Efficient cleaning of effluent gases from optical fibre production processes using a V-tex™ scrubber

Introduction

In this paper we discuss a unique process technology called the V-tex™. Its design makes it suitable for a wide range of difficult scrubbing and stripping applications, where it delivers economic and technical advantages versus conventional packed tower, tray, venturi and fluidised bed scrubbers.

In cases where there are both particulate and gaseous contaminations present, or when the contamination reacts to form a glutinous by-product or slurry, there are challenging design issues for scrubbing or stripping systems in terms of reliability and performance.

V-tex™ not only overcomes many of the reliability issues of traditional scrubbers but with its vortex process flow design and non-clogging opposed jet nozzle also allows highly efficient process intensification.

This technology has gained wide acceptance over the last 10 plus years and is used in the nuclear, petrochemical, chemical, pharmaceutical, metal finishing, optical fibre, and microelectronics industries and in many other difficult applications.

A gas scrubbing application where the V-tex™ has proved to be the best available technique is for the treatment of off-gas generated in the manufacture of optical fibres, where simultaneous particulate and acid gas capture is achieved in a single stage process.

Application in optical fibre production

Let's take the example of the optical fibre manufacturing process to illustrate a tough off-gas cleaning challenge.

Typically, the modified chemical vapour deposition (MCVD) process is used to deposit glass to build up the optical fibre. The discharge vapour contains unspent silicon tetrachloride, $SiCl_4$. This reacts with moisture in the waste gas to form particulate silicon dioxide (SiO_2) and acidic hydrogen chloride (HCl) gas as follows.

$$SiCl_4 + 2H_2O \rightarrow SiO_2 + 4HCl$$

The HCl and SiO_2 must be removed from the discharge carrier gas to enable the carrier gas to be discharged to the atmosphere.

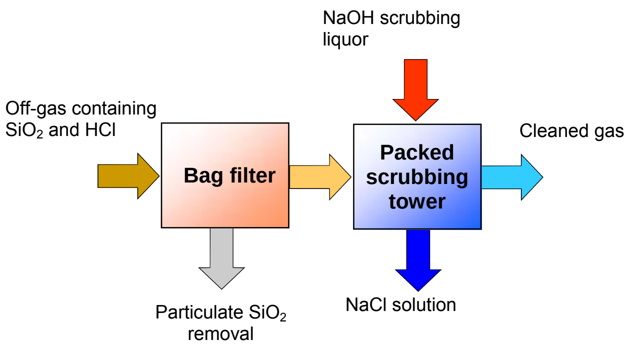
This is a difficult cleaning challenge because the gelatinous hydrolysed silica clogs scrubbing and filtration systems, and the HCl becomes corrosive in the presence of moisture.

Alternative technologies

Prior to the V-tex™ technology becoming available, two options were commonly adopted, both of which are two step processes:

<u>The dry / wet solution</u> is the removal of the SiO_2 by dry filtration using a bag filter, followed by wet alkali scrubbing of the acidic halogenated gases using a packed tower.

Figure 1: The dry / wet process



A difficulty of this approach is that in the 1st stage the dry bag filter is exposed to a corrosive environment. For the particulate to form and thus be able to be captured by the dry filter, the $SiCl_4$ must first hydrolyse in the presence of moisture which also forms highly corrosive HCl. Expensive counter measures are required to handle this aggressive environment typically involving exotic construction materials, temperature control, lagging and lime dosing.

Another problem is that any leakage of un-hydrolysed gaseous contamination though the bag filter results in particulate formation in the alkali packed tower, which then results in the SiO_2 reacting with the alkali scrubbing liquor to form a glutinous by-product which subsequently fouls the mass transfer packing.

Figure 2:
Clogged packing material from a packed tower scrubber

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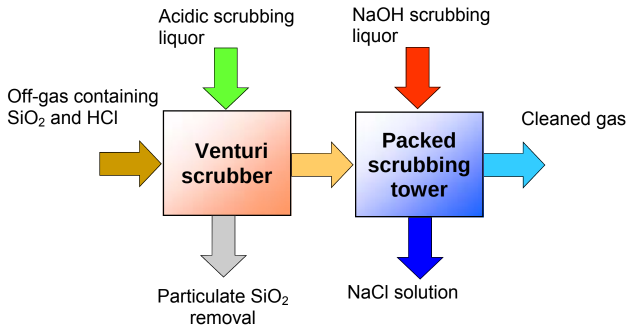
The wet / wet solution is firstly the removal of the silica particulate by high energy venturi scrubbing using acidic scrubbing liquor; and secondly, alkali packed tower scrubbing. This approach is reliable and effective. However it uses considerable energy because the venturi requires a 750mm w.g. pressure drop in order to capture the chemically generated sub-micron particulate and so a high energy fan is required resulting in high energy consumption.

