METALLURGICAL AND ELECTRONIC WASTE RECYCLING

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Lecture-31

Greetings, I welcome you all to the new lecture of this course. Till now we have had multiple rounds of discussions on the metallurgical wastes and now we will be focusing on the electronic wastes which will be the next segment of this course and first we will be focusing on the recycling of the waste printed circuit boards and then gradually we will be moving towards the recycling of batteries. The couple of lectures that we will follow presently will be on printed circuit board recycling, whereas afterwards we will be focusing on the batteries. When we think of electronic waste recycling, the first thing that we have actually done the categorization. Coming back to what we had studied previously, we know that electronic waste basically means the waste that is coming back from the consumer end. Suppose that there is an industry that produces electronic devices, electronic gadgets. These gadgets will be coming into the market and people will buy these gadgets, they will use it. The gadget performs its application for a given span of its life, let's say 5 years or 10 years or whatever it is and then after its intended use, it reaches its end of life. There could be some technical faults in the electronic device or it can experience some sort of mechanical damage due to also whatsoever reasons, the device may stop functioning. What happens when these devices are out of their use?

Most of these devices will be gradually discarded by the users. Now, these discarded electronic devices are basically ending up in the material scrapyard. If you look at the general scrapyard, we can see discarded automobiles, we have discarded cars, we have a segment that has the discarded electronic wastes as well. When we look at e-waste, the first thing that really comes to mind is we have those wastes that are stacked in the scrapyard. What do we do with such a stack of electronic waste? One way is to clearly identify the valuable materials in it just as we have done with the metallurgical wastes for let us say aluminium, copper, zinc and then we design the recycling strategy and then extract the valuable materials. But we have a slight bit of a challenge here. The challenge in electronic waste recycling is we have no control over what we are trying to recycle.

Because when we look at e-waste stream, it can contain large segments of variety of electronic devices that can be discarded. The first step is what we have discussed so far and emphasized so many times, sorting of wastes. If we sort our electronic wastes into various categories, the broad categories of e-waste we have already discussed. There could be small equipments, large equipments and so on so forth.

If we sort our waste right at the beginning of recycling, the moment we let us say get a stream of e-waste, what do we do? We should sort it because it helps us in developing the recycling strategies for the sorted waste materials. In the present lecture course we are focusing on two main streams, the PCBs and the batteries but, of course, there are so many different types of wastes that we can actually explore and have lengthy discussions and detailed recycling strategies. Such investigations really help us to identify what are the valuables that we can extract directly or what are the valuable materials that we can produce using these raw materials. We will now be having some general discussions on e-waste recycling and then we will gradually focus on waste printed circuit board recycling. Let us go.

We have e-waste recycling. we know that the recycling of e-waste is one of the most challenging aspects of modern-day recycling. E-waste recycling is one of the segments of wastes generated by modern society and there is the problem of material cycle. What do we mean by material cycle we already know so we have the generation application and then it's recycling but we need to understand material cycle in e-waste. So, material cycle of e-waste has to be discussed. And we have already seen that we have the categorization of e-waste. Coming back to those categories. The categories are small equipment, large equipment, telecommunication devices, signals and telecommunication devices, temperature regulation; so ACs and temperature regulations, ACs and refrigerators are here, lamps and lights and we have screens. Some other categorization can also be done but we know that these are the primary categories.

When we think of these categories, what is the first thing that we should be thinking of, sorting of e-waste. Whatever is the stream we sorted on these into these categories and then we device are recycling strategy. We know that the challenge that we talk of is that the complexity, complex nature of discarded materials. This itself means that we have wide variety of materials. We have metals, composites, some parts of ceramics also, and so on and so forth, which are directly used in and we have polymers also. These materials are directly used in electronic devices which end up in e-waste. So, think of it in this direction. What are the materials that we are using to make the electronic devices?

