COMBUSTION CONTROL IN PROCESS HEATERS AND THERMAL CRACKERS

Servomex
LEADERS IN GAS ANALYSIS

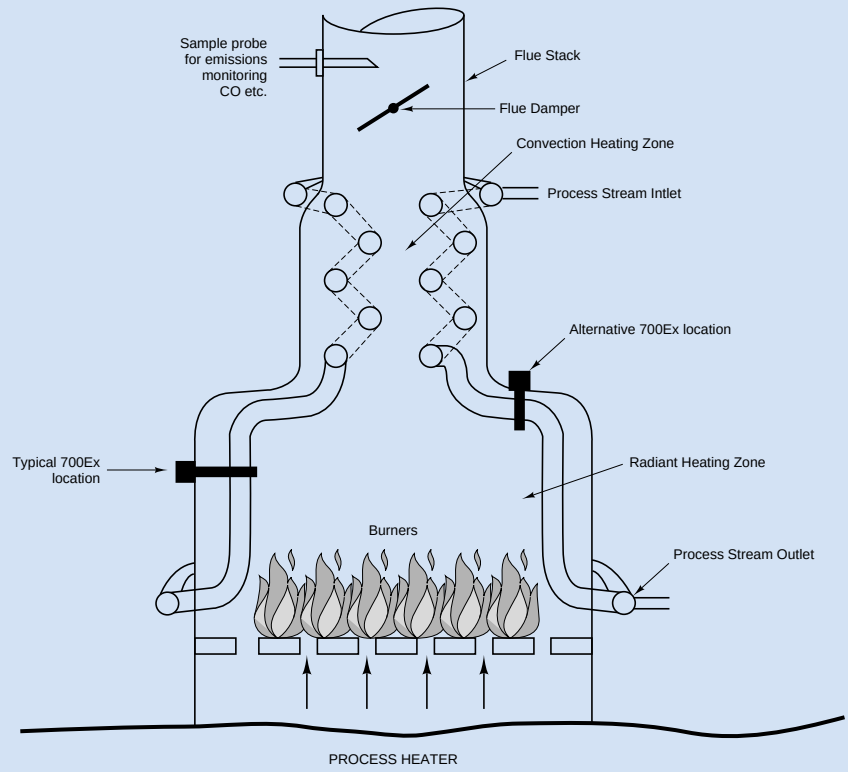


Figure 1

The term "process heater" is generally applied to any process plant unit directly employing the hot gases of combustion to raise the temperature of a gas or liquid process stream. Similar units operating at higher temperatures are also used (e.g. on ethylene production plants) to produce thermal breakdown ("cracking") of hydrocarbon process streams – generally referred to as "thermal crackers".

Both units are in widespread use, on refinery and petrochemical plants and, are major consumers of fuel on the site. This makes them prime candidates for combustion efficiency optimisation measures, to reduce fuel costs.

To enable this to be done a flue gas oxygen measurement is required. The Servomex 700EX analyser is ideally suited for these applications because of its inherent fast response and self diagnostics which ensure the integrity of the analyser. Specifying the optional combustibles feature enables operators to control the excess oxygen level even more tightly. In addition the 700EX is certified for use in hazardous areas which is usually a critical requirement for process heater or thermal cracker applications.

Process Description and Requirements

Although there are many types of process heaters and thermal crackers the general analyser application details are similar for all of them. The typical example shown in the illustration is a natural draught unit, fired by banks of burners using natural gas, sour gas, or waste oil as fuel. The process heater consists of a large vertical furnace containing multiple coils through which the process stream flows. In a typical refinery this is normally a liquid hydrocarbon stream which needs to be heated to a set temperature before entering a refining stage of the plant. The firing rate and fuel supply to the process heater burners are controlled by both the process stream exit temperature and the required rate of process production. The combustion air flow control is derived from the fuel control and adjusts the position of the flue damper.

