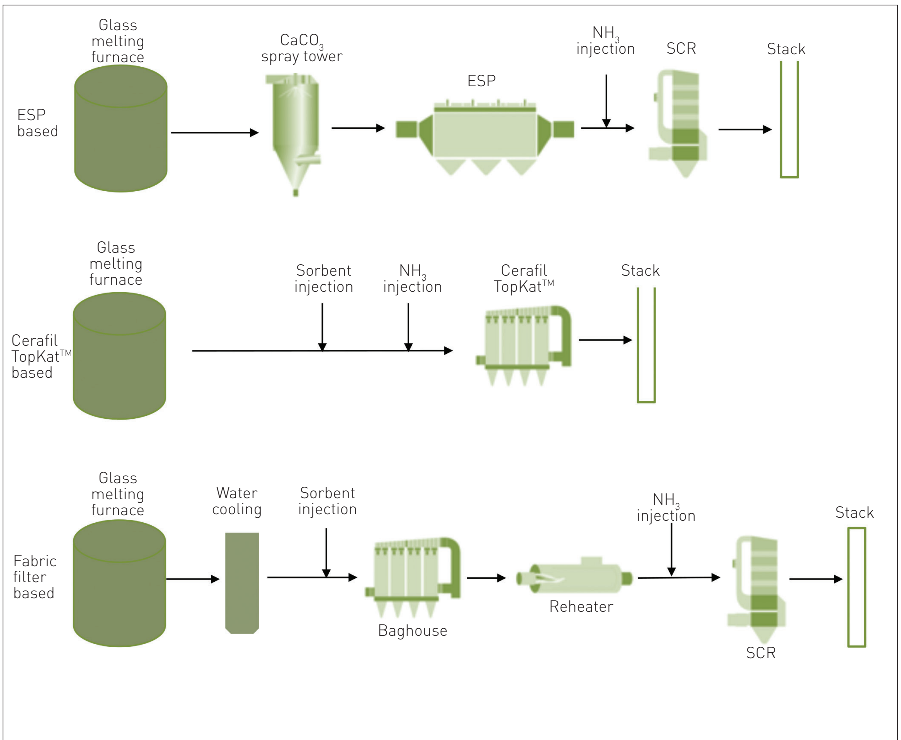
Ceramic filters for glass furnace off-gas treatment

Filtration using low density ceramic filter elements is now a well-established technique for air pollution control and product recovery. Dr. Purv J. Purohit*, Dr. Ian Chisem** and Prof. Richard Lydon*** discuss a technology in use in the glass industry that reduces high levels of pollution while operating at elevated temperature.

The global glass industry is extremely diverse in its products made and the manufacturing techniques employed. Products range from intricate handmade lead crystal goblets to huge volumes of float glass produced for the construction and automotive industries. Manufacturing techniques vary from small electrically-heated furnaces in the high temperature insulation wools (HTIW) sector to the cross-fired regenerative furnaces in the flat glass sector, producing up to 1000 tonnes per day. The wider glass industry also includes many smaller installations that fall below the 20 tonnes per day threshold.

The production of glass involves high temperatures and high energy input processing, which results in the emission of combustion products and oxidation of atmospheric nitrogen. The main pollutants in the glass furnace off-gas are particulate matter (PM), oxides of sulphur (SO_x) and nitrogen (NO_x).



▲Fig 1. Flow chart of glass production with various secondary abatement technologies.

To reduce the risk to the environment, a Directive was annexed in the Directive 2010/75/EU of the European Parliament and the Council on industrial emissions (integrated pollution prevention and control). The purpose of the Directive is to achieve integrated prevention and control of pollution arising from the activities in the industry leading to a high level of protection of the environment as a whole.

The legal basis of the Directive relates to environmental protection. The term 'best available techniques' (BAT) is defined in Article 2(11) of the Directive as: "The most effective and advanced stage in the development of activities and their methods of operation which indicate the practical suitability of particular techniques for providing in principle the basis for emission limit values designed to prevent and, where that is not practicable, generally to reduce emissions and the impact on the environment as a whole.

"Different emission levels are defined and permitted in Best available techniques reference document (BREF) depending on the type of glass produced, yearly production, type of furnace and if any primary abatement in place."

The United States Environmental Protection Agency (EPA) is currently introducing stricter legislation to control these mixed pollutants across industries including glass, carbon black manufacture, cement kilns and coal production.

Background

There are other techniques available to treat the glass furnace off-gas to meet emission requirements. These solutions are always installed downstream of the

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Key features	Benefits
HIgh efficiency	- < 2 mg/m³ emissions (0.0008 grains per scfm)project - easily handles sub-micron particles and PM2.5's
High temperatures capability	- temperature resistant up to 900°C (1650°F) - normally used up to 500°C (932°F) - maintains a stable buoyancy of to plant
Corrosion resistant	- virtually chemically inert - can tolerate changes in operational conditions and temperature
Range of product variations and sizes	- up to 3m long x 150mm diameter (10 ' long x 6 " diameter) - normally incorporated into new plant design, but can be retrofitted into existing systems

▲ Table 1. Main highlights of the Cerafil technology.

