Urban Services Planning
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Lecture 27
Waste Processing, Recycling and Recovery Part 2

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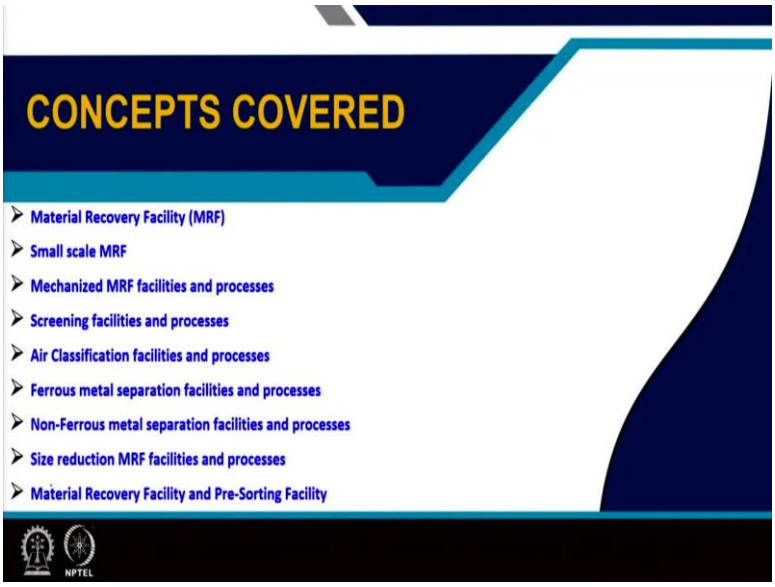

Welcome back in lecture 27, we will talk about waste processing, recycling and recovery and this is part 2. So, the concepts that we will cover are on Material Recovery Facility, Small Scale Material Recovery Facility, Mechanized MRF Facilities and Processes, Screening Facilities and Process, Air Classification Facilities and Processes, then Ferrous Metal Separation, Non-Ferrous Metal Separation, Size Reduction and then finally, Material Recovery Facility and Pre-Sorting Facility design overall.

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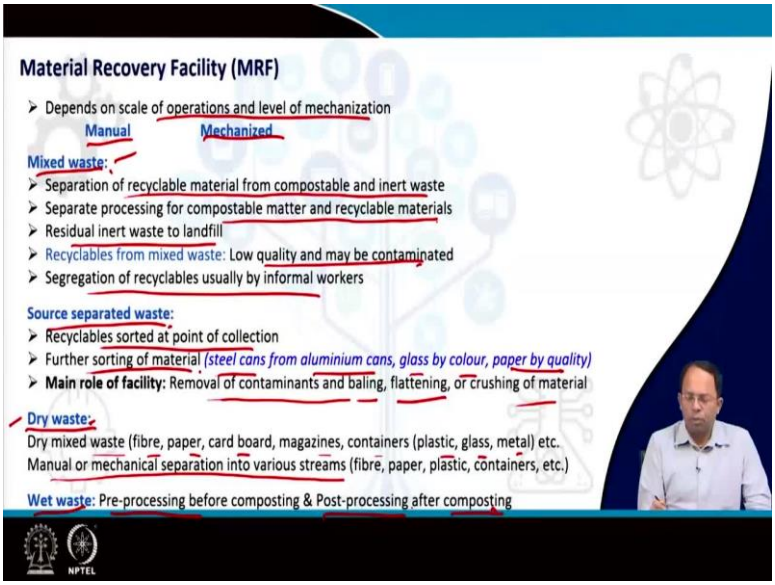

So, we have already learnt about the basics of Material Recovery Facility in this particular lecture, we talk about design of material recovery facilities and what sort of equipment and prices are being adapted. And as we have discussed earlier, depending on the scale of operations and level of mechanization, we will adopt either a manual system of material recovery or a mechanized system or it could be a mix of both manual and mechanized system.

Now, the waste that a Material Recovery Facility receives is could be mixed waste or it could be source separated waste. So, it depends the processes that we will adopt depends on what kind of waste facility receives. So, if the facility receives mixed waste in that particular case, first we have to separate the recyclable materials from the compostable and inert waste.

So, that is the first job separate processing for compostable matter and recyclable materials. So, first we have to take out the recyclable materials and the compostable materials and both goes into different waste streams, the residual inert waste goes into the landfill and recyclables from mixed waste usually are of low quality and may be contaminated and segregation of recyclables is usually done by the informal workers.

In case of source separated waste, that means the waste is already separated, the recyclable are sorted at the point of collection. So, they are automatically some amount of categorization is done for the sorting of materials can happen for example, if we have got metal sorted together, then in that steel cans and aluminium cans can be segregated in this particular facility, if glass is separated, but we have to now separate glasses by different color.

Similarly, paper of different quality or different types will be also separated in this particular facility. So, the main role of facility is to remove contaminants that means remove dust remove your sand some amount of pebbles from the waste stream, then we have to build the waste we have to shake the waste if required, then we have to make it into big bails or we have to flatten or crash the material so that we can make the packaging effective for transport to the processing facility.

So, this is only if we receive separate waste, but usually we receive dry waste and wet waste. So, that means neither we are these days we receive mixed waste, some plants do receive mixed waste, but we are trying to make our waste into these two categories dry and wet waste. So, source separation is also not done everywhere only in few municipalities they do a lot of categorization like a case of Panaji, we have discussed earlier, but usually we get dry waste and waste in case of drivers the dry mixed waste includes fiber, paper, cardboard, magazines containers, which also have plastic, glass, metal different kinds of containers.

