METALLURGICAL AND ELECTRONIC WASTE RECYCLING

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Week-1

Lecture-5

Greetings, I welcome you all to the new lecture of this course and we will now be focusing on what we had started in the previous lectures. And we will be focusing on the importance of unit operations and why is this so important. The main reason is that if we are having good quality raw materials, we will be having good quality finished products and the treatment of raw materials of waste streams that we have discussed so far. The pretreatment and the unit operations that are done initially right at the beginning, let us say after sorting and classification. These unit operations hold the key to providing us better quality raw material for other subsequent processes.

So, in the upcoming lectures we will be discussing on various types of processes for different waste streams. However, at the same time it is very important to note that these unit operations that are done initially at the very beginning of the process hold the key to giving us a good quality raw material. So, previously we had discussed various types of comminution operations, crushing grinding and other operations. We will now continue on that and see how these operations help us in achieving our target. Now, we know that waste streams require treatment and by treatment we need prior treatment for upgradation.

So, that we are actually able to reach the new recycling processes. we will now focus on concentration operations, which we had discussed previously to some extent in the previous classes. So, the key idea is basically identification. Identification of the waste streams and analyzing them, analyzing the key materials. Key materials as in the materials that are worth, the materials that are worth of extraction from these wastes and what we can reuse or resell or bring back into the material cycle for economic benefit as well. So, it is not just bringing back the whole material, whole waste stream back into the cycle that would be very much beneficial but in reality, one must understand what are the key materials that can give us economic impact, economic benefit. So, analyzing the

waste stream and identifying the key materials. Now, this is also possible at an individual scale.

Task of handpicking. Now, we know that hand picking is one of the most trustworthy method of identifying the raw materials. Once we have good idea about which materials are really useful, we can simply hand pick them. So, there are some processes that would involve hand picking, but of course, we know that this is a very challenging task and intensely it is heavily labor-intensive process and it involves lots of skills to identify and hand pick the materials that are economically important and which could be brought back into the material cycle.

So, the task of hand picking. The quality of the separation is high, but we know that is very tedious operation. So, very tedious operation one should have lot many skilled people to help us in the hand-picking operation and many a times it is not very safe. Waste streams could be contaminated with very with a large variety of different waste streams which could be hazardous for human exposure. So, although it is a good way of separating it is not always recommended.

So, we know that wide range of wastes are present with the given waste stream. What this means is the chance of contamination is very large. So, we know that hand picking is not the only way of concentration of concentrating our waste stream. We can go for magnetic separation or gravity separation or frost flotation. These are some various important methods by which we can help in concentrating our waste feed and then we can work upon these finished raw materials for further recycling operations. So, we will go ahead we have magnetic separation. So, we have to some extent discuss some parts of this process. We will try and make a very simple diagram to understand how it really works.

