METALLURGICAL AND ELECTRONIC WASTE RECYCLING

Dr. Arunabh Meshram

Department of Materials Science and Engineering

Indian Institute of Technology Kanpur

Week-1

Lecture-3

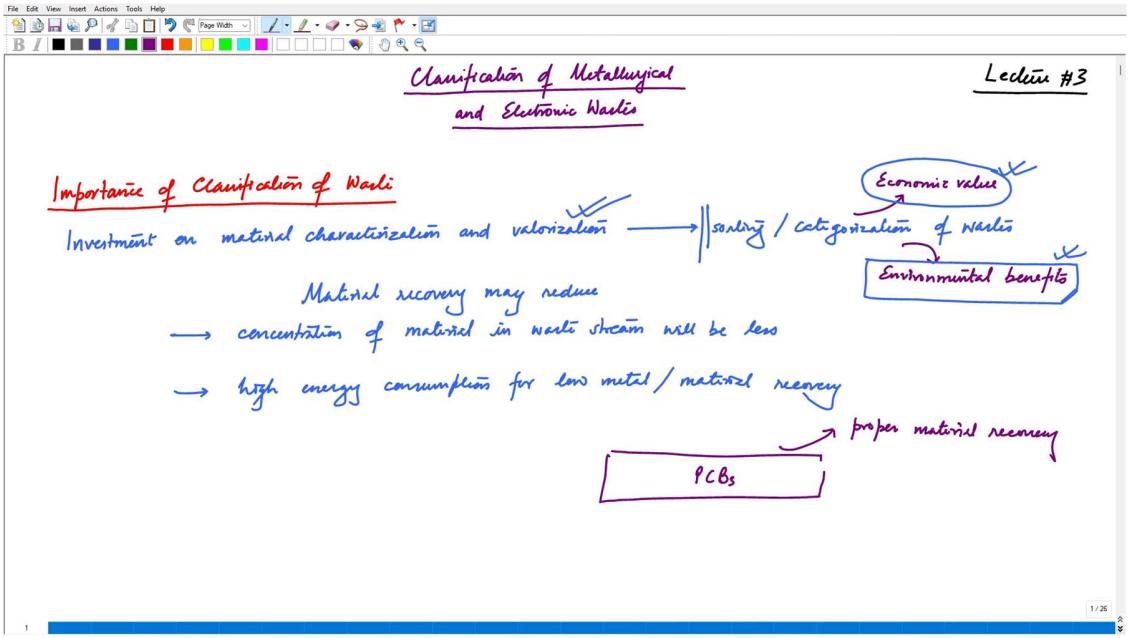
Greetings, so this is the third lecture and we will be continuing on our discussion that we had on classification of metallurgical and electronic wastes. So, in the previous lecture, we were discussing what happens when we get a stream of electronic waste on let us say a conveyor belt. So, what we have maintained is that we must devise methods for categorizing, classification and sorting of waste so that the basic idea of economic worth of the waste is identified and we are able to put some numbers on the electronic base. For instance, we have X amount of gold or silver or platinum or palladium or at the same time, what is the concentration of hazardous metals?

What are the polymers that are present that are hazardous to humans and flora and fauna and environment in general? So, continuing on that, today we will be focusing on the metallurgical wastes. So, again importance of classification of wastes, investment on material characterization and valorization, this is very important. One has to think on the characterization and putting some sort of value on the wastes and this actually leads to the sorting, categorization which gives us some sort of economic value. This I've just mentioned and what are the environmental benefits so not only are we just thinking of reducing pollution we are also trying to do some benefit while we think of developing a good recycling process.

So apart from our economic benefit if we can think of environmental benefits as well it would be a two-way win. So what happens if we are not doing it so when we have when we are not thinking of categorizing and classifying the waste we will be thinking of basically reducing material recovery the overall material recovery will drop down and on the other hand, we will be focusing on large amount of material will be lost. So, the loss that we are experiencing because of not sorting wastes will be enormous because it will get coupled one after the other. High energy consumption for low metal or material recovery.

