Introduction to Mineral Processing
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Lecture - 60
Flotation Machines (Contd.)

Hello welcome, so we are discussing about the flotation and this is the last lecture on flotation. So, we are talking about the cell design that is the bank of cells. So, this is a schematic of a flotation circuit.

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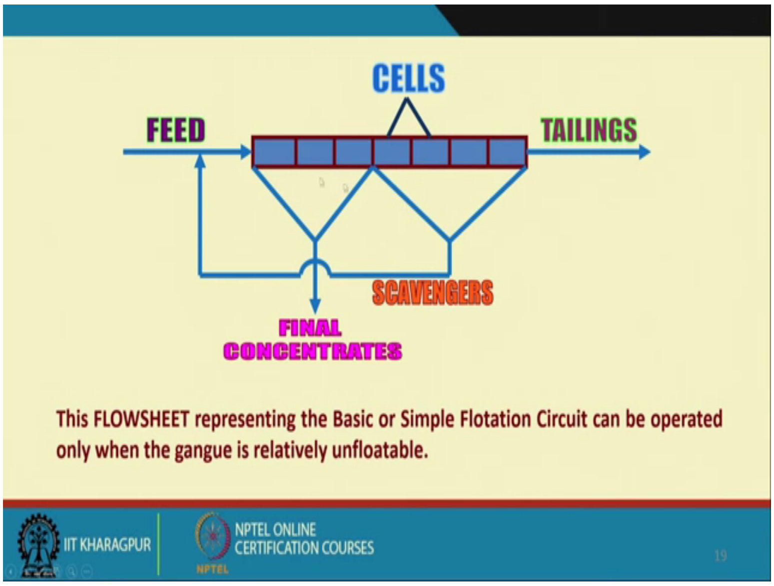

So, the feed enters here, as I suppose these three cells are called it as the say suppose you are getting a concentrate, and then what you are doing; whatever you are basically removing, you are saying that this is a your tailing, but you are not sure that whether you are losing some of your wanted materials with that or not.

So, you have some other cells kept for that we call it scavenging and you try to again ah float them give them an opportunity to be floated. And the materials which are floated, again they may not be that selective because you may be floating some of the unwanted materials also. So, that is called the scavengers; and you mix it with feed and whatever is still in the sink we call it tailings; that is the final tailings. So, if you are understood clearly the closed circuit grinding process, it is analogous to that; that is you try to break the particles to a particular size below particular size, but you are not sure that whether the entire particle are broken below that size limit.

So, you have got a classifier normally the hydrocyclone classifier you are using, and the hydrocyclone overflow you are very sure that these particles are finer than; what I needed. So, we just send it to another circuit, that is your final product of your say grinding circuit, but the cyclone under flow that you are again recycling back with your fresh feed that is called a closed circuit grinding process.

So, it is like your closed circuit floatation process, that the first one you have taken out your concentrates and is the easily floatable materials, you are very sure that they are your concentrates and next one whatever is the tailings, I want to recover much of my lost materials, that is your wanted material, which are being lost in the tailings.

So, I do not want to use it as a called as a tailing like that; so I use another bank of floatation cells; that is called as scavengers. So, the final after that whatever is the tailing that is my final tailings, but the scavenger floated fraction may not be having that high grade as we got it in the first stage. So, I want to first again purify it, so I mix it up with the feed. So, this depends this is not a fixed type of your design, it can vary I will show you in due course of time.

So, it depends on the characteristics of your material, it depends on your; the response of that material through the chemicals you have used and the cells you have used in the laboratory and the pilot plant scale, but for some general guidelines I will try to show you that, your the froth column and the first few cells is kept high and if the material has to be transported automatically. So, why do not you use the gravity. So, what is being done that the froth column in the first few cells is kept high, since there are plenty of hydrophobic particles to sustain it ok.

