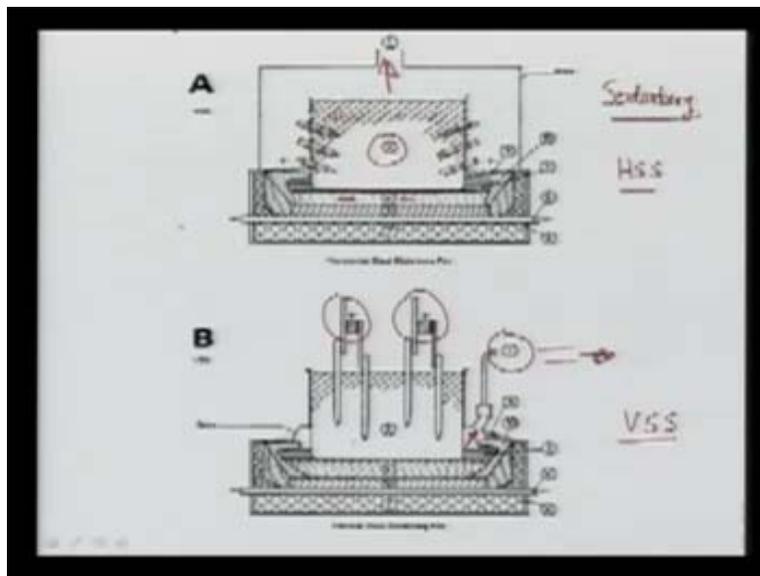


**Environmental Air Pollution**  
**Prof. Mukesh Sharma**  
**Department of Civil Engineering**  
**Indian Institute of Technology, Kanpur**

**Lecture No. 19**  
**Aluminum Production and Air Pollution – 2**

If you recall, we were talking about the aluminum production through the electrolysis of  $\text{Al}_2\text{O}_3$  and molten cryolite. We also said that there were two kinds of technology that were in use: one was prebaked in which the anode is previously baked in the prebaking furnace and we also introduced a technology called Soderberg Technology.

(Refer Slide Time: 00:51)

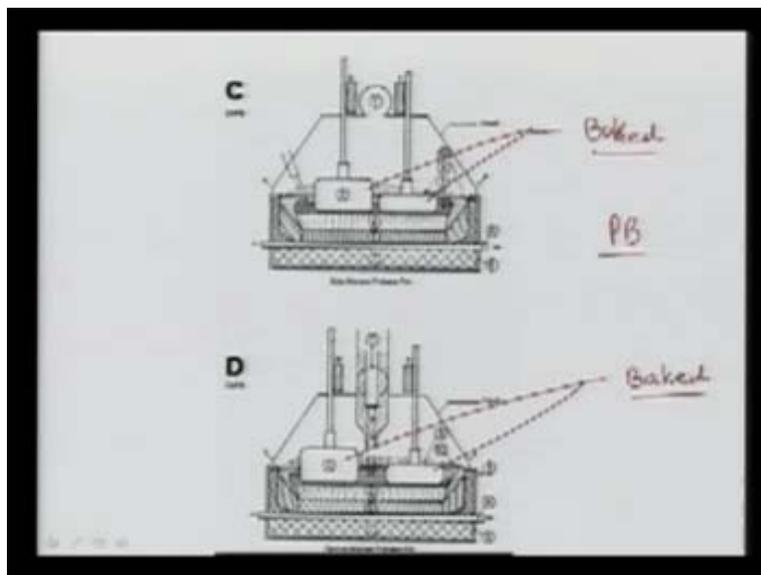


Let me write it. If you recall, the next technology that we discussed was Soderberg. The difference between the Soderberg technology and prebaked technology was that in this process, we have the anode paste rather than baked anode – the idea was to use the energy of the heat available in the pot and use that energy to solidify or bake the anode rather than doing it somewhere else. In this picture you see in terms of A and B, both are Soderberg technologies. Here, this technology is called HSS and this is called VSS.

What you see here, the number 2 here is the anode block, I will not call it block but it is a system that contains the anode. The little hatched part that you are seeing here is the anode that is still in the form of the paste. As the anode comes into contact with the molten cryolite – that is number 4 and that is in here, it solidifies at this point; it solidifies and then, there is no previous baking that needs to be done – this technology is called Soderberg technology. The idea is that it can probably save lot of money in terms of energy because you do not have to do any prebaking.

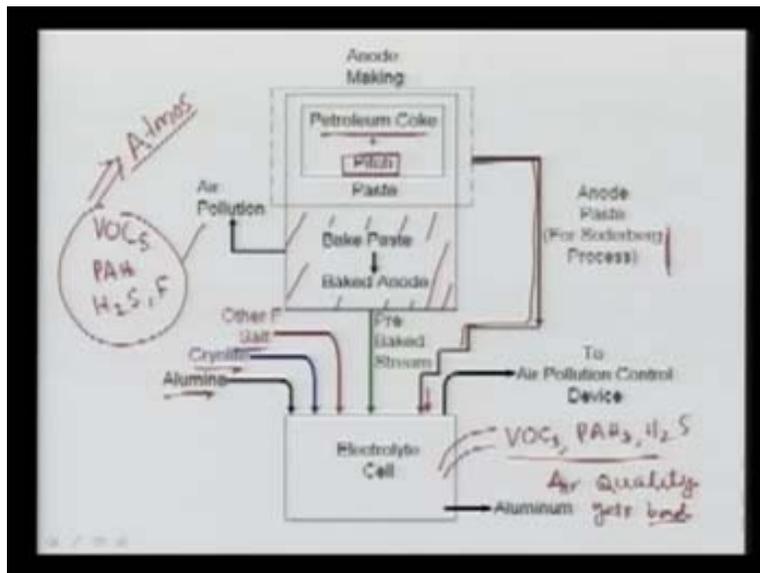
You see here the rods are horizontal, the rods that are bringing the current are horizontal and that is why it is called Horizontal Stud Soderberg. Similarly, if the rods are vertical – you can see the rods that are containing or bringing the current are vertical, they are called Vertical Stud Soderberg. It is the same thing again here – you have the green anode on top and as it goes down, it solidifies because of the high temperature available at the cryolite or the molten cryolite. You see here what is of interest to us as air pollution engineers or air pollution technologists is the collection of the emissions and that is the part I am showing. This is the emission collection and we are collecting all the emission that is occurring in the plant (Refer Slide Time: 03:33) and here was the emission collection. Now, you have fairly understood the Soderberg technology. We will discuss what are the issues associated with the air quality when we are talking about Soderberg vis-à-vis the prebaked technology.