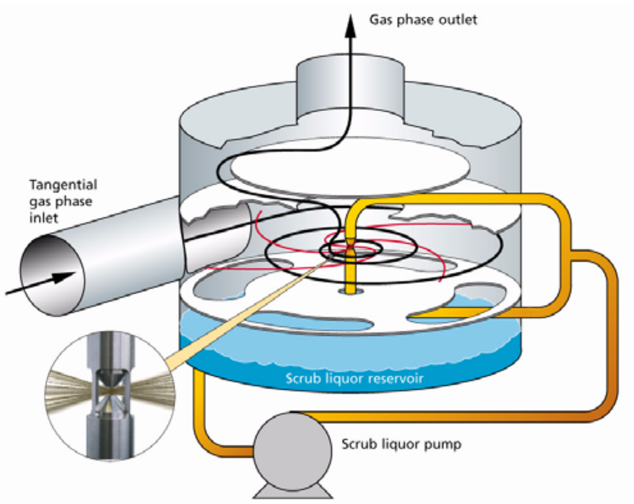
Figure 3: The wet / wet process



New technology – the V-tex™ scrubber

The draw backs of both the above described solutions are overcome by the V-tex™ technology. Figure 4 illustrates the V-tex™ scrubber mechanism.

Figure 4
Mechanism of a V-tex™ scrubber

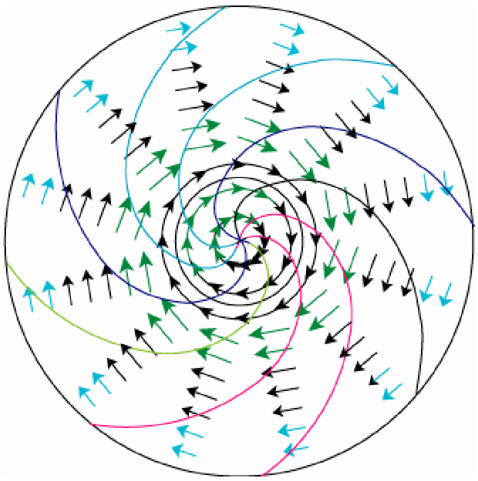


The unique features of the V-tex™ scrubber are:

The path of the gas stream is a vortex - The gas enters the scrubbing chamber tangentially, and exits axially. This means that the gas travels at least 15m in a spiral within the chamber while it is continually exposed to a bombardment of fine droplets travelling at high speed. By comparison, in a packed tower designed for the equivalent efficiency the gas typically only travels about 3m.

Self-cleaning, non-clogging, opposed jet nozzle - The opposed jet design is a unique patented design based on the discovery that directly aligned, opposed jets of liquor, correctly configured at sufficient pressure, shatter the liquor into an array of fine droplets moving at rapid speed uniformly away from the source, see figure 5. This fine droplet array, with its high droplet surface area, together with the high velocity of the droplets across the path of the vortex, achieves high efficiency of contamination removal. Not only is process intensification achieved, but the nozzle is able to tolerate up to 10% suspended solids in the liquor stream without loss of performance. In addition, the nozzle is self cleaning in that if one of the opposed nozzles fouls, the jet from the other directly opposed nozzle simply drives down into it and cleans the obstruction.

Figure 5:
Typical gas vector arrows and droplet trajectories (spiraling radially from the centre) within a V-tex™ chamber, shown in plan



Process intensification - The high speed of the gas promotes turbulent mixing with the shattered and rapidly propelled scrubbing droplets, which present a liquor surface area for mass transfer an order of magnitude larger than traditional packed tower scrubbers. This enhances the mass / heat transfer and particulate collision / agglomeration. This, combined with the long path of the vortex gas stream achieves process intensification in a compact space. (This is why the nuclear industry use V-tex™ scrubbers as the volume of material contaminated is minimised).

No packing - Removal of the contaminants into the liquor phase is achieved by the process intensification described above without the need for packing. V-tex™ scrubbers recirculate more liquor at a greater pressure than traditional scrubbers to achieve this intensification and so use more energy. However compared to high energy venturi scrubbing this increased power usage is relatively low.

