METALLURGICAL AND ELECTRONIC WASTE RECYCLING

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Week-3

Lecture-15

Greetings, I now welcome you all to the fourteenth lecture of this course. We are now going to discuss on the salt slags, the salt cakes of aluminium and these are basically generated when we are looking at aluminium melting and remelting. Apart from dross, if we are melting and remelting let us say aluminum scraps or we see the generation of slags that take place during let's say secondary aluminum smelting or any other source.

What we see here is when we are using fluxes for melting and remelting, there is a fair chance that these flux will be the dominant component and the metal entrapped in these fluxes would actually eventually show up in the salt cakes. The source is just the same when we are melting scraps, some metallic content that is getting oxidized will entrapped will get entrapped into the slag phase and these of course would be removed so that the molten metal is used.

After removal of these slags, these are allowed to cool down and we get the salt cakes, the slags, the aluminium slag. We will begin the discussion. Scraps are remelted in furnaces with fluxes near eutectic mixtures. We have just discussed in the previous class that the scraps are good sources aluminum metal. These are good sources of aluminum metal and these are remelted in furnaces and you need fluxes and sodium and potassium salts are common fluxes that are used. What it does is basically it helps in reducing the oxidation losses so the slags will act as the physical barrier and thermal barrier so that we have the thermal isolation and physical isolation and it also picks up all of the impurities basically acting as a reservoir for all of the impurities that are getting removed from the molten metal.

Not only it is just acting as a protective layer from oxidation but it also protects the loss of heat from the top of the metal and most of the impurities that can be removed get entrapped in the slag. It has multiple functions and it also helps in improving separation of aluminum from other phases. What we finally get is molten metal which could be directly used for various types of casting.

We will have finished products and at the same time we will have the slags or the salt cakes and it is these slags that need to be recycled because we are extensively using sodium and potassium salts and the mixture itself is fairly complex. The recovery of these salts as well as some entrapped metallic content that may be present in these salt case.

We need to recover these wastes. The other aspect of looking at it is that it is a waste that is generated in the let us say pyrometallurgical route of recycling aluminum scraps. Since it would require a separate method, it is best to devise such recycling strategies beforehand. Growth of production rate of secondary aluminium relates to scrap utilization.

Secondary aluminium production, basically reutilization of aluminium sources for extraction of aluminium. Aluminium scraps, reutilization of aluminium scraps for generation of aluminium. This is basically interrelated and at the same time since we are just melting scraps and salt cake formation is just happening in that step itself. What happens is salt cake formation is basically related to secondary aluminium production. Since scrap is being melted and during the melting of the scrap, we see the salt cake formation.

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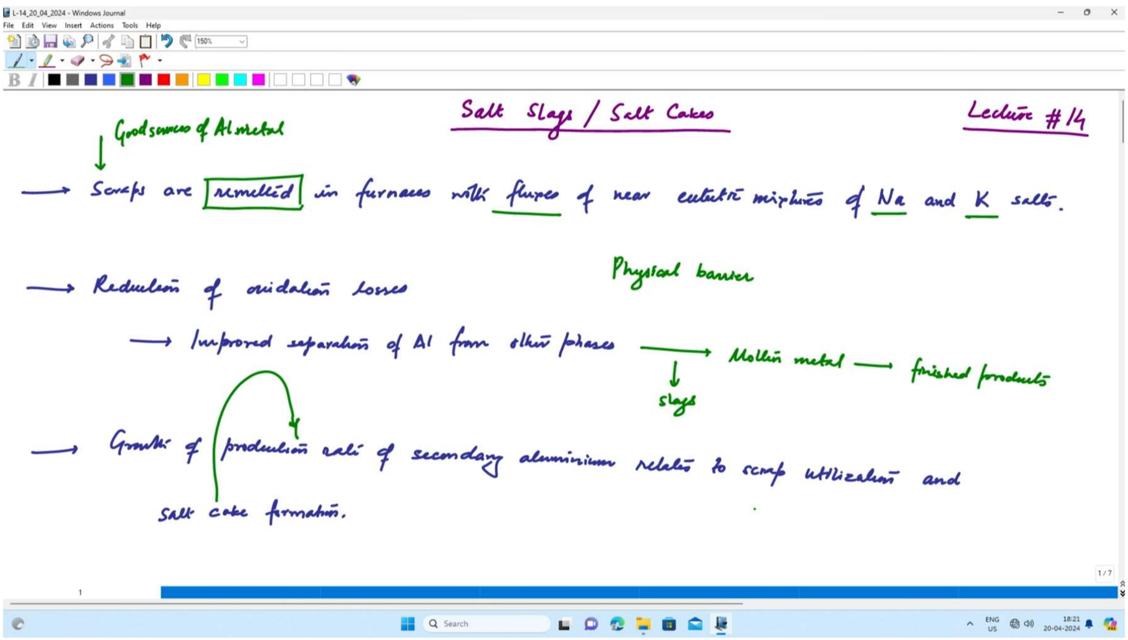

