METALLURGICAL AND ELECTRONIC WASTE RECYCLING

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Week-3

Lecture-14

Greetings, I welcome you all to the 13th lecture of this course wherein now we are going to discuss aluminium scrap recycling and previously we have seen aluminium dross, we have seen red mud and now it is important to understand that we are now going to look at the most common way of recovering metals which is basically consuming the scraps. One of the easiest and the most common methods of recycling scraps is using it as a raw material for recovering the metal itself and that is done by remelting. The route of recycling is already decided, we take the scrap, we do some pretreatment if it is required.

Many a times, the pretreatment may not be required if the scrap is generated in house that is if the scrap is generated in the plant itself and it is basically sourced from any manufacturing unit in the plant. Under such circumstances the scrap is basically circulating within the plant itself, so in-house scrap. The other scrap that is normally recycled is basically the scrap that is coming from the consumers.

We will be looking at the categories of scrap and how we normally go about recycling it and as we have just mentioned the most go to method is consuming the scrap, bringing it for remelting and based upon what is the desired composition adjustment of the composition and development of the metallic product or at times we can think of composites as well. But predominantly the scraps are used for pyrometallurgical route of recycling basically melting in a remelting unit. Let us go ahead and discuss the aluminum scraps.

These are rich sources of metal and commonly recycled to recover and for recovery and reutilization. The aim has been to recover the metal for reutilization and this basically completes the material cycle. Rich sources of metal.

Recycle for completion of material cycle. Chemical composition depends on service conditions before end-of-life state of scraps. The chemical composition of the scrap depends on what service condition it was in. It depends on the application itself. Application of finished product and then the service conditions before it reaches before it reaches the end-of-life state and then we can decide upon what happens with it. A general observation that has been seen is basically nearly 35% of metal, 35% of aluminium metal that is observed is already produced by scraps. What we see here is, suppose we have a given quantity X tons of metal. we can assume 35% of this product, this part is actually coming from scraps itself. It is already well established process, well adapted process in industries and it is basically helping in recovering the metal from the wastes.

And the other statistics is 40% is projected as scrap metal in manufacturing units. On top of 35%, we have additional segment that can be treated as scrap that would be coming in for metal recovery soon. A major chunk of aluminium is already in recycling. That is the beauty of aluminium.

It has been projected in many of the literature research articles that it is fairly very easy to recycle aluminium just continue on to the cycle of melting and remelting and casting and applying it in the different areas and then repeating the cycle. The energy consumption, we are going to see that the energy consumption for material recycling, the melting process itself is significantly very less compared to the primary mode of aluminium production which is basically combination of the Bayer process and the Hall-Harold process.

What it exactly means is? It's easier, it's easier to pick metal from the scraps and reuse it. Tentative loss that has been reported in some of the articles is, it's around 2% when we think of efficiently devising the process nearly 2% or of the same order, the loss of the same order is expected while we are looking at aluminum scrap recycling. When we look at aluminum industries, aluminum industries generate nearly around 12 to 16 tons of GHGs, greenhouse gases. What we see here is a significantly large amount of greenhouse gases generated per ton of metal. It is nearly around 12 to 16 times the generation of the metal itself. This means primary root of aluminium production contributes to greenhouse gas evolution and this quantity is significantly very large.

