METALLURGICAL AND ELECTRONIC WASTE RECYCLING

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Week- 5

Lecture-23

I welcome you all to the new lecture of this course so now in the previous lectures we have been discussing on zinc wastes and we had begun discussing zinc dross and we ended on the note that zinc dross is a very valuable raw material for recycling because it has a significantly large quantity of zinc. We know that at least 80 percent or above quantity of zinc dross can have metallic zinc in it or it will have zinc related phases in it. And we have also seen the key phases that could be present and what are the peripheral phases that are present in zinc dross. We wish to think on how we should be recycling zinc dross.

The motivation for recycling zinc dross itself comes from the fact that it is a valuable material by looking at the composition of zinc dross and seeing the weight percentage of how much zinc is present in it. When we think of devising a good recycling process for zinc dross, the most common method would be to just use it as a raw material for pyrometallurgical route that could be one way. The other way could be using it as a raw material for hydrometallurgical route. We know the conventional route of recycling would be just using it as a raw material after crushing, grinding the initial comminution is done and then we use it as a raw material for leaching then we would go for solution purification and then electro winning. The third method could be directly using it as a raw material for extraction of zinc. Many methods have been explored by various researchers and they have achieved various degrees of successes. We are going to see what are the various methods for recycling zinc dross.

And we will also be looking at what are the valuable products that are produced from zinc dross at the end of this lecture. We will begin with remelting and electrorefining of zinc dross. We are trying to do it in multiple steps. The first thing would be melting, which would initially give us a feeling that this process is pyrometallurgical in nature. If

we just melt zinc dross and cast it, it would just give us a feeling that, okay, we are looking at conventional pyrometallurgical route of recycling.

But it also gives an advantage that using this process as a primary step, first step, we can go into multiple different steps. I have already discussed this in the previous lectures that none of the processes are now standalone. Pyrometallurgy has to be combined with electrometallurgy or hydrometallurgy and hydrometallurgy would be combined into pyrometallurgy or electrometallurgy and so on and so forth. These combinations of various processes is a must to achieve a higher recovery of metals.

When we think of the first step it is basically just melting of zinc dross and forming the ingots. Melting of zinc dross to form ingots. And what we are we doing, we are doing it at around 400 °C and we do the casting of the metal, what do we want to do with, we want to form the anodes for electro refining. We have done this first part and then what do we do?

We go for electrorefining operation. We have aluminium cathode. And, of course, we have the anodes these are anodes that are this is basically what, this is the formation of anode itself so we know that we have anode we have the cathode and we need an electrolyte, so the electrolyte is basically ammonia-based electrolyte so we can have NH_4Cl, NH_3 and of course, in this we need zinc

Depending upon what was the zinc feed in this ammoniacal electrolyte, we can have different quantities of different recovery rates after the electrorefining process. And in the end, what do we get? We have zinc recovery. Now the advantage of this process, if you just try to see what are the advantages of the process and what were the first steps? The first step was basically taking zinc dross and melting it to form ingots and ingots of course we need to cool these ingots and clean these ingots after these ingots are used

as a raw material for electrorefining. Essentially, it is just a two-step process. Melting casting and then electrorefining. What have we bypassed? If we think of a conventional route of recycling zinc wastes, one could just go into comminution and then hydrometallurgy.

If we are thinking of bringing in hydrometallurgy before electrorefining, then we have actually bypassed multiple steps, let us say, leaching and purification of leach liquor that we had seen in the case of zinc ash recycling. These types of wastes that we see for zinc recycling have different types of recycling routes. One of them is being discussed that we

are totally trying to bypass the hydrometallurgical processes. We will just write that. And this is just a probable advantage. We can think of bypassing as this process does not involve hydrometallurgical processes. This includes the leaching and separation and purification process.