All of the processes are interconnected. What normally is seen for a given raw feed, so for instance if we have one ton of dross feed what we see in various types of melting and remelting furnaces we see different type of waste generation. For instance if we have fixed shaft rotary furnace or and tilting rotary furnace we if we see that 1140 kg waste is generated for fixed shaft whereas for tilting rotary furnace we have 658 kg of waste generated and these quantities of wastes involve the production, they take care, they take account of the salt cake that is being produced. The gaseous wastes, the metallic aluminium waste or all types of losses including the salt cakes, these slags that are generated. This type of distribution is taken into account while we are putting up these numbers.

We see that tilting rotary furnaces generates relatively lesser waste and eventually the technology has been shifted towards making the rotary furnaces tilted and at times this rotation and the angle of tilt helps in the separation of metal and the optimization of the process parameters are also done at the plant scale so that most of the metal can be extracted which would also eventually mean that the waste generation in the form of dust or in the form of salt cakes these are also getting eventually reduced. Let us look at the composition of salt cakes and of course these phases are basically collected from literature. We see that alumina, sodium chloride, potassium chloride, SiO_2, Na_2O, MgO, CaO and Fe_2O_3 are the important phases that are present and these are present in different quantities. Alumina being one of the most important phases is present in the salt cakes along with that the addition of NaCl and KCl of course these were added as the raw feed when the fluxing was done.

Silica, Na_2O, MgO, CaO these can be coming from various sources Fe_2O_3 similarly. What we see here is it is a fairly very complex structure, the composition of salt cakes, the slags that are produced after melting remelting it depends upon what is the raw feed, what is the raw material and how was the fluxing done and how efficiently the metal was extracted. It is possible that some amount of metallic aluminium may also be entrapped here. We have already seen when we were discussing aluminium dross that some quantity of aluminium may be entrapped but it is very difficult to put numbers what should be the exact quantity of metallic aluminium present in the salt cakes. Right now understanding the phases helps us in devising the plan that would be used for the valuable product development from the salt cakes. Because it is at times essential to note that metallic value itself is relatively very less in salt cakes. The thinking on a process to extract metal may not be the best option so development of valuable products so for instance if we can recover the fluxes itself the soil fluxes itself that could be a more viable option more economical option rather than thinking on metal recovery. The other important phases that are present are basically Al_4C_3 carbide, Al_2S_3, $MgCl_2$, NaF, $AlCl_3$, Na_3AlF_6 and this also means that these phases may be present in different composition and quantities.