Those materials are going to show up when we are looking at the electronic wastes. Until the equipment itself does not experience heavy wear and tear, we don't expect the material to totally disappear. For instance, all the metal components of an electronic waste is lost. This may be due to certain actions that can happen, but generally speaking whatever materials that we are adding while manufacturing will end up in the e-waste and, then this heterogeneity of materials itself creates the complexity. When we talk about complexity it is just these materials creating the catch that we have to deal with metals separately, we have to deal with polymers, we have to deal with composites and if at all there are other categories also, we have to deal with these materials separately if you wish to extract valuable materials from all segments.

There is a possibility of discarding some materials and using the others while that may be economical but if we are strictly speaking about utilizing every aspect then we will have to segregate these wastes and these categorization of materials within e-waste is different for every category. Small equipments may have different composition, large equipment may have different composition. Similarly, telecommunication, screens, lamps, temperature regulating devices, every device has its own composition variation and handling this becomes a challenge. Plus, there is one more inherent challenge that we should be noting. Electronic devices can be manufactured by large number of companies. Every company has its own way of making their own devices. Cell phones can be prepared by large number of companies. Discarded cell phones, when it reaches the scrap yard, when it reaches the recycling unit, it may be originating from a different company altogether, which for which the recycling industry may not be completely ready. One has to adopt a new strategy how to accommodate as much e-waste of a given base stream as they can. We'll continue. The proportion of inherent chemistry of materials.

We are talking about proportion of inherent materials. We don't know, it has to be analyzed and, varies a lot, of each chemistry of materials, of each waste stream. I am thinking about this is a sorted waste stream. This proportion is a variable actually. The proportion of inherent chemistry of materials of each waste stream needs to be analyzed. One has to think about developing some sort of overall data bank before we even start developing our recycling strategies. Why is this necessary? I have just mentioned. Suppose, we are thinking of recycling TV screens or washing machines. We will be discussing those types of waste also. We know that TV can be produced by large number of manufacturers and the components that are used to make these electronic devices, they

vary in composition. They vary in chemical composition. Their proportion in use that is used to make these devices can vary from company to company.

That data bank is extremely important to get. This data bank can help us in understanding how we should proceed in in a way that can accommodate to most of the wastes. If we are looking at TV recycling, most of the TVs that end up in recycling unit can be recycled. Proportion of inherent chemistry of materials, inherent chemistry of materials. What materials are we talking about? These materials, of each waste stream so, which waste stream? Again, we need to be very focused and we've already mentioned that it is a sorted waste stream. When we think of waste stream these waste streams and we have to be at times very specific be very specific for example, TVs or refrigerators or ACs. When we think of sorted waste stream it better be classified even before it reaches for recycling and that needs to be analyzed so that we get a good overall output.

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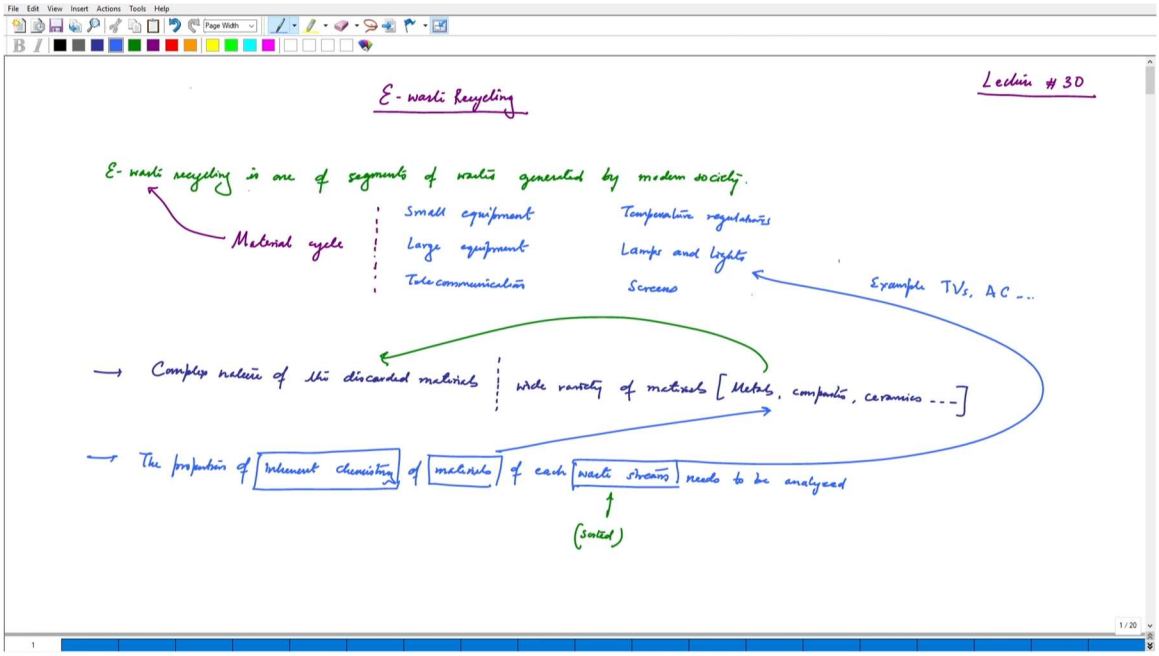