(Refer Slide Time: 04:29)



I will also quickly remind you what was the prebaked technology. Although I showed you the slide, we will have a very quick look. What you are seeing here is the anode blocks that are already baked and here also, the anode blocks are baked in the anode baking furnace. Now, the issue is.... We discussed this in great detail last time, but now you have a clear understanding or you can clearly differentiate between the prebaked pot and the Soderberg pot. Let us go into something more about the functional aspects.

(Refer Slide Time: 04:57)



Essentially, this picture is again more of a schematic. You see here the first thing that is done is the anode making. In anode making, essentially you need petroleum coke plus pitch. Pitch is nothing but a binding material; it can bind the coke – binding together like a cementing material. First, you do a little heating of this area and you make the paste. If it is a prebaked pot that you have, then the paste is baked first. Here, after this dash line, what you see is essentially a baking furnace – I am trying to hatch this area for you. But when you do the baking part, it causes some air pollution.

In air pollution, as you recall last time, we said there can be VOCs – volatile organic compounds, there could be PAHs, which are organic but not so volatile – some of them, you can also get some H<sub>2</sub>S and you can also get emission from some of the fluorides. If it is a prebaked kind of electrolyte cell, we send the prebaked anode, but if it is a Soderberg type, we do not do baking

and we [06:23] that baking or baking will be done in the pot room itself. We do not do the baking and before baking itself, we bring the thing that is still in the form of the paste – you can see the line I am drawing along with the flow sheet, it is brought in there. Then, there is an electrolyte cell that is doing the electrolysis of  $\text{Al}_2\text{O}_3$ . Then, it goes on to the pollution control device, but do not forget here the emissions that are occurring in the baking furnace nor these emissions if I am following this stream. Again, I repeat: we can follow this stream or we can follow this stream.

If I am following this stream, the pollution is caused here and after some control, it goes to the atmosphere, but if I am following this stream, I still have the pollution potential here and the pollution starts occurring from the pot itself. Now, I will have the emissions of the VOCs, I will have the same emission of the PAHs and I will have some emission of  $\text{H}_2\text{S}$ . Now, the question is this pot room is the area where a lot of people work and so the air quality in the pot room gets, we can simply say, bad and that can affect the workers there.

In fact, now the recent trend is to not follow the Soderberg process and go for the prebaked process because in the baking furnace, you can have it separately, where the people are not exposed. Apart from that, I do not have to mention because we it did last time – we have to put in the alumina here, we have to put in the cryolite in the pot and we have to put in the other salts and other fluorides for the electrolysis to be successful.

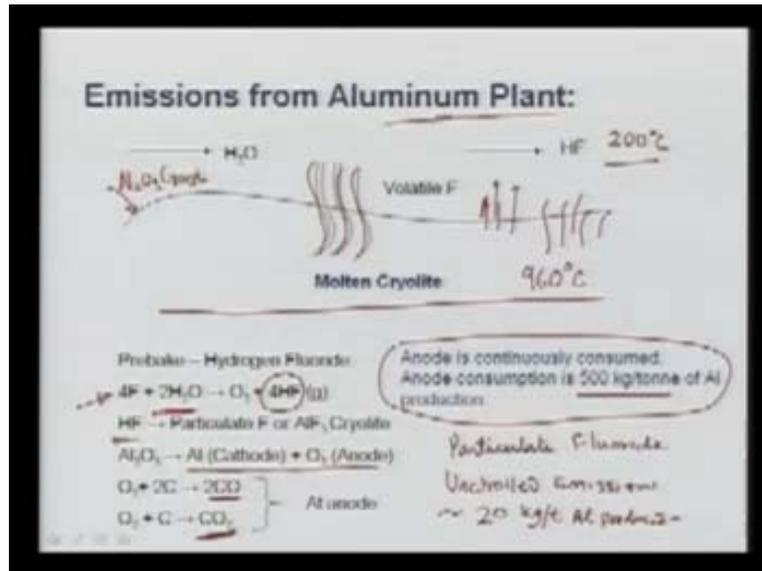
(Refer Slide Time: 08:57)

Prebaked ✓	Soderberg ✓
Clean Work Place	Dirty work place
Very little HC, PAH, H <sub>2</sub> S, SO <sub>2</sub> .	Lots of HC, PAH, H <sub>2</sub> S, SO <sub>2</sub> .

Let us go to the next slide. It is again a repetition of what I said – what is the difference between prebaked and Soderberg not from the technological point of view but from the air pollution point of view because that is what we are trying to address. Let us compare prebaked versus the Soderberg technology. Prebaked gives you very good, clean environment of the workplace and so, the workers will be very happy, they are not exposed to the high pollution level. Emissions will be there but these emissions will be very small whereas in the Soderberg process, the place is very dirty. Why? It is because there will be emissions of the hydrocarbons or volatile organic compounds, PAHs, H<sub>2</sub>S and some SO<sub>2</sub> – that makes the working environment in the pot room very dirty.

Now, in the latest trend or the latest technology from the air pollution point of view, from the public health point of view for the workers who are working in the pot room, people go more for prebaked technology. That briefly summarizes the two technologies and the differences not only in the technological or the production point of view but also from the air pollution point of view. So far, we talked about many things but we have not talked about the emissions that take place from the pot.