What does that mean? We have actually discussed this to some extent in the previous lecture. What it means is, supposing that we have a block of waste and it could be of a given category. For instance, since we had discussed electronic waste, we could think of going into a PCB that we had seen. So, when we look at PCBs, if we do not identify the wastes that are the identification of valuable materials in the waste printed circuit boards, we may not be able to devise proper material recovery.

That will be very difficult if this PCB or such PCBs are not sorted and they are not categorized and they are not characterized. So, identification of valuable material in a given stream is of immense importance. And same goes on with the metallurgical wastes as well. What are the metallurgical wastes and how can we really classify them? So, there are numerous methods by which we can really classify metallurgical wastes. **(Ref. 4:45)**



One of these methods is basically thinking of the primary route in which these wastes are generated. So, for instance there are three primary methods of making metals and these could be pyrometallurgical route, hydrometallurgical route and electrometallurgical route and these processes have their own wastes. These wastes are generated at different processes and of course, classification of wastes can be done on the basis of the origin where the process origin not just the unit process but the overall process in which these wastes were generated now so for instance if we look at if we look at pyrometallurgical route we'll see we'll have blast furnace slags. We have BOF, basic oxygen furnace slags.

We have flue dusts. So, of course, these wastes are generated at different locations in, let's say, seal making, iron making industries. But these can be categorized into the pyrometallurgical wastes. Similarly, when we think of hydrometallurgical wastes, we can say it could be having spent leach liquor. So, after the extraction of metal from the leach liquor which was used in hydrometallurgical system, we are left with spent leach liquor.

These types of leach liquor solutions are still have some amount of ionic concentrations, cationic and ionic which could be used for different applications. Similarly, the residual solids which are basically left behind after leaching can be used in different applications based upon characterization. So, we will think of characterization, I will just write here characterization of wastes the methods for alternative recycling. So when we are able to identify and characterize these wastes, we will be able to develop alternative routes of reusing these wastes and bringing them back to the material cycle.

So the complexity of metallurgical wastes would depend upon what happened during the unit process and what is the current composition of these wastes? Similarly, when we look at electrometallurgical wastes, we can have spent electrodes, we can have electrolytes. Of course, these electrolytes have been used for metal extraction. We will have pot linings. So, for instance, if we have a cell what happens after the recovery of a given metal? What happens to the pot lining? It's also ending up as a waste stream. Similarly, when we look at various other categories of waste and these can be clubbed into the conventional routes as well as these can be classified as different categories. So, we will have refractories, drosses.

Red mud is one of the most important wastes that is classified in metallurgical engineering wastes and lot of effort has been put and is being put to recycle the huge quantity of red mud that is generated in aluminium industries. Categories of metallurgical waste and this classification is done on the basis of where these wastes were generated. Of course, one can think of classifying wastes on the basis of principal element that is present in a given waste. So for instance, one can think of wastes that are rich in aluminium or iron or copper or nickel and then classify the wastes accordingly. And of course, these types of classifications are also available.

So for this example, I have just put the metallurgical wastes on the basis of the origin. the primary process origin where these wastes are generated. Now, when you think of fixed composition of streamlined wastes, what does that even mean? Fixed composition of

streamlined wastes. Normally, when we think of a waste, attaining of fixed composition is very difficult.

Say for instance if you look at slags when we look at slags we look at flue dusts we can have a wide variety of composition fluctuation in these metallurgical wastes. But if we look at a fixed category of waste then adjusting the range of composition in a given category becomes relatively easier. Of course, it still depends upon the process parameters during which these wastes were generated. But when we think of just one category of waste, adjusting the composition and devising the composition range becomes relatively easier. So, in that sense, having a fixed composition range, there could be just range of streamlined.

Streamlined means one does not really have to categorize different wastes that are piled up at, let us say, a dump yard or a landfill near an industry. That should not be. If we are looking at, let us say, slags, then it should be that a given category of waste could be collected at one place. If we have multiple types of wastes coming together, then it's not streamlined and again, valorization, putting numbers, putting economical values behind such wastes is very difficult. So, having fixed composition range of streamlined waste improves the benefits, improves the recycling process.