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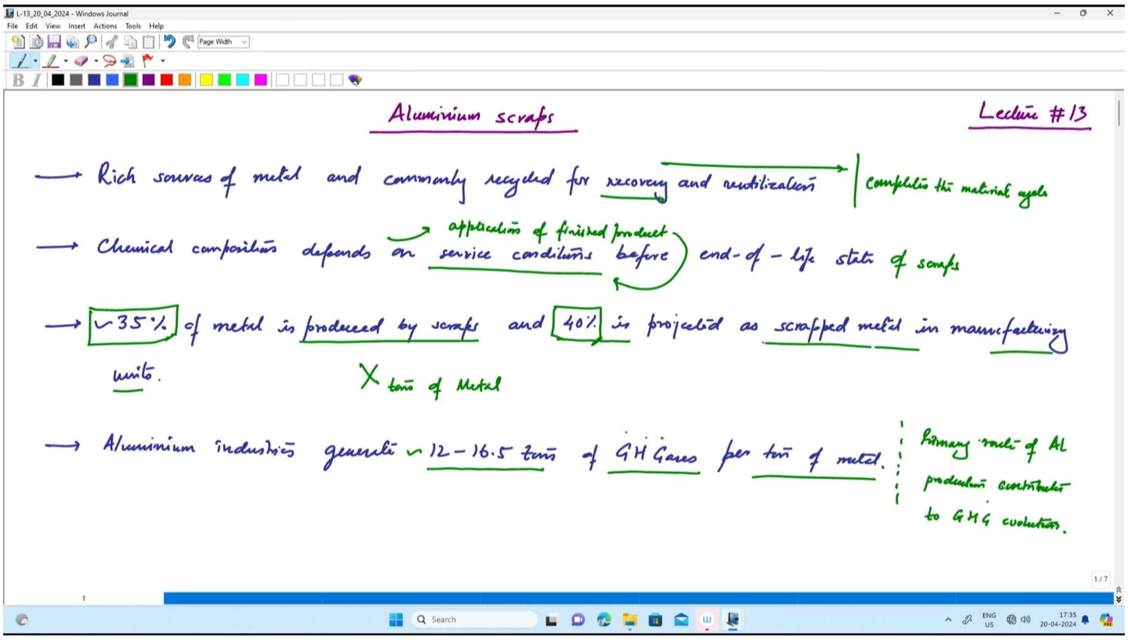


Primary route of aluminium production contributes to greenhouse gas evolution. And there has to be a way of stopping it. We can just keep on continuing the primary aluminium extraction. And that is being done because the demand of aluminium is on the rise. Which means we can't really stop primary aluminium production.

But at the same time to match up with the need, to make up with the need of the world, it is essential to bring in all of the scraps and keep on recycling these scraps. Actually we are not stopping or we are not thinking of stopping primary aluminium production, the conventional Bayer process andHall-Heroult process. It is that we need to recycle aluminium to basically facilitate the other surrounding industries that consume aluminum.

Recycling scraps reduces environmental burden by reducing greenhouse gas evolution. We have just seen that the greenhouse gas evolution is a big problem. But if we are investing on scrap recycling, If we are investing on scrap recycling, the environmental burden gets reduced because we are actually connecting it to the greenhouse gas.