(Refer Slide Time: 10:19)



What I am doing is I am taking some small portion of the pot and blowing it up as you can see here. The whole thing is molten cryolite. What happens is that the temperature in here is about 960 degree Celsius. With this temperature, what we are expecting is some of the fluorides, because we are using cryolite, we are using calcium fluoride, we are using sodium fluoride. Some of the fluoride at this temperature becomes volatile as it is being shown here. Some of the fluoride becomes volatile.

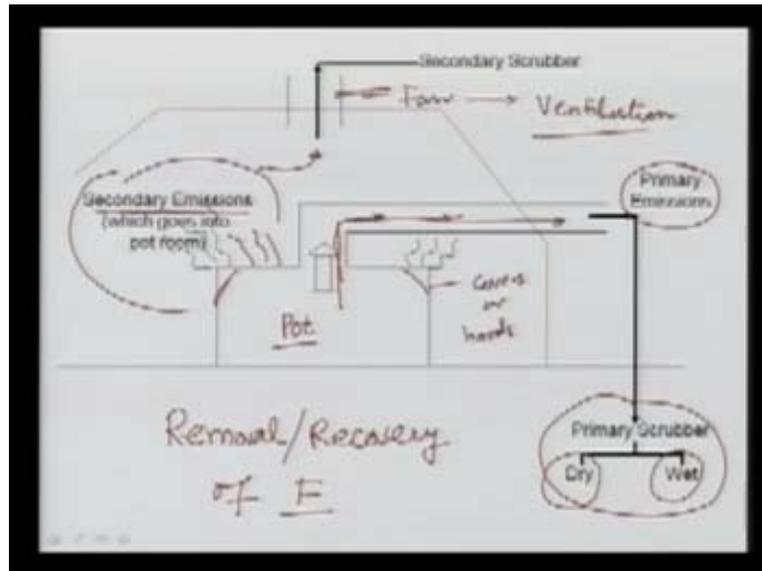
This is a crust, if you recall – we had said that this is the alumina crust. Then, as the pressure is building up inside because of the volatile compounds being emitted from the molten this thing, they tend to break open and get outside the pot and there can be the emissions of volatile fluoride. Once this volatile fluoride comes out, then what happens? In the process, you will have a certain amount of water vapor. Where will the water vapor come from? Some moisture is always there and we are also having some hydrogen in the process – in the anode, we may have some hydrogen associated with the carbon and that may have produced the water.

This fluoride, the volatile fluoride that came out of the pot can quickly react with water and produce hydrogen fluoride acid – that you see here (Refer Slide Time: 12:07). This becomes a serious pollutant that is emitted out from the pot – it can cause a serious problem. Remember that this is in the gaseous form and this is very very corrosive and very very problematic from the

public health point of view. Then, what happens? Apart from the gaseous thing that is coming out, which you see as g here, there is also a possibility that as these volatile compounds coming out from the pot room reach the cold area (the temperature is very high here and it could be let us say around 200 degree Celsius), the volatile compounds of the fluoride quickly condense to form the particulate fluoride.

Then, in addition to the [13:02] gaseous fluoride, we can also get the particulate fluoride. Let us write that we also get the particulate fluoride. What can we say if we summarize? An aluminum pot will produce both kinds of fluoride – it will largely be HF in the gaseous form and also the particulate fluoride, which will be the various compounds of the fluoride. This is the reaction that we discussed yesterday in the last lecture. The reaction was taking place and when the combustion is incomplete, it can additionally produce CO and of course CO<sub>2</sub>. Now, we have a fairly good idea of what will be the emissions from the pot room – the emissions will be largely that of fluoride. To give you a little idea of the uncontrolled emissions, let me write here. We cannot pinpoint the number, but it can be approximately 20 kg of uncontrolled fluoride emission per ton of aluminum produced. I want to just remind you here that we are constantly consuming the anode and the anode consumption is almost about 500 kg per ton of aluminum production – some plants may have a little higher, some plants may have a little lower. What we have learnt is that fluoride is the key pollution problem from aluminum production or aluminum smelting if you like – that is the word we use.

(Refer Slide Time: 15:11)



From a blown-up picture, let us go to a picture that gives us a bigger view of things. If you recall, this is my pot, the pollution is occurring from the pot room and it is going back and forth. It is going further to the device where I want to take it, but if you recall, we used to have covers here and hoods. If you recall, we had covers or hoods. These covers or hoods are not perfect – they cannot hold on to everything, there will be some leakages always. These leakages as you can see here are shown this way. You can collect some part and some part you cannot collect.

The part that you are able to collect and channelize as you can see here, following my arrow, to the pollution control device (we will discuss that in a moment), these emissions are called primary emissions. The emissions that I cannot capture or somehow is not captured by the hood because of the leakages, they can open up in the room where you are working or they can open up in the pot room – they are called as you can see here secondary emissions and they go into the pot room. They will follow some pattern and go up not only because the temperature is high but also because you may have some kind of fan here to suck these emissions. Otherwise, the emission concentration will become very very large in the pot room and can become very difficult for the operators, the working force – they will be very much disturbed because of the high pollution and so you provide a fan. This fan can be a natural draft also, but many plants provide a fan as it provides good ventilation in the pot room.

Now, what we have done is we have introduced another concept here that the primary emissions are there and also there are secondary emissions and we need to handle both of them because both are pollutants for us. When we talk about the handling of these emissions, the first part I will again repeat is the proper collection. The one that is collected goes through some kind of scrubbing system – it could be wet scrubbing system and there is the dry scrubbing system. Do not forget our objective of any scrubbing is the removal and we should also say recovery of fluoride.