This can be done when we have better methods of collection. So, in this class and the previous lecture that we had seen, we have focused heavily on devising and prioritizing methods of collection and sorting and classification. This is very important because if we are able to properly collect and sort and classify these wastes, the economic worth of each waste stream can be identified very easily. Organize comminution and waste management.

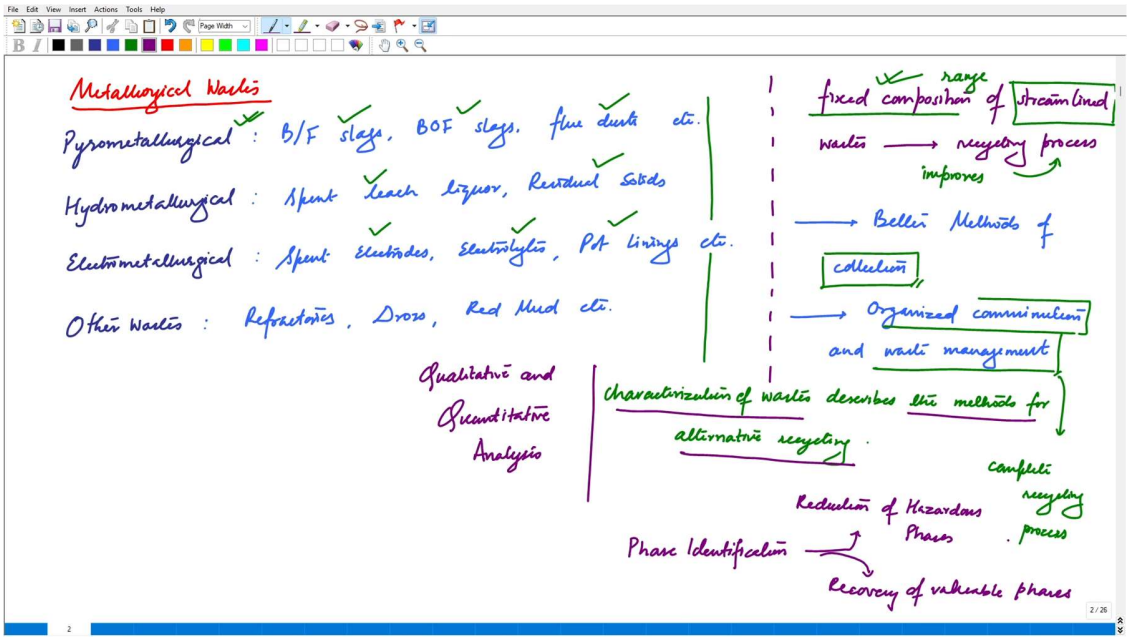
What do you mean by comminution? Which is basically just bringing down the particle size and having some sort of mechanical, physical pre-treatment done on the waste streams so that valuable materials can be concentrated and the materials that are not of much economical worth can be separated or materials that are hazardous can be separated out. It is very important that when we look at a given waste stream, we devise methods of proper pretreatment which involves comminution and it means basically reducing the particle size so that the further operations, the operations that follow are benefited.

So, for instance, it is lot more challenging when we think of a process that is looking at larger particles versus smaller particles the exposure of the surface area exposure of smaller particles is higher as compared to larger particles due to specific surface area

being higher in smaller particles so what happens is So, for instance, if we have smaller particles and we would like to expose them to a given gas environment, the tentative reactions that we are imagining for smaller particles, it would be higher. The rate of reaction would be higher as compared to that of the larger particles. And this change in observation is because of the different surface areas of the particles that we have used.

And of course, it basically helps us in benefiting the overall recovery of valuable materials. So, organized communication and waste management. Again, waste management is basically assuming that we are taking care of complete recycling process. Now, we will focus on what we had written here. Characterization of wastes describes methods for alternative recycling.