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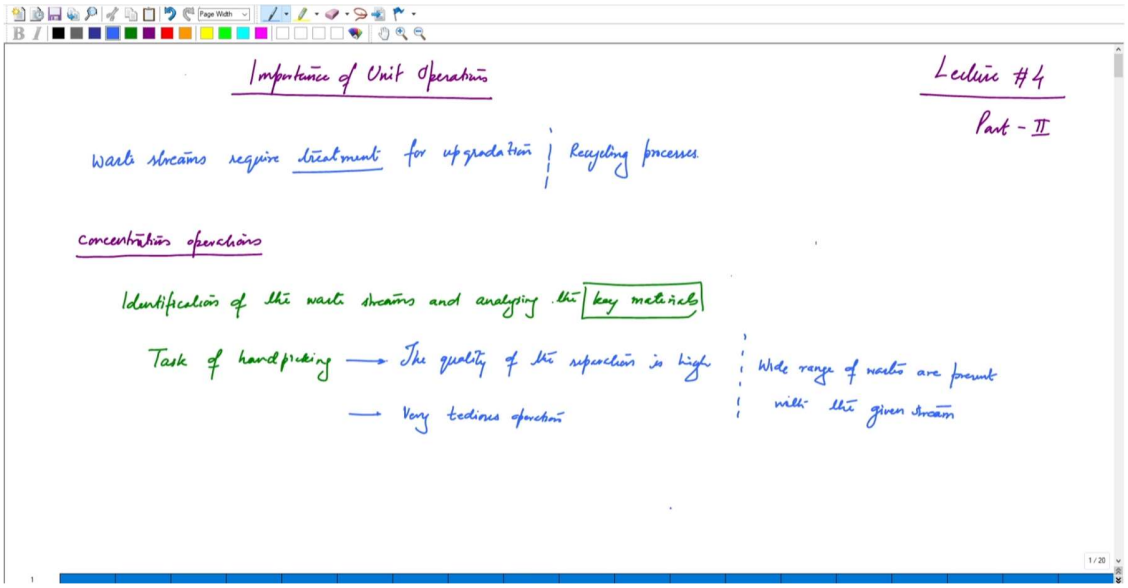
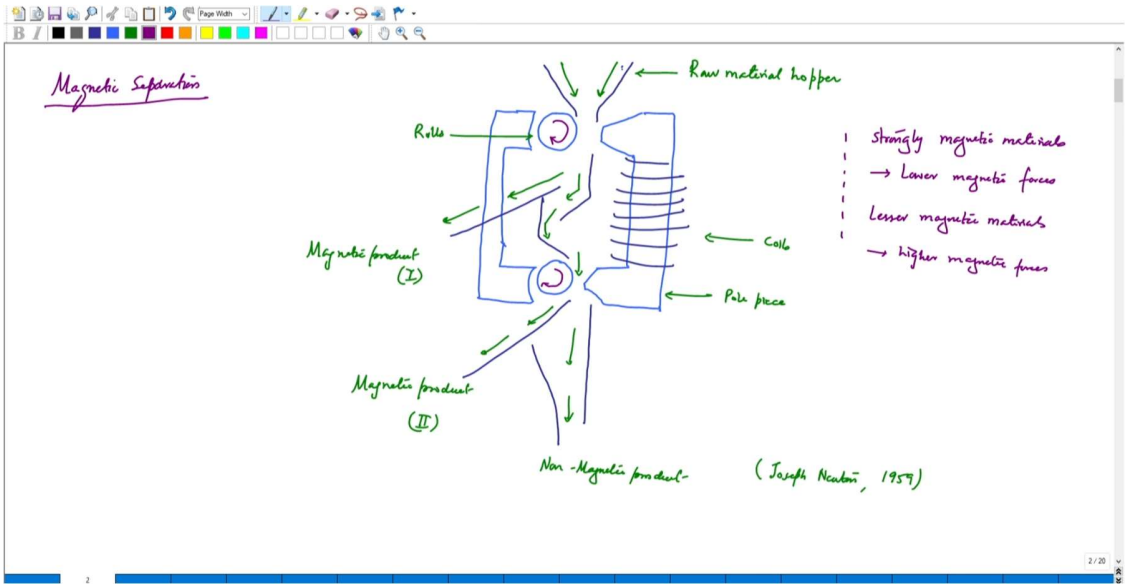


So, suppose that we have two rolls and we have a whole piece like this and we have the other whole piece like this and we have a coil that goes about like this. So, we have the coil and of course, the rolling is happening and we have various walls. So, let us draw the walls in this system we have the hopper feeding hopper first product and then we have so now that we have our schematic done let us try to understand how material flows inside it so we have the first stream of product coming in from this end and we know that this is the raw material upper this is our pole piece these are our coils, these are our rolls and what happens here is when it first comes down first set of magnetic product, magnetic product 1 is generated just after the first roll, but what happens if it is not getting completely removed? The rest of it comes down here and then we can have second product. So, we have magnetic product 2 and we have finally, the non-magnetic product. So, we know that this is a very simple diagram that describes how magnetic separator really works.

So, we have the raw material coming in, we have different rolls into which these this raw material is coming into and then along with this roles and the magnetic field that is around it. Different fractions of materials are separated based on how they are behaving towards the incoming magnetic field. Now, what we see here is we have different products magnetic product 1, product 2 and non-magnetic products. This is fairly important in separating out the magnetic materials the materials that the metals that behave to different magnetic fields of different intensities. So, the susceptibility how they behave to different magnetic fields is what we are expecting to target.

Now, what we know is strongly magnetic materials would require low intensity because they are already behaving, they are already magnetic materials. So, would require low magnetic, lower magnetic forces or lower intensities. And high intensity magnetic forces would be used for lesser magnetic materials, lesser And of course, this could mean that we will be using high intensity magnets or electromagnets. **(Ref. 13:30)**



So, we will now continue on the separation and we will see another device that could be used. So, we have electrostatic separator. We will draw schematic of electrostatic separator. So, first of all we will have and then we need a pole piece. So, this is a fairly simple diagram that shows the separator and we have a comb electrode here.

