Pollution Problems with Electric Reduction Furnaces in the Ferro-alloy Industry

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SYNOPSIS

Air-pollution problems caused by the operation of closed reduction furnaces must be considered as technically solved. From modern furnaces equipped with submerged electrodes and high-efficiency venturi scrubbers there will be practically no air pollution. By the use of efficient sludge-cleaning plant, the gas-cleaning water can be recirculated, thus keeping water pollution to a minimum.

To clean smoke from open furnaces is more complicated, particularly for furnaces producing high-percentage ferrosilicon. Most of the dust particles from these furnaces (80 per cent) are below 0,4 μm, and between 85 and 98 per cent of the dust is formed of silica particles.

The first smoke-cleaning plant at Fiskaa Verk, in southern Norway, was an electrostatic precipitator installed in 1965. For such an installation to operate efficiently, the dust particles must have high enough electrical conductivity to transmit the current in the dust layer already settled on the collecting electrode. In order to obtain this, the dust had to be conditioned with water, which created corrosion problems.

The tendency during the last few years has been towards bag collectors. Such a filter was installed at Fiskaa in 1971. The first year of operation was troublesome. When silicon metal was produced, the filter capacity was only about 60 to 70 per cent of the rated capacity because of the high pressure drop across the filter fabric. However, when the bag cleaning system was changed and some mechanical parts were adjusted, the rated capacity was obtained with a reasonable pressure drop. Together with the other members of the Ferrosilicon Producers' Association in Norway and the Norwegian Research Institute, we have operated a single-compartment test filter with full-sized bags. The aim with this test filter, which is located at Fiskaa, has been to find the optimum combination of filter fabric, filtering load and velocity, and bag-cleaning mechanism especially suitable for dust from silicon-alloy production.

The electric-smelting industry is not very old. The first electric-smelting furnace of any significance was designed by Werner von Siemens in 1878. During the early years, development was slow. As late as 1959, when the largest furnace, with a transformer capacity of 24 MVA, was installed at Fiskaa Verk near Kristiansand, this was one of the world's largest furnaces for the smelting of ferrosilicon. However, development during the last ten years has been remarkable, and today furnaces with transformer capacity of 75 MVA for the production of ferrosilicon are in operation.

Owing to the abundant supply of cheap electric power, it was natural for Norway to be interested quite early in the production of ferro-alloys and pig iron in electric smelting furnaces. In recent years, Norway was fourth among the world's leading ferro-alloys producers, surpassed only by the U.S.A., the Soviet Union, and Japan. As a considerable part of the production in these countries is in blast furnaces, it is likely that Norway has a larger installed electric-smelting-furnace capacity than any country in the world, except perhaps Japan. Norway is also the world's largest exporter of ferro-alloys.

However, during the past few years, the most rapid increase in furnace capacity has taken place in South Africa. While, for instance, the U.S.A., Japan, and Norway had very little increase in furnace capacity in 1972, a number of big furnaces were commissioned or under erection in South Africa.

In discussing the pollution problems of the ferro-alloy industry when using electrical reduction furnaces, we have to distinguish between cleaning problems for open and closed types of furnaces.

As far as the cleaning of gas from closed furnaces is concerned, this is usually no longer considered a technically difficult problem. Until about ten years ago, the most frequently used cleaning installations for gas from closed reduction furnaces were the so-called Theissen and Buffalo scrubbers. Common to both of these types of cleaning plants was their requirement of large quantities of water for satisfactory cleaning results.

As an illustration, it can be mentioned that, for a pig-iron furnace with a capacity of 22 to 24 MW, the water requirement for a cleaning plant with Buffalo scrubbers is about 400 to 500 m³/h.

In the gas-cleaning installation employed today, namely the high-efficiency venturi scrubber, the water requirement for cleaning the same amount of gas is about 40 to 50 m³/h, i.e., about one-tenth of the water consumption of Buffalo scrubbers. As water in most places of the world is in short supply, this is of decisive importance in the choice of cleaning installation.

In recent years, we have delivered only gas-cleaning plants of the venturi type for closed furnaces.

There are two types of venturi installations that have proved to be especially suitable, viz, the Svenska Fläktfabrikens (S.F.) venturi (Figure 1) and the Finnish Ahlstrøm Group's Warkaus scrubber (Figure 2).