And so, manual or mechanical separation is done for this kind of waste into different waste strips. And in case of wet waste we have we will go for composting or even biomethanation for that we have got pre-processing and also post processing that means the waste is first pre-processed usually the sorting is done to remove the recyclables in inert and other materials. And post processing is once a compost is prepared then also we have to do some amount of processing to take out some of the materials which are larger in size and then they are again taken to the landfill site so some post processing is also needs to be done.

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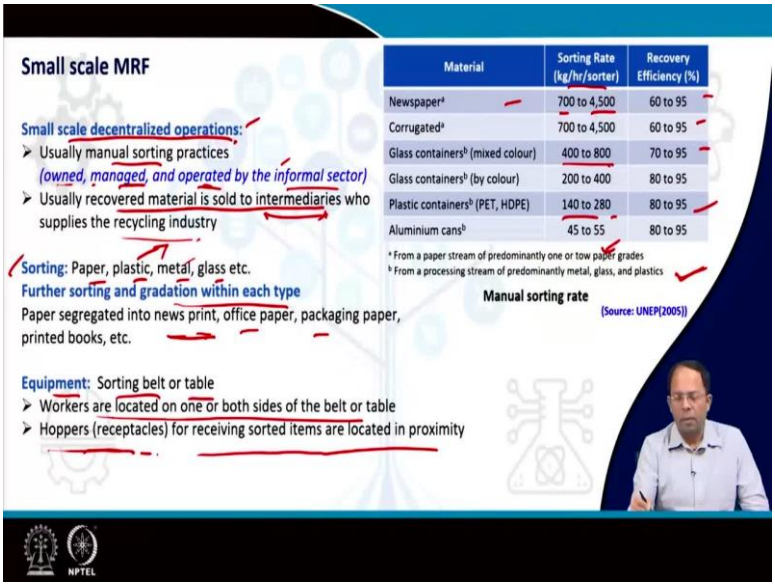

So the scale of MRF facilities could be both small as well as large so we have already discussed this to certain extent. So if it is a small scale decentralized operation, usually the operation is manual, because if you want to install a lot of machines and all the entire process will become too costly that the total amount of money that you will recover by selling the materials will not be adequate.

So, better to use manual sorting practices and also the kind of waste that we generate in India requires manual sorting, because we require because the organic production and the moisture content all this thing plays a role. So, usually this kind of decentralized operations are also owned, managed and operated by informal sectors.

So, ULB's do support by financially as well as providing space, maybe some equipment and all but usually it is owned managed and operated by informal sector. And the recovered material is sold to intermediaries who supplies the recycling industry because we are doing it a decentralized operation at the ward level. So, these operations are run by self help groups, some informal workers say they do not have those linkages with the industry at all. So, they will sell their material to some intermediary, and the intermediary then will take it to the recycling industry.

So, that is usually what we see. But of course, there could be some variations of this. The sorting is usually done at this facility for paper, plastic, metal, glass. So, these are the things which are recovered from the waste and for the sorting and gradation can be also done within each category based on what are my final end product requirements. That means if I have like paper can be segregated further into print, newsprint, office paper, packaging paper, because, if I have an agreement with a newspaper company to send the newsprint, then I will separate newsprint if I have not then I will keep all of them together.

Or similarly, if for plastic, I have got agreement with Tetra pak then I will separate the tetra packs or if I have an agreement with some metal industry like some bottling plant, I will separate the aluminium. So, it depends on what sort of agreements you have got accordingly will sort the product to different levels of hierarchy.

The equipment utilized in this particular facilities is like a sorting belt or a table. So, sorting belt is like a conveyor which carries the waste and you can take it out workers are located on both sides of the belt or table and hoppers, receptacles for receiving sorted items are located in proximity. So, once you separate the item from the waste stream some recycle you have to

put it in some container. So, that also needs to be… this receptacle stage should be nearby so that people can put them over there.

So, over here you can see a table this is not from India, but from some other country. And so, here you see that these are the sorting rates that means for newspaper around 700 kilograms per hour per sorter can be 700 to 4500 kilograms of newspaper can be recovered. Of course, this rate varies on how much amount of waste, what kind of waste we are receiving. Now, last containers it is 400 to 800 kilograms per hour per sorter plastic containers 142 to 280 kilograms per hour per sorter.

So, these are the sorting rates based on that you can determine how many workers are required. Similarly, the efficiency of recovery could be also determined from each for each of this. So, some of these things, this shows you an example. So, this could be also worked out for Indian facilities or Indian conditions depending on waste, depending on people, this kind of rates would vary, but this has to be sorted out or determined so that using this kind of your design parameters, we can design the MRF facilities.