Key features	Benefits
Single-step process	- it can replace or be used to supplement inefficient electrostatic precipitators (ESPs), SCR catalysis and conversion processes, providing a single-step process (Fig. 1)
Dual purpose filter	- the dual-purpose filter consolidates the equipment train, which saves on capital, footprint, and energy costs and simplifies the process - maintains gas temperatures and plant/stack buoyancy for downstream processes or energy recovery.
Dust	- removes particulate matter below 2 mg/m3 dust
Gaseous mixed pollutants removal	- ca. 95% HCl removal; - ca. 80% SO2 removal; - up to 95% NOX removal; - >99% dioxin removal.

▲ Table 2. Main highlights of the Cerafil TopKat technology.

Year	Dust	*Nox (mg/m³)	*SOx (mg/m³)
2012	< 5	< 600 mg/m	< 400 mg/m
2013	< 5	< 600 mg/m	< 400 mg/m
2014	< 5	< 600 mg/m	< 400 mg/m

*Permitted limits: NOX: 800 mg/m3 and SOX: 800 mg/m³

▲ Table 3. NOx, SOx and Dust emissions noted over a three-year period.

furnace and can be operated while it is running. For de-dusting, techniques such as electrostatic precipitator (ESP) or bag filters are used. ESP's can attain dust levels of less than 20 mg/Nm³ while bag filters may achieve less than 10 mg/Nm³. In terms of costing, bag filters are comparable to ESPs, however the durability of bag filters is always an issue. In general, bag filters need to be replaced every two to three years depending on the operating conditions, thus increasing the OPEX of the abatement system. ESPs are not very efficient in de-dusting as current legislation dust emission levels need to be maintained below 10 mg/Nm³.

For deNOx, techniques such as Selective Catalytic Reduction (SCR) or Selective Non-Catalytic Reduction (SCNR) are available as abatement system downstream of the glass furnace. Both SCR and SCNR are related processes where ammonia or urea is reacted with NO_X to reduce the NO_X to nitrogen and water. SCNR usually requires high temperatures of between 800°C–1100°C and operates close to the glass furnace: deNOX conversion of around 30–70%, depending on process and operation factors, can be achieved. SCR systems can achieve around 70 to 90% $deNO_X$ conversion, however unreacted NH_3, or in other words ammonia slip, needs to be minimised.

For $deSO_X$, usually a scrubbing agent such as lime or sodium bicarbonate is used before the de-dusting and SCR system. A reaction chamber upstream of the filter or ESP is usually required for high SO_X removal.

These clean-up processes are used, often in combination, to achieve at least the regulated emission limits (***Fig. 1***). Process choice is affected by many factors, apart from the regulations in force, not least of which are economics and reliability. To meet tighter legislation and permit limits these technologies need to be used sequentially and sometimes in various steps of the process flow diagram to bring the emissions below the newly mandated EPA and EC requirements.

High temperature ceramic filters

Cerafil, from Clear Edge, is a range of low-density ceramic filters used in filter plants in much the same way as filter bags, albeit at higher temperatures. Cerafil is typically used in the 200 to 800°C (ca. 400 to 1500°F) range, thereby avoiding acid and water dew points and allowing for application at the temperature that best suits the duty. In addition, Cerafil elements are extremely efficient, corrosion resistant and can be used in the most challenging conditions (***Table 1***).

Cerafil is a monolithic ceramic filter candle comprising alumino-silicate fibres developed over several years and formed by a proprietary process. The resulting filter element is effective at handling sub-micron particles in industrial gas processes.

The applications of this Best Available Technology include air pollution control (APC), product collection and product recovery. The one-piece element is self-supporting and robust, can be utilised in a variety of conditions and exhibits long service life. The highly porous candle, which is capable of filtering gas to limits of <2 mg/m³, provides a future proof solution for forthcoming tighter environmental legislation.

Some of the features of Cerafil technology are in ***Table 1***.

Catalytic ceramic filters

Clear Edge has recently advanced the technology to develop Cerafil TopKat, a technology that combines the advantages of Cerafil with an incorporated active catalyst for the removal of NO_X, dioxin, SO_X, and VOCs. This patented technology protects the catalyst from poisoning and deactivation, a common problem with selective catalytic reduction (SCR) technology, by incorporating it in the wall of the filter element (***Table 2***).

Clear Edge has researched and developed the Cerafil TopKat technology platform for more than 10 years and has built up experience applying this technology in critical applications.

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Fig 2. Filter installation.

Thousands of TopKat filter elements are in circulation in applications worldwide covering a variety of industrial uses.

Case Study: Glass furnace exhaust

There are 22 installations housing Cerafil TopKat filters in the glass furnace exhaust. With all these sites taken together there are more than 24,500 filter elements in operation.

Cerafil TopKat installations have shown remarkable levels of operational stability over a period of time. In many cases, filter installations remain operational with high levels of filtration and catalytic performance even after five to six years of use (***Table 3***). Control of emissions from glass furnaces has become a key market for Cerafil TopKat. For example, one installation ***(Fig. 2***), dating from 2009, which uses 1700 TopKat 3000mm elements, is still performing with efficiency in excess of 95% of initial performance. To date, no elements have been replaced.

Application: Glass furnace
Cerafil TopKat (3 m): 1700 elements
Commissioned: September 2009
Volumetric flow: 85,000 Nm^3/h
Operating temperature: 325°C-350°C ■

References

1) I. Chisem, R. Lydon, Developments and Case Studies in Hot Gas Filtration for Gaseous Waste Streams, Filtration Journal, Vol 14, Issue 4, 208 – 210.

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