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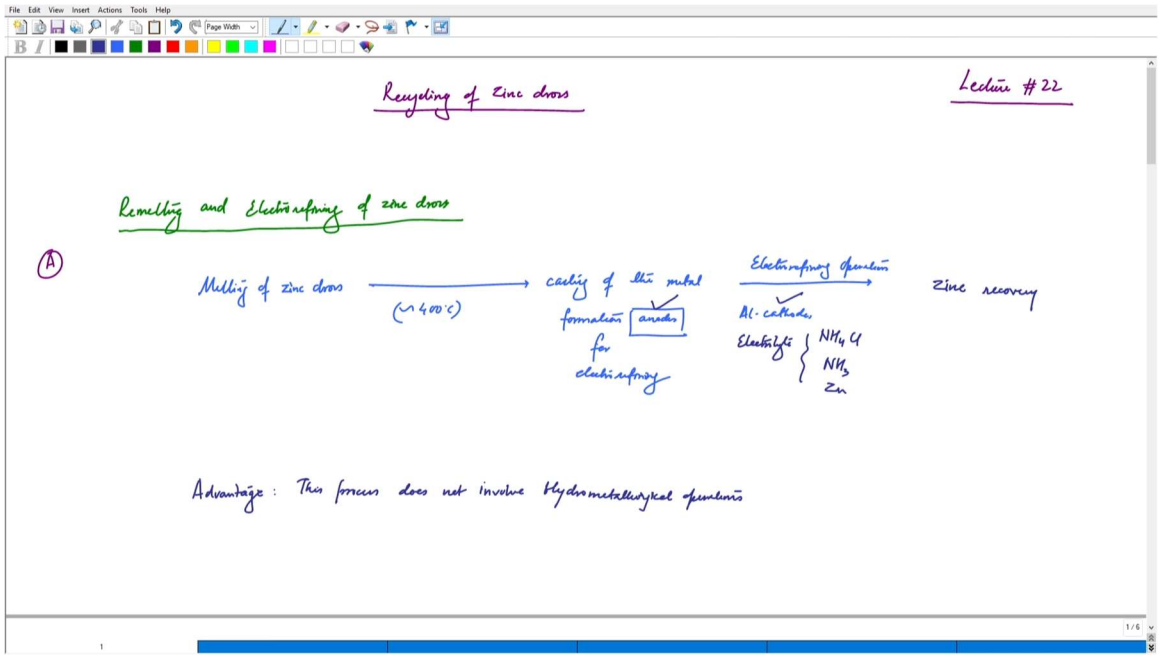

But it involves two crucial steps. One has to think of first treating the zinc dross by melting and remelting and casting into anodes. That is the first step. And the second step would be electrorefining. The other way in which you can think of recycling dross by electrometallurgy and right now we are focusing on electrometallurgy. The second way could be use of zinc dross and here we are using powder. Now, we know that we are going to go for comminution and this powder is produced after comminution with stainless steel cathode. If we are going to use zinc dross and the zinc dross is coming after the comminution, we will be getting zinc powder, zinc dross powder and this dross powder has to be collected if it is supposed to be used. This dross powder is collected in let us say an anode and this anode is wired.