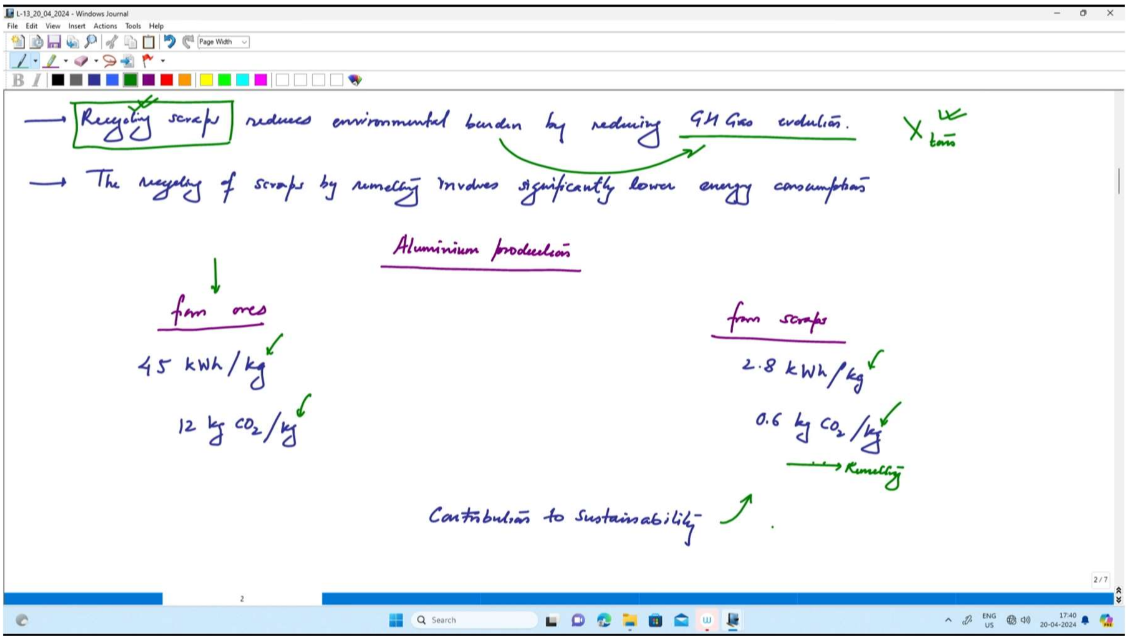
Supposing that the requirement for aluminum production is supposed to be X tons and some parts could be produced by scraps. The greenhouse gas evolution for matching the requirement would be relatively lesser if scraps are used as sources of metal and of course the recycling is done properly. Recycling of scraps by remelting involves significantly lower energy consumption. We have already been discussing this.

It is basically going to have a lower energy requirement and it is going to give us the same quantity of metal. Why does not shift towards the remelting of scraps? That is the idea that most of the aluminum industries have already worked on and aluminum scraps from various sources are being brought into the unit and recovery of metal is being done.

It consumes relatively lesser amount of energy, we will see. If we look at aluminum production, if we look at the conventional Hall-Heroult process which consumes ore, we see that per kg of metal and of course, all of the values are given per kg of metal. We consume 45 kilowatt hours. If you look at the consumption from scraps, we will see 2.8 kilowatt per hours, which is significantly very less.

Similarly, 12 kg CO2 production is seen compared to 0.6 kg CO2 production per kg from scraps. The primary process is consuming large amount of energy and large CO2 generation as well compared to just remelting it. An obvious choice that most of the metal recovery Would actually help us in saving energy. As well as reducing the CO2 generation.

Which is basically helping us in contribution to the sustainability. On top of the primary route using the scraps for raw materials for remelting would help in contribution to sustainability because we are able to reduce the environmental burden and we are also able to reduce the energy consumption. Both the objectives are being met and it is a good way of achieving sustainability in that sense. **(Ref. 13:40)**



If you look at the classification of scraps, it's basically pre-consumer scrap. We've already seen that we call it as in-house scrap, the scrap that is generated within the plant or some other manufacturing unit. It has not reached the consumer circle. The material was not converted into the finished product. It's still in the manufacturing unit and due to some defects, the scrap is produced and it has to be brought back for material recovery. The advantage of this is that we get fairly pure alloy or fairly pure metal that has not experienced any service conditions, which means the primary composition of the raw material or alloy is just the same. It has not tarnished.

The service conditions were not present, which means the material has not degraded. However, when we look at post consumer scraps, it is unsorted. We don't really need to sort the alloy scraps because it is already generated, generated in-house or in a manufacturing unit. We don't really need to sort it.

It's already available. However, the post consumer scrap has to be unsorted. It is normally unsorted and heterogeneous. It is unsorted and heterogeneous. It is of low quality scrap.

This is high quality scrap. This is relatively lower quality of scrap because of so many different sources, multiple sources and different service conditions. One really has to do pre-treatment and characterization to match it up to pre-consumer scrap.