Turn Down Flow Capability - Unlike traditional packed towers, V-tex™ scrubbers do not suffer from loss of contamination removal performance due to “channelling”, which allows contaminated gas to “short-circuit” the scrubbing process. This is because the mass transfer process

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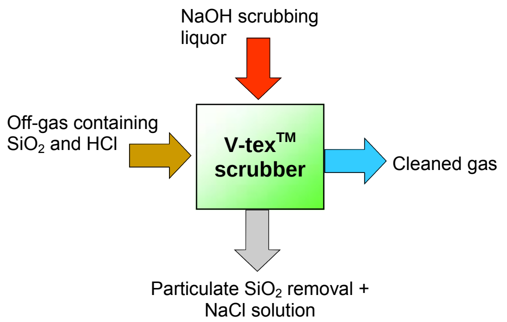
is dominated by the rapidly moving array of fine droplets away from the centre of the scrubber. So at low gas flow the V-tex™ scrubber is able to adapt from a vortex scrubber with a long quickly moving gas pathway to a highly efficient spray chamber with a slowly moving short pathway. Short-circuiting of the gas is impossible as the gas has to pass the source of intense shattered fine droplets to reach the outlet from the chamber.

The features described above mean that in a single process step the V-tex™ scrubber can perform all the cleaning requirements for the optical fibre off-gas application.

Figure 6: The V-tex™ process



Sub micron particulate capture at low energy

For many applications a V-tex™ scrubber operating with only 100mm w.g. pressure drop achieves the same particulate removal efficiency as 750mm w.g. pressure drop high energy venturi scrubbing. In addition V-tex™ scrubbers can operate with alkali slurry liquor and remove acidic gases without the requirement for a 2nd stage of scrubbing.

In a typical venturi scrubber, treating 3,000 m^3/hr of gas, the collision zone is in the throat and the path length is approximately 0.3m. By contrast in a V-tex™ the gas path length is more than 15m, and the residence time of the gas is around 50 times greater. In addition, because the high velocity droplets are moving at right angles to the gas flow the probability of collision is far higher than in a venturi where the gas and liquor are moving co-currently for only a short period.

V-tex™ solution at an optical fibre customer

In one installation in Demark the client initially pilot trialled the technology and then purchased a V-tex™ production unit to treat the off-gases from four MCVD optical fibre manufacturing units. This client then went on to purchase a V-tex™ scrubbing system to treat the off gases from twenty seven MCVD units.

This larger system comprises four V-tex™ dual scrubbing chamber units 1m diameter by 1m in height mounted on a single rectangular sump tank. Experience has shown that using two chambers in series for this application achieves exceptional performance as the 1st chamber acts a roughing stage removing the bulk of the contamination and ensuring complete hydrolysis of the contamination. The second chamber then removes any residual contamination.

Figure 7:
Schematic diagram of a dual stage V-tex™ gas scrubber unit. The top stage shows the gas flows and the lower stage shows the liquor flows

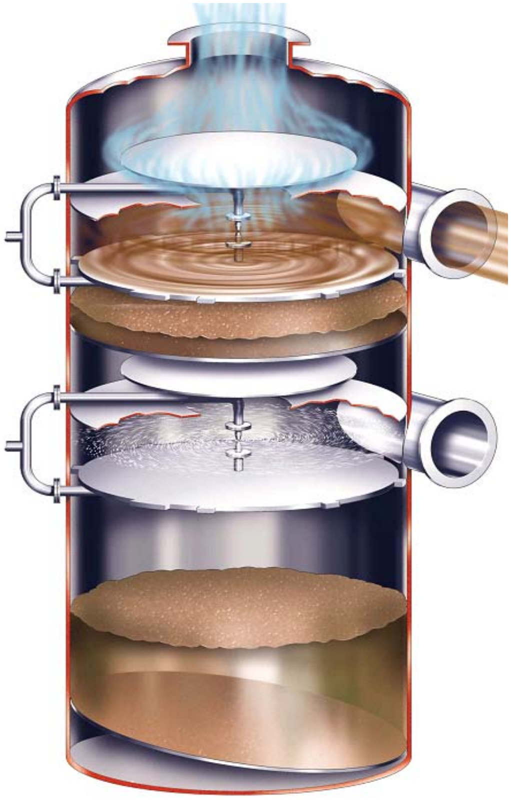
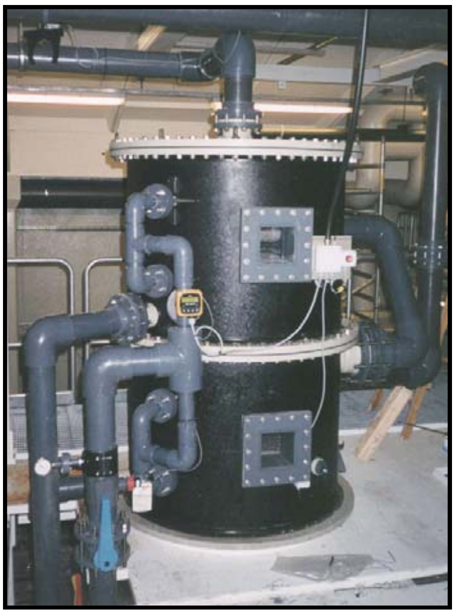