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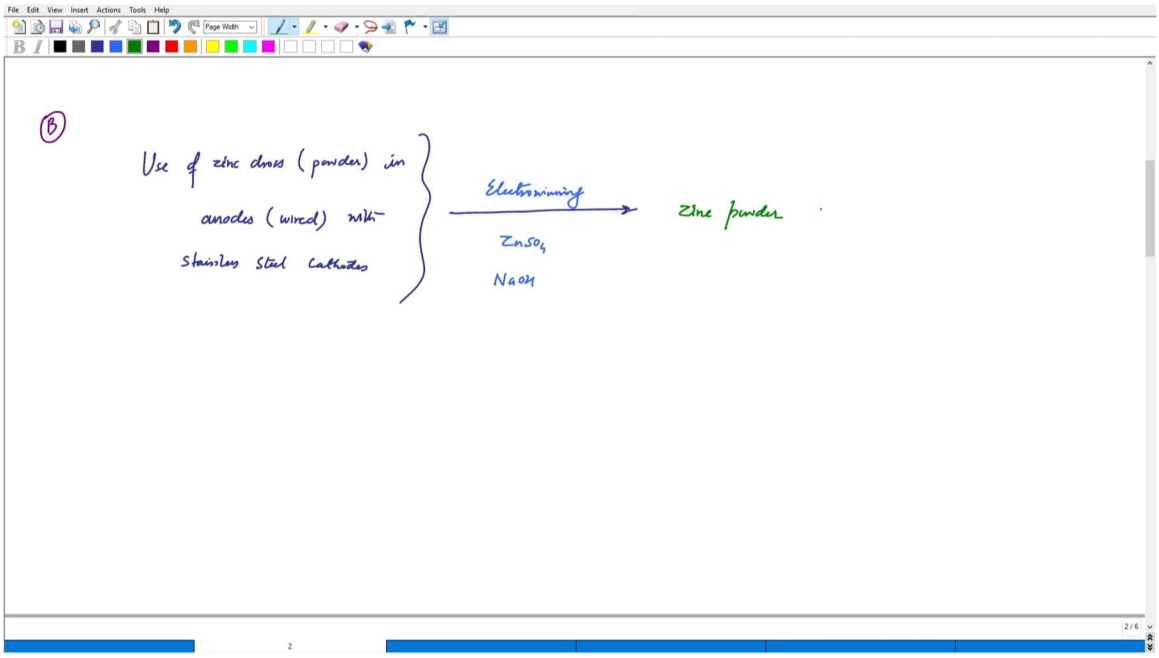

The solution, the electrolyte has the freedom of getting in contact with zinc and this zinc that is present in this artificially made or specially made anode is being used in the electrowinning system. Such type of experiments have been performed and they have been used to produce zinc powder and the quantity and quality of the zinc produced have been reported to be very good. They can be as good as nearly 90 or 95 percent metal recovery from these wastes with very few other impurities like aluminium or iron coming into this finished product.

This tells us that we can actually bypass multiple steps. In the previous process we were bypassing hydrometallurgy. Now, we can even think of bypassing pyrometallurgy also or if we do not want to melt just crush, grind and devise the anode in that way. That itself is a very difficult process

that we are directly using the powdered zinc as anode for recycling. And one might want to have multiple other types of processes arranged one after the other for achieving higher metal recovery. The advantage of this process could be that we have bypassed so many different key processes that would have been used but at the same time the disadvantage could be that these processes could require large investments. These are some pros and cons of various processes.

Super gravity separation. This is another interesting route of recycling of zinc dross where we have a different super gravity centrifugation setup as it requires the material to

be brought into the molten state and the centrifugation is being carried out in such a way that the purity of zinc is achieved in different crucibles that are arranged in the apparatus. This is done by simultaneously applying heat and centrifugation. We will just note the outline of the process because the process itself is very complicated.

Zinc doss is melted and cast as ingots and these ingots are machined for super gravity separation. How do we do super gravity? It is basically centrifugation. Super gravity separation by centrifugation setup with simultaneous heating.

And since we have brought the material into the molten state, it was in the molten state before and then we cast it to make ingots and then from ingots, we have machined it and then we again bring it back into the supergravity apparatus, the supergravity setup where it is being melted and centrifuged. The centrifugation and melting is happening simultaneously. This means that the separation of various phases would be done in this process due to the centrifugation that is being done. This will lead to this will lead to separation of products in various crucibles. There are multiple crucibles that are present in this setup and these phases are getting collected due to this centrifugation and these phases get separated out. In the end what do we get is highly pure zinc to be used for hot dip galvanization.