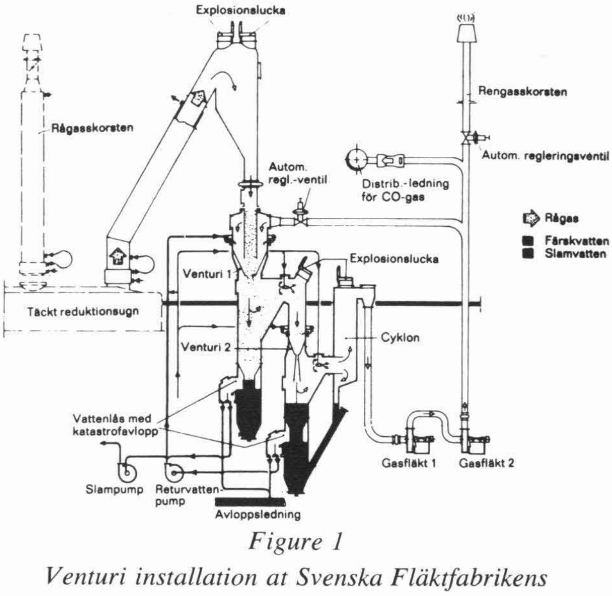

Figure 1

Venturi installation at Svenska Fläktfabrikens

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As will be seen from Figure 1, S.F. are using two venturi steps. The pressure drop for the whole venturi plant is usually about 1200 to 1300 mm w.g. With this pressure drop and a dust load of up to 200 g/Nm^3 in the raw gas, S.F. guarantee a maximum dust content in the cleaned gas of 50 mg/Nm^3.

The principle of operation of a venturi installation can be seen from the chart from S.F. The venturi principle is briefly as follows. By means of pressure drop in the venturi throat with subsequent expansion, the water particles are atomized to a suitable size in relation to the size of the dust particles. The collision between the water and the dust particles gives effective cleaning. It is chiefly the degree of pressure drop in the venturi throat that determines the dust content in the cleaned gas.

Our experience has been that the dust content in the cleaned gas, with the abovementioned pressure drop, has often been less than 30 mg/Nm^3. However, the dust concentration at the inlet to the venturi plant is also as a rule considerably less than 200 g/Nm^3.

By weighing the sludge deposited in the cleaning plant for furnace 10 at PEA, we have found that the dust concentration in the gas to the venturi plant has been about 10 to 25 g/Nm^3.

Since the S.F. venturi plant has only fixed (i.e., not adjustable) venturi throats, it is necessary to recirculate part of the gas to maintain a constant gas flow through the venturi throat, thus maintaining the same pressure drop and cleaning efficiency. The recirculating gas flow is controlled by means of a butterfly valve, which receives its impulses from the pressure underneath the furnace cover.

The Finnish installation (Figure 2) is based on a somewhat different venturi principle in that the energy is supplied by means of water pumps and water nozzles instead of gas fans. The water pressure in the cleaning plants we have employed thus far has been about 24 to 25 kg/cm^2.

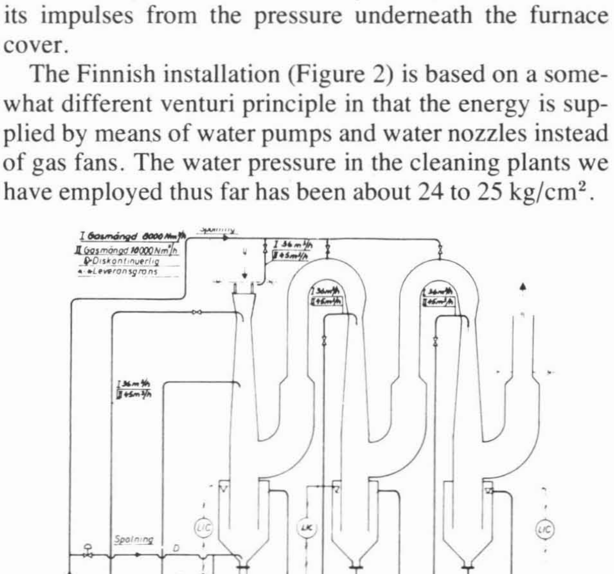

Figure 2

Venturi installation at Warkaus, Finnland

This type of venturi was developed originally by Ahlstrøm Oy for use in connection with the pulp-and-paper industry. To find an alternative to S.F.'s excellent scrubber, we had Ahlstrøm install an experimental plant at PEA. This was in 1964, before PEA was taken over by Elkem. The adjustment of the Warkaus venturi to the special conditions existing in an electric reduction furnace was carried out as a cooperative effort by engineers from Ahlstrøm and from Elkem. Today it can be said that the Warkaus venturi scrubber is fully equivalent to the Svenska Fläktfabrikens venturi.

However, the water consumption with the Warkaus venturi is about 30 to 40 per cent higher than with S.F.'s installation, which means that some countries will prefer the S.F. plant. There are certainly several types of cleaning installations that can be utilized in connection with the cleaning of gas from closed reduction furnaces. Our experience has shown, however, that, if they have not previously been tried out for this purpose, the first installations will require considerable rebuilding and adjustments.