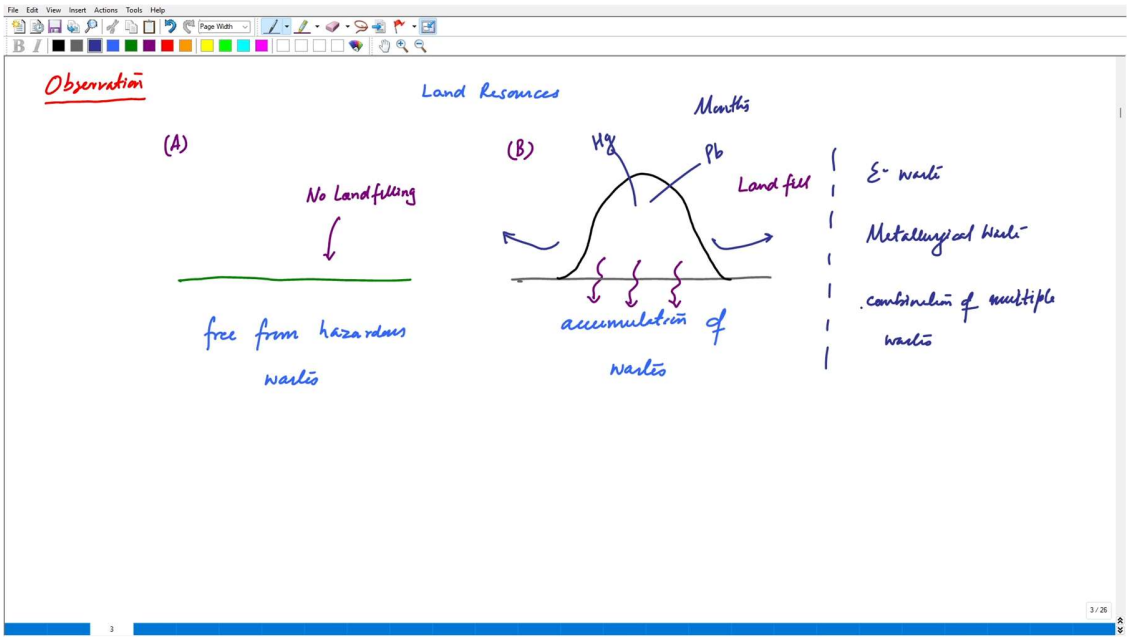
So, we have seen some examples of metallurgical wastes here. We see that it is essential to note what phases are present in these wastes. So, we will just write quantitative, qualitative, qualitative and quantitative qualitative and quantitative analysis. Analysis of these wastes so that we understand what are the phases present in them, which phases are we really interested in and what are the elements that are hazardous and how we are able to extract these hazardous materials, keep them out of the main recycling route and deal with them separately and then come back to the original stream and extract the valuable materials. So, a tentative route could be and of course, for every waste, one has to think and rethink and redevelop this whole recycling process again. So, and of course, after we have sorted, so we'll have, we'll just begin the phase identification. Reduction of hazardous phases followed by recovery of valuable phases. So, now that we know that the primary target of material characterization would be the reduction of hazardous phases and the recovery of valuable phases. **(Ref. 19:15)**



We can really go ahead and do the back calculation that what could be the roots of recycling for each of these wastes given in these major classification of metallurgical wastes. So let us just do a small experiment. Here, we see the land resources and I have drawn two straight lines representing land resources that we have. One of them does not have a landfill on it. So, of course, we have drawn it with green.

So, it signifies that the land in, let us say, part A and part B, part A looks free from any hazardous materials. So, and this is because we do not have a landfill on it. So, of course, no landfilling. The flora and fauna, the environment that is close to such exposed land does not experience much change as compared to a case B where we see that there is a landfill and this landfill could have right now I'm just not categorizing what type of landfill it is so it can have electronic waste it can have metallurgical waste Or it can have a combination of both. Combination of multiple, not just both. Multiple wastes. What does it normally do?