We have and of course, we need from the center we need separating zone. So, this is our separating zone. separation zone. What really happens here is we are feeding this separator with fine, very fine raw materials and based on the electric fields that are generated here and the magnetic fields these are getting separated into various fractions. We will see how.

So, suppose that we use different colors, magnetic as well as non-magnetic. So, we have the non-magnetic material getting collected in bin 1. The magnetic material gets ejected right in this bin and some of the materials that behave that are partially behaving in between would be collected in the second bin. So, if this is bin 1, this is bin 2, bin 3 then we have 1 is non-conducting.

Second one would be middlings. Middings would be carrying out both the types of materials and the third would be conducting. So, it gets ejected very easily because of the effect of the comb electrode. So, comb electrode provides the charge and it gets ejected very easily. So, since it is getting affected, it is getting ejected.

The other materials that do not feel the effect of the comb electrode these get still stuck and we also need a scrubber at the end because of course we need a scrubber so that it gets ejected. So, we have a scrubber scrapping it helps in removing, scrubbing the removal of the material that is still stuck to this separator. So, that is getting ejected in bin 1. Middlings are those materials that are coming in the between.

So, some of these middlings will be conducting some of them will not be conducting, but then it is fine we have different we cannot really have clear cut division of conducting as well as non-conducting that is why we have the middling bin as well. So, this is one another way of making our material concentrated. Now, one of the key problems with both of these processes magnetic separation as well as electrostatic separator we the most important challenge is the feed size, the feed size of these processes is very less which means ideally they would ask for a particle deep thick raw feed which is very difficult to achieve of after commutation we can have wide range of particles.

And of course, we can try and reuse the coarser particles for further communication and bringing down the particle size. But achieving a very fine particle size is going to require large energy, large scope of working on the grinder unit. because it would require the reinsertion of the finished product back into the raw material so that finer and finer fractions are achieved for separation into the for separation using the magnetic separator or the electrostatic separator because the feed size itself is very small and this is the first disadvantage and the hourly tonnage hourly tonnage means basically the production the hourly tonnage of the process is less.

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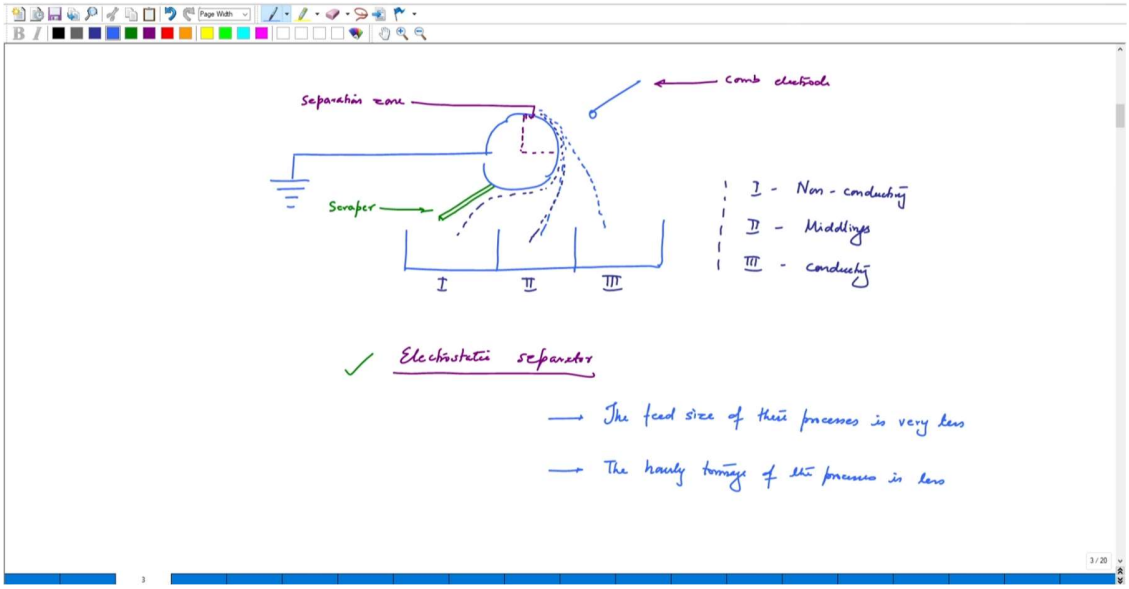


Since, you are consuming very fine particles the feed that can be actually provided for efficient removal also goes down. So, the feed size is a constraint and the amount of feed that can be used in the early tonnage is also a constraint which is why magnetic separators may not be useful when you have larger sample size, larger feed size and larger quantities. Now, the next process that we can discuss and we have started in the previous classes as well is jigs. Now, these are essentially going to handle particles that are up to 2 millimeter. So, nearly let us say 2 millimeter diameter particles. Of course, larger particles can be taken up, but at least 2 millimeter diameter is what is expected. So, we have beds of ores or raw materials and they are sitting on a screen. So, we have screens that have these beds of ores and all of this is underwater.

