Company Profile Including Development in Stack Emission Filtration Technology

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SUMMARY

Elkem ASA is the world's largest producer of ferroalloys and a major producer of aluminium.
As the pioneer in electric smelting technology, Elkem has designed and delivered electric reduction furnaces that cover more than 50% of the world's electro metallurgical production capacity for ferroalloys, pigiron, calcium carbide and Cu/Ni-mattes.
Having developed the advanced technology needed for refining the ninerl resources of the earth, Elkem is now engaged in solving the mounting problems of industrial pollution and waste with Elkem ASA, Materials,FPT.
The result of Elkem's developments is a new trend in bag filtration, " Surface Fitration". Elkem's customer adapted membrane filtration systems allow high ratio filtration of conventional processes both open and closed, as well as high temperature filtration of controversial powder and gases.
The new and highly effective filtration systems first being used in the ferro silicon industry, have made powder processing a profitable field of engagement .
Some types of powder which previously created disposal problems have proved to be extremely valuable and in some cases- invaluabie . Elkem has extensive know-how in powder processing, including densifying and packaging. The Elkem organisation can offer support and assistance in connection with profitable processing and marketing of filtered material.
Elkem ASA, Materials is certified according to NS-ISO 9001 quality assurance system, thus a solid and experienced partner within the field of environmental technology.
This paper presents the recent developments and future trends in Elkem's Stack Emission Filtration Technology.

INTRODUCTION

Elkem ASA is an international metals, materials and technology group of companies which services customers in a wide range of industry market segments.
Elkem's 17 wholly or partly owned production facilities are located in Brazil, Canada, Iceland, Norway and the United States, which are supported by a global network of sales offices throughout Europe, America and Asia. Elkem's world-wide net sales exceeded USD 1. 3 bilion in 1997 and the company employs around 5000 people world wide.
Since the late fifties, the Elkem group of companies has invested more than 100 million US dollars in filter installations and more than 40 million US dollars in research within the pollution control area and powder processing .
Elkem initially became involved in environmental technology process to solve the problems facing its own metallurgical facilities. The experience has included air particle filtration, cleaning of acid gas emissions, powder and ash handling and processing . These activities are organised in Elkem ASA, Materials' department Filtration and Powder Technology(FPT).
Elkem's effort in the pollution control field started early in the fifties when they decided to test a bag filter for cleaning ferroalloy smoke. The result was

not convincing . Therefore, when it was decided to clean the first ferroalloy furnace in the Elkem group in 1966, a dry electrostatic precipitator was installed at a silicon metal furnace in Norway.
However, due to evaporative water cooling and conditioning , extensive corrosion problems occurred. In order to teduce the corrosion problems, a compromise solution was adapted with reduced conditioning and consequently low efficiency before the plant was finally closed down.
A baghouse filter from another company was installed in 1971, at the same plant, to clean the smoke from a similar furnace. The performance of this filter was also not satisfactory and major parts had to be completely rebuilt. Mechanical details were improved and the bag cleaning operation was converted from shaking to reverse air.
As a part of Elkem's effort to make the best decisions, Elkem ASA, Research went through a test programme during the period 1972—1975 which included:

>all types of fabrics
>all types of cleaning systems
>available filter suppliers in the market
>gas cooling systems

DEVELOPMENT IN FILTRATION TECHNOLOGY

Since the start in 1974, Elkem has built and rehabilitated approx. 80 filter installations with reverse air/gas cleaning around the world.
Other types of filters have also been in use at Elkem plants, but generally the bag life is shorter and there is also a lower temperature limit on the bag material.
The commonly used filter material was not satisfactory for the high temperatures and submicron powder which has to be cleaned in the modern process industries.
Elkem's urgent need to find effective solutions to the industrial filtration problems , showed the best results with the use of Gore-Tex membrane filter materials. (of W. L. Gore & Associates, Inc.). This kicked off the new trend in bag filtration—Surface Filtration.
Parallel, the development of filter types and bag materials has continued , and since 1983 Elkem has documented that the combination of Elkem's filter types and membrane filter materials-surface filtration — has given extremely good results regarding minimising of investment and operating/ maintenance costs.
The surface filtration technology opened a market for high efficient baghouse filters for different applications like sinter plants and coal- oil fired boilers. In 1987 Elkem commissioned its first pilot plant at a coal fired boiler at Skærbækværket in Denmark. This plant was successfully operating for approx. 5 years, strongly contributing to the know-how and filter technology Elkem possesses today.
During the 1990's new and stricter surface filtration emission limitations are , and will be , introduced by governments world wide. Elkem's technology satisfies today's and tomorrow's demand with regard to both degree of cleaning efficiency and high reliability.