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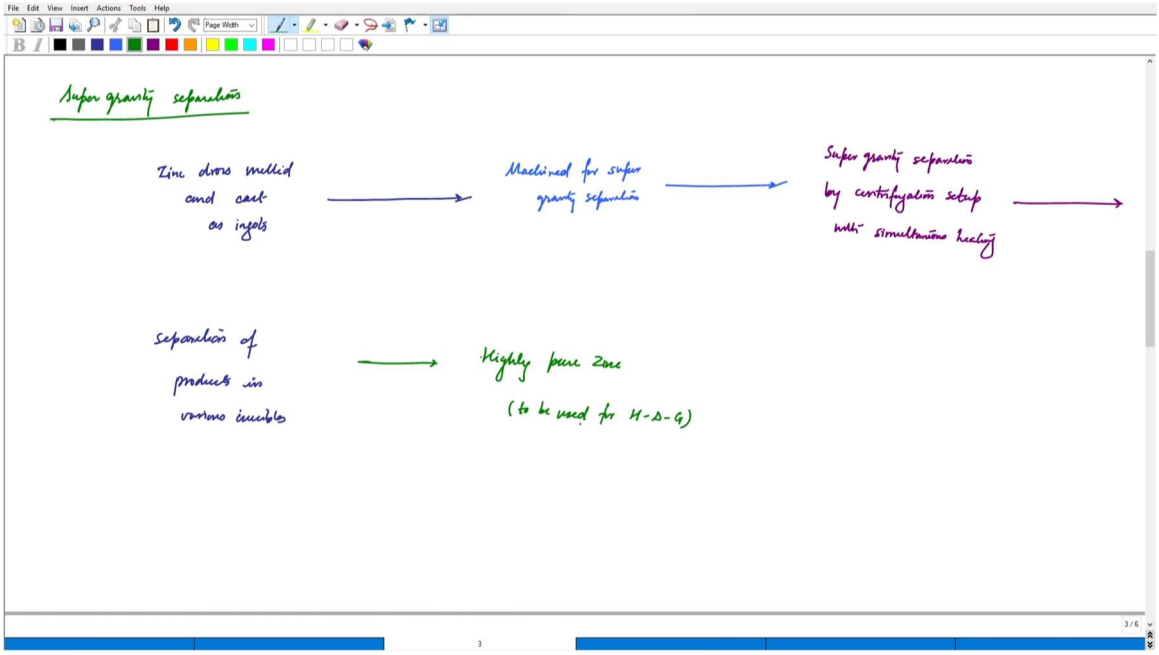

It can be directly used back in for the galvanization process or if we have one wishes to go for further refining then one can go for electro refining of this product and then use it for various applications where you would really need high purity of zinc. These processes, what do we mean? What do we understand when we see these processes? We know that these processes are going to have various inputs and outputs, various operational parameters. We have not gone in extreme detail of these processes, operational parameters that is and we see that at each step, the raw material, the operation parameters are very crucial because if we are missing out on something the finished product itself is not going to be of good quality which means even if we do every step right and we are able to optimize everything if let's say the raw material itself is of not high quality we won't be getting good finished product. That is the reason why one has to think judiciously how to achieve high metal recovery and how to reduce the whole jargon of optimization, if at all it is possible, how to minimize the disadvantages that happen during these multiple stages of operations.

We will now be looking at what are the valuable materials that can be made from zinc dross. And before that we also need to think of one different category of dross that I would like to mention here because it also contains zinc and this is zinc solder dross. When we are doing the soldering operation the solder dross is also produced and it is very rich in zinc not as rich as the conventional zinc dross, the hard zinc that we have been discussing as of yet. This solder zinc the zinc dross solder zinc dross is relatively lesser rich in zinc, but it has different other valuable materials like tin and lead. We know that if zinc dross has nearly 65 percent zinc and we have tin and lead of around 15-15 percent, we can try and think of devising a route for zinc soldered dross recycling. The most common method that can be used is basically multistage leaching and precipitation. If we have zinc solder dross, we can have leaching of H_2SO_4. That could be the first stage of leaching. If zinc and aluminium get leached out and the other phases are not getting leached out, these could be collected into the residual solid, which could be used as a raw material for the next step leaching.

If we are using H_2SO_4 in the first step, we could have a different acid or alkali for the next levels of leaching. Similarly, this and for the precipitation could be you could be done by adding the counter of the acid, so if we have used acids in the first step, we could have alkalis in the second step. This would help us in achieving various salts and various metal-rich phases or metal containing phases not metal rich phases, metal containing phases with hydroxides or salts and these phases could be reported as valuable materials.