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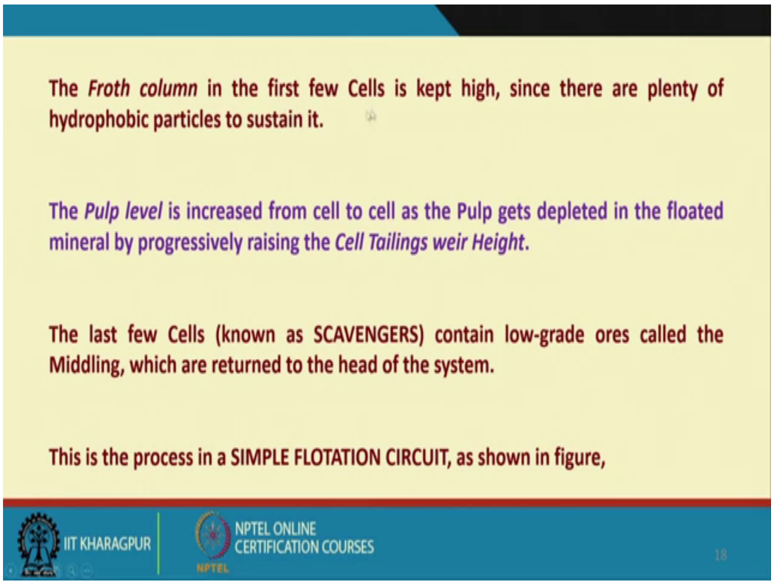

And you have got plenty of materials coming in. The pulp level is increased from cell to cell as the pulp gets depleted in the floated mineral by progressively raising the cell tailings weir height. That is the froth height will be lesser and lesser as you go down.

How you control it; that is by the way our height by arranging that. The last few cells known as scavengers contain low-grade ores called the middling, that is you have a mixed of your say wanted and unwanted materials and they are returned to the head of the system, because the middlings may not be of any use. But you cannot afford to lose that much of wanted material as along with the tailings. So, this is the process in a simple floatation circuit, as I had shown you that is the cell, which I had shown you before. So, this is the simple floatation circuit.

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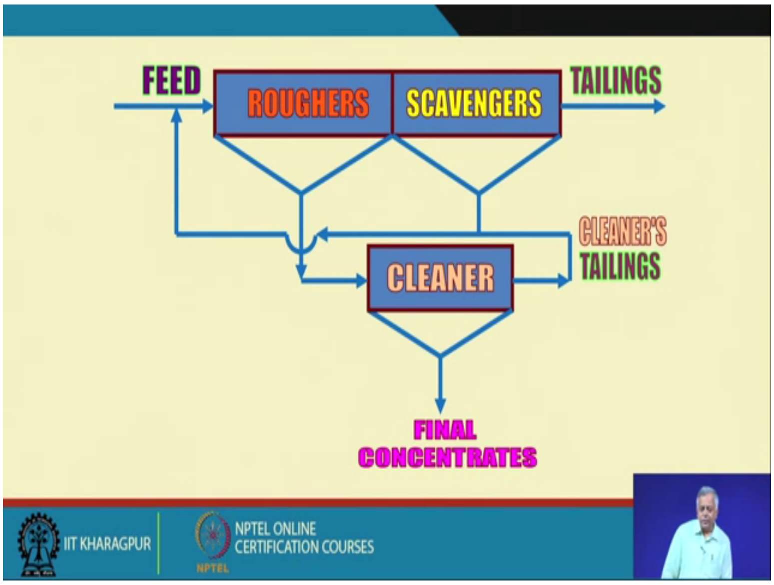

That could be another way of doing it; that is the arrangement could be different like the first cell we call it rougher's; and in the rougher whatever concentrate we get that is I will put it into a cleaner stage. Why it is required? Though the rougher what I have used; and is I wanted to separate out losing a certain degree of selectivity of all the hydrophobic minerals. Now, all the hydrophobic minerals, as I said losing certain degree of selectivity; now I have reduced the bulk of my material.

So, I am with the froth product is giving me most of the hydrophobic minerals along with some entrained particles and all that. So, I want to further upgrade this quality of that product, primarily we try to get rid of my entrained particles and I want to, but the volume has been reduced now; and I am very sure that we do not have much of hydrophilic materials into that.

So, that is called the cleaning stage; and in the cleaner stage that is also again a floatation, but this is a much more controlled one much more selective one and then we get a final concentrate. The rougher's that material which I have got it as a sink there also I may have lost some of my wanted materials. So, they that I send it to a scavenger, and in the scavenger actually; whatever I am getting that is the middling and that I am mixing it with the fresh feed. And the scavenger what is the final tailing I am getting that is the final tailing, but this is the some part is the cleaner tailings also that is your cleaner also I get a tailing also that is the cleaner tailing.