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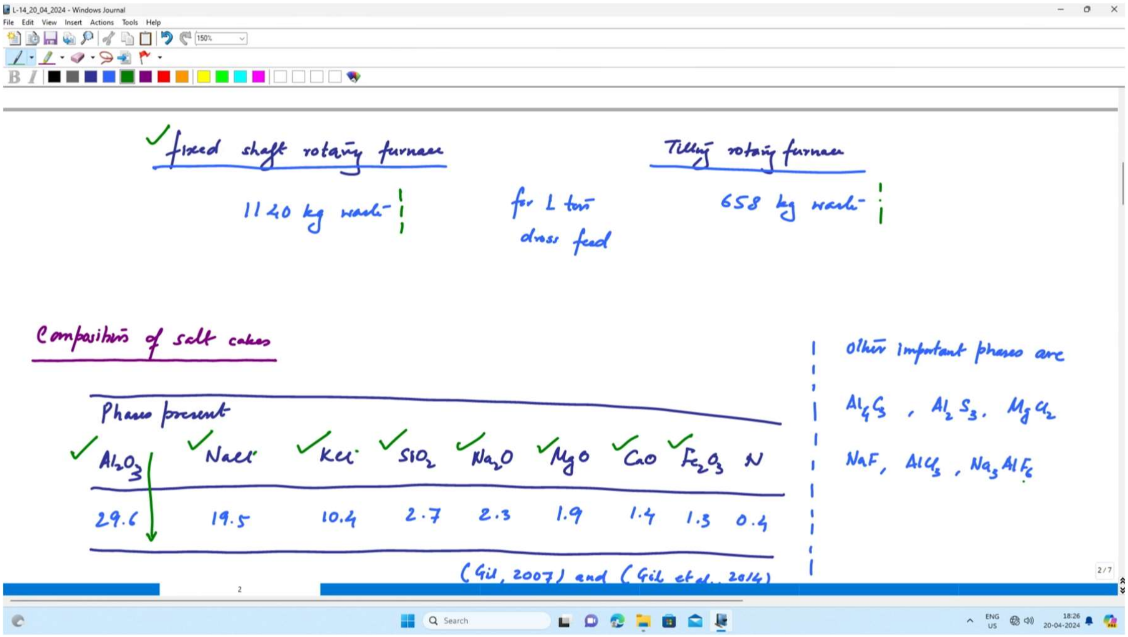


Again this makes our life a bit more challenging. When we think of aluminium scraps, there is absolutely no doubt how we should be recycling scraps. We take the scraps, we do pretreatments, if at all it is necessary, we do compaction, adjusting the composition and directly thinking on melting and remelting. And that's it. But when we think of aluminium salt cakes, the salt slags, here the phases itself are so complex that the and the metal content itself is very less. One has to think on what exactly is the target material that should be aimed for a recycling process.

When we think of methods of recycling we will just discuss these various scraps and byproducts of aluminum suppose we are taking that as a raw material and of course, we can have some aluminum cake it could also be some other aluminum source. When we put it in a rotary furnace we can extract aluminum and we have the generation of salt cakes. We have just seen we have just discussed this flow sheet before coming to this slide.