Now, what happens is partial suspension, this is the assembly actually, this describes the assembly of the jigs. So, we have bed of ores or raw materials. In our case, it is basically the waste stream sitting on screens. And these screens are underwater. What happens is we have partial suspension.

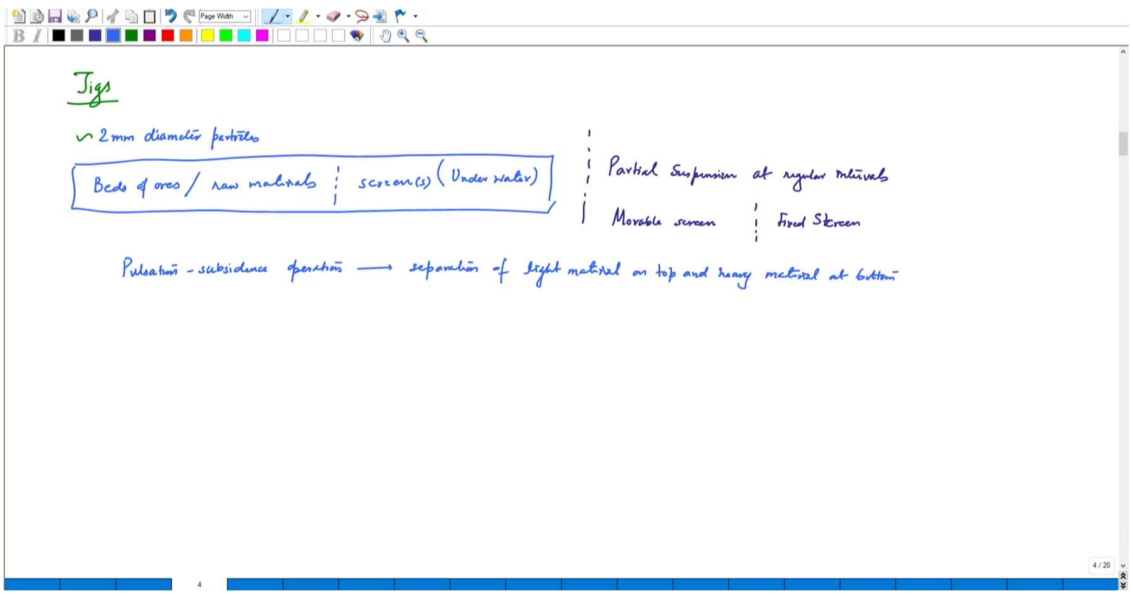
Partial suspension at regular intervals. So, we have suspensions. How does it really work? What can happen is the screen itself can move or if the screen is stationary, we can have jet of water coming in from the bottom, the stream of water coming in from the bottom so that the bed itself starts to vibrate. So, what it does is basically there is a screen.

What jig really means is there is a screen. We have bed of raw material sitting on top of it and whole system is underwater. Now, either the screen itself should vibrate or water

inside, if the screen is stationary, the water inside should be pumped in such a way that the ores start to, ores or raw material starts to vibrate. And this is systematic and rhythmic. So, one set of motion and the raw material is allowed to settle down.

Then again, and this is basically periodic. When this happens, we know that the ores will get readjusted based on their densities and how they behave in a medium. And in this case, the medium is water. So, we have just discussed, we will either have a movable screen or we will have a stationary screen, constant stationary or fixed screen. So, we will have a movable screen or a fixed screen.

And the pulsation, how really do we describe this? Pulsation and subsidence operation is done, this pulsation and subsidence operation is done for separation. What it does is basically separation of light material on top and heavy material at bottom. So, we have a light material coming on top and heavy material at the bottom and this helps in the separation of the various raw feeds. So, jig is moving either jig is moving or the water is being pumped and we have the separation of the light material and the heavier material from each other and they get settled based on this stratification and what is continuously done is feed is being charged and light materials that are getting settled are also being removed. So, the jigging process is a continuous process, it is not that one set of feed is provided and it is to be continued, it is a continuous process. So, light separated materials are removed and fresh feed is also added so that the jigging process is continuously done. Now, we will move on to the next method of concentration. **(Ref. 25:33)**



We will have the concentration tables. This also we had discussed previously. Concentration tables. So, in this we need to have, we need to first understand what it really means. So, we have a long table and along the length we will have riffles. Riffles are basically the wooden strips.