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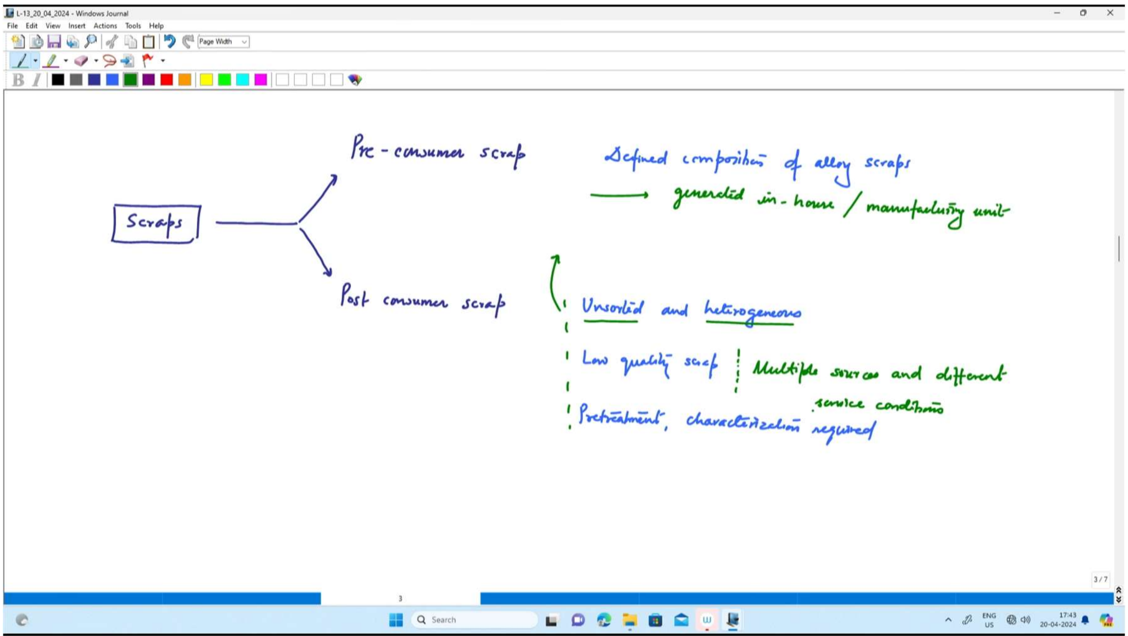

These grades really can't be matched, but if they have to be used in a nexus, then pre-treatment and characterization and composition adjustment becomes absolutely necessary. It's essential. Scraps have been categorized. The scraps that are coming from the consumers have to be pre-treated and characterized so that we understand the composition of the scraps, what are the pre-treatments essential for the scraps and what composition adjustment would be required to achieve the final desired composition. Expensive and rare alloying elements are difficult to recover. Suppose that if we have an alloy that has relatively rare alloying element and these alloying elements can at times become very expensive if we do not have a very dedicated recycling strategy for such alloys, it becomes very difficult to recycle these elements.

What will gradually happen is metals, the alloying elements from these alloys would gradually end up in landfills and they would be very difficult to recover. It will be very difficult to recover because the dedicated recycling strategy for such expensive and relatively rare alloying elements were not present. If all newer alloys are being developed, proper recycling mechanism should be developed simultaneously. Because if this is not done and suppose the alloying element is very expensive, since we do not have a good recycling strategy, that particular element may get lost because the particular alloy will be difficult to recycle and such alloy may not be used as a raw feed for making common metals. Alloys are segregated based on their composition so that the melting and remelting becomes easy. The recovery of metal itself becomes easy that again depends upon composition. But if such alloys are made that are difficult to recycle, the overall process just becomes tedious and material gets lost.

Low solubilities of many elements in aluminium generates intermetallics. It's fairly possible that the elements may have low solubilities and it will eventually lead to generation of intermetallics. What it does is basically changes the physical properties of alloys.

