Measuring Hydrocarbon Dew Point of Natural Gas Fuel for Gas Turbine Power Plants using Automatic Hydrocarbon Dew Point Analyzers

Application Background

Natural gas is used by a number of industries, most notably in power generation by gas turbines.

Gas turbine manufacturers will always provide specifications defining the quality of the natural gas fuel provided to the turbine - designed to prevent damage to the turbine and the additional problems that can result. These specifications can include a number of parameters, including pressure, flow, acceptable contaminant limits and gas temperature – frequently with the inclusion of the term 'superheat'.

When operating modern DLN (Dry low NOx) turbines, the following of these guidelines is critical to avoiding severe damage to the turbine, and criteria such as superheat have been set up to help prevent this. Superheat is defined as the temperature 50°F (28°C) above the Hydrocarbon and water Dew Points of the fuel gas, so if the dew point of the gas is -12°C, then the gas should be heated to +16°C.

Prior to combustion, the gas is running at pipeline pressure, much too great for the gas turbine, therefore the gas must be expanded in order to be suitable for use. As the pressure of the gas drops, so does the temperature. If this Joule-Thompson effect drops the temperature below the HCDP, then liquids will condense inside the burner tubes of the turbine and the cans and nozzles coke up and become significantly less efficient, causing dramatically increased NOx emissions. If this situation is allowed to continue for a short time, the burner section will need to be rebuilt. This means a 3-5 day unplanned shut-down, a large crew on-site around the clock for the expensive rebuild and lost revenue and plant availability. This will dramatically impact the profitability of the plant.

Another seriously costly effect of condensation is flashback. This can be caused by hydrocarbon condensates, and the effect is for a flame to be held downstream of the burners, in the recirculation area. This region is not designed to withstand heat of this nature, and the metal temperatures will increase dramatically, frequently causing physical damage to the hardware.

Superheat is designed to help prevent either of these occurrences by ensuring that the gas never comes close to its HCDP. Natural gas fuel conditioning systems are most commonly used to heat the incoming gas, but this heat requires energy to generate, and if overheating due to a lack of awareness of the gas dew point occurs, then large costs can be incurred: "Because on-line dew-point analysis typically is not conducted, the gas is often heated by 50°F continuously. For a GE Frame 7 gas turbine, 50°F of superheat amounts to about 740kW, which means energy costs can be as high as $324,120 per year. But if the gas is well above its dew point under normal conditions, the additional heating is wasteful" (C. Tiras, PE, Flowtronex International, "DLN combustors demand better fuel-gas conditioning", Power, Mar-Apr 2001).

Essentially, it is critically important for the operator to have a good knowledge of the HCDP, as condensation occurring during the expanding process would be devastating to the turbine. But conversely, if the HCDP is lower than expected, then huge amounts of money can be spent unnecessarily heating the gas.

Measurement Techniques

There are a number of different accepted methods for measuring HCDP, the original technique being to use a cooled mirror dewscope. This requires a skilled operator to view a mirror over which the sample is flowed. The mirror is then cooled, and the temperature at which the first drops of condensation are viewed is noted.

For:

- ✓ Widely used industry standard measurement technique
- ✓ Low capital investment

Against:

- × Periodic spot checking only
- × 'Subjective', operator dependant measurement of variable sensitive and repeatability
- × Labour intensive, therefore high running costs

Another method of determining the HCDP is by means of a gas chromatograph (GC). This method determines the concentrations of each hydrocarbon element (up to C12 in most cases), and, through an equation of state calculation, the condensing points of the quantities of each component present are identified and calculated to give a hydrocarbon dew point for the complete mixture. However, due to the limitations of the device, when analysing heavy hydrocarbon molecules the calculations of the HCDP can frequently be quite inaccurate, suggesting that the HCDP is drier than the actual value.

For:

- ✓ Potential to combine a number of gas quality/tariff parameters into one analyzer
- ✓ The components contributing to a high dew point level may be identified and so help to determine the reason/source
- ✓ Possibility to provide a theoretical phase envelope curve

Against:

- × Accuracy of analysis, and thus hydrocarbon dew-point calculation, is dependent on correct and regular use of specialist reference gases
- × An indirect method of determining hydrocarbon dew point relying on the correct application and suitability of the equation of state being used
- × Susceptible to measurement errors due to limit of analysis sensitivity and composition changes
- × Specialist staff required to operate/maintain performance

× Very high initial outlay, including installation costs (analyzer house) and running costs (personnel and reference gases)

The alternative is to use an automatic, optical condensation dew-point analyser, such as the Michell Instruments Condumax II. The Condumax II functions in a similar manner to the Cooled mirror dewscope. The cell has an etched optical surface with a central conical depression which normally refracts light unevenly. An LED shines at this surface and a photo-detector looks at an image of the light shining back, which in dry conditions, appears as a ring of light. The photo-detector is focussed on the light scattered into the centre of the ring. A thermoelectric peltier device cools the surface until condensates begin to appear. The condensates alter the reflective properties of the surface, with the circle of light around the perimeter intensifying, and the scattered light in the centre dispersing according to the amount of condensate on the mirror. The exact signal level can be accurately monitored by looking at the signal from the photodetector. The mirror temperature is recorded when the desired level of condensates are deposited. The factory setting of the Condumax II gives readings which are comparable to readings obtained by an experienced dewscope operator.

For:

✓ Direct fundamental 'objective' measurement of high sensitivity and repeatability

✓ Stand alone operation - In-built verification routines

✓ Sensitivity may be adjusted to conform with measurement techniques agreed between gas supplier and receiver

✓ No specialist operation/maintenance staff requirements

✓ Ability to produce phase envelopes through direct measurement rather than theoretical estimation

Against:

× Significant initial investment, though low installation and running cost

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