(Refer Slide Time: 18:25)

If:

- $F_t$  → Total fluoride ✓
- $F_p$  → Particulate component. ✓
- $F_g$  → Gaseous component. ✓

$$F_t = (F_t)_{\text{primary}} + (F_t)_{\text{secondary}}$$

$$= (F_p + F_g)_{\text{primary}} + (F_p + F_g)_{\text{secondary}}$$

Note: All units are in: kg of  $F_t$ /tonne of Al produced.

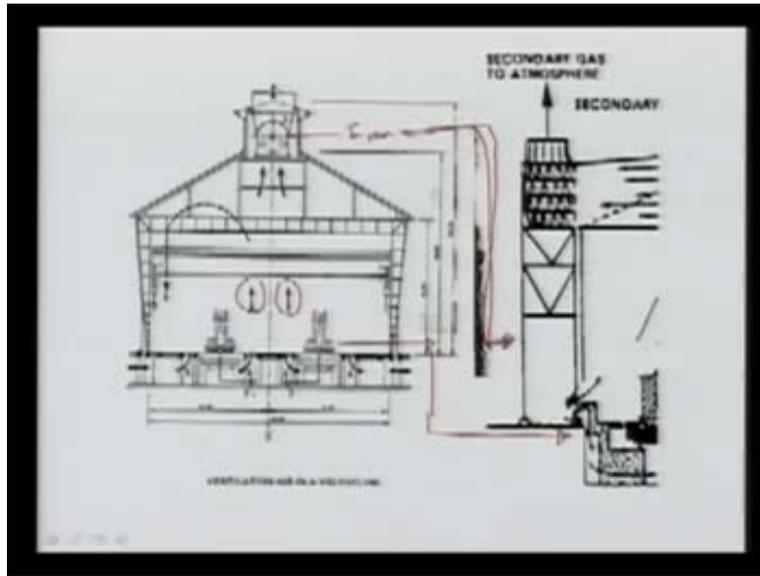
(Emission Uncontrolled.)

Now I would like explain to you some more terminologies before we go to the scrubbing system. Generally, we like to write that  $F_t$  is the total fluoride. Why total fluoride? It is because it has two components: one is the particulate component and then the gaseous component as we described in our earlier slides –  $F_t$  is the total fluoride. Now, this  $F_t$  that we are referring here is a kind of uncontrolled emission and so  $F_t$  can be from primary (some part will come from primary emission) and then some part will come from the secondary emission.

Within the group,  $F_t$  is further divided – some part will be particulate and some will be gaseous and again, some will be particulate and some from the gaseous but those are from the secondary emissions. Always remember that in the aluminum plant, the basic units through which we work (it is a more of a convention and you can of course change them) – the fluoride emission,

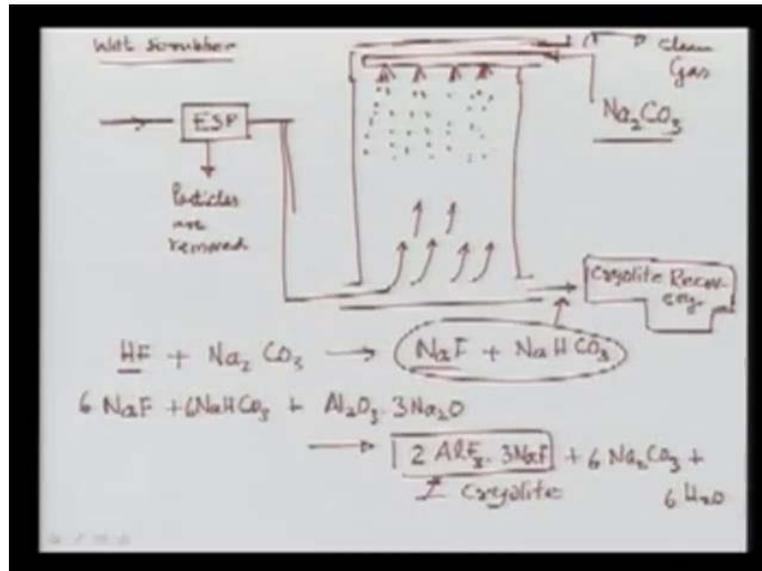
fluoride requirement, anything, it is in terms of kg of fluoride and that is rather kg of total fluoride per ton of aluminum produced. This gives us the basic units through which we work.

(Refer Slide Time: 20:17)



Let me also show the same thing we discussed through the actual schematic. As you can see here, there are pots, these are the secondary emissions that are taking place (Refer Slide Time: 20:21) and this is the fan I was referring to. When it comes to control, not only are the primary emissions controlled – the primary collections will occur, the primary emissions will be collected here as I was referring to the figure, but even the emissions that are collected through the fan, which we call as secondary, are passed through a control device. So what you can see is the primary emissions can go to another process here and once the secondary emissions are collected, they can also be treated and you can see a tower where a chemical in the form of liquid is falling down. We will see this, I will probably explain to you a little bit more about the wet scrubber.

(Refer Slide Time: 21:21)



Quickly, what I want do is I want explain to you what is the wet scrubber. This wet scrubber is for the removal of fluoride, the total fluoride. The system is very simple. First of all, whatever the primary collection of the fluoride that we are bringing in from the pot, you pass it through a device for the control of particulate, which we call as ESP – ESP stands for electrostatic precipitator, so that most of the particles are removed. Let us write particles are removed.

Then, the stream that now has the gaseous fluoride is passed through a chamber. Let me draw this picture for you. The dirty air that still has a gaseous component is passed through here and it travels up inside a chamber. In the chamber, what we do is we spray some chemical (I will explain that to you) through the nozzles. This is a nozzle, again there is an opening and then the nozzle. A nozzle is something... You can think of a shower – we all take shower in the bathroom. The shower is something with fine droplets. It is similar to how the water falls in the shower in the bathroom. There are many showers that are making very fine droplets of the liquid. These gases and this falling liquid come in very close contact (these are the little liquid droplets) and then they can react in the process. What is this chemical that we are using here? We are using the solution of  $\text{Na}_2\text{CO}_3$ .