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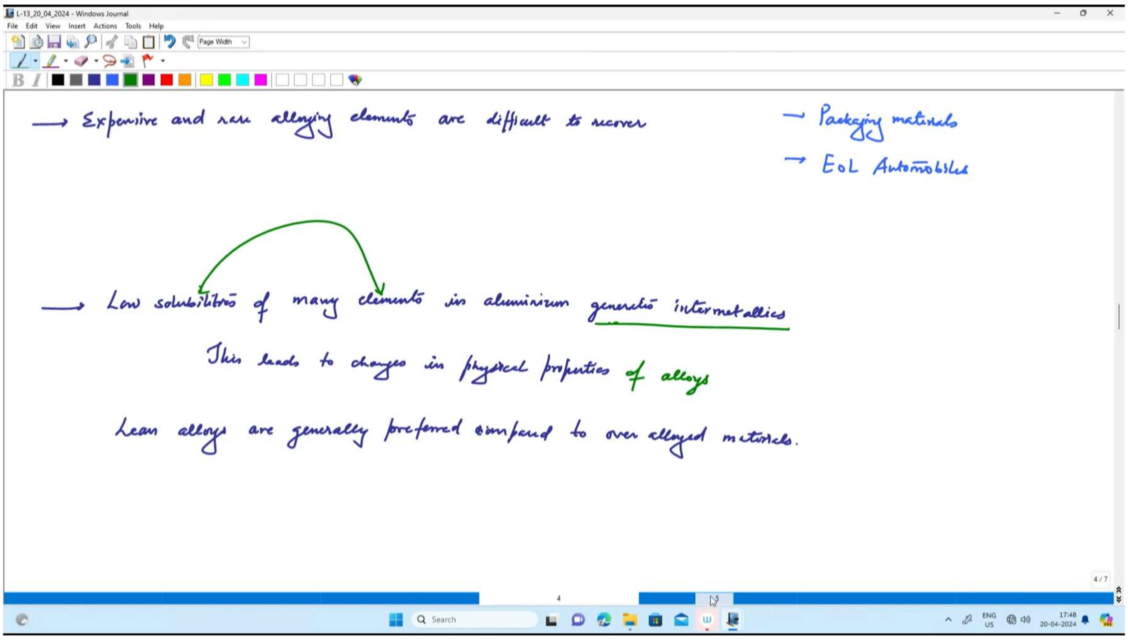

The recycling of lean alloys is relatively easier compared to overly or heavily alloyed materials. Lean alloys are preferred because the composition can be attained. Heavily alloyed scraps may not be the right choice for beginning the process of material recovery because again it's the matter of recovering these elements into various segments of or making the master alloy. If heavily alloyed scraps are used the chances are that it may get lost. The preferred scrap category would be of leaner alloys. Distribution of scraps. When we think of alloys and aluminium scraps, what are the distribution of scraps? Of course, on the basis of applications. What are the key applications where aluminium scraps are generated?

Transportation, of course, automobile, applications that will generate nearly 33 percent. Packaging, single time aluminum cans and others other packaging material 26 percent. Electrical and cable applications nearly 13 percent. Building and construction applications nearly 16 percent and the rest is for other specific applications. And we see that transportation and packaging are essentially one of the most important fields in which aluminium scraps are generated and these are good sources. We directly need to utilize these sources after the removal of all foreign materials so that only aluminium alloys of different categories are present for the melting-remelting process. When we think of scrap remelting, it is just the cold pressed and compacted raw feed.

That is one way of looking at scraps. If in a furnace, we would like to just go ahead for compacting, it can help in adjusting the raw feed in the furnace and the feed can be remelted with various fluxes KCl, NaCl, KF etc. can be used. Different salt fluxes of different compositions like NaCl, KCl, KBr, NaBr and so on and so forth, can be used for the melting and the preferred temperature is around 750 degree Celcius. What happens if we have a relatively higher melting point? The operation temperature itself.