SURFACE FILTRATION

What is Surface Filtration?

Surface filtration is the deposition of all dust, both coarse and fine, on the surface of the filter media (the membrane). This eliminates the need for a primary powder cake to be formed in the space between fibres of the filter media.
The membrane may be described as a manmade, quality controlled, factory applied primary powder cake which provides for excellent filtration efficiencies immediately upon putting the membrane into service. This keeps a relatively constant pressure drop over the bag material for the whole lifetime of the filter material, which has in most cases been over 10 years, and in other cases the bags have not yet broken down to define a lifetime.

Function of Backing Materials

The backing materials, which are bonded to the membrane, have no role in the filtering capabilities. They serve only as a strengthening coefficient which takes the abuse and wear of baghouse service and do not affect the pressure loss or filtration efficiency.
The selection of the PTFE (Poly Tetra Fluor Ethylene) Membrane laminate is very different from

the selection process used for fabric media.

Surface Filtration with the Gore-Tex Fibreglass Bags

The membrane filter bags consist of an ultra-fine expanded PTFE membrane laminated to a backing material. In most cases, fibreglass, due to the high temperatures. All particles in the waste gases being directed through the baghouses are stopped completely on the bags'nonstick PTFE surface. Rather than forming a cake on the inside or penetrating into the bag fabric, particles are repelled from the membrane thus forming a smaller cake.
Since the membrane filter bags are kept cleaner, air flow is maintained at a constantly high level (up to three times the air flow of conventional bags) and pressure drop (resistance to air flow) is kept low. When the bag is cleaned the small filter cake will loosen, due to the membrane's smooth surface and the cleaning method applied (reverse air cleaning). After each cleaning cycle, the bags are restored to almost new conditions so that their filtering rate remains constant.

This leads to the following:

> The filter can be utilised constantly at temperatures up to approx. 260℃.
> The filter's energy consumption is reduced compared to traditional bag house filters.
> The filter can tolerate larger differences in process variations.
> The membrane bags give substantially lower emission than traditional bags.
> Expected bag life is 6-10 years for most processes.

By introducing the membrane technology in rehabilitation of existing fabric filters, the customers have achieved highly increased capacity, even with a reduced nuber of filter bags , obviously a cost effective and competitive alternative to new installations.
Elkem's baghouse filter is therefore the best solution for most cleaning and filtering jobs.

ELKEM FILTRATION TECHNOLOGY

Ffilter istallations are more and more regarded as part of the production unit. New and stronger legislation from governments world wide will obviously not allow the processes to run without strict gas—and powder emission control equipment. This should be taken into consideration when investments in filtration instaallations are made.
Some key factors are of utmost importance to ensure a successful investment, and the following recommendations will be relevant:

1. Combine the process technology know-how and the powder treatment technology know-how when designing a filter installation.

Lack of combined knowledge may easily result in failure regarding fulfilment of the plant. Capacity prodblems or a too high shut-down time may occur due to filter suppliers' usatisfactory process experience or exaggerated savings in investment . The consequences may be loss of production, short bag life with high operating and maintenance costs. Elkem has vast experience in the above fields as operator of its own production facilities and power plants.
The Elkem R & D centre is heavily engaged in continuously improving proccess technology and powder treatment technologies for a better environment.