We can have multistage leaching and precipitation. Some of the valuable materials that people have reported using zinc solder dross are$ZnSO_4$ if you are using, of course, this implies that sulfuric acid has been used. $ZnCO_3$. If we are using some sort of precipitating agent, we can have carbonate coming as a valuable material. $PbCl_2$, if we are using HCl as a raw material for leaching as a leaching reagent and we are able to get $PbCl_2$ or we can have $SnO_2.xH_2O$.

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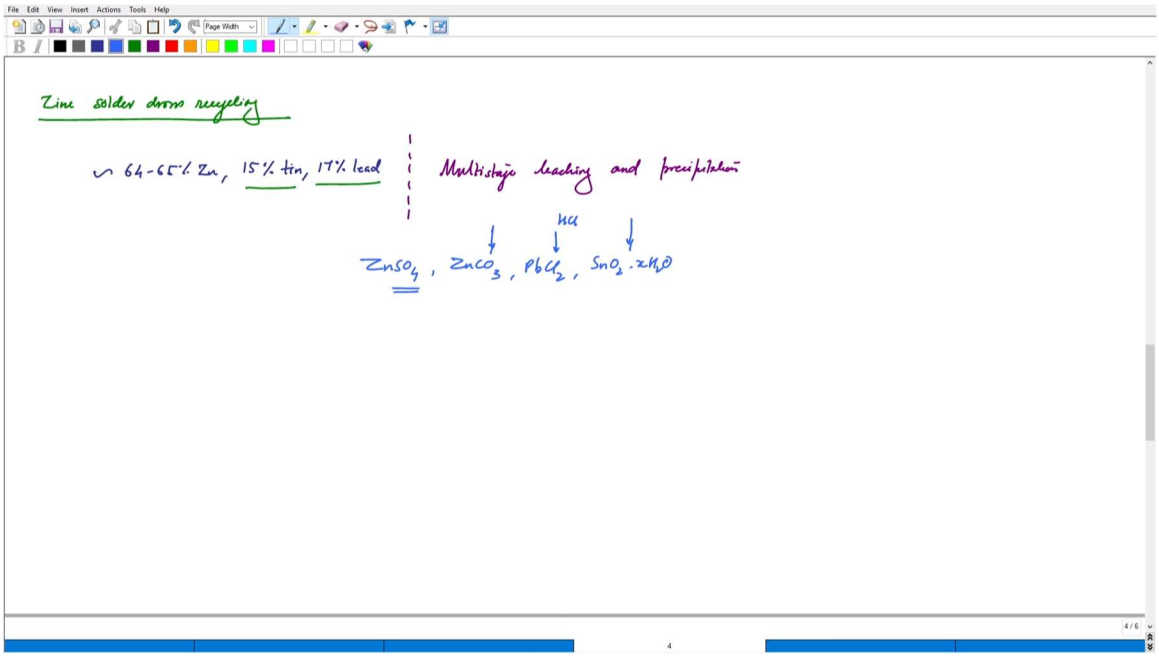

If we have this as the precipitate that is also possible. This means that depending on various types of raw materials that we are using we can have different types of products and this is a multi stage, multi reagent leaching process. If some materials are leached at stage 1 it is fine if not then we go to the stage 2 if not then we go to the stage 3. These are the multi level leaching operations. We are going to look at the valuable materials that are present that can be produced using zinc dross.

If we have zinc dross, the most important material that people would like to make is the zinc metal itself. Metallic value. And you can think of making zinc oxide. People have tried to make zinc nanopowders. Zinc oxide nanopowders. Nanopowders. And this comes by leaching it with HNO_3 and maybe adjusting the pH to remove the impurities and then precipitating the zinc oxide. And again one has to use various precipitating agents and we

can go for thermal treatment after the precipitation is done so as to achieve the zinc oxide composition that we are the zinc oxide composition making the nano powders. These are various routes by which you can make zinc oxide nano powders and the many other methods are also available. But zinc dross essentially is used as a raw material to make zinc that is the most go to material for using zinc dross as a raw material because it has very large quantity of zinc to be ignored. The most obvious answer to what product you should be making is zinc metal itself.