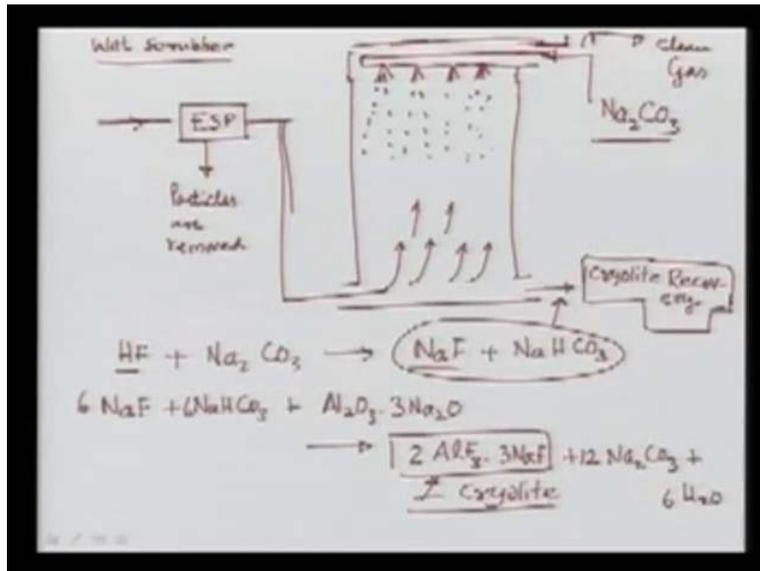
Some  $\text{Na}_2\text{CO}_3$  solution is prepared and then it goes through this. After this contact, the hydrogen fluoride will be removed because hydrogen fluoride is largely in the gaseous form, if you recall.

The reaction that may take place is HF plus  $\text{Na}_2\text{CO}_3$  [25:02] producing sodium fluoride plus sodium bicarbonate. What you have succeeded in doing is that you have brought this gaseous component into the liquid component. As a result, what you will get outside of this chamber as I was trying to show will be clean gas. Then, what we do is we have to still recover the fluoride from here. This NaF, this liquid, which is this liquid here that is now passing out (Refer Slide Time: 25:47), you send to a process called cryolite (because that will always be required in the pot) recovery.

We need to recover this. How do we do this recovery? Whatever this liquid is, this is the same as this – do not forget that. We have  $\text{NaHCO}_3$  reacted with some kind of  $\text{Al}_2\text{O}_3$  with molecules of  $\text{Na}_2\text{O}$  and we make it react now. Once these react, eventually the reaction is completed and I must get cryolite because that is what I want to recover. What was the fluoride, do you recall? This was the fluoride and cryolite was formed. In the process, I recover my  $\text{Na}_2\text{CO}_3$ , which I need to recycle again, plus some amount of water.

Let us balance the whole thing. You get here 6, then we need to have 12, then 2 here, then 6 here, 6 here – 12 and then this also becomes 6. You can balance it and then finally what you are recovering really is your cryolite. There are certain issues with the the wet scrubbing process and we have to see that these difficulties of wet scrubbing are taken care of. Otherwise, there can be a serious problem with this.

(Refer Slide Time: 28:46)



Let me correct the number here. If I am doing the balancing here, this should be 12 and then, this is 2 is fine. The main thing is that we are recovering the cryolite here.

(Refer Slide Time: 29:20)

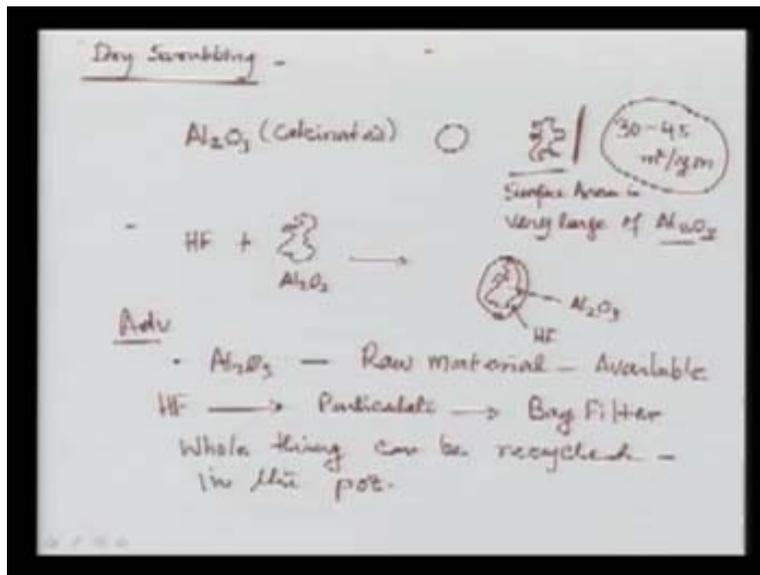
- Disadvantages of Wet Method -
- \* Water Pollution
  - \* WW Treatment plant
  - \* Particulate control is not efficient in wet Scrubber
  - \* Sodium build-up
  - \*  $\text{SO}_2$  —  $\text{Na}_2\text{CO}_3$  → TDS - Problem for Disposal

If I go on and say what are the issues and difficulties or disadvantages of the wet method, one little problem is that it converted the air pollution into water pollution and so you need to have a wastewater (WW stands for wastewater) treatment plant and if you do not have for example the

ESP, the particulate control is not efficient in wet scrubber. The other thing is there is a sodium buildup that causes a little problem in the pot. Why does the sodium buildup cause a problem in the pot? It is because it affects the very processing in the pot room and you might have a little difficulty with the quality of production of aluminum. The other little problem that people refer to is some of the  $\text{SO}_2$  is also removed in the process. Why? It is because it can react with  $\text{Na}_2\text{CO}_3$ . In a way, it is good that  $\text{SO}_2$  is removed but the level of total dissolved solids in the liquid that is coming out from the treatment plant or the cryolite recovery plant becomes very high and this becomes a problem for disposal.