Without an on-line analysis of the excess oxygen in the waste combustion gas the unit operator has to estimate the position of the damper and err on the side of safety, using a significant excess of air to ensure that all of the

GRAPH: PRODUCTS OF COMBUSTION

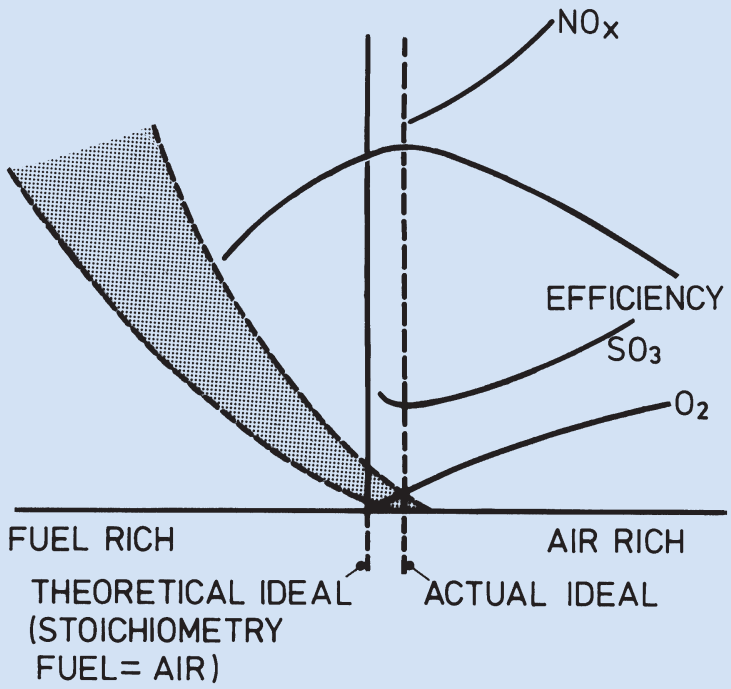


Figure 2

fuel is burnt under all conditions. This is because a lack of air would mean the potential for carbon monoxide and unburnt hydrocarbons occurring in the flue gas, which wastes fuel and could ultimately lead to unsafe conditions. However, a significant excess of air means that combustion efficiency is compromised because the high excess air levels will be causing excessive heat loss. This is particularly the case when frequently switching between different fuels of different calorific values and hence different excess air requirements.

With the installation of a fast and accurate flue gas oxygen analyser these heat losses can be minimised and the safe operation of the process heater assured, by enabling the unit operator to use the flue gas oxygen level signal to control the damper position. This can be done manually or automatically, to continuously attain just the right, safe, minimum flue gas oxygen level, under all conditions.

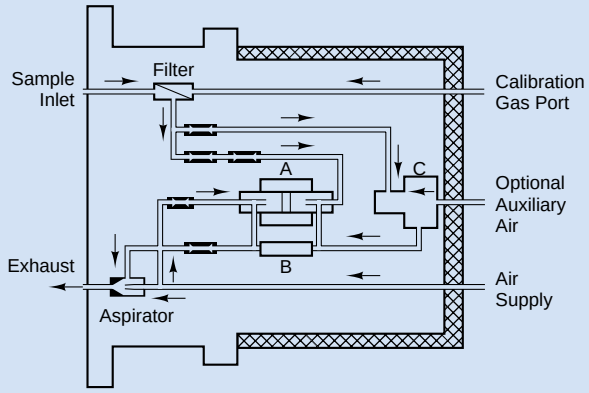
With many burners being used in a process heater there is always the risk that one (or more) of them is not as efficient as the others and hence releases some amount of unburnt fuel into the furnace. This unburnt fuel would only become fully combusted at a higher excess air level than is required for the other burners and hence may be only partially combusted to produce carbon monoxide in the stack gas, decreasing combustion efficiency and adding to pollution. The analysis of flue gas oxygen alone would not be able to detect this phenomenon. However, if a combined oxygen and combustibles analysis of the flue gas is made, then the onset of this incomplete combustion can be seen when it is occurring. Additional air can then be admitted to the furnace to aid full combustion, reducing residual combustibles to a minimum. This also means that efficiency can be maximised safely and the excess air reduced to a minimum, by reducing the flue gas oxygen level and controlling it at a point just before the onset of incomplete combustion is detected.

The above graph (Figure 2) shows the effect of changing excess air levels.