In a modern closed furnace with submerged electrodes, satisfactory gas collection can be obtained. By means of a venturi gas-cleaning installation, the gas can be cleaned to under 50 mg/Nm^3. Where the gases are not utilized, it is necessary, owing to the high content of carbon monoxide, to burn the gas in a flare above the chimney. In daytime, the flame is hardly visible. At night, a bluish flame with some yellow streaks can be seen.

Thus, for closed smelting furnaces, it can be said that air-pollution problems are essentially solved. However, there remains the problem of water pollution, about which something must be done. Accordingly, we have in the course of the last two or three years done a number of sedimentation experiments for ferromanganese, silicomanganese, and ferrochromium. We are still working with these problems, and our aim is to obtain sufficient purified water to allow cooling and recirculation of the water without having to shut down the plant for maintenance because of the build-up of carbonates in the piping system.

With regard to the air-pollution problems, this must be considered to be more difficult and costly for open than for closed furnaces and particularly for those producing high-percentage-silicon alloys.

In order to give a better idea of the magnitude of the problems that have to be dealt with when cleaning this type of gas, I should first like to say a few words about the smelting process itself.

The raw materials that are utilized in the production of ferrosilicon and silicon metal are quartz, coke, and coal, plus electric energy. In some instances, wood chips in a suitable form are used to supply a part of the carbon requirement. In the production of ferrosilicon, iron is also added, for example in the form of scrap, turnings, iron-ore concentrates, mill scale, or the like, and in sufficient quantities to give a product with the desired specifications.

The gas generated in the reaction zone in a ferrosilicon furnace is a mixture of CO and SiO (the higher the Si content of the alloy, the more SiO in the gas). Normally, most of the SiO gases are recovered in the upper layers of the charge, but some will always escape with the furnace gas and be oxidized to fine SiO_2 particles, which give the characteristic white smoke. At the same time, CO is oxidized to CO_2.

Under difficult operating conditions, gas channels may be formed in the charge. The gas from the reaction zone escapes through these channels up to the surface of the furnace. Owing to the high content of SiO, intense heat and smoke are developed. This is the so-called 'gas blow,' which is eliminated by poking or by the addition of charge to the area of the gas channels, or by both.

These are the conditions that have made it difficult to smelt silicon alloys in closed furnaces. Although 45 to 65 per cent ferrosilicon can be produced in closed furnaces, we must assume that 75 per cent ferrosilicon and higher alloys, which today constitute the largest volume of the production, will be produced in open furnaces for many years to come, at least if this production takes place in large furnaces.

In normal operation, the reaction gases from an open furnace account for only 1 to 3 per cent of the volume emitted from the stack. The rest is dilution air. Ordinarily, the volume of gas emission is of the order of 12 to 17 Nm^3/kWh. This means that the gas volume from a 30 MW furnace may be as high as 500 000 Nm^3/h.

Some of the dust from ferrosilicon and silicon-metal furnaces is unreduced quartzite dust and coke particles carried away with the gas flow before entering the smoke stack. About 85 to 98 per cent of the dust, however, is SiO_2 derived from the oxidation of SiO gas. (This dust is extremely fine, examinations having shown that about 80 per cent is smaller than 0,4 micron.) This means that the amount of dust is related mainly to the silicon recovery.

As an example, it can be mentioned that a 30 MW furnace producing 75 per cent ferrosilicon with 85 per cent silicon recovery will discharge about 1 tonne of dust per hour. It has not been possible to prove that smoke from the production of ferrosilicon harms vegetation, animals, and man. Nevertheless, the smoke cloud from a smelting plant located near cities or densely populated areas is so annoying, especially in periods of atmospheric inversion, that one cannot continue to discharge the smoke, but efforts must be made to clean it.

Before proceeding to a description of the various cleaning methods, I should like to say a few words about furnace construction itself. This is an area in which considerable development has taken place in the past ten years, so that a distinction must be made between old and modern installations.

For open furnaces, the most important structural change is in the arrangement regarding the current supply and the smoke hood (Figure 3). The flexible copper cables are now located above the roof of the smoke hood (Figure 4). Consequently, under the smoke hood there are only the cylindrical electrode holders, which surround the electrode itself. In this way, one does not have furnace equipment such as copper pipes and cables, connection pieces, and suspension yokes, etc., exposed to blows and corrosive gas streams. An important improvement, in addition to what has been mentioned, is the capacity of the modern smoke hood to collect the smoke emitted from the furnace. It has been mentioned previously that the smoke-gas volume from an open ferrosilicon furnace is about 12 to 17 Nm^3/kWh. In tests recently performed on Furnace No. 2 at Salten Verk, the volume of smoke was reduced to about 50 per cent of the normal emission without any apparent greater strain on the furnace equipment. However, it should be noted that furnace operation during the test was extremely good.