Why exactly is this important? We look at some of the classic waste streams that we can really identify. Household, a general household can have washing machine or at times we are more comfortable with ACs or refrigerators or televisions. We look at these waste streams first because, if we understand the recycling of these equipments we will be able to understand the recycling of WPCBs and why exactly WPCBs is one of the most

important raw materials when we think of e-waste? We will go there, but before that we are now looking at these examples. Material composition of e-waste. Consumer end, we have this consumer end and we have the generation of e-waste and we are again assuming that we have sorted sorted the waste stream and then we have to basically analyze chemical composition of the wastes. We will be taking the example of washing machine so that we understand the recycling group better We have discarded, discarded end-of-life washing machines, so EoL is basically end-of-life, WM is washing machine. We have discarded washing machine and then we have, how do we basically recycle so this is basically a recycling strategy, recycling strategy or recycling route for EoL-WM, end-of-life washing machine.

We have manual dismantling. This basically means the removal of parts for direct reuse. We take the discarded washing machine and then we just start dismantling the machine. This is done manually. One just might wonder, is it really safe to handle electronic wastes manually and is it really worth it? One just might want to argue to put everything into a shredder and let us just get some shredded scrap. It may work but at times we need to understand that manual dismantling can help us get those wastes recovered right at the front that that may hinder the process in the in the other processes that follow or we may not recover them at all and because they are shredded, they may just dilute the concentration of materials that we may get in case of sorted and manually dismantled materials. It is just important to recover materials as we can. Manual dismantling can help us get those materials separated out so that main shredding and recovery just gives us good overall material output and when we are doing when we are thinking about shredding mostly, we will get metals and plastic pastes. Those separation can be done properly and nothing else interferes that is why we focusing on manual dismantling. And this is just one of those strategies there are many strategies that can that may totally avoid manual dismantling they have a different way of removing those components that can interfere but we are just looking at one of those strategies that wherein we have manual dismantling and then we can just send these parts for reuse. What else, we have shredding and this leads and after that we can just go for magnetic separation, we have eddy current separation and then we have residual solid.

Discarded end-of-life washing machine goes into manual dismantling wherein we get our parts removed for reuse. Then we have shredding and then we have magnetic separation followed by eddy current separation. But what really happens in shredding? We have the reduction of size and then the shreds are formed. And these shreds reach magnetic

separation where you get ferrous scraps. Eddy currents are going to give us non-ferrous scraps and we know that using magnetic separation and eddy current separation we are going to get ferrous and non-ferrous scraps. Metal parts are totally removed just by thinking and arranging the processes in a befitting manner. We shredded, we added magnetic separation, removed the iron or ferrous scraps, then we add eddy current separation, we remove the non-ferrous scrap and then whatever is left, we have some parts of residual solids and plastic waste. Most of the wastes are already taken care of. But one has to think what is the best route for their own let's say recycling unit or industry. When we think of manual dismantling what are we talking about when we are thinking of manual dismantling?