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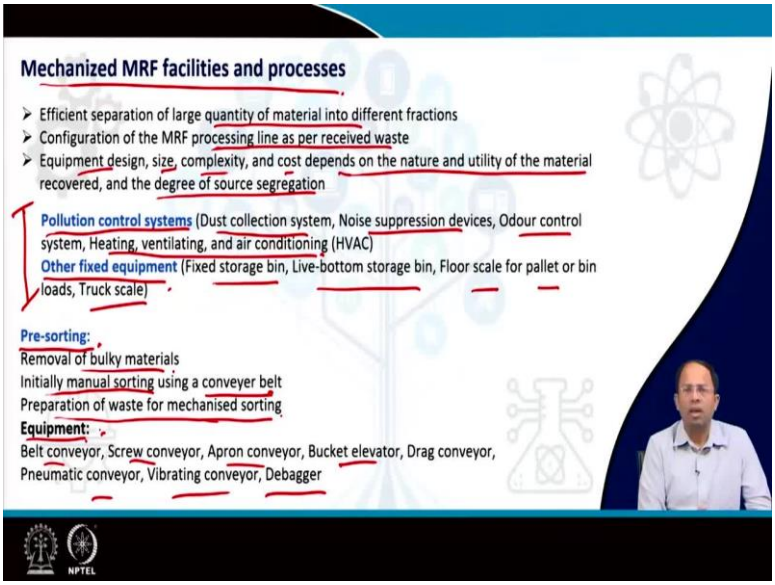

Now coming to mechanized MRF facilities and processes. So, where manual sorting is not possible, we are getting a huge quantity of waste and the waste is relatively segregated and all in that case we can go with mechanized facilities. Now, it is efficient for large quantity of material and configuration of MRF processing line is as per the receipt base based on the different kinds of waste that we receive, what kind of fractions are there for plastic paper?

What are their densities, what are their characteristics, what is the moisture content accordingly, we will be designing the overall MRF processing line. It is the industry so, if there is lot of moisture, we have to first dry it by blowing hot air. So, once it is dried up, then we can put it into a waste stream then we can separate the metals we can separate the ferrous metals by using magnets, non-ferrous metals using some other mechanisms, then we can separate the papers.

So, we have to like papers and plastics are lighter, we can pass the waste through air stream so that the lighter fractions or the heavier fractions get separated. So there are so many mechanical process that we can adopt. So equipment design, size, complexity and cost depends on the nature and utility of material recovered and the degree of source segregation. So, that means we can separate anything of course, the complexity of the equipment and the cost of the equipment will be high.

So, if I cannot recover that kind of money by selling the recyclables what is the point of setting investing so much money in that recycling equipment and all. So, of course, considering environmental cost and actual material cost, we have to consider this equipment design, the size or the complexity of this kind of processing setup. So, in addition to the facilities required for segregation and all these kind of facilities have got pollution control system and also other kinds of fixed equipment.

Now, what are these pollution control system, dust collection system, noise suppression devices, because it is an industry a lot of noises happen, they odour control, heat, HVAC systems, climate control, all these things are required. Similarly, other equipments include storage bins, light bottom storage bins, different kinds of scales, scales for pallet in the, at the industry floor or truck scales where trucks are checked for their load for the weight and so on.

So, this kind of equipment is also there in this kind of facilities along with your office spaces and all these things. Now, in any if you go for a mechanized facility, a larger facility of course, so, the first step you will find is pre-sorting. Now, if presorting we removed the bulky materials like suppose you get some large cushion or you get a large mattress. So, all these things are bulky material or even, larger plastic parts and all these things could be recovered.

So, initially, we do once a bulky materials are recovered or maybe some of it could be recovered even from using this conveyor belt as well. We do manual sorting using a conveyor belt and then we start recovering the materials. So, we prepare the waste for mechanized

sorting. So we removed the major items, bulky items and even large size items or things which can be definitely be separated out immediately.

Those could be taken out and we prepared the waste for further mechanized sorting. Then the equipment that he uses in presorting are belt conveyors, screw conveyors, apron conveyors, vibrating conveyors, pneumatic conveyors and different kinds of conveyors, some elevators, bucket elevators for lifting the waste and all, then debagger, the ones which takes out the waste from bags and also all these things are equipment that is used in the pre-sorting waste.

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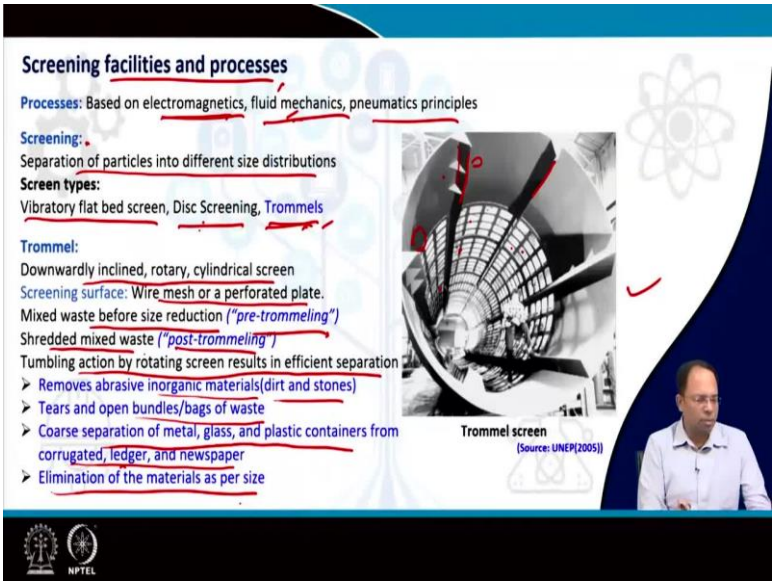

Then comes the screening phase, where we talk about screening facilities and processes, this overall processes that you will see in the, in this kind of plants are either based on electromagnetics or fluid mechanics or pneumatics that means using air or using (mag) using this air classification is by using the properties of air, which is a fluid, so fluid mechanics is involved, and based on electromagnetics, where we use magnets and all, so these are the things which we will use in different steps.