In the conventional type of furnace, it is hardly possible for the volume of smoke gas to be reduced to below 13 to 14 Nm^3/kWh. As the cost for smoke-cleaning equipment is approximately proportional to the volume of smoke gas, the significance of the results from the tests at Salten is apparent.

The first gas-cleaning plant at Fiskaa was built in 1965. It was a dry electrostatic precipitator delivered by Svenska Fläktfabriken.

To obtain a better understanding of the problem, we should look at the principle of the electrostatic precipitator

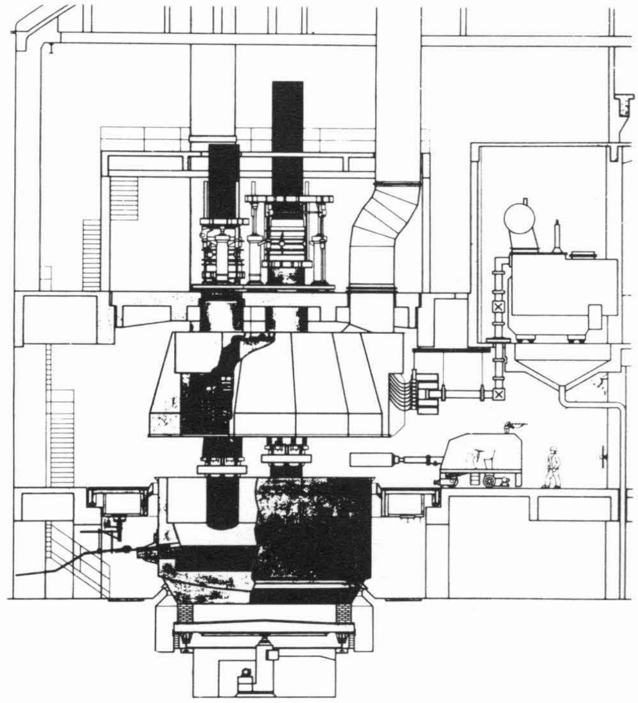

Figure 3
Former arrangement for an open furnace

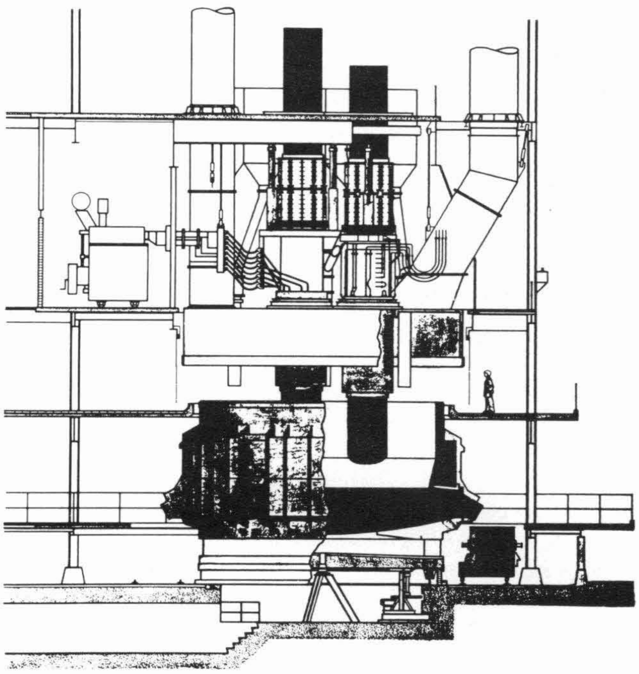

Figure 4
Modern arrangement for an open furnace

(Figure 5). The dust-laden gases enter the precipitator at A, and the cleaned gases leave at B. The gases pass between the discharge electrode E and the collecting electrode U. In S.F.'s precipitator, the discharge electrode consists of steel wires mounted in a framework, and the collecting electrodes of vertical plates. The rectifier supplies a voltage that can vary between 30 and 60 kV, depending on the nature of the process. Because of the strong magnetic field at the discharge electrode E, a so-called corona discharge takes place. In the collision between the electrons and gas molecules, a large number of positively and negatively charged ions are formed. The positive ions lose their electric charge at the negative discharge electrodes and become neutral, while the nega-