2. Consider both initial costs and operating/ maintenance costs befor designing the filter system

Investment-wise pulse-jet and baghouse filters are evaluated as equal. Due to the higher operating and maintenance costs for pulse-jet filters (shorter bag life, more mechanical equipment, large consumption of compressed air) the baghouse filter with membrane bags will give a better overall cost result . The main difference between the two filter types has previously been the air to cloth ratio . This is changed, due to the introduction of the baghouse filters with membrane bags.
Initial investment costs using Surface Filtration Technology compared with installations with conventional bags, document that by using the combined technology from Elken and Gore , a reduction in initial investment costs up to 25% can

be obtained .
Operating costs using Surface Filtration Technology compared with installations with conventional bags , document that by using the combined technology of Elkem and Gore, a reduction in operating costs from 10%-20% can be obtained.

3. Simple construction—not sophisticated

Comparisons between pulse jet filters and baghouse filters give advantages to the baghouse due to a limited number of rotating (movable) parts and a simpler construction . This leads to higher operating time and less shut down for maintenance.

4. Try to maximise bag life

* Due to inconvenience when changing bags.
* Bag cost is a large part of maintenance costs.
* Minimising the spare part stock is good economy.
* Maintenance capacity and down time must be considered in the capital cost calculation.

Elkem has within the company both pulse jet filter systems and membrane/fibreglass baghouse filters with conventional fibreglass baghouse filters or Nomex and polyester equipped filters , and our experience shows as follows (see Tab. 1).

* The pulse jet filter system has installed needle felt bag materials with cages. (The powder is deposited on the outside of the bags.)
* Bag costs (in maintenance) ares times higher than for the membrane alternative due to shortened bag life in the pulse jet filter system
* Previously, the high air to cloth ratio for the pulse jet filter system was the system's biggest advantage. The air to cloth ratios for the pulse jet filter system and membrane fibreglass baghouse filter are now comparable.

Tab. 1 Comparisons between filter systems:

	PULSE JET FILTER	MEMBRANE/ ELEM FILTER	FIBREGLASS BAGHOUSE FILTER
Air to cloth ratio	80-90m/h	70-90m/h	30-35m/h
Temperature limits	200℃(390°F)	280℃(535°F)	280℃(535°F)
Bag type	Polyester/Nomex	Gore-Tex membrane/fibre glass	Fibre glass
Bag size	0.126×6.0m	0.292×10m	0.292×10m
Cloth area per bag	2.0m²	9,0m²	9.0m²
Cage	Yes	No	No
Pressure drop	2.0kPa	2.0kPa	2,5kPa
Bag life	Up to 30 months	6-10 years	6-10 years
Bag cost,maintenance	5×membrane bag cost		

The PTFE membrane/fibreglass bag is an excellent choice to replace the Nomex (a registered trademark of I. E. du Pont de Nemours & Co, Inc.) felt bag which is affected by high temperature moisture, hydrolysis and cannot withstand temperatures exceeding 200℃.
The PTFE membrane /fireglass bag is cheaper than a Nomex bag without a membrane.

Remarks

Following the recommendations of the above four points, Elkem as a standard utilises membrane technology in its new filter installations with reverse air cleaning.
Much of the experimental work which Elkem has conducted on the membrane bags has been centred on defining the most effective method of cleaning and allowing for all process operating parameters. After each cleaning cycle, the bags are restored to almost new conditions so that their productivity rate remains constant. Because the bags are free from caking , air flow remains extremely high. Thanks to the bags' breathabilit4y, the reverse air filter can operate at more than 70 m/h, which compares

favourably with the velocity of normally faster pulse jet filters.
As a result of high air flow, Elkem has gone into areas with their Baghouse Technology where in general, previously, pulse jet filters have been the most economical solutions and built compact smooth operating units.
In Norway both pulse jet and baghouse filters are used in connection with cleaning of ferro-alloys furnaces. Nine of the total fourteen smelting plants are cleaned by Elkem baghose filters.