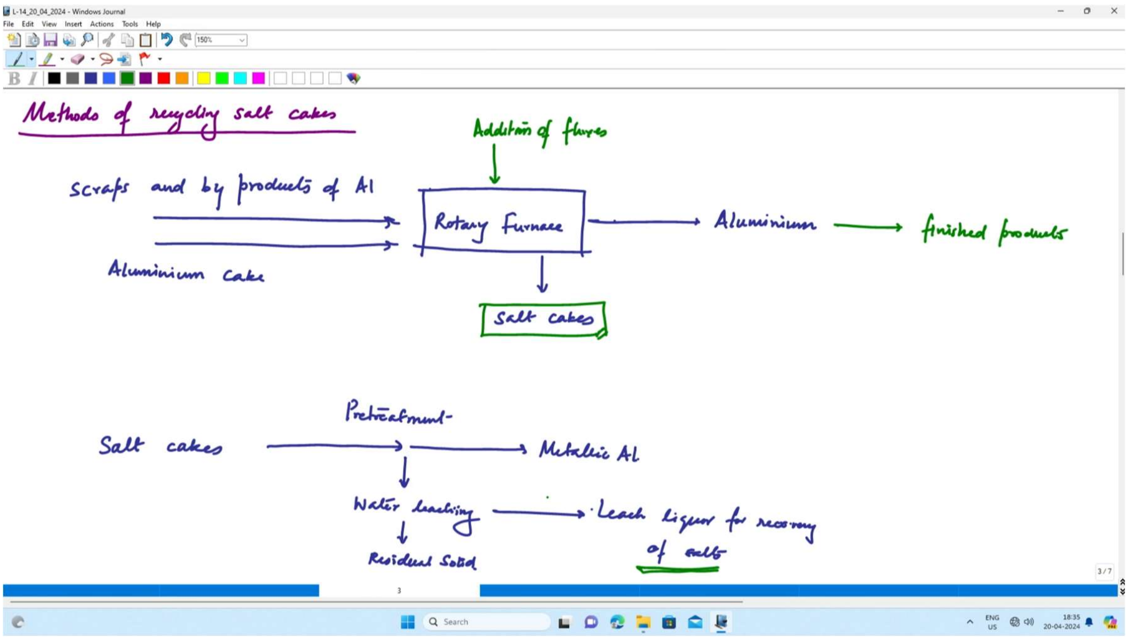
What it means is we take the raw feed we put it in the furnace we take aluminium sources we can take aluminium dross sets as well we put it in the furnace and of course we are not going to mix each other mix it with each other we are going to take it separately but the furnace uses basically a rotary salt furnace we add fluxes. We are now going to discuss the methods of recycling the salt cakes.

We begin by let us say scraps or byproducts of aluminium or aluminium cake. We are going to use these materials as raw materials for basically extraction of metal. We have just discussed this previously. We need to have a rotary furnace and we have these raw materials coming into picture. And of course, right now we are taking all of these raw materials separately and not mixing them that is not the objective we are taking all of the raw material separately. We are just showing the application of the rotary furnace and we need to produce metal. The idea is to use all of these sources for extraction of metallic aluminum. what we need to see here is the addition of fluxes. The addition of fluxes is done and of course, at appropriate temperatures we are now able to process this and we are able to extract molten aluminium again for finished products.

This completes our material cycle but at the same time we see the generation of salt cakes; how do we cycle that. When this salt cake is removed and it is allowed to cool down it again becomes the hard mass these salt cakes would be subjected to pretreatment the pretreatment that directly can be used is basically the comminution, bringing down the particle size crushing, grinding so that if at all there is some quantity of metallic aluminium, we already know in previously in this class itself, we were discussing that the chances of, presence of metallic aluminium in large quantity is very less almost negligible because most of the metal is already getting extracted in the rotary furnace itself. What we are getting here is a mixture of phases that are present in different compositions. Our target is to recover valuable materials from this, but if at all some amount of aluminum is present.

By comminution these metallic aluminum fragments can be separated out and the rest could be used for water leaching. Why water leaching? Because it helps in the generation of leach liquor for recovery of salts. We already know that the presence of salts NaCl and KaCl is significantly large if the addition of these fluxes is done heavily and again it depends upon the process melting-remelting process itself, it is important to recover these salts from the salt cakes. The first and the most common step for employing recycling for salt cakes is to basically just go for water leaching. What we will get is the two fragments that we always discuss for hydrometallurgical process. The first one would be the leach liquor and the second one would be the residual solid. Leach liquor again would be rich in the ions, it would be rich in the ions of the salt fluxes and the various phases.

We are talking about the phases that can be dissolved in water without actually having to change without actually changing the pH of the solution basically making it either acidic or alkaline, we are not doing that just taking water as the medium and recovering salts. So, dissolvable soluble impurities can be easily extracted that actually really helps in reducing the phases that are present in the salt cakes because some phases would remain insoluble, but a good fraction of phases can be easily removed. And what we are getting is basically leach liquor as well as residual solid, both of them after water leaching. And beyond that residual solid composition can be observed and based on that the further process can be devised. **(Ref. 19:00)**