So, the design of this table is such that we can have riffles either on the almost whole of the table or partially these riffles can just vary in length. Now, these riffles are normally arranged along the length in which the table is designed and there are mechanisms of including water. So, what happens is the if riffles are arranged along the length, the flow of water is done across the riffles. Now, feeding is done and the longest riffles are usually on the feeding side. and the width starts to gradually go down on the product end.

So, what happens is when we are feeding the raw material these tables are shaking toward in the direction of the refills itself and water is being charged. So, there are two forces that are normally observed when we are seeing the concentration shaking tables as we call them tabling process shaking table. So, the table itself is moving and there is the flow of water. We will see how really the particles are getting separated out and how we are getting various types of feeds in this concentration tables.

So, we know that there are riffles Riffles are basically wooden strips. And of course, this table is basically lined with linoleum. So, these riffles are present. They are normally parallel, parallel to long dimensions of table.

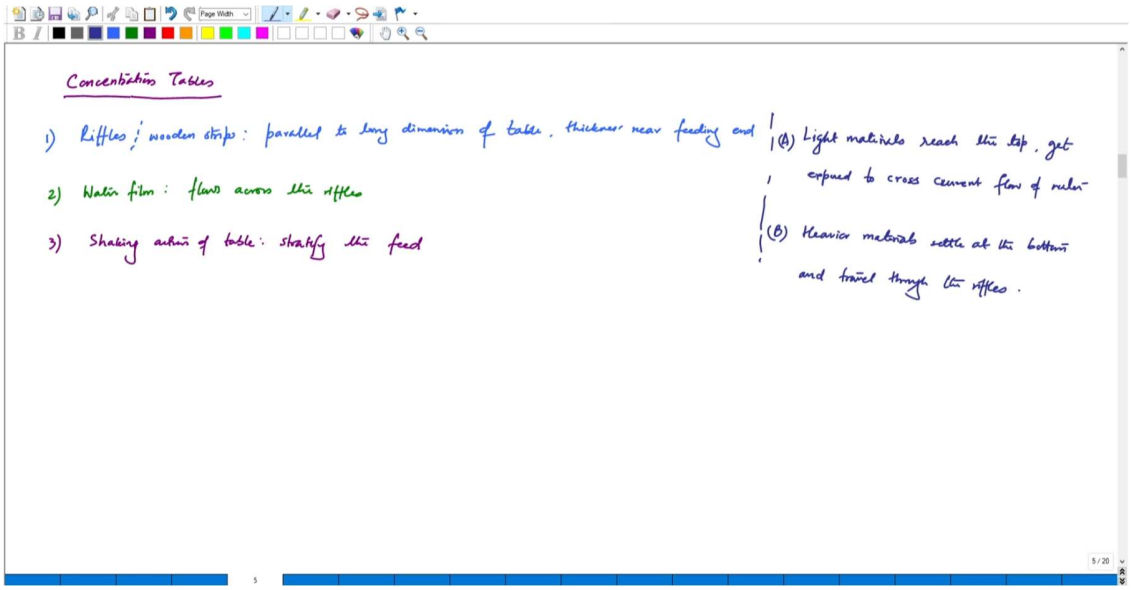
So, along the length, these are arranged thicker near the feeding as I have just mentioned, thicker near feeding and of course, it will gradually taper down at the other end. Water film, how does really water film flows? Water film, it flows across the riffles, flows across the refilles. And the third thing, that is point one is there are refilles.

Point two, there are water. There is water stream. And the third most important, the table itself is shaking. Shaking action of table. What does that do?

This vibration causes the feed to stratify. This is basically going to stratify, stratify the feed. And what really happens here is in all of this, due to all of this, what really happens is light metals, light materials reach the top, top of what; the flowing water and they get exposed. These materials get exposed, get exposed to criss-cross, the cross current flow of water.