So, one of the first step is screening after pre-sorting, the mechanical stuff is screening. So here we separate particles into as per different size distribution. So screens does not understand what material what character and all it just understand materials of different sizes. So there are different kinds of screens that are used vibratory flat bed stream, disc screens and trommels we will talk about disc screens later. But coming to trommels, usually for mixed waste this trommels are found to be very, very effective in separating.

Now what are trommels, you can see this is the image of a trommels, it is a cylinder. And you can see this this kind of protrusions from the cylinder and then there are openings in the cylinder. This openings are as per different sizes that we require. So this cylinder rotates, its inclined, and because it is rotates, it will pick up garbage over in this particular protrusions, and it will pick it up and then drop it. So bags and all these things gets torn.

So, it effectively mixes up the waste and also separates the waste at the same point of time. And once it is done, then it gradually based on the size of this particular this openings the waste which is a bigger than this smaller than these openings will go out and the other is treated. So usually we can take out very small sand particles, dust particles using these kind of trommels screens.

Similarly, if we can categorize larger particles, we can say that we retain some of the larger particles inside. So those could be taken out and the rest which goes out would be further process. So that also could be considered. So it is a downwardly inclined rotaries cylindrical screen, we use wire mesh or a perforated plate the screening surface.

So this could be a perforated plate or a wire mesh. Mix waste, before we reduce the size of mixed waste for further processing downstream we can do pre trommeling or after the waste is studied there, we can also use trommels to segregate it further which is called post-trommeling. So, that means we can do trommeling even before we shred the waste into smaller sizes.

The tumbling action by diverting screen results in efficient separation and we can remove abrasive inorganic materials like dirt and stones, tear open bundles of bags of waste, coarse separation of metal, glass, plastic containers, from corrugated ledger and newspaper. So this ledger newspapers and all goes into one site based on sizes whereas glass, metal, plastic containers as per their size goes into another sites and it remains inside the trommel or goes outside the trommel depending on what design we have done.

So we eliminate material as per site. So it is basically a screening procedure based on size up materials, but it still does not understand what category of materials that has to be taken up in subsequent stages.

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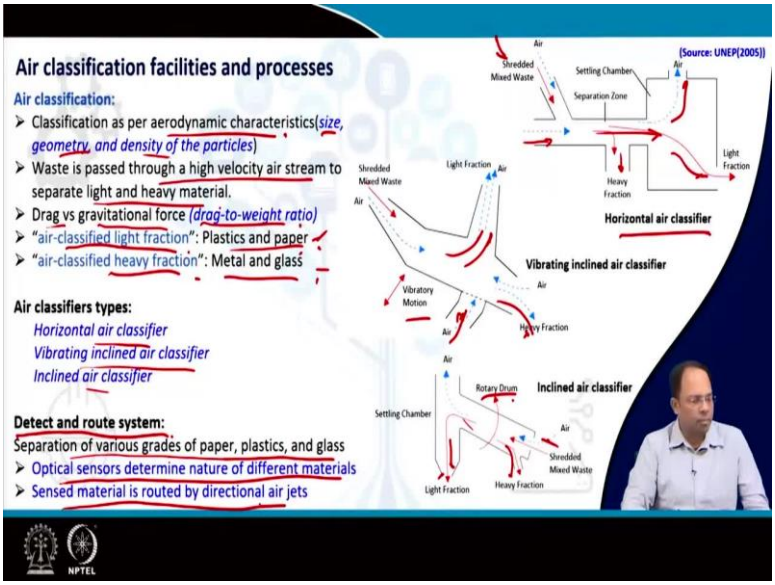

So the next is that we will talk about his air classification, here we use the aerodynamic characteristics and where size geometry and density of particles are utilized to determine what will float in a stream of air and what will not float. So, its waste is passed through a high velocity at stream to separate light and heavy material.

Now, hear the theory behind is the drag force versus the gravitational force, the air drags the lighter materials whereas gravity pulls back the heavier materials down. So drag to weight ratio is a very important factor. So, usually air classified light fraction includes plastics and paper, whereas for heavy fraction we have got metal and glass. So, that means in this stage, we can separate papers and plastic as well as metals and glass, but still you have to separate plastic from paper and also metal from grass.

There are different designs of this classifiers horizontal layer classifier, vibrating inclined air classifier, inclined air classifier and even vertical layer classifiers. So, here you can see some designs of that this is a horizontal layer classifier this is through which mixed waste goes in air is also pushed in through here. So air is also coming in like this the heavy fraction drops down whereas the lighter fraction is pushed and then over here we can collect the lighter fraction whereas the air can go out from this side.

Then this is a vibratory motion and then this is a rotary drum, these are moving parts over here. So, not only here is mixed, but we also vibrate the waste or we rotate the waste. So that effective segregation happens between this kind of waste. And here you can also see that the air goes up it carries the light fraction over here, the air is sent via this and the heavy fraction

is taken out from this particular pathway. Over here also you can see the air pushes the waste, the heavy fraction falls back whereas the light fraction is carried and eventually it falls back over here. So, this is how you classify the waste.

So, there is also your subsequent stages for this process, where we have detect and root system where we all can also separate the various grades of paper, plastics and glass. So that means not only we can separate them into these categories, but we can have subcategories as well. So here optical sensors determine the nature of the different materials.