But as I said that from the rougher, I have separated out all my hydrophobic materials. So, here the target is like you collect all your hydrophobic minerals, without being selective that; whether I need that material that hydrophobic mineral or not. And after that at the cleaning stages, your change maybe reagent dozes or maybe the reagent maybe the frother maybe the other things and then you finally, ensure that only the targeted hydrophobic materials are basically collected as a final concentrate.

But, doing that you are not very sure; that whether the cleaner tailings I could take I could recover all my wanted hydrophobic minerals not. So, to ensure that, I again recycle back with the fresh feed; same thing we do it to the scavenger, but the scavenger tailings is the final tailings and scavenger concentrate is again mixed with the fresh feed. The advantages of doing this, like in a rougher I can use a very low cost chemicals, which may not be that selective to your wanted material, but it will create the material surfaces sacrificing a bit of selectivity the hydrophobicity.

So, what you essentially you are trying to do? You are trying to reduce the bulk of your material, which are floatable. So, that I need some costly chemical in the cleaner stages, and I can reduce the consumption of my chemical, and I can have a separation the overall economics is much more favorable and this is what when mostly this type of circuit that is your rougher scavenger and cleaner is being arranged in this way. So, these are only the examples of the different your floatation circuits.

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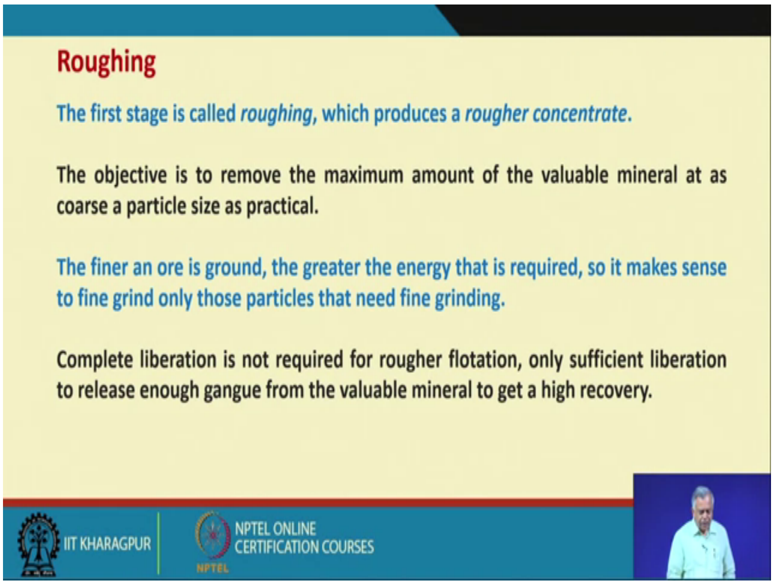

So, the roughing as I said is the first stage is called roughing, which produces a rougher concentrate. The objective is to remove the maximum amount of the valuable mineral at as coarse a particle size as practical. The finer and ore is ground, the greater the energy that is required, so it makes sense to find grind only those particles that need fine grinding; that means, says suppose I have got only 1 percent copper in my copper mineral. So, I want to use a flotation process and I have seen that the liberation size is say suppose below 40 micrometer.

So, if I want to grind the entire material to below 40 micron that will consume lot of energy. But, if I find that; if I grind them to a size of say suppose 70 micron, the material which I lose as tailings is not much of having not much of copper bearing minerals. So, the issue is many times it is being engineered in such a manner, that first you grind it to a 70 micron and try to float all the 70 micron particles, which are hydrophobic; that is the copper bearing minerals.

So, you can reduce the bulk of the material and you can use much lesser amount of chemicals, because they are coarser sizes; so your surface area is much less and as the surface area is less, because they are coarser, so your chemical consumption also will be less. Next stage you may grind it now to below 40 micrometer, so that they are appropriately liberated, but you are handling much lesser quantity of material and you can use a costly chemical and to get the final concentrate.

