SIEMENS

Case Study

Real-time O_2 monitoring in VCM plants using the In-situ laser gas analyzer

Chemical Industry

Vinyl Chloride Monomer (VCM)
Vinyl Chloride Monomer is a colorless, flammable gas. It is of very great importance as feedstock in the production of polyvinyl chloride (PVC), one of the world´s most versatile thermoplastics. Originally, acetylene has been used as feedstock for VCM production but was replaced stepwise by the inexpensive ethylene. Complete changeover to almost exclusive use of ethylene became possible in 1955, when the large-scale oxychlorination of ethylene to 1, 2 dichlorethane became possible. Today, more than 90 % of the world wide VCM production is based on ethylene.

Modern VCM plants use integrated processes combining the highly exothermic reactions of ethylene chlorination and oxychlorination with the endothermic cracking process, which results in an almost energy balanced plant operation.

Modern VCM plants are optimized with regard to the reuse of by-products. A mixture of high-boiling and low-boiling compounds is formed during the process steps in liquid or gaseous form. They are almost completely converted into reusable compounds (which are returned into the process), energy and water. This principle is the basis of the VCM production flow diagram as shown in fig.1.

Vinyl chloride monomer (VCM) is used as feedstock in the production of Polyvinyl chloride (PVC). Although modern VCM plants are optimized to recycle almost all by-products, some residues (waste gases) must be disposed from the process through incineration. Because of their composition, waste gases from VCM plants are potentially explosive and must be continuously and reliably monitored for their oxygen content.

The In-situ Laser Gas Analyzer offers the best possible capabilities for this application. It is installed right in the process gas flow and delivers fast and accurate O_2 concentration data in real-time. This case study presents details of this application.

VCM production and recovery

Application task

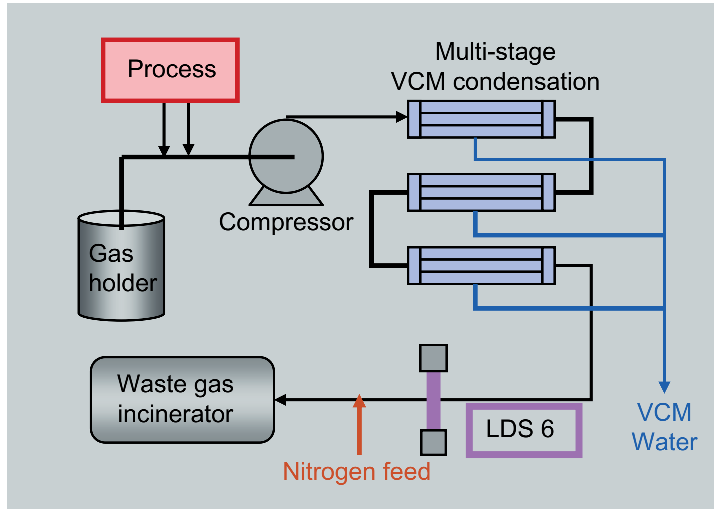

Fig. 2: VCM recovery. gas incineration and LDS 6 location

VCM production at a glance (fig. 1)

In the "Direct Chlorination" route, ethylene and chlorine form 1,2-dichlorethane (EDC), in a catalytic reaction, together with heat, water and HCl-rich waste gas. The EDC is stored and the exhaust gas fed as a reactant to the oxychlorination process.

In the "Oxychlorination" route, ethylene, oxygen and hydrochloric acid react in a fluidized-bed reactor. Raw EDC is formed, removed by condensation and fed to the EDC distillation and from there to the storage tank. Exhaust gas and effluent are fed to further treatment units.

Cracking of EDC to form vinyl chloride monomer (VCM) and HCl is performed in a cracking furnace at 500 °C and above. Some EDC remains unconverted and is recycled. HCl is fed back into the oxychlorination unit and is reused. The VCM is used for the production of PVC.

Cryogenic VCM recovery

Waste gases containing VCM, oxygen and other components are generated during VCM production at different sections of the plant (fig. 1). For environmental and economical reasons the gases must be further treated and recycled as far as possible.

To recover VCM, the waste gases containing unreacted vinyl chloride are first transferred into a gas holding tank (fig.2).

From there, the gas is compressed and fed to a single or multi-stage VCM recovery unit where the VCM is separated from the gas by condensation. VCM and water leave the condensation plant while the rest of the waste gas is forwarded for further treatment, typically by incineration.