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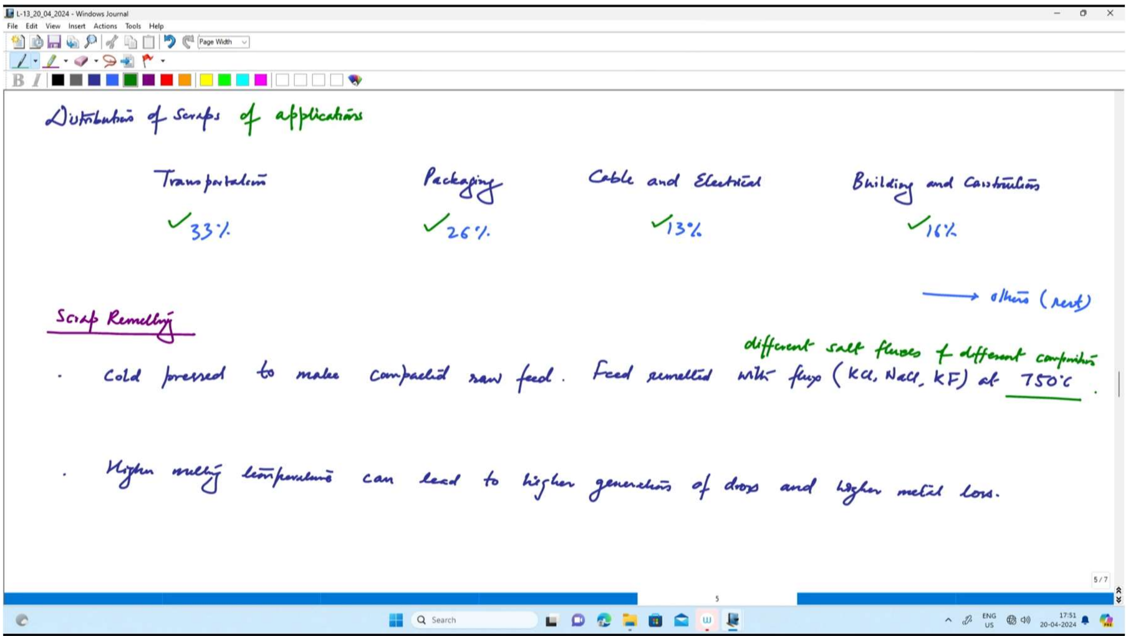

Suppose that we have let us say 800 degree Celsius or 850 degree Celsius for melting the scraps. What happens is if at all there are other metals that are present in the scrap they may get oxidized because, and this will lead to the generation of oxides and such oxides would be picked up into the slag phase which again would lead to the generation of dross. We know that the dross generation depends upon the melting of aluminium and it depends upon how quickly aluminium is getting exposed to atmospheric air and it how it combines with the oxygen to form alumina, aluminium oxide and how it is getting separated. The same fundamental is observed here when we look at scraps again molten metal will come in contact with air, if temperature is extremely high and in literature it is observed that 750 to 800 is supposedly fairly high temperature enough and we should not be going beyond that because it may lead to generation of dross. So, in this class, in this discussion we have seen different categories of aluminum scraps.

We have seen that the source of generation of scraps is of immense importance. It is these sources that help in defining what type of pre-treatment is required. Essentially it is just remelting and we have different categories of scraps that are being used. But the pre-treatment, the necessity of pre-treatment is decided by the source and we know that the alloys that are present, the alloys that are present should help us in developing the finished product. Lean grade ores versus overly alloyed lean grade alloys or overly alloyed raw feed of scraps these are the various bifurcations that one has to keep in mind that what is the finished product that we would like to make. And again, development of newer alloys can be done, but at the same time it is essential to devise good recycling strategies simultaneously so that expensive and relatively rare elements are not lost in landfilling. Aluminium industries are already having facilities of melting and remelting and recovering metal using the pyrometallurgical technology. In the upcoming class, we will be discussing the recycling of aluminum salt cakes, the salt slags and we will be focusing on how the salt slags can be used as raw materials for various material recovery.

Thank you.