That means once we have this light fraction, we use cameras to determine what is what and since material is routed by directional air jets that we can direct air jets to that particular material and push it out. So that is when a screen is passing, when material is passing on a screen we by optical sensor can see what is where and then it uses the air jets to push the material as per different directions in which those particular categories will be segregated.

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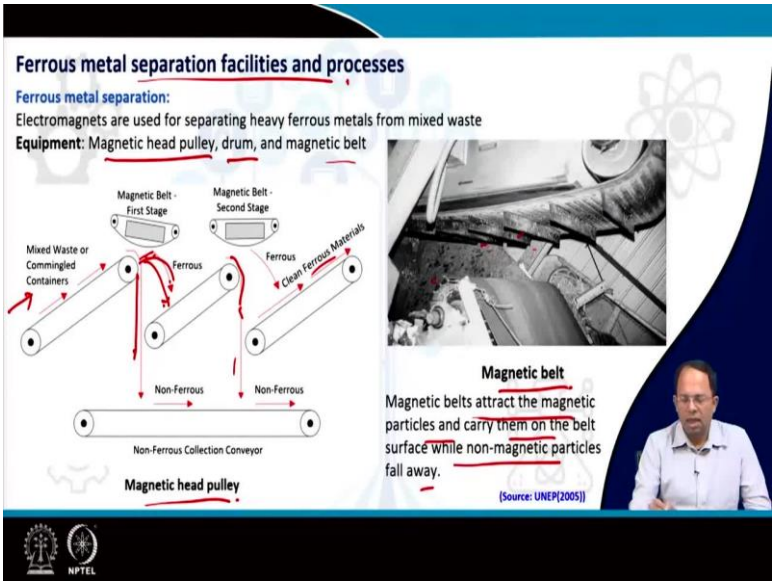

Then coming to ferrous metal separation facilities and processes. So here of course it is Ferrous, so use magnets particularly electromagnets and the equipment, there are different kinds of equipment use magnetic head pulley drums, magnetic belts and so on. So, this image shows a magnetic head pulley.

So the waste is moving around this particular pulley system or belt system you can say there it is a mixed race the magnetic, electromagnet actually keeps the waste attached the ferrous waste attached and it falls on this surface because of that electromagnetic force, it will move and then fall like this it will not move directly whereas the other waste falls down.

So this is done a few number of times and automatically you have got clean ferrous material coming out from by the side now, this image shows a magnetic belt type of equipment where magnetic belt attracts the magnetic particles and carry them on the belt surface while non-magnetic particles fall away. As you can see, this is the magnetic belt which carries on this material whereas the other material falls downwards.

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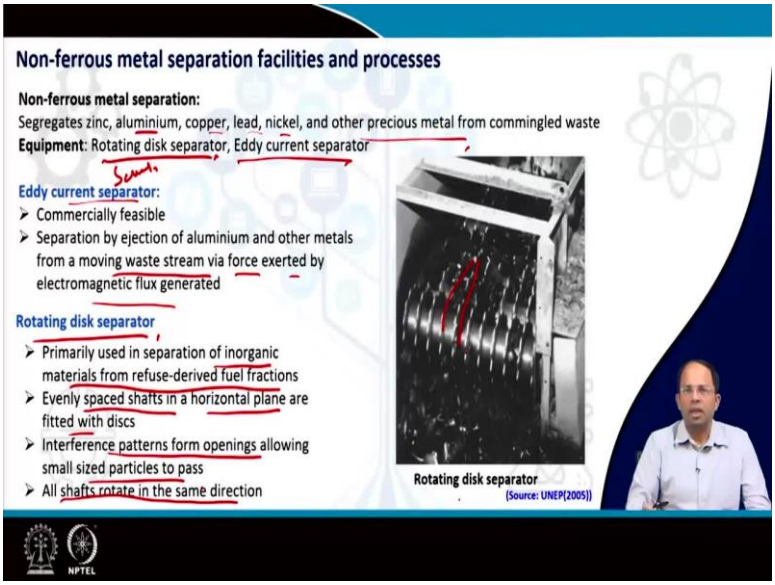

Then for non-ferrous metal separation facilities like aluminium, copper, lead, nickel and other precious metals materials where these are all commingled together as metal waste. So, here we have to separate them there are different processes for that either we can use a rotating disk separator again this is a screening system.

So, we are doing a screen we are using a screen to separate the material as per size or we can use something called an eddy current separator. Now, Eddy current separator usually what happens there are more costly processes, but these are not commercially feasible, but eddy current separator is a commercially feasible process for separating metal and what it does is it ejects aluminium and other metals from a moving waste stream via force exerted by electromagnetic flux generated.

Each of these metal generate different kinds of electromagnetic flux and that is used to separate the material. So, like you said there it is separate your electromagnet set and as part each magnet different flux will be generated and that will separate different kinds of material. Whereas, the rotating disk separator it is usually used in separation of inorganic materials from refuse derived fuel fractions, but we can also use it over here, it includes evenly spaced

shafts in a horizontal plane and these are fitted with this disc and interference patterns from openings allowing small sized particles to pass to this particular disc.

So, these are the different discs that you can see over here in this image. So, the movement of this disc happens simultaneously and within the gaps the particles pass through and all shafts rotate in the same direction and the particles will pass through this and then we can get the separated material.