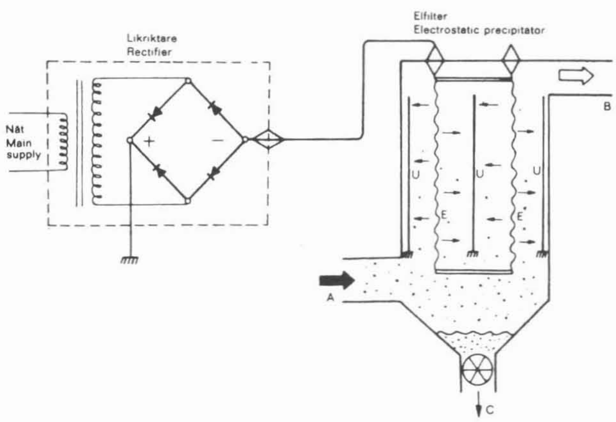

Figure 5
Electrostatic precipitator

tive ions migrate over to the positive collecting electrodes. On their way, the ions collide with dust particles, which then receive a negative charge and are attracted by the collecting electrodes, where the dust settles. In a dry precipitator, the dust is removed from the electrodes by a mechanical arrangement, e.g., hammers that strike the electrodes at certain intervals. In a wet precipitator, the layer of dust is washed off with water. For such a precipitator to work effectively, the dust particles in the layer that has settled on the collecting electrodes must have a high enough electrical conductivity to conduct current. Herein lie the difficulties with SiO_2 dust from ferrosilicon furnaces. The electrical resistivity is so high that the dust must be conditioned with water for the process to work. This is done in a tower of considerable dimensions.

It has turned out that, for satisfactory cleaning, the gas must be conditioned with water so that the temperature is about 65°C. But then serious corrosion problems arise. During the time the precipitator has been in operation at Fiskaa Verk, it has been necessary to replace most of the contents of the precipitator. At the same time, the conditioning tower has had to be reinforced.

If one operates with a gas temperature of 85°C, the most serious corrosion problems can be avoided. However, the cleaning efficiency will then not be better than 60 to 70 per cent. Experiments with the addition of ammonia in the gas have improved the precipitation, but the corrosion problems are still significant.

In the U.S.A. especially, various types of cleaning plant for open furnaces have been tried. In addition to the electrostatic precipitator of both dry and wet types, high-pressure venturi installations of somewhat the same type as described earlier for use with closed furnaces have been tried.

Because of the large volumes of gas that are involved, these venturi plants are too expensive. The power consumption for the operation of the venturi is 10 to 15 per cent of the capacity of the smelting furnace. This means that, for a 30 MW furnace, about 3000 to 4500 kW is required for the operation of the venturi installation. Some years ago, this capacity was considered to be equivalent to a medium-sized furnace. Venturi plants have the further disadvantage that they need to be shut down for regular cleaning.

At Chromasco Inc.'s plant at Memphis, high-energy steam scrubbers designed and installed by Aronetics Inc. have been used for three or four semiclosed furnaces. This type of cleaning equipment requires an elaborate water-treatment plant, and it is probably justified to state that some development work still has to be done before a plant of this type can be installed and operated without problems.

An interesting filter installation has been in operation at Airco AB in Sweden for about two years. It cleans the smoke gas from the new ferrosilicon furnace delivered by Elkem. Like the other ferrosilicon furnaces at Wargon, it is equipped with a furnace cover with a built-in water-tube boiler for steam production, so that the gas volume is reduced to about one-fifth of the volume from an ordinary open furnace.

The filter is a Drallschichtfilter (or sand-bed filter), delivered by Gesellschaft für Enstaubungsanlagen in Germany (Figure 6). With such a filter, however, it cannot be expected that the dust content in the cleaned gas will be much below 400 to 500 mg/Nm^3 when a reasonable pressure drop is applied. Nevertheless, because of the small volume of gas, Airco AB will probably succeed in meeting the norm for new installations, which is 15 kg of dust per tonne of metal produced. To obtain invisible smoke discharge, however, it is necessary to get down to about 50 to 100 mg/Nm^3.