Manual dismantling means we will be having salt waste. If we have a front-loading automatic washing machine, we can have these types of waste also, so salt waste is one of the waste that is in it, of course, this is in very less quantities but it is there, so salt waste, we have power cord, we have condensers, hose, PCBs, again the PCB is here. PCB is present in a washing machine that PCB is altogether different from PCB that is present in a computer for instance or cell phone. PCB is there in the electronic device. We need to remove it before it we just put it into a shredder because it is going to somehow interfere in the overall material recovery. Once we have done the shredding, we cannot really get a good recovery from the PCB component itself. We might get some metal out of it. But it is going to get affected or the overall metal recovery may be affected because of indiscriminate addition of PCB into a shredder directly with the overall body of the washing machine and there is the motor. We have so many components that are present salt, condensers, hose, PCBs, and the motor and this can be done by manual dismantling. This is the reason why the dismantling becomes an important task before we send our scrap to shredding.

We look at the material balance because this is also important, we have just seen a overall process but and about manual dismantling also but we do not know much about what is the material balance? We will discuss material balance. Total waste material from manual scrap, manual scrap dismantling and separation. One part of waste is coming from this end. Manual dismantling. The others will come from the magnetic separation and all. Plus total waste material from shredding and other operations. Other operations that follow that mean magnetic separation or eddy current separation. Shredding till magnetic separation and beyond we have the other fraction and there are the other wastes. Some wastes we really cannot categorize. Those wastes are also to be taken into account. We

see that 24.99 percent is from manual dismantling, 74.71 percent is by shredding and the rest is waste and when we think about what we could recover from scraps. We can just have a glance that plastics and metals have an internal division within this fraction.

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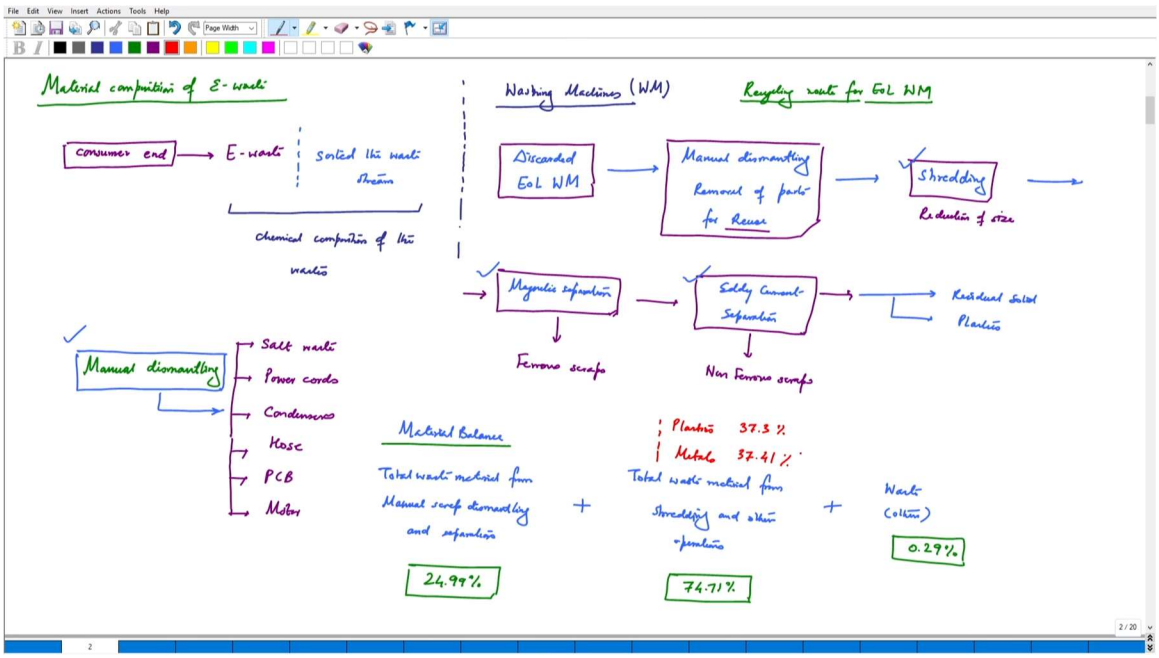

Plastics could be having 37.3% whereas metals could be 37.4% that gives us the overall composition which means, we have seen the division of metals within this as an example we see that just by looking at washing machine we see this split. Such discussion can be done for other components as well. We look at one more example of ACs, air conditioners, and then we will be then focusing into the WPCB. Let us just draw the same diagram material balance and all that we have the discarded EoL-AC which gives us manual dismantling and separation then we have the shredder then we have magnetic separation then we have eddy current separation and finally we have residual solid and plastics. Just previously we had seen what are the inputs and outputs. We'll just discuss what are the components that we see in manual dismantling. If we look at manual dismantling, what we can get is basically the CFCs.