So, the finer an ore is ground, that is what it is written that complete liberation is not required for rougher floatation that is what I said; that your complete liberation may be at 40 micron, but you may do it the roughing at a 70 micron size. Only sufficient liberation to release enough gangue from the valuable mineral to get a high recovery; that means you just ensure that your gangue materials are removed.

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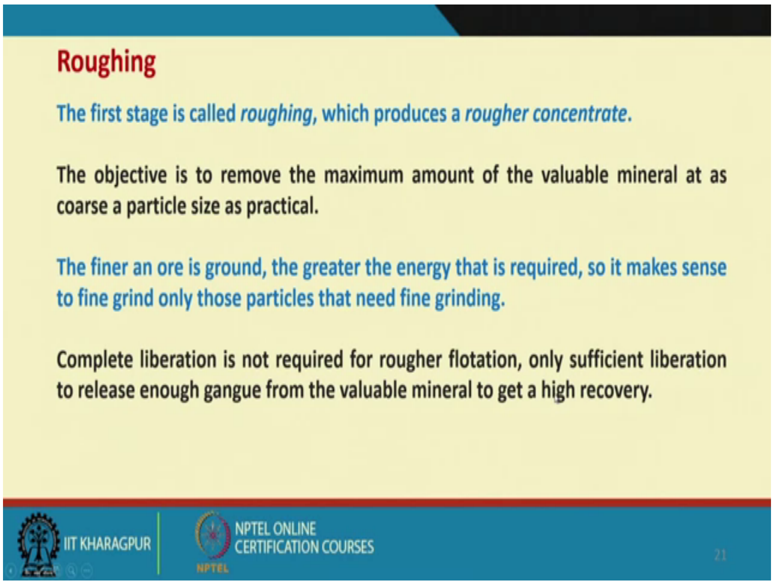

Now, at the 70 micron particles your sizes you may have association associated your attached gangue and your say copper bearing minerals.

But, if you have a higher proportions of free gangue particles, which is quite possible it makes sensible it makes sense, because when you have only 1 percent of copper in that; you will be having many more particles which are completely gangue materials does not have much of your copper bearing minerals, why do not you separate it out at a coarser size? So, that you can reduce the cost of your energy for breaking the entire material to finer sizes.

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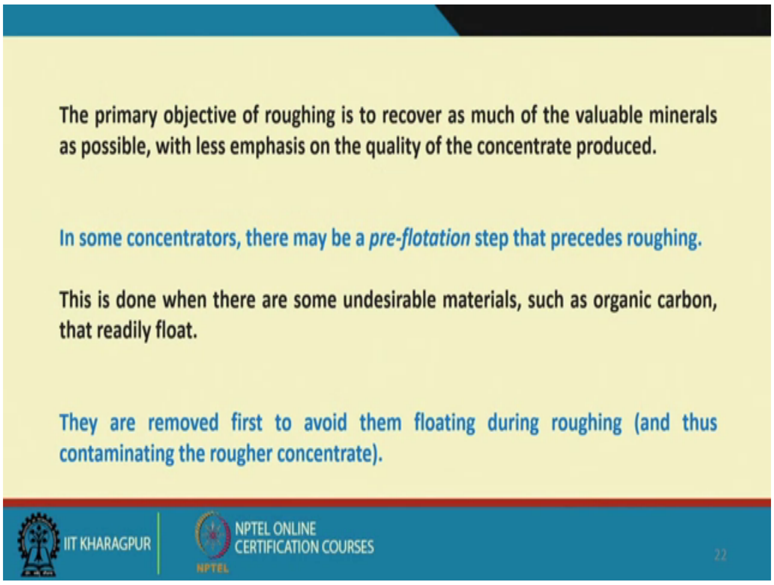

The primary objective of roughing is to recover as much of the valuable minerals as possible, with less emphasis on the quality of the concentrate produced, but what we should emphasize; that we should not lose my wanted material, that is the your hydrophobic material.

In some concentrators there may be a pre floatation step that precedes roughing. That is even before the roughing also you can have a pre flotation step. This is done, when there are some undesirable materials, such as organic carbon, that readily float. They are removed fast to avoid them floating during roughing and thus contaminating the rougher concentrate it is very interesting.