Waste gas incineration

Waste gas from VCM production generally contains oxygen because oxygen is an important reactant in the process. Oxygen, when present in a gas in a certain concentration, generally imposes the risk of explosion. Therefore it is crucial for personnel and plant protection to monitor the oxygen concentration of the waste gas continuously up-stream the inlet of the incinerator (fig 2). As the oxygen concentration comes close to the critical level, a limit switch is activated causing nitrogen to be automatically fed to the stream to dilute the gas and to keep it in a safe concentration range.

Measuring task

Measuring task is to determine continuously, with high accuracy and reliability the oxygen concentration level in the waste gas upstream the incineration plant and to provide limit value signals when critical limits values are reached. A short response time, of course, is the most crucial request on the measuring device for this application in order to detect fast critical O_2 contents.

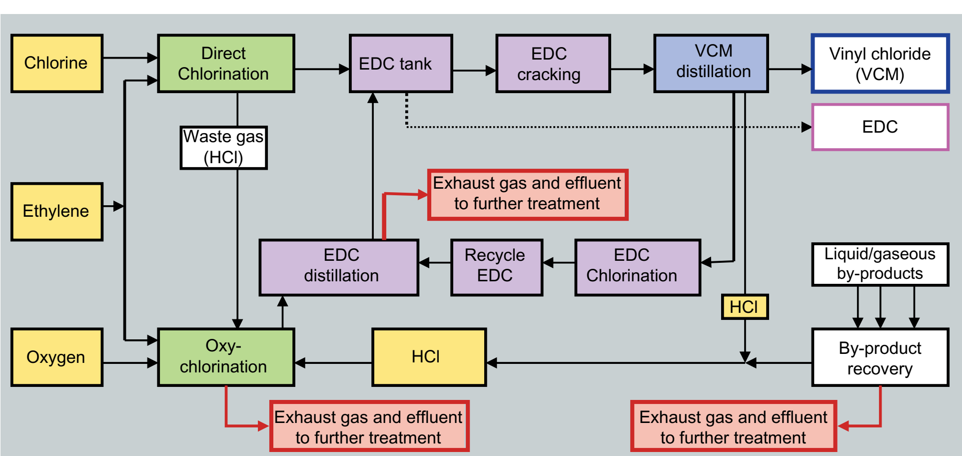

Fig. 1: Integrated VCM production with direct chlorination and oxychlorination routes.

LDS 6, the perfect solution for real-time O_2 measurement

LDS 6 gas analyzer

LDS 6 (fig. 4) is a diode laser-based in-situ gas analyzer for measuring specific gas components directly in a process gas stream.

LDS 6 consists of a central unit and up to three pairs of cross duct sensors in a transmitter / receiver configuration. The central unit is separated from the sensors by using fibre optics. Regardless how hostile the environment is, the analyzer can always be placed outside any hazardous areas. Measurements are carried out free of spectral interferences and in real-time enabling proactive control of dynamic processes.

Full network connectivity via ethernet allows remote maintenance. Key features include
- In-situ principle, no gas sampling
- Three measuring points are monitored simultaneously
- Temperature up to 1500 °C
- Exversion available (option) LDS 6 is designed for fast and non-intrusive measurements in many industrial processes.

Measuring components include:
O_2/temp., NH_3/H_2O, HF/H_2O, HCl/H_2O, CO/CO_2, low ppm H_2O, ...

Application solution

The Siemens LDS 6 diode laser in-situ gas analyzer (fig. 4) is very much suited to accomplish this application. It routinely measures O_2 and features a real-time response performance. Fig. 5 shows an installation example of a LDS 6 in bypass configuration to the main process gas stream. The measurement environment is characterized by great temperature changes from -30 °C to +30 °C and Ex-zone 2 conditions.

LDS 6 advantages for gas incinerator protection

- **Performance**
  Faster response than with other analyzers (fig. 3), e.g. electrochemical cells, and therefore most efficient explosion protection. The in-situ approach allows measurements without side effects or cross interferences.
- **No recalibration**
  Due to the internal reference cell, no recalibration in the field is required.
- **Easiness**
  The central unit can be placed in the control room several hundred meters away from the measurement points by using fiber optic cables. Three measuring points can be handled simultaneously with one single central unit. No calibration is necessary in the field.
- **Robustness**
  The sensor pair at the measuring point contains a minimum of electrical and optical components to ensure highest reliability and availability. The residual maintenance is reduced to cleaning the sensor windows after several months of continuous operation. No optical realignment is necessary after cleaning.