What we have done is we have understood the method and wet processing, but it is not perfect – it has its own problems and difficulties and so people thought about different technologies and different methods. We will see the other technologies. What I will do is I will remove this and talk about the other technology that we call as dry scrubbing. Dry scrubbing is very interesting, efficient and very useful because it can recover almost the entire fluoride from the process. Most of the new plants will always have dry scrubbing rather than wet scrubbing. The idea of dry scrubbing is a very nice idea.

(Refer Slide Time: 33:00)



Let us discuss about dry scrubbing – we do not need any water, liquid or even any chemical because the use of the chemical will always make things more expensive. The idea was... if you

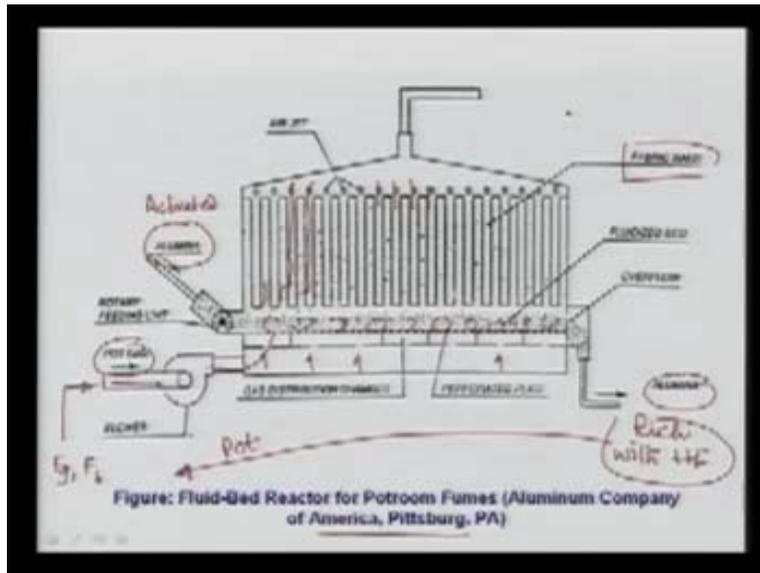
look at  $\text{Al}_2\text{O}_3$  from the calciner or let me say calcinated, if I look at the particle of  $\text{Al}_2\text{O}_3$ , the particle is not like this. In fact, for the same size of the particle, the particle will be something like this. What it is really saying is the surface area of activated alumina or calcined alumina is very large. If the surface area is very large, then we can use the surface area to adsorb the HF. In fact, the reaction or the adsorption of HF onto this  $\text{Al}_2\text{O}_3$ , which is highly activated, is very quick and very efficient. What we say is that if we are having the HF plus alumina particle, it goes through what you call as chemisorption – the same particle I am drawing and along with this, the HF will be adsorbed.

This is my HF, which was gas, if you remember and this is the  $\text{Al}_2\text{O}_3$  particle. Because of the large surface area, things tend to get adsorbed on this. This is what is the technology that is used. The advantage is.... The interesting part is that alumina is already available to you because it itself is a raw material, so you do not need to bring in anything from outside to be able to control the emissions – it is already a raw material. That is a very healthy situation, happy situation that you have – the raw material is available, it is always available to you.

The good thing about this HF, which was in the gas, is that it goes into the particulate form and the control of particulate matter is a little simpler sometimes. You can capture it through the bag filters and then once it is captured, the whole thing can be recycled in the pot or if I may say so, the pots are always hungry for the fluoride – they need more and more fluoride. If you can capture the fluoride, put it back into the pot, you are almost 100 percent recycling the fluoride and that makes the operation even more cost-effective. Now, what is happening is that most of the plants in the aluminum industry have dry scrubbing.

It is a relatively new technology, it is probably 30 years old now. If every new plant or in fact the older plants can quickly somehow shift, they would rather shift to the dry scrubbing technology. To give you a little feel of the surface area here of the alumina, it is anywhere from 30 to 45 meter square per gram. You can imagine the amount of surface area that is available for adsorption or in fact, we call it chemisorption – it is very very high. Having spoken about dry scrubbing, I would like to show you a picture about dry scrubbing.

(Refer Slide Time: 37:15)



This is in fact being used. We have taken this picture from a company from the available literature, but what you see here is a very interesting part. If you recall, all the dirty gases with a lot of fluoride are coming from the pot room and these are written as pot gases. You remember this will have  $F_g$  and it will have  $F_b$ . It enters from here, there is a blower and then you can see that there are little openings here – distributed openings, so that the pot gases can pass through these openings as you can see here.

The alumina from the calciner or activated alumina that is available (because this is raw material) is also pushed through this mechanism, which is a rotary feeding unit and it is put onto the perforated bed – little, small openings. See here – the openings are large and here, the openings are small. These are the perforated openings and then this gets distributed all through and then, this becomes a fluidized bed and the dirty gases come through this and then they come into contact with the  $Al_2O_3$  or the aluminum.

