FLOX®-LCV combustor for low calorific value purge gases

Description of the FLOX®-LCV combustor

Figure 1 shows a 3D sketch of the LCV combustor. The plant is designed for a throughput of 100 Nm³/h (LCV-C 100). By modifying burner nozzles it can be adopted for flows from 50 to max. 125 Nm³/h. Air is preheated via a recuperator made of high temperature resistant steel. An additional recuperator preheats the LCV gas if required.

The LCV gas has to be fed to the combustor at a pressure of 50-80 mbar. The gas line is locked by a double-solenoid valve which is only opened if the combustor is ready for burning the LCV gas. On start-up of the plant the combustion chamber is heated up to about 850°C with a conventional start-up flame burner. An air fan supplies the combustor with air via the preheater (primary air) or directly without preheating (secondary air). The primary air is preheated to 500-600°C. When reaching the required temperature the system switches in the flameless oxidation (FLOX®) mode. The solenoid valve opens and the LCV gas is preheated in the LCV recuperator to temperatures between 250-500°C (depending on the heating value of the gas). The LCV gas is oxidised together with the primary and secondary air at about 900°C in the patented FLOX mode in the adiabatic combustion chamber. Due to the special FLOX-design LCV gas and air mixes quickly with internally recirculated flue gas before it oxidises. This results in a smooth and stable process which works independent of the gas compositions and guaranties very low emissions of NO and CO. The air excess ratio is controlled by a Lambda probe in order to make sure that always sufficient oxygen is available for the oxidation.

The flue gas leaves the combustor at temperatures of 500-800°C (again depending on the heating value of the gas). It can be used for direct drying or in a hot water boiler. If the heat can not be used continuously, an additional hot gas stack can be supplied.

The entire system can either be installed tailor made in a given environment or it can be shipped pre-mounted in a 20 feet HC container.

Operation of the LCV combustor

The following configurations and control technologies are available to adopt the LCV combustor to the given Methane concentration of the LCV gas and to react on short term fluctuations in gas concentrations and gas streams:

Basic set-up: The length of the air- and LCV gas preheater is designed to adopt to the expected heating value and gas composition of the LCV gas. This allows to adopt the system to Methane concentrations in between 6-17%. If higher methane concentrations are expected a further hot gas bypass has to be installed to avoid excess temperature.

Temporary fluctuations: Variations of +/- 3% Methane can be controlled by shifting between
primary (pre-heated) and secondary (not preheated) air and by increasing the secondary air amount.

**Fuel addition:** If the Methane concentration in the product gas is not sufficient to maintain the operation temperature, additional fuel can be dosed in the LCV gas. Typically natural gas, biogas or LPG is used for this task. This is only for short term compensation. If the LCV heating value decreases on a long term base (e.g. ageing land fills) the recuperator configuration hast to be adopted.

The following rules summarize the way the LCV combustor is operated:

1. The start-up burner heats up the combustion chamber to a temperature of about 950°C.
2. Once the temperature is reached the control system switches to FLOX mode. In this mode LCV gas is fed to the combustor and burned with air.
3. If the combustion temperature decreases below 850°C additional fuel is dosed to the LCV gas line.
4. The air flow to the plant is controlled by a lambda-probe in order to maintain a minimum air excess ratio. If the combustion temperature increases to more than 1000°C further air is added in order to limit the operation temperature.
5. The combustion air is shifted between the preheated primary and the not preheated secondary air in order to allow further temperature control.
6. A further method to adopt to higher heating values is to control the flue gas flow through the preheaters and through a hot gas bypass system.

**Waste heat utilization**

The combustor produces, depending on the heating value of the LCV gas, a flue gas with 500-800°C. If there is no direct use for the hot flue gas, e.g. in a drying process, a hot water boiler can be attached. Due to the relatively low input temperatures it is important to cool down the flue gas to low temperatures. Therefore, e-flox uses a condensing boiler with flue gas temperatures of 50-60°C. Even if no condensation appears due to the fuel composition (low hydrogen content)
these low temperatures ensure a high efficiency, due to the typically high CO₂ concentrations (high heating capacity) in the flue gas. The heat production can be up to 150 kW in the system described here, again depending on the heating value of the LCV gas.

**An example**
The following picture shows a plant which was built for the utilization of LCV gas generated in a biogas upgrading plant based on pressure swing absorption (PSA) technology. The system was built up in Switzerland where the biogas upgrading system feeds the produced methane in the natural gas grid. The waste heat is used to heat the biogas fermenters. The LCV gas has a methane concentration of about 7%. Depending on the operational requirements of the biogas plant the LCV combustor produces 30-70 kW by adding more or less natural gas to the LCV gas.

**Figure 2:** An operational LCV-combustor in Switzerland serving a biogas upgrading plant