Figure 8:
A dual chamber V-tex™ scrubber as installed at an optical fibre manufacturing plant



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Once commissioned, the V-tex™ scrubber achieved the following performance results in operation:

- Removal of HCl and SiO_2 in carrier gas flow from 600m^3/hr to 10,000 m^3/hr
- Removal of HCl gas from the carrier gas stream from 4,000ppm down to less than 10ppm i.e. better than 99.75% removal efficiency
- Maximum discharged solids content of less than 10mg/m^3
- Scrub liquor contained up to 5% weight SiO_2 with no blockages

Summary

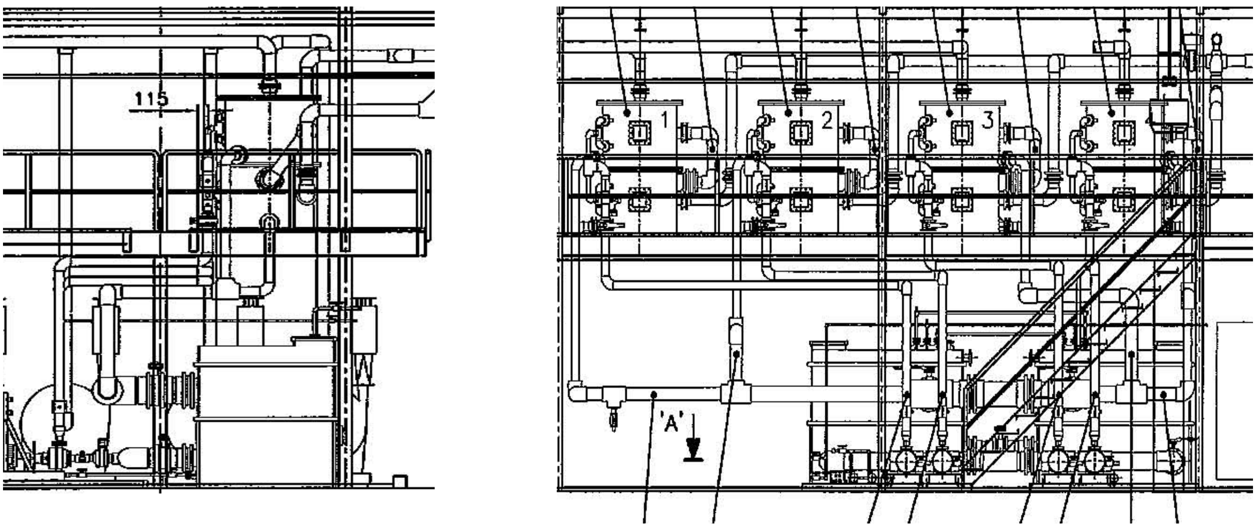
For challenging applications such as $SiCl_4$ and $GeCl_4$ scrubbing, the V-tex™ technology overcomes many of the drawbacks of traditional scrubbers. Its unique features enable cost effective and efficient solutions to be provided for applications which previously would have required multiple stages, considerable complexity and high power usage. In addition, the robust nature of the V-tex™ technology reduces the need for internal equipment maintenance and so minimises operator exposure to hazardous environments.

As this paper explains, the V-tex™ technology overcomes many of the issues that have hampered optical fibre manufacturers from achieving cost effective compliance to increasingly stringent atmospheric emission standards.

The benefits of the V-tex™ technology for both scrubbing and stripping applications are now recognised across a wide range of industries with over 200 installations worldwide.

For details of the other V-tex™ scrubbing and stripping applications, visit www.ergapc.co.uk.

Figure 9:
Engineering drawings showing the actual installation



About ERG (Air Pollution Control) Ltd.

ERG (Air Pollution Control) is a leading supplier of air pollution control systems and services with a 30 year track record. We provide turnkey tailor made solutions that are optimised to give the best technical solution for the lowest capital and running cost.

ERG is based in Horsham, near Gatwick airport with satellite offices around the UK, a branch office in the Middle East, and a global network of V-tex™ technology licensees.

ERG specialsies in odour control systems; V-tex™ scrubbing, stripping and condensing technology; soluble contamination capture and recovery; particulate removal systems; hazardous waste flue gas cleaning systems, and VOC contamination abatement.

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