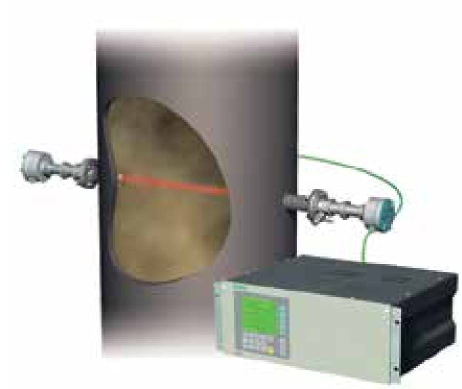

Fig. 4: LDS 6 In-situ laser gas analyzer

User benefits

Real-time monitoring of O_2 upstream of the incinerator using the LDS 6 means:

- Providing best possible explosion protection to personnel and plant by real-time warning of dangerous concentration level
- Optimizing maintenance intervals and minimizing maintenance costs (no gas sampling, no consumable parts, no recalibrations)
- Saving costs for nitrogen flushing by avoiding false alarms
- Improving risk management.

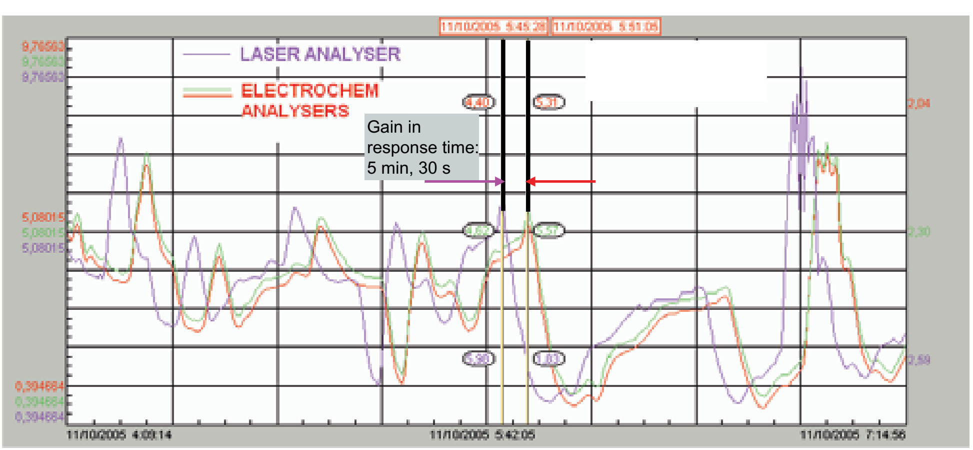

Fig. 3: LDS 6 response performance compared to the electrochemical measuring principle

Measuring conditions

Typical measuring conditions for the O_2 measurement in a VCM recovery plant are shown in (fig. 6). If the ranges of typical values are kept unchanged in the actual installation, the gas and application codes given in the last lines of Fig. 6 can be used for ordering the analyzer. In other cases, please use the given contact addresses for technical clarification. User lists are available for different fields of application. Please contact the addresses shown below.

Fig. 5: Installation example of a LDS 6 in by-pass configuration to the meain process gas stream

Conditions for O2 measurement in waste gas from VCM production	
Gas to be measured	O_2
Measuring range	0...21%
Average gas composition	79% N_2, 16% VC, 5% O_2
Typical thresholds [O_2]	12% Vol.: Open Nitrogen bypass 6% Vol.: Shut off Nitrogen bypass Regulation at 8%
Gas temperature	0...30° C
Optical path length	1...6 m
Pressure	1...5 bar
Required response time	2 s
Recommended purging mode	D
Purging media	N_2
MLFB gas code	A
MLFB application code	P

Fig. 6: LDS 6 measuring conditions for the VCM application

For more information, please contact:

Siemens Industry, Inc.
5980 West Sam Houston Parkway North
Suite 500
Houston, TX 77041
Phone: 713-939-7400
Email: ProcessAnalyticsSales.industry@siemens.com

Siemens Industry, Inc.
3333 Old Milton Parkway
Alpharetta, GA 30005

1-800-241-4453
info.us@siemens.com

usa.siemens.com/analyticalproducts

Subject to change without prior notice
Order No.: PIACS-00002-0515
Printed in USA