So, the light metals reach the top and they get exposed to the cross current. Because the table is moving in one direction, the materials, the light materials tend to tip off and they

get carried away with the counter current, the cross current flow of water. Whereas this is fate 1, option A. The other option is if the materials are heavy. So, heavier materials settle at the bottom, settle at the bottom and travel through the riffles. So, based on what do we wish to separate and whether these particles have variety of densities. **(Ref. 31:00)**



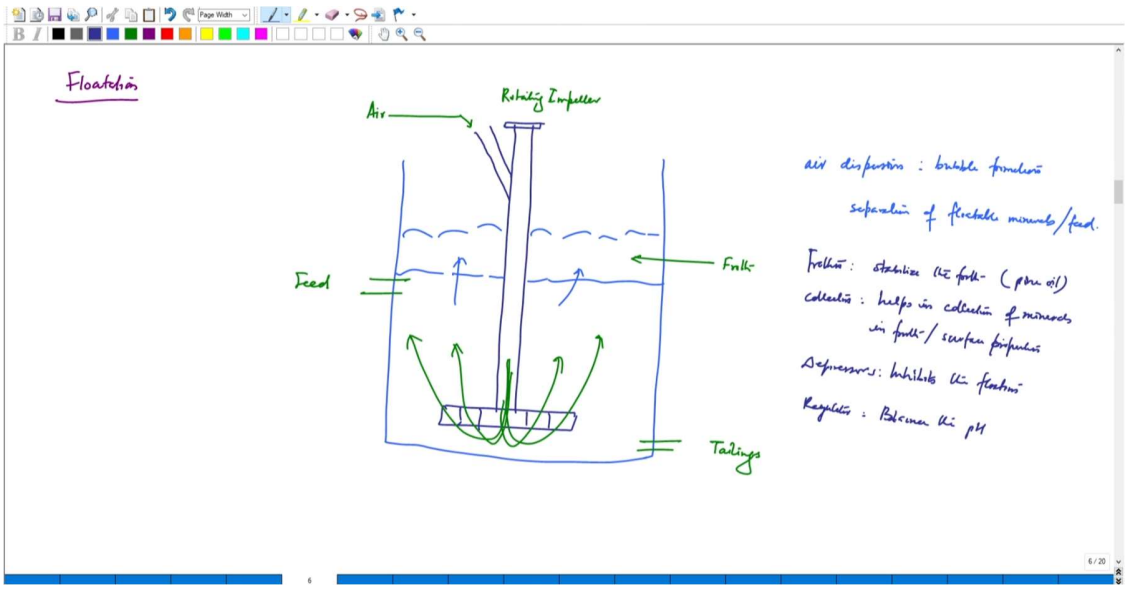
The shaker table is an amazing device that helps us in separating out these different particles one from the other. The last and one of the most interesting routes that we would be discussing now is flotation for which we would be needing a diagram. So, let us just quickly draw. This is a simplified diagram of flotation tank where we will have an impeller, rotating impeller. We have the input of air and gradually we will see the flotation process.

What really is happening? Let us just describe this. Tailing will have feed. Air supply and we have the rotating impeller and this exactly is froth so what we are discussing is basically the froth flotation process which you must have come across if you have done a mineral ore beneficiation course so now what really is happening is this impeller is pulling out air and we have feed materials that are already fed into the bath. So, what really is happening here is this impeller is pulling out air and it is charging it into the bath. And it's rotating. So what happens is the air bubbles are generated and these air bubbles are picking up the raw materials along with them and reaching at the surface. Now what happens at the top is these bubbles are not normally stable.

So, we have different types of raw materials that are added onto this bath so that the froth itself becomes stabilized. What this process essentially does is it helps us in separating out specific type of phase. So, normally it is used for sulphide ores but at the same time we can think of using it for separating out various different types of phases that are present in the raw feed. So, air dispersion, we will just quickly write air dispersion. Air dispersion is done for bubble formation and floatable minerals reach at the top.

So, if it is going to float, it is going to reach at the top. So, if there are no floatable minerals, they would not float and they will eventually be removed in the non-floatable end. What are different raw materials? Of course, bubble formation is there and there is the separation of floatable minerals feed. So we have different four different categories of materials, frothers, frothers basically stabilize the froth.

We have collectors which basically helps in collection of minerals in froth by basically changing the surface properties. Depressors basically inhibits the flotation and then there are regulators which basically balance the pH. So, where we have different types of materials that help in doing this. We have pine oil as a starting frother material that is very commonly used. We can also have xanthates as collectors, depressors we can have NaCN and for regulators we can use Na_2CO_3, sodium carbonate. **(Ref. 36:40)**



So, these are different types of raw materials that can be added onto this bath to make the whole process more efficient and these are the processes that are essential as unit

operations for separating and concentrating our feed and as we had discussed we wish to have good raw materials for good, finished products. These operations are absolutely essential for this. We will continue in the next class. Thank you.