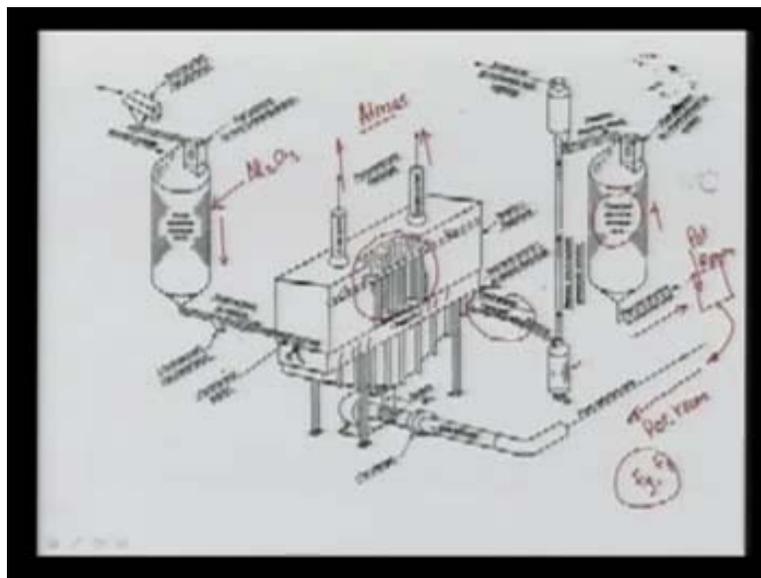
The gases come here and mix with these things and HF continuously gets adsorbed onto these alumina particles. A fluidized bed really means that the alumina is as if it is slightly floating. To understand this fluidized bed, you can think of popcorn – large surface area and they are popping up slowly. They are just slightly in suspension, they tend to become in suspension and then as a result, the entire surface area is available for the absorption. But then, we are still in particle form

and so over and above this, we have the bag filters. What you see here are really the fabric bags. You see here this is a bag and this is outside the bag.

The fluoride reaches alumina [39:36], then it is passed through the bag, it becomes clean – you see here this side is clean, and this comes out. Similarly, this is the dirty portion, it goes through the fabric filter and then it is coming out more like a clean gas. Everywhere, you are seeing little dots here. This is the clean air that is coming out and these are the bags in which the fluoride will be trapped. Then, the alumina is taken out and do not forget that this alumina is rich with HF, because we have completely removed it.

What we have done is we have not used any other chemical and yet, we are able to capture almost the entire amount of fluoride. The question for you is where will this go? This should go back to the pot, because we need alumina in the pot, we need fluoride in the pot and so the natural choice for this is to send it back to the pot room. This is what is the dry scrubbing method – we are not using any water and things work very very efficiently. If this is clear, then, I want to make a little example and little bit of efficiency derived thing. This figure that you see here is a summary of the gas-cleaning process in the aluminum industry.

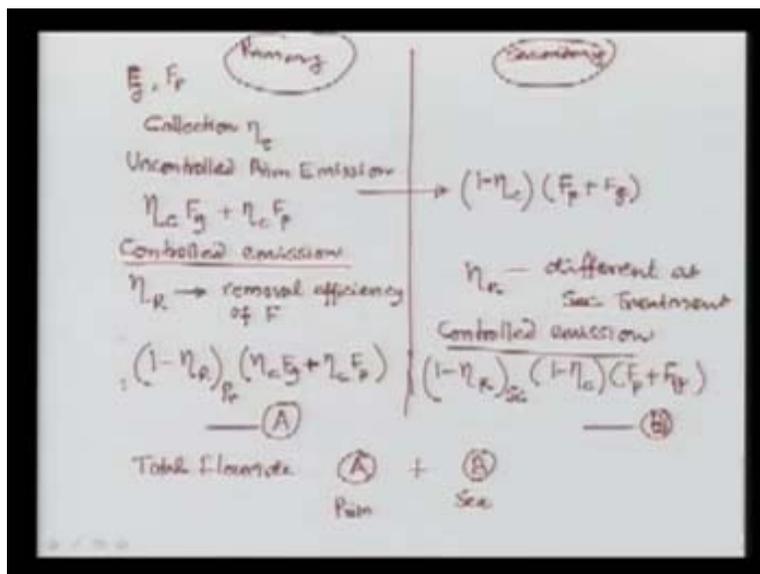
(Refer Slide Time: 41:17)



What are you seeing here is this is the [41:23] for alumina, activated alumina that you have here. This is where the emissions are coming from the pot rooms and here we are talking about gaseous fluoride and the particulate fluoride. With this storage of  $Al_2O_3$ , this is pushed into the gas-cleaning plant and then you remember this was the fluidized bed reactor that we discussed. This gas is the polluting or the dirty gas if I can call it. It is pushed through this reactor where a chemical reaction takes place, HF is absorbed onto the particles and then the particles are controlled from the bag filters. This little section you are seeing are the bag filters (Refer Slide Time: 42:24) inside this thing. After the things are cleaned through the bag filters, the clean gases are discharged to the atmosphere. Now, the alumina that was rich with the fluoride is collected from this end and then it is taken and stored in this tank.

What you can see here clearly is it says rich alumina storage and now this can go to the pot room. Then again, the emissions from the pot room come this way and this kind of recycling cycle continues and as a result, almost I am able to do that fluoride is sustained is kind of more like watertight, it cannot escape or disappear and that makes the process very efficient and very advantageous. This was the little dry scrubbing that we see. Dry scrubbing overcomes all the issues and the problems with the wet scrubbing. You can see the picture very clearly – everything is completely recycled. Now, what I will do is derive some expression to say what are the total emissions that can take place from the aluminum plant.

(Refer Slide Time: 44:18)



You recall that we have discussed that there are two kinds of emission that are taking place: one is the primary emissions and, if I can divide this, there are secondary emissions. The final emission is the sum of primary and secondary emission after it has been controlled to the extent it is possible. It might be a good idea to quickly go back and maybe see some of the slides here, but you recall what are the primary and secondary emissions. If I say that the total primary emission is  $F_g$  and  $F_p$  (from the pot), what will happen? In the primary process, certain part of this emission will be collected – it will be collected at the hoods.

Suppose the collection efficiency is I will write this as  $\eta$  and call it  $\eta_C$  (the collection efficiency is  $\eta_C$ ), this suggests the amount of fluoride that will be captured through the hoods. So let me write uncontrolled primary emission and I am assuming this collection efficiency is the same for the gaseous fluoride as well as for the particulate fluoride. Since the efficiency is the same, the collection part is  $\eta_C F_g$  plus  $\eta_C F_p$ . Now, if this is what is collected at the hood, whatever is not collected goes out as secondary emission.