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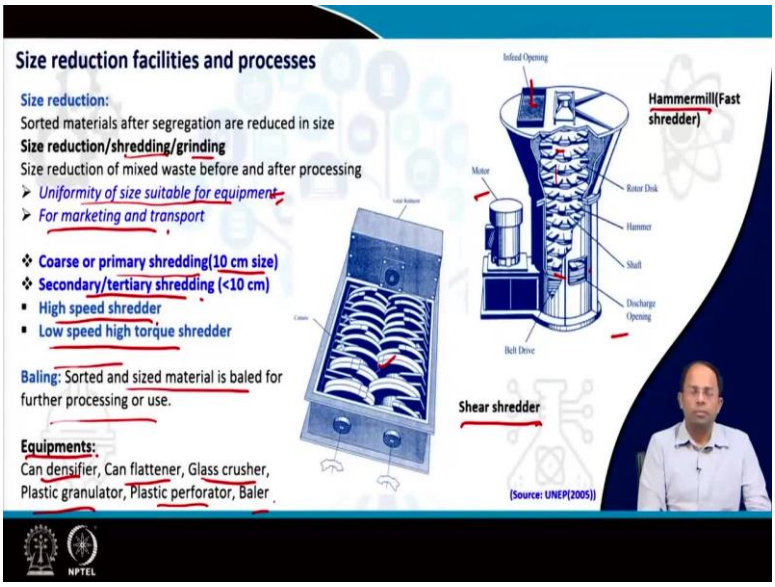

Then would finally be once the basic separation is done before we want to send it to the processing plants or to the different recycling plants and all this we have to reduce the size why because transporting large sized items is inefficient and we require larger volume. So, instead if I can shred it into smaller pieces then could be packed tightly and we can reduce the transportation cost. So, size reduction is done and it is done via shredding or grinding.

It is, so it, first of all, it makes all this size uniform for all the shredded material, which is suitable for subsequent use of equipment because all waste that goes into is uniform in size or it is also useful for marketing and for transport. So, for example, in biomethanation plants, you will see that the waste is shredded and then put into the biomethanation digester. So, that is the same thing that is if uniformity is there, then usually the processes improve.

So, either coarse or prime we can do coarse shredding which is 10 centimeter and above or secondary or tertiary setting which is less than 10 centimeters. So, that means we can you do a very coarse shredding or we can go find shredding as well.

Similarly, then we have got high speed shredders and we have got low speed shredders with high torque. So for example, this is a high speed shredders which is a hammer mill. So, you put the material from the top and you can see this kind of rotating tooths which will grind the material into this smaller pieces.

So, this is this is run by a motor and there is a belt drive which drives this entire shaft and automatically the materials are shredded into smaller pieces. So, these are these are very high speed mechanism. Whereas this is a low speed mechanism. This is a shear shredder and but the problem but here the torque is very high that means you can shred very complicated metal parts and all this thing using this kind of shredder. So it will take more time but it will eventually shredded into smaller pieces.

Once shredding is done then the next job is to consolidate them so we can use we can bale those wastes, sorted and size material is baled for further processing or use. The different kinds of equipment used in this particular phase are can densifiers, can flatteners, aluminum can flatteners, can densifies, glass crushers, plastic granulators, plastic perforators, balers and so on.

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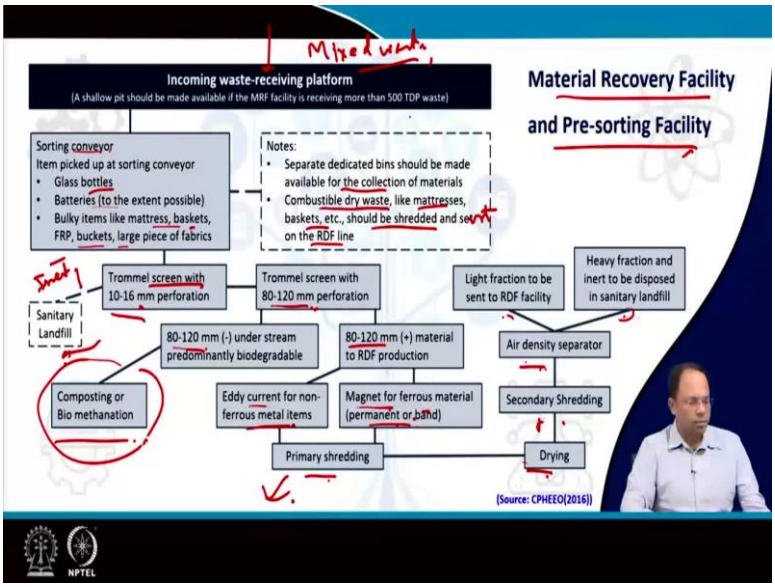

So this image shows you the broad… The flowchart or the process flowchart of a Material Recovery Facility or a pre-sorting facility. So, incoming waste first is received in our platform from where using a sorting conveyor, this is particularly useful in the context of India, you will first do manual sorting maybe glass bottles, batteries, bulky items like mattresses, basket FRP buckets, all these things could be taken out.

So, these separate dedicated bins should be made available so, that this kind of materials could be stored in there and combustible drivers like mattresses basket etc. they should be immediately shredded and then sent to the RDF line.

So, the next, once the basic sorting is done now, we can go for mechanical sorting, where a trommel screen is utilized, where we use a small operation or 10 to 16 millimeter, which will remove the inert material, maybe some sandstone tables, all these things are removed and they can be directly sent to the landfill site, then whatever remains in the trommel screen, then it is taken to a second trommel screen which is 80 to 120 centimeter perforation.

