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Experiences of the application of Hot Gas Filtration to Industrial Processes

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Introduction

Hot Gas Filtration (HGF) is defined as the dry scrubbing of gaseous process effluent above 250 degrees Centigrade .The potential applications for this technology can be found in Atmospheric Pollution Control (APC) and In-Line Equipment Protection (ILEP) .

In recent years novel rigid refractory filter media have emerged with several advantages over conventional fabric bag filters and other particulate arrestment systems e.g. electrostatic precipitators . It has been proven that they achieve superior filtration efficiency , in excess of 99.9% and offer unequalled temperature resistance and chemical inertness .

Other manufacturers use alumino-silicate glass fibres and the terms “ceramic “ and “ceramic fibre “ are used to describe the filters , so the more general meaning of the phrase is lost . The refractory filters studied here are made from calcium silicate and mineral fibres .

Alumino-silicate fibres are now considered to be potential carcinogens and could cause mesotheliomas (1) . TENMAT ceased manufacture of candle filters using ceramic fibres at an early stage in preference for the stronger CS1150 media . TENMAT have taken out a patent covering the manufacture of CS1150 (2) Refractory Filters .

Refractory Filters are made using a vacuum forming process and are usually cylindrical with a flange and one closed end .They are available in a range of external diameters e.g. from 60 mm to 150 mm and a range of lengths e.g. 350mm to 3000 mm .

The filter elements are located in the filter plant cell plate in a very similar manner to conventional filter bags . Dust laden hot gas is drawn through the filter , from outside to in by means of an external fan (see figure 1).The dust particles and sorbents , if used , are drawn onto the outer surface and the clean gas passes through the wall of the filter element to exit from the flange mouth to the clean side .

The dust cake is allowed to build up until the pressure drop reaches design level , typically 250 mm WG (2.5 kPa) , and then the cleaning or regenerative pulse of compressed gas , usually air , is initiated . A pressure drop sensor or electronic timer activates a pilot valve which in turn opens a diaphragm valve allowing a short pulse of compressed air into the jet tube .The compressed air enters the filter element via a venturi nozzle thus drawing a larger volume of air into it . The momentary reversal of the gas flow through the filter element results in removal of the dust cake from the outer surface of the element . The filter element is then ready for the next dust collection period .

Objective
To accumulate operational experiences of the application of FIREFLY Refractory hot gas filters to a range of APC equipment in various industrial processes world wide and define the important operational parameters . Applications studied include soil remediation , clinical waste incineration and aluminium metal recycling .

Approach
A study has been made of the effect of a wide range of operational conditions , including gas volume and velocity , temperature , particle size distribution , and organic / moisture content **,** in real process situations on filter elements performance and life expectancy .

Project Description
HGF technology has been used in a large number of applications in the last five years including :-
* Incineration of industrial , chemical , animal and clinical waste.
* Precious metal recovery .
* Soil Remediation .
* Metal processing .
* Waste to energy .
* Cement and brick industries .
* Wood and paper industries .
* Furniture manufacture .

The study undertaken covered all of these applications and the results obtained are discussed with reference to three main types of industry .

Case Study 1 - Clinical Waste Incineration (see Table 1)
The incineration of clinical waste is one of the most demanding applications because of the wide variety of waste materials presented to the incinerator . The incinerator could be burning cellulose based products containing large quantities of water e.g nappies , bedpans etc , with sudden changes to glass sharps and low level radioactive waste contained within heavy duty plastic containers . This leads to large variations in the composition of the flue gas and the size and types of particulate that need to be collected . In addition , acid gases are captured using Sodium Bicarbonate which is injected into the dirty gas stream . Activated Carbon is also used as a sorbent material to reduce the level of Dioxins in the flue gas . Some reduction in the level of heavy metals is also achieved . A reaction vessel is often used in order to increase the contact time between the flue gases and the sorbent.
TENMAT'S FIREFLY CS1150F filter elements have been used in several clinical waste and animal carcass incinerators and have shown themselves to be particularly strong compared to other rigid filter elements in the presence of high moisture levels . The life expectancy can be in excess of 12 months .