So, there is no hard and fast guideline, I cannot give you a hard and fast guideline that for this copper road you should go for this chemical and it should be your strategy. Entire thing I am reiterating it that it should be driven by your material characteristics, whether it is flotation, whether it is gravity concentration, whether it is combination anything.

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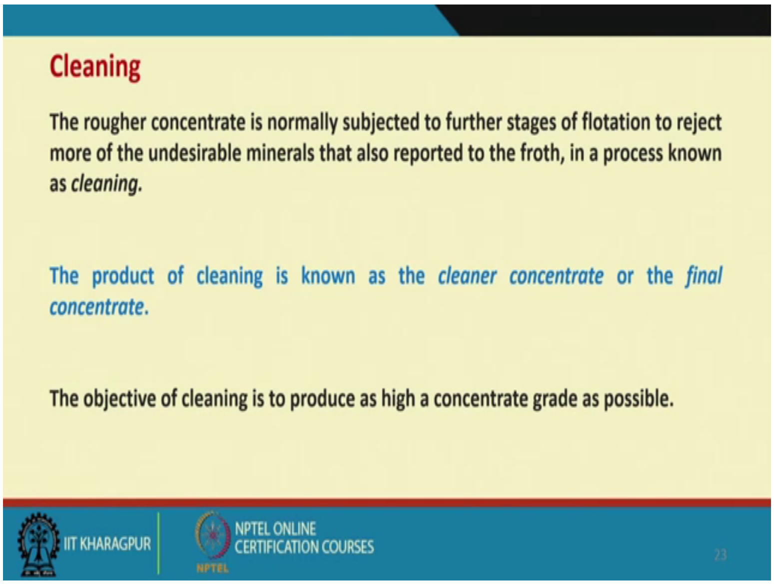

Now, cleaning stage; what is the purpose of this? The rougher concentrate is normally subjected to further stages of flotation to reject more of the undesirable minerals that also reported to the froth, in a process known as cleaning. The product of cleaning is known as the cleaner concentrate or the final concentrate. The objective of cleaning is to produce as high a concentrate grade as possible that is what I have already explained it?

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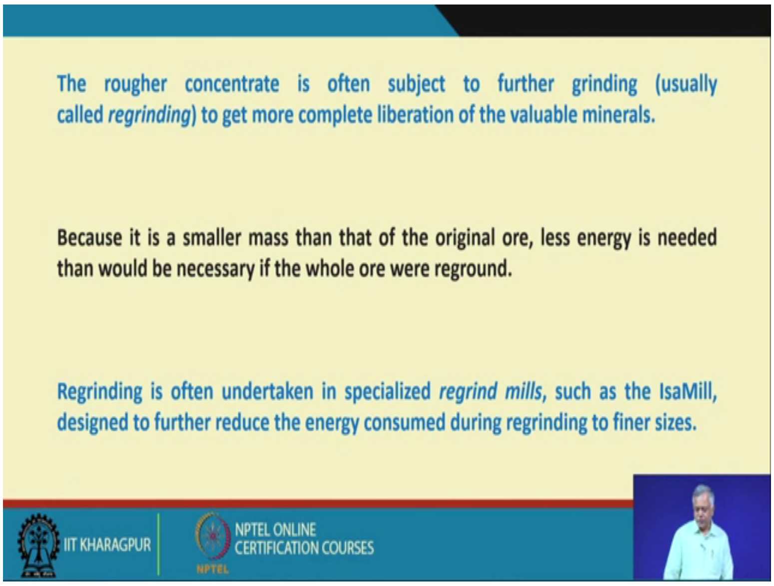

This is interesting the, what is not shown in that circuit; that the rougher concentrate is often subject to further grinding, that is why when I do the laboratory test I should do it at a size by size your floatation kinetics analysis also; that will tell you that whether a roughing stage is better or not.

And that will also give you some idea about the; your likely liberation behavior of your material. So, the rougher concentrate is often subject to further grinding usually called regrinding to get more complete liberation of the valuable minerals. Because it is a smaller mass than that of the original ore, less energy is needed then would be necessary if the whole ore were reground. This point I have already explained it there is a very very important part, if you look at from a engineering point of view that is the economics if you bring into picture.

Regrinding is often undertaken in specialized regrind mill, such as the IsaMill, designed to further reduce the energy consumed during regrinding to finer sizes.