Zinc-rich phases like zinc oxide and zinc oxide nanoparticles or other products can also be made, but the zinc metal itself is the most valuable metal that can be produced. The other products are zinc phosphate, zinc sulphate and similarly one can think of generation of zinc rich phases/compounds that can have various different applications in different areas.

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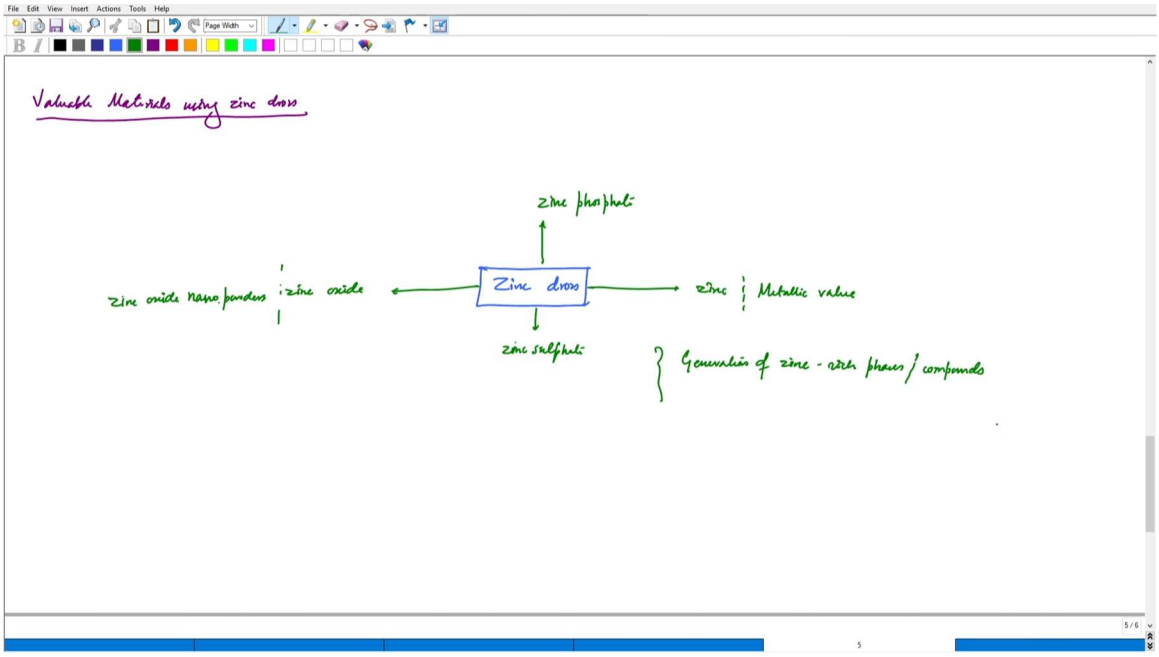

In this class what have we discussed? We have discussed the recycling of zinc dross which we actually started in the previous lecture and we are now coming to the end of this recycling of zinc dross and we have seen how crucial it gets when we think of applying or bypassing a given type of waste recycling process. For instance, if we want to apply pyrometallurgy, what should be doing and what are the advantages and

disadvantages? If we want to apply hydrometallurgy, what are the other steps that would be involved with leaching?

And if we want to go directly into electrometallurgy, what are the challenges? It should be noted that a good recycling process is very difficult to achieve. And it again depends upon process optimization. And what are the unit operations that have been used? These play a very crucial role in achieving the overall zinc recovery in the finished product at the end of the process. We have seen lot many processes that involve pyrometallurgy, electrometallurgy and multi-stage leaching of zinc solder dross. With this we come to an end to this lecture, we will be continuing on zinc wastes in the upcoming lectures. Thank you.