Typical excess oxygen levels on process heaters not using oxygen analysis are between 4-5%. With oxygen only analysis, these levels reduce to around 3%. With the additional combustibles analysis levels down to about 1% excess oxygen may be safely achieved. Bearing in mind that around 3% excess oxygen represents 1% loss in combustion efficiency, it can be seen that significant savings can be made.

The ideal location for the analyser is at the top of the furnace where the typical flue gas temperature is 800-1000°C. However, this location is normally in a certified hazardous area and is usually environmentally exposed. Additionally it is also important that the analyser mounting is readily accessible to enable maintenance and calibration to be performed.

SCHEMATIC: SENSOR HEAD



Key:
A = Oxygen Sensor
B = Flow Sensor
C = Combustibles Sensor
= Flame Trap

Analysis Technique

The Servomex 700EX flue gas oxygen analyser has been specifically developed for the analysis of high temperature combustion gases in these hazardous areas. The analyser sensor head is flameproof to CENELEC requirements, marked EEx de IIB T3, and is certified for use in Zone 1 hazardous areas such as in oil refineries and chemical plant. A unique zirconia-based sensor measures the oxygen content of the flue gas and, for optimum combustion control, an optional combustibles sensor may be included to give an indication of the onset of incomplete combustion, reading in units equivalent to carbon monoxide.

The 700EX sensor head is rated IP 65 (with suitable glands) and mounts directly on the process wall near the top of the furnace. For typical process heater applications it uses a 1 metre long, high temperature alloy probe to extract a sample. If the sensor head cannot be mounted directly on the wall it is important that any stand-off used is as short as possible and is well insulated. The sample probe must always penetrate completely into the flue gas stream. The sensor head incorporates a low flow aspirator which is used to produce a positive sample flow to the sensor(s). Flame traps for complete safety in operation, and a flow sensor which gives early warning of diminished sample flow, are fitted as standard.

The analyser control unit is rated IP54 and can normally be located up to 300 metres from the sensor head. However, particularly in process heater applications it should be located as near as possible to the sensor head, bearing in mind hazardous area requirements and the need for environmental protection, since this will minimise installation costs and maximise ease of calibration and operation. The control unit offers isolated current outputs for oxygen level and combustibles level (where fitted) and these can be fed into the process heater combustion control system so that combustion efficiency can be maximised.

Features and Benefits

The Servomex 700EX is a rugged, reliable analyser specifically designed and certified for use on process heaters where fast response to oxygen changes and self-diagnostics make it ideal for close combustion control.

Servomex 700Ex Oxygen Analyser

- ✓ Unique zirconia oxygen sensor provides excellent performance and long life even with the variety of waste fuels used on process heaters.
- ✓ The analyser samples directly from the process with no requirement for traditional bypass legs required by diffusion type analysers. This results in a much faster response and additional reliability, both essential features for combustion control.
- ✓ The analyser sensor head is certified for use in Zone 1 hazardous areas with no need for additional safety requirements (for example, purge systems).
- ✓ An optional combustibles sensor may be fitted to the sensor head providing a rapid indication of incomplete combustion, reading at the same location as the oxygen measurement; this is an essential requirement for achieving optimum combustion control.
- ✓ Standard flame traps ensure that the analyser is safe and operable at all times, even during start-up when hazardous (flammable) flue conditions may occur. Other flue gas oxygen analysers may require shut-down during these conditions.
- ✓ All of the components in the sensor head may be serviced without the need to remove it from the process.
- ✓ The analyser self-diagnostics including the flow alarm ensure the integrity of the analysis, vital for combustion control.

Other Applications

Process heaters and thermal crackers come in a variety of shapes and sizes, but essentially perform similar functions. Very large plant comprise several different heater cells each with their own combustion control system. In these cases an analyser is typically required for each cell in order to control combustion to its optimum efficiency.

Where local legislation requires an emissions measurement of carbon monoxide to be made from a process heater a Servomex Xendos 2510 gas filter correlation emissions analyser should be used. This makes highly specific, continuous measurements of carbon monoxide in the flue gas down to very low levels when coupled to a suitable extractive sampling system. The 2510 is virtually unaffected by other potential interferents in the flue gas, and provides high measurement stability with no routine maintenance. Consult Servomex for further details of continuous emission monitoring systems.

Certificate No. _____Q5166
BS EN ISO 9001

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