THE COAL FIRED EXPERIENCE

Elkem's experience in flue gas cleaning of coal fired boilers started with the pilot plant installation in Denmark in 1987. The pilot plant was installed upstream a Haldor Tops∅e SNOX plant, a catalytic process for cleaning of SO_2 and NO_x from the boiler off gass. The process produces sulphuric acid as a saleable product.
After 2 years of operation, Elkem's filter showed an extremely low emission which kept the desulphurization system on stream with a minimum of maintenance. Emissions below 1 mg/m^3_N have been obtained and kept during continuous operations.
During the period of operating the pilot plant, several coal types were tested in the boiler, varying from low sulphur to high sulphur content. Elkem also tested several bag types, and the conclusion was obvious: The best result was obtained with Gore-Tex membrane bags, both with respect to emission level and wear of bags. During the test period, the operating time was 100% .
Due to the experence with the pilot plant and a competitive price combined with a proven technology, Elkem was chosen as the filter supplier for the first power plant in Denmark installing a desulphurization plant. The contract was signed in 1989 and the plant was commissioned in 1991. Since then, several filter units in the Czech Rpublic have been commissioned.
Elkem's baghouse filters with surface filtration technology clean today approx. 1,500,000m^3_N/h flue gases, with an average guaranteed emission level of less than 10mg/m^3_N.

ELKEM FILTER SYSTEMS

1. Baghouse Filter with Reverse Air Cleaning

Baghouse filters have traditionally been pressure filters with fans on the dirty gas/smoke side. This is still the most common filtration technology in the ferroalloy and metallurgical industry today. Due to the high filtration velocity in the Elkem filter equipment with membrane bags, this system is now in operation for different gas volumes at temperatures up to 260℃.
Elkem has, however, developed a closed suction filter with fans on the clean-gas side. Functionally this suction filter operates on the same principle as a traditional pressure baghouse filter. This combines the advantages of gentle bag cleaning (longer bag life), low operating/maintenance costs and a defined cleaned gas volume (closed filter). The suction filter has been especially developed for coal powered energy plants and other processes where filters can be integrated in systems where the exhaust gases are to be treated after filtering, for example SO_2 NO_x cleaning.
Since 1989 Elkem has commissioned several closed baghouse filter plants, all installations eqquipped with membrane filter bags. The gas volumes vary from 48,000 to 1,000,000m^3_N/h, and the guaranteed powder emission from 2 to 20 mg/m^3_N.
In order to adapt to our customers' requirements with regard to space and locations of the filter plants, Elkem can tailor-make baghouse filters for more or less any location and within reasonable space limitations. This gives a unique flexibility when new filter plants are to be adapted to old production facilities.

2. Elkem Rotor—Step filters

Apart from Elkem baghouse filter technology-surface/membrane filtration, Elkem offers an extensive range of modular fabric filters to meet most filtration requirements.
The Elkem Rotor-Step filters are excellent for gases with:

* High dust load
* Corrosive content
* Abrasive dust

The cleaning principle is somewhat similar to pulse

jet but more gentle.
The dust loaded gas enters a distributor, which ensures even and uniform downwards distribution to all the bags and to minimise bag wear . The gas passes through the fabric, and clean gas is drawn upwards through a cleaning section and into the central clean air outlet. Bag cleaning is achieved by reversing a pulse of atmospheric air through the bag, causing instantaneous bag expansion. The dust cake on the outside of the bags is broken up and falls down into the hopper. The triple filter bags are held on a retainer of extruded aluminium. Wear and tear is therefore minimised.

3. Standard equipment

Most of Elkem smoke cleaning and powder handling plants are tailor made.
Elkem supplies, however, standard rotary valves especially designed for abrasive materials (SVC, SVCK)and a standard range small filter,Rotor-Step RA15-504, with filtration areas between 15 and 504m^2.

POWDER AND FLY ASH PROCESSING

Elkem, due to its vast experience in product processing for various customers as well as for Elkem's own works, possesses a unique know-how in powder processing including transport, pelletizing, storage and packaging of powder and fly ash.
New and highly effective filtration systems are installed world wide, creating a new handling and disposal problem. Some types of powder have proved to be valuable products, but most types are still waste materials.
Elkem considers powder/fly ash handing and treatment to be an integral part of the filter design. Therefore, Elkem has made substantial efforts in solving powder treatment problems, and possesses advanced technology for both pneumatic and mechanical powder/fly ash transport from filters to storage/handing facilities as well as storage systems themselves.
Saleable material can be packed in suitable bags/containers by an Elkem packing plant.
The major part of powder and fly ash filtered world wide,must be disposed of.
Elkem has extensive experience in pelletizing of material from various metallurgical processes, and tests carried out at Elkem Research show that quality pellets from powder and fly ash can be made with or without additives, Elkem pelletizing units are available with a capacity up to 20 tons per hour.
By pelletizing the powder/fly ash, transport and disposal problems can be minimised.