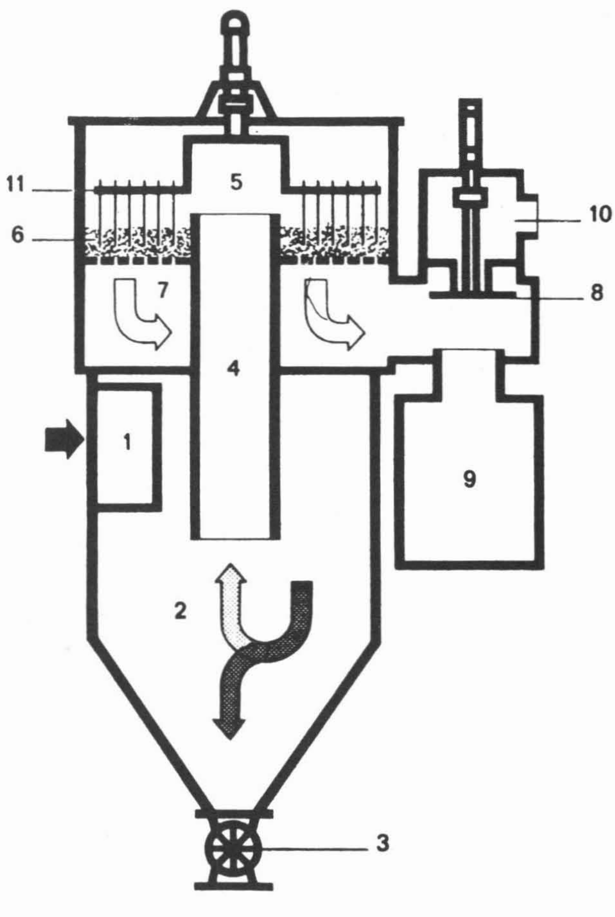

Figure 6
A Drallschichtfilter

The tendency in recent years, both in the U.S.A. and in Europe, has been in the direction of bag filters. Union Carbide, which is probably the company with the longest experience and the largest number of cleaning installations for open furnaces, now appears to have gone completely over to bag filters. It was this trend towards bag filters, together with our own careful considerations, that led us in 1970 to order a bag-house filter from Tilghman Wheelabrator for furnace No. 10 at Fiskaa Verk (Figure 7). It is a pressure-type filter – that is, the fans are located ahead of the filter. The bag-house is divided into 8 com-

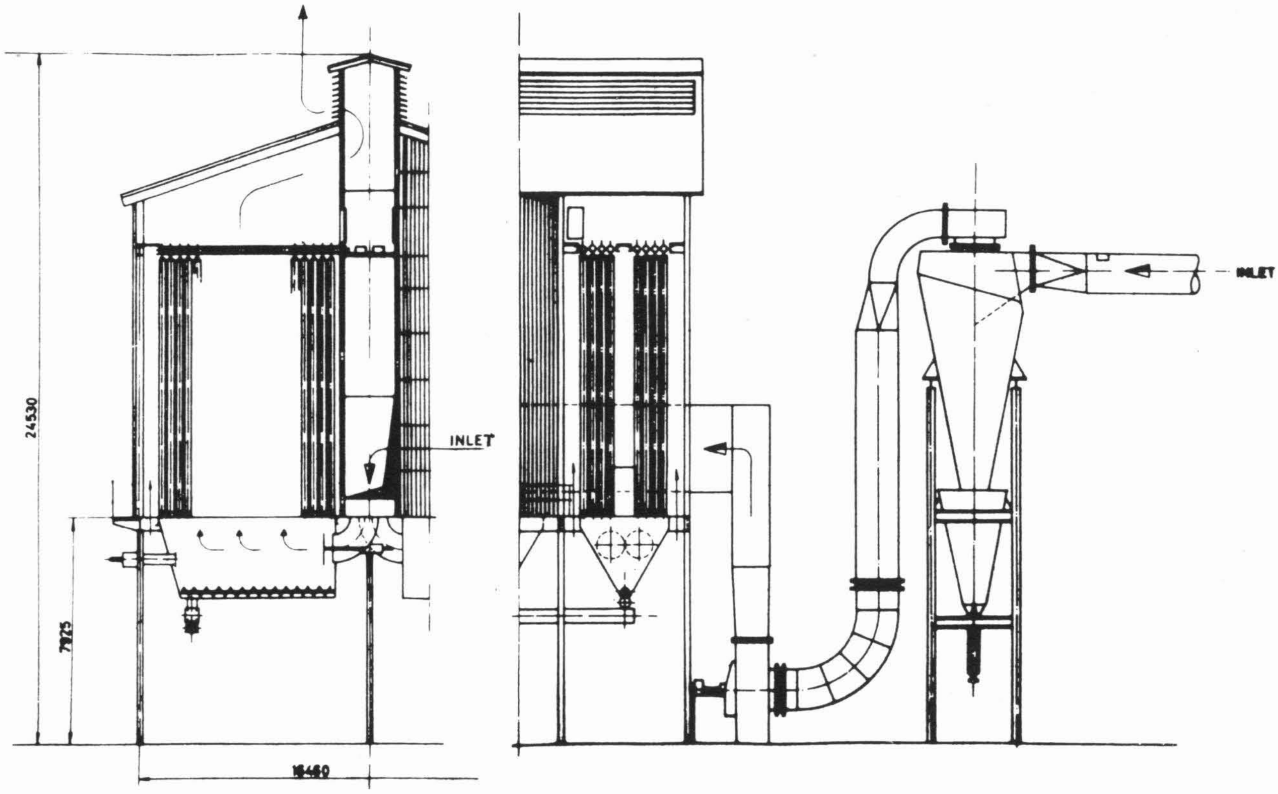

Figure 7
Baghouse filter from Tilghman Wheelabrator

partments, each with 144 bags, giving a total of 1152 bags. The bags are 292 mm in diameter and 9,3 m long. They are of glass fibre, are silicon-graphite treated, and should tolerate a working temperature of up to 260°C.