Case study 2 - Soil Remediation (see Table 2)
Heavily contaminated soils may not lend themselves to cleaning technologies such as Bioremediation or Washing and the preferred solution is incineration . A study of one such plant revealed some amazing facts . The incinerator is located within the environs of a large

town which previously relied upon it's steel plant as it's main source of employment . Following closure , the land was found to be heavily contaminated with coke , tars and heavy metals ; a legacy of the large coking operation . Over a period of three years , over 0.5 million tonnes of contaminated soil have been burnt and the cleaned soil returned to the site in readiness for domestic housing and retail development .
The tars present are poly aromatic hydrocarbons of high vapour points in excess of 400 degrees Centigrade and readily deposit in the filter elements . The elements have withstood several fires , which would have destroyed a normal baghouse and have operated at pressure drops in excess of 700mm WG without damage .
The life expectancy for the elements in such an arduous environment would probably not exceed 6 months but in practice one set has survived over 15 months !

Case study 3 - Aluminium Foundry (see Table 3)
Many Aluminium foundries use scrap as the sole source of raw material . Used automotive engine components contain large quantities of oils .Recycling scrap through reverbatory furnaces generates large quantities of fine carbonaceous dust which must be collected by filtration .When dealing with this type of dust it is common practice to condition the filter elements with inert powders of known particle size distribution e.g. talc . The purpose of this conditioning process is to reduce the penetration of the very fine particles into the filter pores. Talc can also be used as a general filter aid by agglomerating fine sticky particles.. Emission levels well below 1 mg / m3 of particulate are frequently achieved and can be used as a control limit in the continuous monitoring system to identify problems such as damaged elements or other leaks.
The life expectancy is affected by many conditions but in particular great care must be exercised when using Fluorides to refine the aluminium as operation below the dew point will result in damage to the elements , as a result of hydrofluoric acid attack . The problem can be reduced and even eliminated by the use of sodium bicarbonate .

Results
The results are presented with reference to actual industrial processes and the performance achieved .
All emissions meet European legislation **.**
Volume and velocity :-

Standard element sizes allow cost effective treatment of hot gas volumes up to 0.5 million Am3 / h . The chosen velocity will depend upon the temperature , particle size distribution and nature of the dust . Aluminium foundry applications can run as fast as 150 m / h providing that fluoride capture is not necessary because the speed would be dictated by the reaction time of the sodium bicarbonate . As a result plant sizes are usually smaller than fabric bag filters which need to run at much slower velocities . Applications that run at very high temperature e.g 600 degrees Centigrade or have sticky dusts e.g Soil Remediation need to run at much slower velocities , typically 100 m / h or high pressure drops result .
Temperature:-

Basically ' the higher the better ' although , of course , the higher the temperature the higher the running pressure drop .Higher temperatures also put a strain on the metal components of the filter plant . Continuously operated plant generally show better element life than

intermittently operated ones .Refractory filters are able to withstand flash fires which would otherwise destroy the baghouse .
Most hot gas filtration applications fall in the range 200 - 650 degrees Centigrade . 'High temperature' filter bags which are usually made from Nomex can only be used continuously at 180 degrees . Higher temperatures result in heat setting of the bags causing blinding and eventually pin-holing and fracture .
Particle size distribution:-

Experience has shown that these filters are capable of filtering particles down to less than 1 micron with 99.9% efficiency . Efficiencies and running pressure drops can be aided by controlled conditioning . It is common practice to use cyclones prior to the filter plant to remove very coarse particles . These should not be operated too efficiently as a narrow size range particulate collecting on the element wall , will produce a dense filter cake , which may be difficult to remove .
Fabric filters typically emit 2-10 mg/m3 of dust particles to the clean side which is adequate for today's regulatory limits . Refractory filters typically achieve clean side emission levels significantly below 1 mg / m3 ! Although this level is not yet a legal requirement , future legislation is expected to be more demanding and also this level of dust can be extremely advantageous in the ILEP applications and in the reduction of the poisoning rate and protection of catalysts .
Organic / moisture content:-

Clinical / animal waste and soil remediation applications have shown that care needs to be exercised in the presence of liquids however caused .Operation of the regenerative or cleaning system whilst liquids are present in the filter body can result in the generation of stress fractures . If the moisture or organic liquid is removed from the filter elements before operation of the cleaning system then the filter elements are unharmed . Ideally , the plant should be operated above the dew point or highest boiling point temperature but that is sometimes difficult with intermittently operated plant .
Chemical / Erosion Resistance:-

The chemical and erosion resistance of Refractory Filter elements is superior to many bag materials . In addition rigid Refractory Filters do not need a supporting metal cage which may be susceptible to chemical corrosion . Some bag filter materials and coatings are combustible Most ceramic filter media are inert in oxidising and reducing atmospheres and have excellent resistance to acidic and organic vapours . Applications in Bauxite and cement plants have demonstrated the improved erosion resistance of Refractory Filters at comparable or even higher gas velocities than those normally experienced by bag filters .