Now, the ones which are under stream that is which comes out which is lesser than 80 to 120 millimeter, this goes for composting or biomethanation. So, this is organic waste. So, of course, there is organic waste mixed in the stream then only organic waste if it is already drivers that there will not be any organic waste whatever material is above. So, this is for mix waste. So, this entire thing is for mixed waste.

So, whatever remains 80 to 120 millimeter plus size material. So, we can understand this would be your larger size material and most likely these are not organic material these are inorganic materials. So, then we would use eddy current for non-ferrous metal items, we use eddy current as we have learned earlier like we use this eddy current separators and for ferrous metal items use magnets or permanent or electromagnetic band magnets and so on. So, we can use to separate this this ferrous metals.

So, once this ferric can non-ferrous metals are separated then they can be taken to shredding where they are first dried and then we go for secondary shredding making into smaller size particles, then, using air density separator, we can have light fraction can be sent to the RDF facility or heavy fraction goes into the sanitary landfill. So, whatever is remaining out of this after removing the metals whatever remains they are dried they are shredded and finally, we separate it out. So, one part goes into the RDF facility the light fraction whereas the heavy fraction goes into the sanitary landfill site. So, this is our typical process flowchart of a Material Recovery Facility which is suitable for mixed waste in the Indian condition and this can receive around 500 tons per day of waste.

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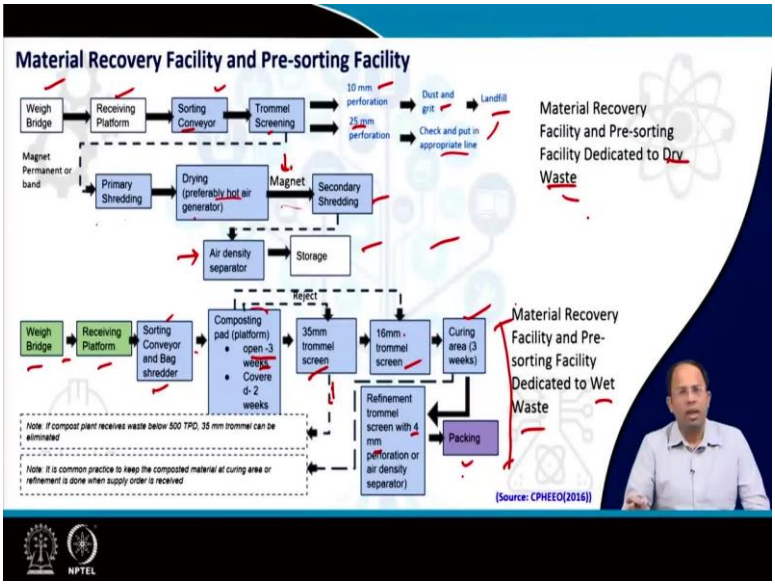

Now, if we get dry waste or wet waste separately that means, instead of getting mixed waste we are getting just dry waste. So, that means this does not have organic content. Here what we are doing first it comes to a weigh bridge we measure the waste, restored the waste in a receiving platform from there it is put in a sorting conveyor with manual sorting could be done. Once the sorted waste is then sent to a trommel screen. Two sets of trommel screen can be used the first set could be a 10 millimeter perforation, the smaller one this takes out the dust and the grit and the stones which goes into the landfill site.

These are inert waste. Then 25 millimeter perforations, these are generally the ones which are coming out of that, that means these are checked and again put back into the appropriate line we will see what material it is and then we can check it or some can even go to the landfill. The ones which remains goes for primary shredding, then we dried using hot air and then it goes then after magnet using we can separate the ferrous metals and then secondary staining using air density separator because separate in to plastic paper and so on and finally it goes into storage.

This is for dry waste, in case of wet waste same thing with Weigh Bridge, receiving platform, sorting conveyor back shredders. So, this plastic bags are shredded, then put in a conveyor belt and once whatever comes out, we can put it… We first do composting. We do it for 3 weeks aerobic composting and then for 2 weeks we can do covered composting or we can do curing of the waste as well more or less this is the composting process. We will discuss that in detail later on.

So whatever is composted, they would be put them again via trommel screen 35 millimeter trommel screen past and then a 16 millimeter trommel screen this results in larger materials which can be again sent back to the landfill site the smaller material some of it could be used as composting cover and all. So we will discuss this in detail later on and finally, whatever remains is cured and we can then pack the compost and we can bag it and we can sell it.

So, finally, before curing is done, we can again run the post processing or we can use a trommel screen again with a 4 millimeter trommel screen. So, the compost will be very fine quality compost is then taken out and then we are bagging it and then we are packing it and marketing it. So, this we will discuss later in detail when we do land composting.