The filter is designed to handle a gas volume of 170 000 Nm^3/h, and the temperature of the gas at the filter inlet is estimated to be about 250°C. This gives an actual gas volume at the filter of 326 000 m^3/h. As one compartment is always out of action for cleaning of the bags, the normal velocity through the filter fabric is 37,8 m/h.

There are two fans, delivered by Flebu Luftteknikk. Each can handle 163 000 m^3/h at 350 mm w.g. and a gas temperature of 250°C.

The filter was commissioned in April 1971. During the first year of operation, we had numerous problems with pack boxes, bearings, valves that did not seal properly, etc. We have made considerable efforts to get the filter to work properly, and today we have a filter with almost 100 per cent operating time.

The system originally delivered for the cleaning of dust from bags was by shaking. As the bag material is glass fibre, the shaking movement had to be very gentle, which resulted in a build-up of a dust layer of several millimetres inside the bags; this layer never came off. This resulted in too high a pressure drop across the filter fabric and a total reduced capacity of the filter to about 60 to 70 per cent of the designed capacity.

The filter has now been rebuilt, and uses only reverse air for bag cleaning. All the bags are equipped with rings to avoid collapsing during this process. Today the filter has sufficient capacity to clean the total gas volume from furnace no. 10, which is connected to the filter.

Another type of bag filter using 13-m-long glass-fibre bags and with the gas inlet at the top of the filter is in use in Japan. In principle, there is no difference in the filtering system itself, but, with the method shown in Figure 8, it seems that a somewhat lower filter resistance (i.e., the relation between the pressure drop across the filter fabric in mm w.g. and filtration velocity in m/h at a certain temperature) may be obtained with the Japanese system than with the conventional bag-house with bottom inlet as used in Europe and the U.S.A.

However, the filter shown in Figure 8 is not very attractive from the point of view of maintenance, and needs to be redesigned to allow maintenance to be done in one compartment while the rest of the filter is in operation.

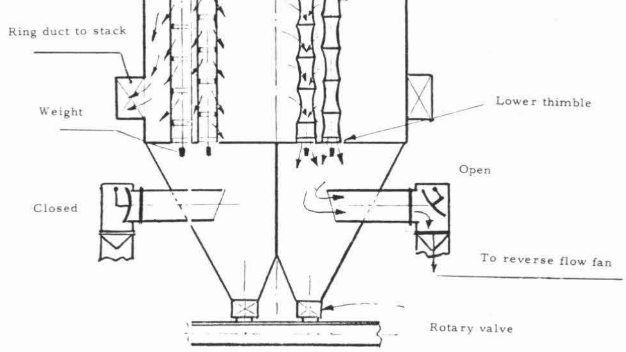

Figure 8
Bag filter in use in Japan

It is very difficult to say which of the various types of filter that are in use today for the cleaning of gas from open reduction furnaces are the most efficient and economical for this purpose. Even though we are quite satisfied with the type of filter we have in use at our Fiskaa plant, it may be that other combinations of bag material, bag-cleaning system, reverse air flow, etc., will give a lower power consumption and a more economical filter.

Without trying out these various factors, we shall not know whether we have attained the optimum solution for the cleaning of the furnace gas. This was the main reason that we, together with the other ferrosilicon producers in Norway and the Norwegian Research Institute, decided in 1972 to build a test filter at Fiskaa where the various combinations of filter fabric and bag-cleaning systems could be tested.

We hope that, from the experience we have gained in the operation of the main filter at Fiskaa and the experience we shall acquire through the operating results from the test filter, we shall be able to specify a filter that will operate satisfactorily. If the mechanical components in such a filter are to operate for a satisfactory life-time, special attention must be given to these items.

DISCUSSION

Mr Meintjes:*

I must congratulate Mr Lømo and Dr Person on their interesting and instructive papers. They have covered the field fully, but I would like to add a few observations. Although in the case of closed smelting furnaces the air pollution problems are essentially solved, Mr Lømo remarks that the wet scrubbing of the gases does leave a water-pollution problem. Dr Nasu, too, mentioned in his paper that, owing to the difficulty of adequately cleaning the gases from a closed 25 MVA charge-chromium furnace by venturi scrubber, and of treating the effluent water to meet the purity standards required, they actually converted the furnace to an open top and collected the dust in fibreglass bags. I wonder whether there may not be an acceptable dry solution to the treatment of the gases from a closed ferro-alloy furnace. The wet scrubbing of gases from a closed carbide furnace, for instance, similarly gives rise to an effluent, which, apart from requiring treatment for the removal of the sludge, has also to be treated with chlorine to eliminate toxic cyanide. Such treatment is troublesome and expensive, so that manufacturers have been seeking a dry solution to the treatment of the gases from closed carbide furnaces. In Japan, I know of two factories where the gases from a closed carbide furnace are successfully treated in glassfibre bags. On the other hand, at Süddeutsche Kalkstickstoff-Werke in Germany, ceramic filters have for very many years been successfully used for the same purpose. Application of either of these methods to ferro-alloy dusts would surely warrant investigation as a means of eliminating the water-pollution problem arising from the wet scrubbing of the dusts from closed ferro-alloy furnaces.