THE ELKEM MICROSILICA STORY

In the fifties and sixties, filter powder from Ferro silicon and Silicon metal production was considered to be a waste product and had to be pelletized and dumped.
As Elkem considered powder handling and treatment to be integrated with the filter design,Elkem made substantial efforts in solving the powder treatment problems. Applied research by Elkem has resulted in material from these metallurgical processes presently being marketed under the trade name Elkem Microsilica.
After being treated in an Elkem Densification Process (downstream from the filter),the densified material is more easily transported to customers.

The Elkem Densification Process

The process involves the micro-pelletization of silica powder-the forming of the powder into small spheres about 0. 5-1 mm in diameter. The reasons for this are threefold:
Firstly, the bulk density of raw silica dust, being almost as fine as cigarette smoke , is less than 0. 2 tons per cubic meter. The bighly advanced process of micro-pelletization increases the bulk density to 0. 5-0. 6 tons per cubic meter. This can reduce the transport costs by as much as 5% and thereby the final cost to the customer.
Secondly, due to its fineness, silica powder is very difficult to handle . This process produces a material with the handling characteristics of fine sand without using a binder,and thereby avoids problems that can be caused by foreign materials in the final mix.
Thirdly,due to their shape and size,the micro pellets move very freely, in fact they will almost "pour".

This factor makes silo storage, in-plant transfer (mechanical or air blown) and eventual use easier than with raw silica dust . The micro pellets do not stick to one another, and therefore clogging problems are virtually eliminated.
Silica dust, whether densified or not, is a valuable product used in several applications in different industries world wide.
Elkem has today a separate department, Elkem ASA, Materials engaged in marketing and utilising powder from the ferroalloy industry.

ELKEM AS SUPPLIER

Elkem ASA, Materials, FPT has vast experience as supplier of environmental technology world wide, from delivery of small engineering packages to large turn-key plants. As not only supplier of technology, but also user of same, Elkem has a deep understanding of the needs and requirements of the customers. Specialising in technology for the metallurgical and coal fired boiler industry, Elkem supplies well proven solutions and concepts, and by using Elkem's R & D facilities, potential results from a new plant installation have been given prior to the full size installation.
In order to be competitive in the world market , Elkem is aiming at having most of the equipment and service supplied locally, either through one of Elkem's cooperative partners or by the client himself. This minimises the imported amount thus giving economic benefits both to the clients and the local industry.
Elkem always considers a contract between two parties to be an agreement on cooperation, not only a plain sale. Following-up after a sale is very important, and to ensure smooth operation of a plant , good connection and frequent contact between the parties are preferential fields within Elkem's business philosophy.
Quality is give high priority, and Elkem ASA, Materials, FPT is certified according to NSISO 9001 , "Quality Systems-Model for Quality Assurance in Design, Development, Production, Installation and Servicing". This, together with a close follow-up of subcontractors, ensures the right quality of the products.
By choosig Elkem as supplier, the client is secured an experienced co-operative partner within the field of environmental technology.

CLOSING REMARKS

Most of the industry today has emission limits/ concessions which are subject to changes during the second half of the 1990's . The new limitations will obviously be stricter regarding emissions to air and water. Demands for higher operating time and lower emission levels will increase.
Most plants today are allowed an emission of between 50-100mg/m^3_N particles to air. Limitations on operating time are often only 96%. Most have no limitations regarding cleaning of SO_2, NO_x and PAH.
New emission levels will, within the year 2000, in all probability be between 10-20mg/m^3_N for powder/ particles, 70-80% cleaning of SO_2, 90% for PAH, and 100% for operating time. NO_x is less definite.
Today Elkem possesses filter technology and technology for gas cleaning and powder handling/ treatment which can satisfy tomorrow's demands/ limits in regard to both emission level and operating time.