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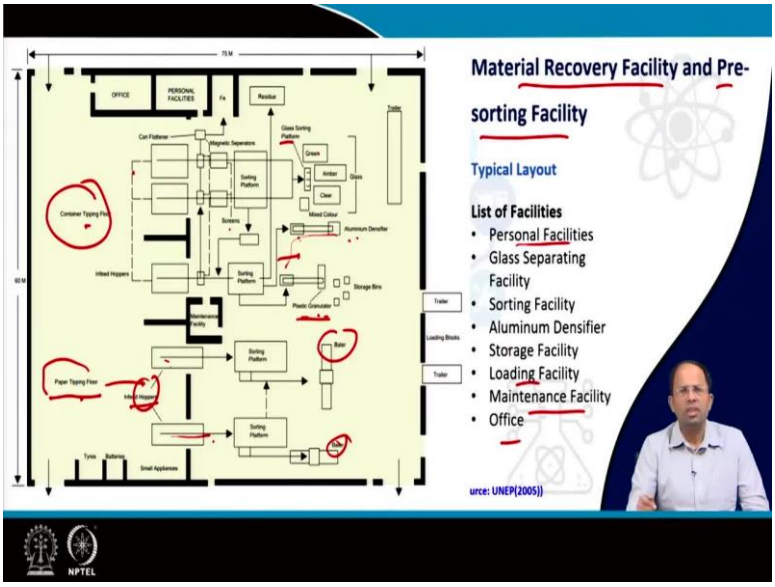

So, this is the typical layout of a pre-sorting facility sorry Material Recovery Facility or a pre-sorting facility. So, you can see that this is the place where already you know segregated waste is coming or sorted waste is coming. So, this is the paper tipping floor. So, here paper is unloaded here the containers are unloaded.

So, here my job is to separate different kinds of containers, glass container, metal ammonium container and other kinds of container, whereas here different kinds of papers are sorted. So, first we put the waste into these hoppers where the waste is loaded and from the hopper it goes into the sorting platforms the conveyor belt, this is the sorting platform. So, once the waste is sorted, we can bail the waste, we can make them into your big bales or big rectangular packs, and then we can sell it or we can transport it to the recycling facilities. In

case of container taping, you can see there is a sorting platform and this is the plastic granulator.

So, here these are the infeed hoppers and we have got magnetic separators we have got different kinds of screens and using this we can have glass segregated which is green Amber clear, these are the three kinds of glass then here we have got aluminium densifiers. So, this is where aluminium is being separated, this is where plastic granulators so, this is where plastic is being separated. So, this is the overall layout of a typical Material Recovery Facility and presorting facility. So, along with that, we have got personnel facilities and maintenance facilities offices, loading facilities, all these things are also there.

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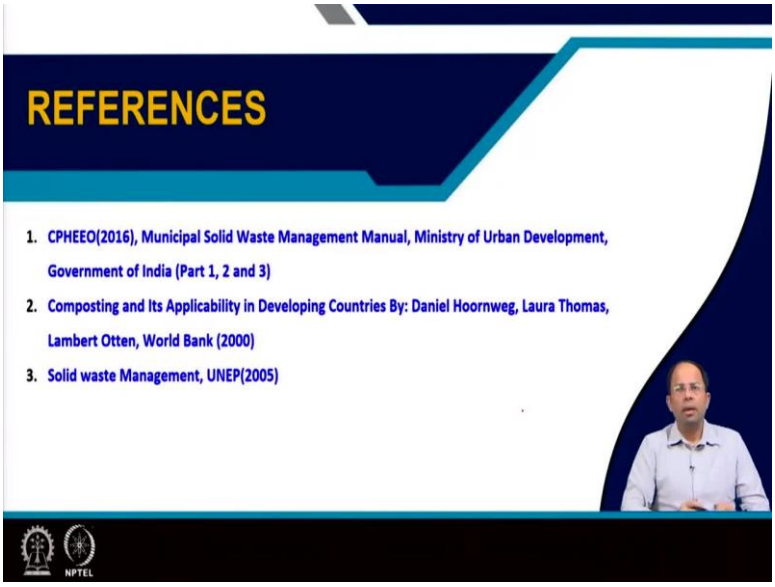

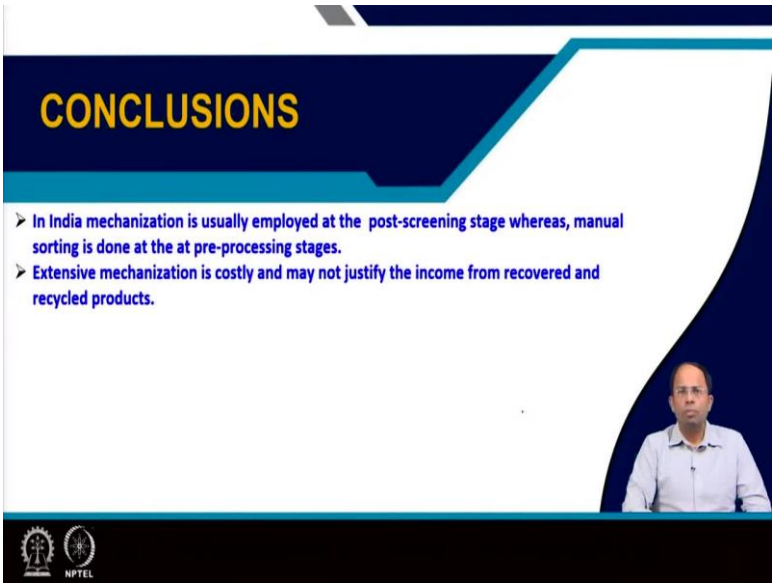

So, these are some of the references you can study. To conclude in India mechanization is usually employed at the post training stage whereas manual sorting is done at the pre-processing stages. Extensive mechanization is costly and may not justify the income from the recovered and recycled products. So accordingly we have to decide on the overall recycling or the material recovery process. Thank you.