Mr Lømo has described the Tilghman Wheelabrator baghouse filter on an open silicon-metal furnace at Fiskaa Verk, and I may mention that at Rand Carbide we are at present installing a similar filter on an open 30 MW 75 per cent ferrosilicon furnace, the supplier being AB Svenska Fläktfabriken. The plant is designed to handle 360 000 Nm^3/h, but with the option of increasing this to 412 000 Nm^3/h if initial experience on the first stage of the plant indicates this to be desirable. The actual m^3/h at 205°C and site pressure will be 755 000 or 862 000, respectively, and the filtering velocity with a compartment off for cleaning will be 0,56 m/min. Cleaning will be by reverse air only. The initial stage comprising 8 compartments will have 6 compartments fitted with glassfibre bags finished with silicone graphite and Teflon, and 2 compartments fitted with Nomex bags containing interwoven stainless-steel threads, it being our intention to compare operating life and efficiency of the two types of filtering material.

Dr Person has reported that, for silica fume, Union Carbide has switched from fibreglass to Nomex, which has been found to be superior owing to reduced filter drag giving increased volumetric capacity per unit of filtering area. There is a difference of opinion between Dr Person and Mr Lømo on whether glassfibre or Nomex is better for silica fume, and I would appreciate further discussion on this topic with resolution of the differing views if possible.

It is worth noting also that, in Japan, where the Government virtually issued an ultimatum to manufacturers to clean up their plants, there are many successful installations employing Tetoron bags, which require a maximum gas temperature of 130°C at inlet to the bag chamber. In northern Italy I have seen similar plants fitted with Dacron bags in which the maximum permissible temperature is the same. In both cases, the gases from the open ferro-alloy furnaces are precooled in serpentine air coolers or so-called wet-wall coolers, or a combination of the two. Where plants of this type had been installed in Japan, the reasons advanced for preferring Tetoron to glassfibre were that Tetoron was cheaper, the filtering area required was less owing to the lower gas volume, and the bags were easy to handle in comparison with the extremely fragile glassfibre ones. The transformation in Japan's air-pollution problems is nothing short of amazing. A few weeks ago I travelled by train through some of the most heavily industrialized areas, and I hardly saw anything resembling a smoking stack. In his plenary address on the first day of the conference, Dr Nasu showed us a photograph of before and after the installation of dust-collecting equipment at a factory. I can confirm that the second photograph was genuine and that he did not, as one may have been tempted to suspect, merely arrange for all the furnaces to be switched off before taking the picture!

Mr Lømo:

I agree with Mr Meintjes that water pollution is probably a more difficult problem when it comes to cleaning of effluent from furnaces. As I mentioned, we are doing quite a lot of work in this respect, and our aim is to be able to recirculate the water. We are doing this in our ferro-alloys plant in Porsgrunn. We are using a plate water cooler, and at the moment we have to clean it every three weeks; our aim is to prolong that period.

When we come to the problem of Nomex bags versus glassfibre bags, the reason why I am in favour of glassfibre bags is their ability to withstand higher temperature (at least we have to dimension the cooling equipment), whereas for Nomex bags we have to reduce the temperature to 50°C less than with glassfibre bags. We are doing some tests on this in the test filter at Fiskaa Verk. These results may be published later, and I shall not give any details here. Our experience with glassfibre is that we have a life of at least three years; and the cost for Nomex is about three times that for glassfibre.

*Rand Carbide Ltd, South Africa.

Dr R.A. Person:*

I might add one other comment that influences our particular decision, and that is the basic physical ability of Nomex to withstand a higher pressure drop without damage, so that under these circumstances we are able to get more flow through a given baghouse, even if the drag numbers themselves are the same. The other advantage, and of course this has not yet been completely answered, is that, in our experience, our bag life with fibre glass was approximately 2 years. Our Nomex bags have been installed approximately 2 years now, and we were originally projecting an approximate bag life of 5 years for Nomex, but, until the 5 years have expired, we cannot comment definitely on this.

Union Carbide Corporation, U.S.A.