Say suppose that this landfill is sitting on this piece of land for let's say a duration of months. What gradually happens is suppose that there is mercury, there is lead and then of course there are other elements and hazardous materials CFCs and other materials that are somehow accumulated in this landfill what happens is these wastes may percolate and disturb the land by changing the soil pH by affecting the groundwater the groundwater contamination is also possible which will affect the flora and fauna that is close that is in vicinity to these waste these landfills and gradually it will happen that this land will this land may lose the potential to grow crops or even common grass. So again it is affecting the vegetation, it is affecting the water resources and gradually it will start affecting the human population in vicinity of these landfills and of course we right now are assuming that these landfills are open to atmosphere which means rainfall is also experienced on these landfills which will again help in the dissemination of hazardous materials onto the land resources that are not even having landfills so gradually it will start distributing. **(Ref. 23:19)**

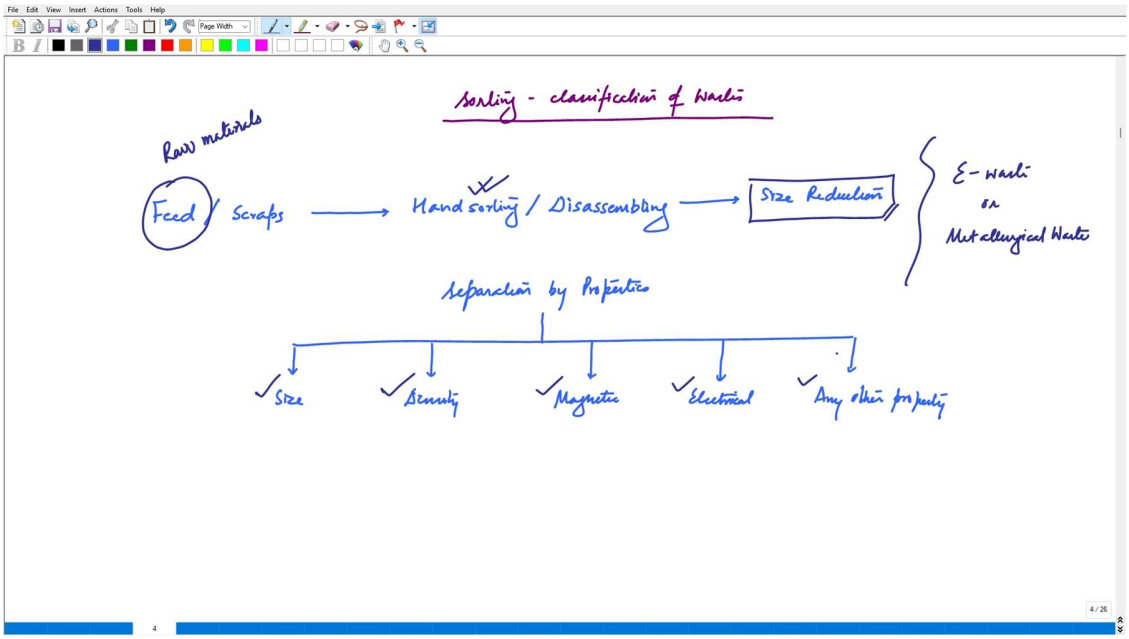


This is very big a challenge for material recyclers to develop good methods to take care of these types of wastes. Now when we look at sorting and classification of wastes one really can think of feed, feed as in what type of starting material we had.

So, we can have raw materials and we can have scraps. So, one way would have been to think of hand sorting it. So, suppose we had the electronic wastes, we could think of hand sorting them. But of course, metallurgical wastes are hazardous to deal with. So, hand sorting would be a bit more difficult.

In such cases, we could directly have size reduction. So, again this part is coming in comminution and we will be looking at it in the upcoming lectures as well. Separation by properties. So, when we have reduced the particle size be it of e-waste or metallurgical waste we can think of separation on the basis of various properties.

So, for instance, what could be the size of the feed stream after the pretreatment that we have done? What is the density of the material? Is the material magnetic or non-magnetic? So, based on that, we can have this classification. And how does the material behave in the presence of electricity and or any other property on the basis of which we can classify these wastes. **(Ref. 25:50)**



So, sorting and classification of materials does not stop at just identifying and characterizing wastes. It can go beyond that and based on various properties that we have, we can think of developing various categories of wastes for both e-waste, electronic waste and metallurgical wastes. We will continue after this. Thank you.