If we look at slags again we can have a different process we have slags again following water leaching, we already know why we are so interested in water leaching, it helps us in removing the soluble salts, following that we can have the leaching in alkaline solutions. We can have sodium hydroxide, potassium hydroxide basically alkaline solution and what exactly are we leaching, we are leaching the residual solid. So, the materials that we could not recover by water leaching are now recovered by alkaline leaching.We can say it's a two step leaching process: first step recovering salts, the second step recovering whatever is left so for instance if we can have recovery of alumina, so alumina may not be recovered in the first step but it can be recovered in the alkaline leaching stage and what we are finally left with is basically NMP, non metallic product What could be the use of these types of materials? Because some phases are recovered here in the leaching, alkaline leaching step. But it is fairly possible that the residual solid produced after alkaline leaching may also have some phases.

Non-metallic residue can be used for inert filling for construction and building applications. Synthetic slags for metallurgical systems. Wherever we would require the presence of slags for metallurgical systems, lets say iron making, steel making industries we can think of this material as a raw material for developing these slags. These could be used in agricultural fields as fertilizers and as mineral wool also. So, we have different applications of various materials that we are producing; water leaching would lead to the salt recovery, alkaline leaching would lead to let's say alumina recovery and other phases. If something is still left then we can think of NMP, non-metallic product and we still have many different applications of the NMP.

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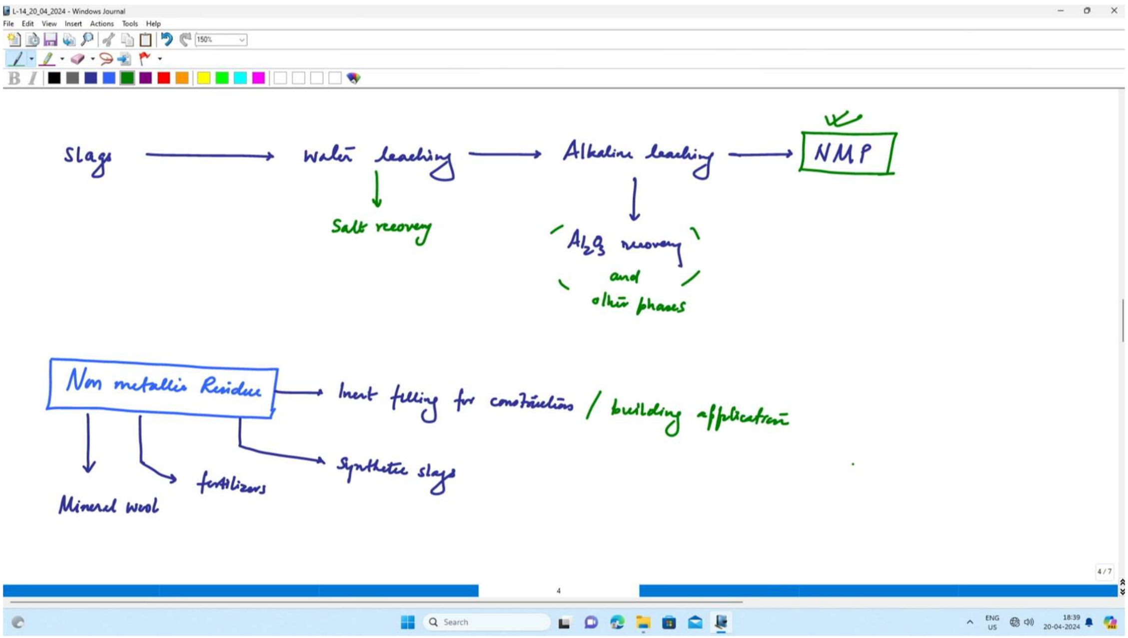

We see that we have multiple methods of recycling the salt cakes. We'll now discuss the last method of recycling the salt cakes, the aluminium slags. There again the first step that we look at is basically water leaching wherein we are interested in basically salt recovery from solution. But at the same time what we are actually making is cement clinker and for that we would be using the residual solid. And to make the cement mixture we would be also needing the addition of other raw materials.