Conclusion
FIREFLY Hot Gas Filtration is a viable technology for the dry scrubbing of hot gaseous effluent from a wide range of industrial processes .
FIREFLY Hot Gas Filtration technology offers far greater filtration efficiencies than other particulate removal systems and can be used in aggressive environments .
It is particularly effective at high temperature i.e. in excess of 250 degrees Centigrade , but can still be a viable and cost effective technology where corrosion is a potential problem or intermittent uncontrolled temperature excursions are a possibility .

The technology is extendible to certain gaseous phase collection by the use of appropriate sorbents . Acid gases are collected by the use of Sodium Bicarbonate ; Dioxins by the use of Activated Carbon and a combination of these can reduce emissions of heavy metals.
FIREFLY Hot Gas Filter elements are unique and are not based upon ceramic fibre , so that apart from the health and safety benefits , they are stronger and more resistant to moisture damage .
High running pressure drops e.g. 700 mm WG are sometimes unavoidable due to high temperature and liquid condensation but the filter elements have sufficient strength not found in fabric bag filters.
As a particular benefit , FIREFLY Hot Gas Filters are totally incombustible . Sparks from Cupolas or wood burning incinerators will not create holes in the elements or , even worse completely destroy the filter house **.**
The resulting particulate emissions are invariably below 1 mg / m3 of gaseous effluent for dirty gas input containing particles of less than 1 micron in diameter . Filtration efficiency is in excess of 99.9 % .

In practical terms , the higher temperature capability facilitates the positioning of the filter house prior to the heat exchanger , rather than afterwards , resulting in less problematical and , therefore , less costly operation of that piece of equipment .

Future Activities

To continue to monitor existing and new applications to collect and collate information on the key parameters that define the boundaries of the technology .
The filtration temperature could be in excess of 1000 degrees Centigrade but that will need further development in filter house design , construction and choice of materials ,

References

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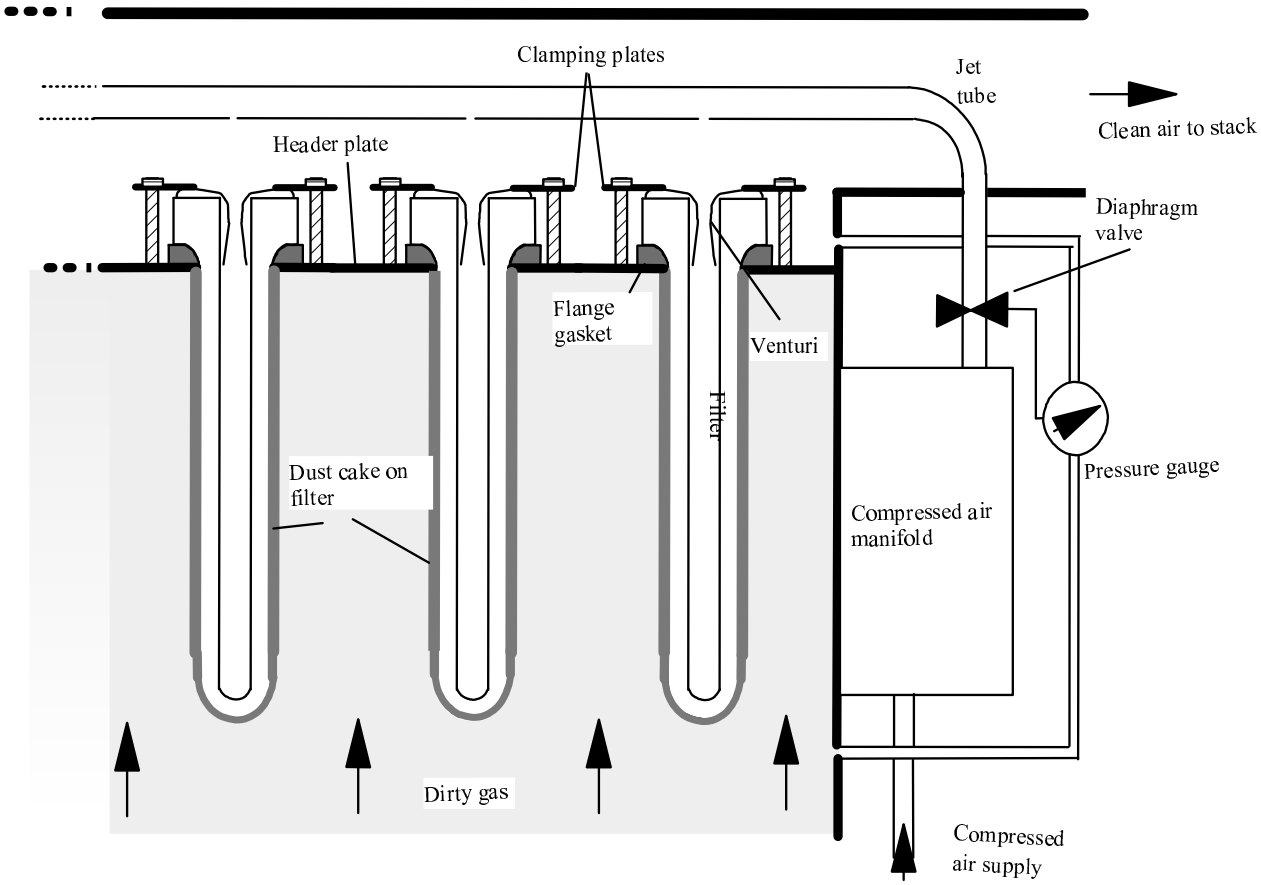