CFC, power cords, copper pipes, condensers, PCBs again. PCBs always there, almost always there. We can have compressor or motors. We have CFC oils whatever in whatever form the CFC is present it is there and we also see what is the material balance

so we will look at that material balances again we will do the same whichever unit we are trying to explain. In most of the cases it is in mass. Total waste material in manual dismantling stage plus total waste material in shredding and other operations plus waste. We know that in this case we are going to get nearly 58.6 percent, in this case we are going to get 40.2 percent, and we have waste of 1.2 percent, something that we could not accommodate here. The division in plastics, plastics can be 14 percent nearly and metals could be 26.1. That is the division here so it could be nearly 14 and 26 percent is the division here for the shredding component of the waste.

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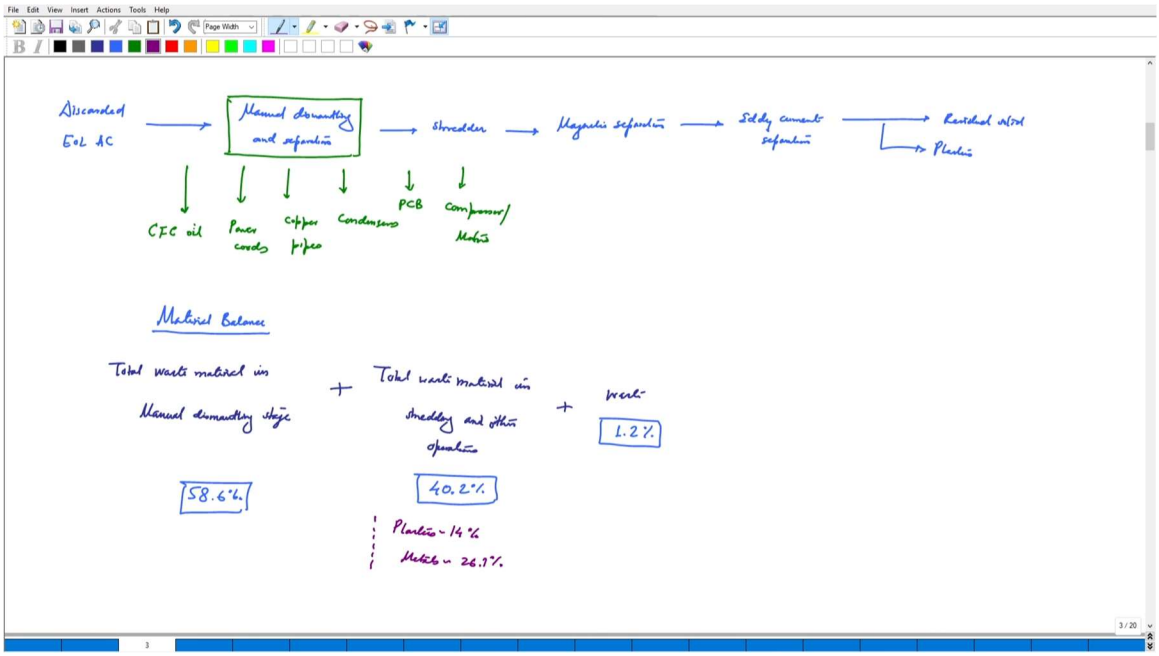

We see that there are so many different types of materials that we can recover from a washing machine or an AC and it is very important to tap those materials before even we send it to the shredder. We will be continuing this recycling of e-waste in the upcoming classes wherein we will now be focusing on why we really need to go into specific wastes like WPCBs. We will continue next class. Thank you.