Heating Value and Wobbe Index Measurement in Natural Gas for Fast Turbine Control

Application

Natural gas shows strong variations in its composition. For instance, the ratio between methane (CH_4) and non-methane hydrocarbons (C2+) is strongly depending on the source of the fuel gas. With the liberalization of the gas market, higher variations occur, especially in regard to the non-combustibles like carbon dioxide (CO_2) or nitrogen (N_2). While natural gas from Russia or Europe typically contains CO_2 only in the range of a few percent, natural gas from Asia Pacific shows CO_2 concentrations up to 20%. These large variations are challenging when using natural gas from different sources in gas turbines. Variation in the natural gas composition affects the calorific value of the gas which may lead to increased pollutant emission (e.g. NO_X), loss of combustion efficiency and eventually turbine damage.

In some instances a fast real time gas analysis of heating value and Wobbe index has become necessary to provide early warning of changes in the composition.

Whilst gas chromatographs provide very accurate measurements of all fuel gas components and physical properties (CV Bias Error +/- 0.1 MJ/m³), the response time is typically more than 90 s for a C6+, N_2 and CO_2 analysis. Emerson therefore offers the X-STREAM process gas analyzer where speed is required in turbine control applications.

Solution

Non-disperse infrared (NDIR) photometry allows the detection of most fuel gas components within seconds. Heating values can be provided by direct measurements of CH_4 and C2+.

For CH_4 detection, a special 0-100 % CH_4 NDIR bench measuring at 7.85 µm is used which shows low cross interferences from ethane (C_2H_6), propane (C_3H_8) and carbon dioxide (CO_2). For the C2+ measurement, two options are available. One option for high BTU applications is a photometric bench at 3.4 µm, which shows response factors of 1, 1.6, 1.9 and 2.0 to C_2H_6, propane, i-butane (i-C_4H_{10}) and n-butane (n-C_4H_{10}). These NDIR response factors closely correspond to the heating values and allow determination of heating value and Wobbe index. The bench shows low interference to water, CO_2 and CH_4, but is restricted to low amounts of nitrogen

(N_2). As second option for low BTU applications, a photometric bench at 6.6 µm with similar response factors for C_2H_6, C_3H_8 and other higher hydrocarbons can be used. This channel has no limitation on the N_2 content, but it has stronger limitations on the C3+ content. Both options do not allow selective measurements of ethane, propane, etc.

For Wobbe index measurement an additional CO_2 optical bench with the measurement range of 0 to 5% or 0 to 20% is integrated into the analyzer. Nitrogen or another selected component can be determined by balance. The response time of the analyzer is 10 s.

Calculation of Heating Value and Wobbe Index

From the measurement of CH_4 and C2+, the upper and lower heating value is calculated according to ISO EN6976-2005. An additional CO_2 measurement allows the determination of mean molar mass and specific density of the sample probe. Wobbe index is calculated from heating value and specific density, according ISO EN 6976-2005.

Field of Applications and Limitations

Both configurations are only suitable for analysis of natural gas or natural gas like mixtures. The presence of interfering components like higher hydrocarbons starting from C_3H_8 (C3+), Helium (He), Hydrogen (H_2) or Hydrogen Sulfide (H_2S) will reduce the accuracy. Field of applications for both configurations are given in Tables 1 and 2 for an accuracy of 2%.

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Table 1: Possible concentration ranges for heating value measurements

	High BTU-version (typically above 40 MJ/m³)	Low BTU-version (typically below 40 MJ/m³)
CH_4, %	70 - 98	70 - 98
CO_2	0 - 10	0 - 10
C_2H_6, %	0 - 12	0 - 12
H_2, %	< 4.0	< 1.0
C3+, %	< 3.5	< 2.0
H_2S, ppm	< 500	< 500

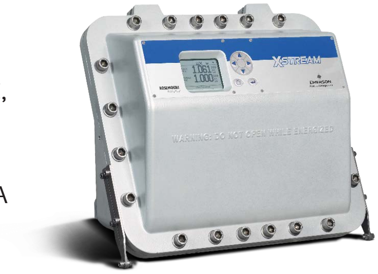
Table 2: Possible concentration ranges for Wobbe index measurements

	High BTU-version (typically above 40 MJ/m³)	Low BTU-version (typically below 40 MJ/m³)
CH_4, %	70 - 98	70 - 98
CO_2	0 - 10	0 - 10
C_2H_6, %	0 - 12	0 - 12
C3+, %	< 3	< 2
H_2, %	< 1	< 0.5
He, %	< 1	< 0.5
N_2, %	< 1	no limitation
H_2S, ppm	< 500	< 500

Other gas compositions on request.

Analyzer Options

The analyzer allows the measurement of lower and upper heating value and Wobbe index. Results can be expressed in MJ/m³, BTU/ft³ or kcal/m³, other units on request. Values can be calculated for following combinations of reference temperatures of combustion and metering: 15/15 °C, 0/0 °C, 15/0 °C, 25/0 °C, 20/20 °C, 25/20 °C.



Beside general purpose solution, flame proof housing for installation in ATEX Zone 1 and Zone 2 and CSA Class I Div 2 or Zone 1 and Zone 2 is available. Optional features are auto-calibration, flow sensor with alarm and an internal sample gas pump.

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