Fig. 1 .Schematic diagram of filter box

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Table 1 . Case study 1 - Clinical Waste Incineration

		Inlet conditions	Outlet conditions
Flue gas	Flowrate ($Nm^3\ h^{-1}$) Actual flowrate ($m^3\ h^{-1}$) Velocity ($mm\ s^{-1}$) Temperature (°C)	12000 22400 30 260	
Particulates	Type Size (µm) Loading ($mg\ m^{-3}$)	fly-ash/sorbent 0.1-10 500	- - 1
Gas constituents	HCl ($mg\ m^{-3}$) $SO_{2\ (mg\ m^{-3})}$ Metals ($mg\ m^{-3}$)	1000 150 1	10 50 0.5
Sorbent used		Sodium bicarbonate	
Filters used		CS1150 1 m long candle, 60 mm OD 1512 off arranged horizontally	
Total filtration area (m^2)		272	
Air: cloth ratio		108	
Operating pressure drop (mm water gauge)		250	

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Table 2 . Case study 2 - Soil Remediation

		Inlet conditions	Outlet conditions
Flue gas	Flowrate ($Nm^3\ h^{-1}$) Actual flowrate ($m^3\ h^{-1}$) Velocity ($mm\ s^{-1}$) Temperature (°C)	26096 50000 19.8 250	
Particulates	Type Size (µm) Loading ($mg\ m^{-3}$)	carbonaceous 10%<1 30000	- - 1
Gas constituents	HCl ($mg\ m^{-3}$) $SO_{2\ (mg\ m^{-3})}$ Metals ($mg\ m^{-3}$)	n/a 2000 1000	 3 10
Sorbent used		Sorbalit	
Filters used		CS1150 1500 mm long candle, 60 mm OD 2592 off arranged vertically	
Total filtration area (m^2)		700	
Air: cloth ratio		71	
Operating pressure drop (mm water gauge)		600	

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Table 3 . Case study 3 - Aluminium Foundry

		Inlet conditions	Outlet conditions
Flue gas	Flowrate ($Nm^3\ h^{-1}$) Actual flowrate ($m^3\ h^{-1}$) Velocity ($mm\ s^{-1}$) Temperature (°C)	22000 40059 39 225	
Particulates	Type Size (µm) Loading ($mg\ m^{-3}$)	carbonaceous 0.2-0.5 600-700	- - <1
Gas constituents	HCl ($mg\ m^{-3}$) $SO_{2\ (mg\ m^{-3})}$ Metals ($mg\ m^{-3}$)	3.33 n/a -	<1 n/a -
Filter aid used		talc	
Filters used		CS1150 1.25 m long candle, 60 mm OD 1512 off arranged vertically	
Total filtration area (m^2)		287.3	
Air: cloth ratio		140	
Operating pressure drop (mm water gauge)		228	

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