2014.

Accurate, Real-time Monitoring of Gas Quality 10th European Conference on Industrial Furnaces and Boilers, Porto, 2015

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Figure 3 – GasPTi pipeline mounted installation

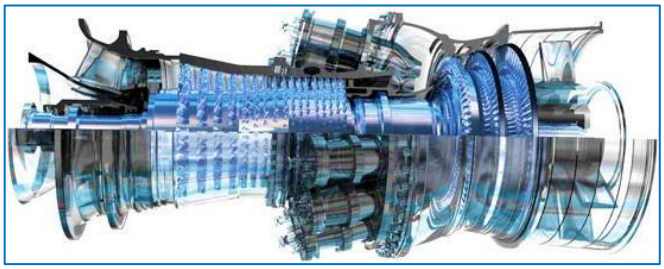

Figure 4 – Real-time monitoring of air to fuel ratio for optimum operation, saving millions in generation costs.

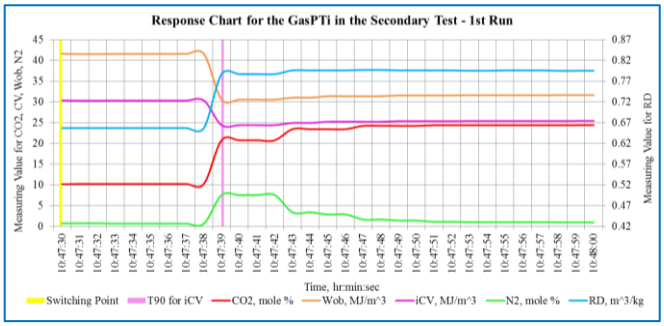

Figure 5 – Graph showing real-time monitoring of gas quality for optimum turbine efficiency; T90 = < 9 seconds.

Above test graph shows response time to T90 when switching between two certified gases:

Gas 1 – 99.995% Methane, Gas 2 – 25% CO2 75% Methane.

Typical outputs: Inferior CV, Superior CV, Wobbe, Modified Wobbe, Relative Density, Density, Specific Heat Ratio, CO_2 N_2.

Accuracy = < ±0.5%, instrument response time = 2 seconds. T90 = 9 seconds.

Note: The above testing required a ~480mm sample line for a specific turbine project. Typically the sample probe length would be shorter, resulting in an even faster response.

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