Other raw materials that are necessary for making the cement mixture. Residual solid and let us say clay and other materials would be used for making the cement mixture and this mixture would be subjected to sintering; let us say at the high temperatures of let us say 1100 degree to 1400 degree Celsius the process can be optimized and for after that the cement linker product can be produced which could be used as a raw material for making other products. So, maybe addition of gypsum can be done after that and milling can be done so that all of the product are totally homogenized with the gypsum addition.

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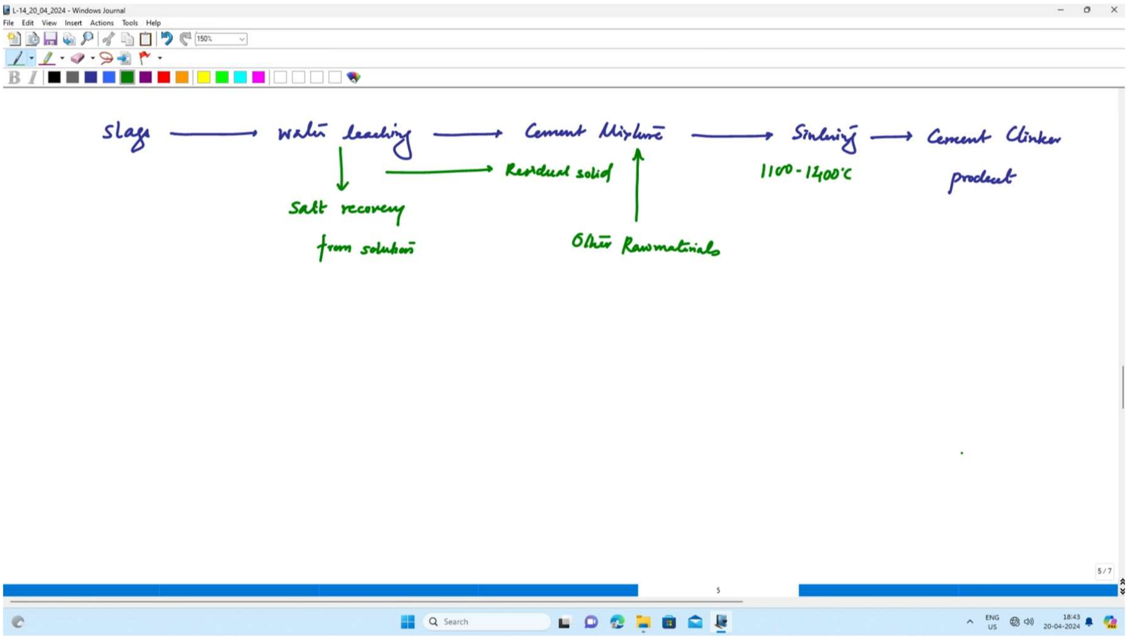

What we see here is the utilization of slag, utilization of salt cakes such that all of the phases are extensively used. Of course, the utilization of each and every phase may not be possible but at the same time the utilization can be done extensively. We've already seen if comminution can help us in recovering metallic values if at all it is present we should be doing that.

The water leaching step is almost common in most of the processes that are hydrometallurgy oriented because it helps us in recovering the salt flux directly itself from the solution. And from the residual solid, we decide based upon the composition what is the desired product that we would like to make say for instance, if we would like to go for alkaline leaching we can get alumina and other phases that are present and again we would get the non-metallic product because most of the metallic values would be leached in the stage 2 of leaching.

Or else, we directly use the residual solid that is produced after water leaching as a raw material for making other valuable products. For instance if we've seen the cement clinker products, we are just using it as mixing it with other raw materials and sintering it and producing the clinker. What we see here is we have wide variety of opportunities and methods for making valuable products from salt cakes.

It depends upon the finished product that we are now able to back calculate, re-engineer our processes and develop a good recycling route. In the upcoming classes, we will be discussing on the recycling of other metallurgical industry wastes. These would be coming from let us say copper industries, zinc industries, steel making industries, iron making industries and then eventually we will be focusing on the electronic wastes that are commonly produced by human society. We will continue in the next class.