Corresponding to this, the secondary emissions will be, if I can show the arrow here, whatever is not collected. What is not collected? 1 minus the collection efficiency is not collected, because  $\eta_C$  was the one that was collected and so we can say here that is equal to whatever that is not collected. Fair enough. What we can do is once it is uncontrolled, now we want to treat or clean it. So now, let us see the controlled emissions. Let us say control or removal. So let me call  $\eta_R$  as my removal efficiency of fluoride and I am assuming that the removal efficiency is the same for gaseous as well as the particulate fluoride. If this is the removal efficiency, the emission will be 1 minus  $\eta_R$ , but this is at the primary, so let us write at  $P_r$  if you like and this is the amount that will be emitted from the primary gas-cleaning device, so that will be  $\eta_C F_g$  plus  $\eta_C F_p$ .

The removal efficiency at the secondary process or the secondary device can be different. So let say  $\eta_R$  is different at secondary treatment. Now, the controlled emission is 1 minus  $\eta_R$  and this is at the secondary level, so I put subscript as secondary. This was the total emission uncontrolled and this is the emission after the controlling. Let us complete this. What we have been able to say is the controlled emission relating to primary and controlled emission relating to secondary. Let me call this as A and let me call this as B.

Therefore, the total emission of fluoride that is occurring from the plant is simply A plus B. Total fluoride from the plant is A (that is from the primary) plus B (that is from secondary) – that is all I need to know. When we talk about the total emission that is occurring from the pot room, then we have to do both summation of A plus B. What we will do is we will do an example here to demonstrate how this little expression, the simple expression that we have developed can be utilized in assisting or in knowing what is the total emission occurring from an aluminum plant. We will go up here or we should go down. The question for you is let us say a problem.

(Refer Slide Time: 51:32)

Prob - An aluminum plant of capacity 100,000 tpy is operating both primary & sec treatment for fluoride control. Determine if it is complying with emission standard of 3 kg F<sub>2</sub>/t Al produced

$F_g = 10 \text{ kg/t}$      $F_p = 10 \text{ kg/t}$

$\eta_a = 0.8$      $\eta_{E-p} = 0.9$ ,     $\eta_{E-sec} = 0.5$

Primary Emission

$$(1 - \eta_a) [(F_g + F_p) \times 0.8] = (0.2) [20 \times 0.8] = 1.6 \text{ kg/t}$$

Sec Emission

$$(1 - \eta_{E-p}) (F_p + F_g) \times 0.5$$

$$= 0.2 \times 20 \times 0.5 = 2 \text{ kg/t of Al} \quad \text{--- (B)}$$

Total Emission (A) + (B) = 1.6 + 2 = 3.6 kg/t of Al

NO - The plant is not able to com. Al. Production.

An aluminum plant of capacity 100,000 tons per year is operating both primary and secondary treatment for fluoride control. Determine if it is complying with the emission standard of 3 kg of total fluoride per ton of aluminum produced, because there will be some norm, there will be some standard given by the Pollution Control Board or pollution control authorities. We have to see the details that are available to you: total  $F_g$  from the pot is 10 kg per ton of aluminum,  $F_p$  is also 10 kg per ton, the collection efficiency is let us say 0.8 – collection efficiency at the hoods, the removal efficiency at the primary that is p r is 0.9 or 90 percent and removal efficiency  $\eta_{R-sec}$  at secondary is let us say 0.5. That is the information that is given to you. Now, you have to find out the emissions.

What I will do is that I will do for you the primary emissions first. Uncontrolled emission will be  $F_g$  plus  $F_p$  and only 80 percent is collected because the collection efficiency is only 80 percent and so I can write 0.8 and out of this, 90 percent is removed. See here, I have given 90 percent. So what will be the emission? 1 minus 0.9, let make it even better for you. These are the primary emissions. The secondary emissions will be.... Let us find out this one. First, we can calculate the primary emission. This will be 0.1 times  $F_p$  plus  $F_g$  is 20 into 0.8 and this will be 1.6 kg per ton.

Now let us look at the secondary emission. The secondary emissions are basically 1 minus 0.8 because this is the portion that was not collected by the primary and so this becomes the part of the secondary,  $F_p$  plus  $F_g$  and out of this, the control is only about 0.5 percent, so you can write 0.5. Simplify this. This is 0.2 times 10 plus 10 – 20 into 0.5. How much does it weigh? That may exit 2 kg per ton of aluminum – this is from the secondary.

The total emission that is occurring from the plant is.... If I recall, this is my A and this my B. The total emission is A plus B, so that is 1.6 plus 2 and that makes it 3.6 kg per ton of aluminum produced. What was my standard? My standard was 3 kg – that was prescribed by the pollution control authorities. So what I conclude is that my treatment devices are not able to comply with the emission standard. My emission standard was 3 kg and actually, the plant is emitting 3.6. So to specifically answer the question, no, the plant is not able to comply with the emission standard. Obviously, then there will be questions if it cannot comply, what can you do then? What you can do is the best thing to try to really do is to improve the collection efficiency, make your pots tighter so that more and more gases are collected. If you are able to increase from 0.8 to 0.9 for example, you make it 0.9 and you see everything is falling in place and you will be able to control things.

If you want, we can certainly do these calculations all over again and you will see things will fall in place. So this is how you can do the final calculation for your aluminum plant and you can see if the aluminum plant will comply with the standard, what are the changes that you need to make in your process, what are the changes that you need to make in your control devices, because sometimes, standards are very legalistic requirements and this is the procedure through which

you do the calculation. This ends the fluoride emissions and issue of pollution or particularly, the air pollution from aluminum plants.