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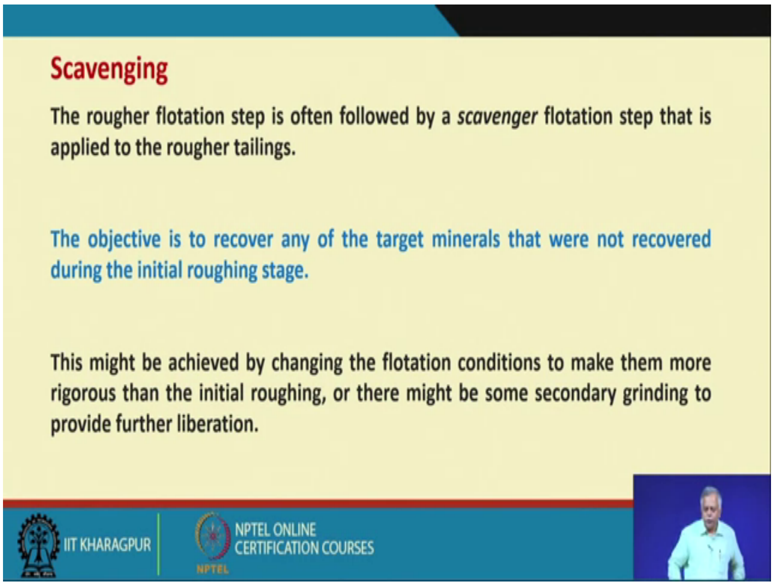

There is a another one also it is called scavenging. The rougher flotation step is often followed by a scavenger flotation step that is applied to the rougher tailings. The objective is to recover any of the target minerals that were not recovered during the initial roughing stage. If the targeted mineral is very valuable and you have already wasted so much of energy in mining, in crossing, in sizing, in grinding, why to waste it; why do not you put another stage of flotation to ensure that not much of my wanted material is being lost into the tailings, and that is the purpose to ensure that; that is the very purpose of this your scavenging.

This might be achieved by changing the floatation conditions to make them more rigorous than the initial roughing, or there might be some secondary grinding to provide further liberation. It is again you may grind it and can do this. So, why I am saying may be, because it depends on ore to ore.

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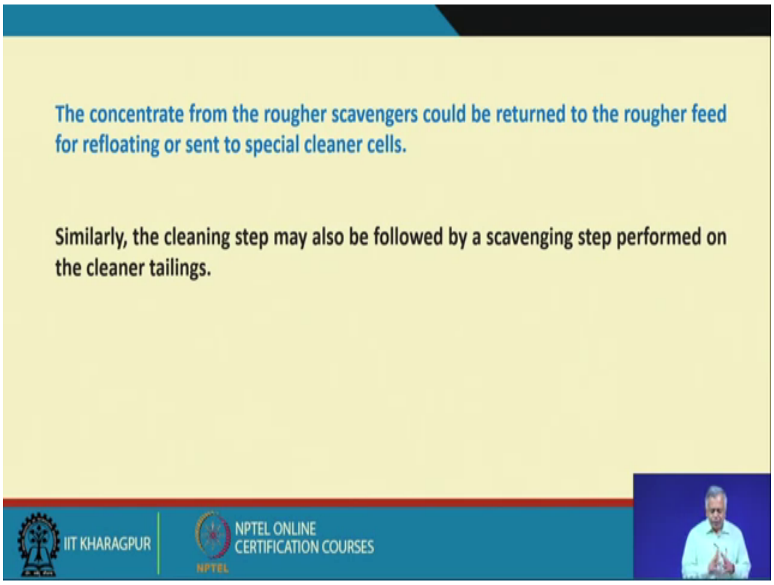

The concentrate from the rougher scavenges could be returned to the rougher feed for refloating or sent to special cleaner cells; that means, either you can have a special cleaner cell and then finally, that product can be added to my your ultimate clean product or sometimes the most of the time it is basically, they are sent back again with the feed to refloat them.

Similarly, the cleaning step may also be followed by a scavenging step performed on the cleaner tailings. Like, if we consider the scavenger is also a your floatation circuit independent floatation circuit I can have again the scavenger and your a cleaner or a still also attached to that.

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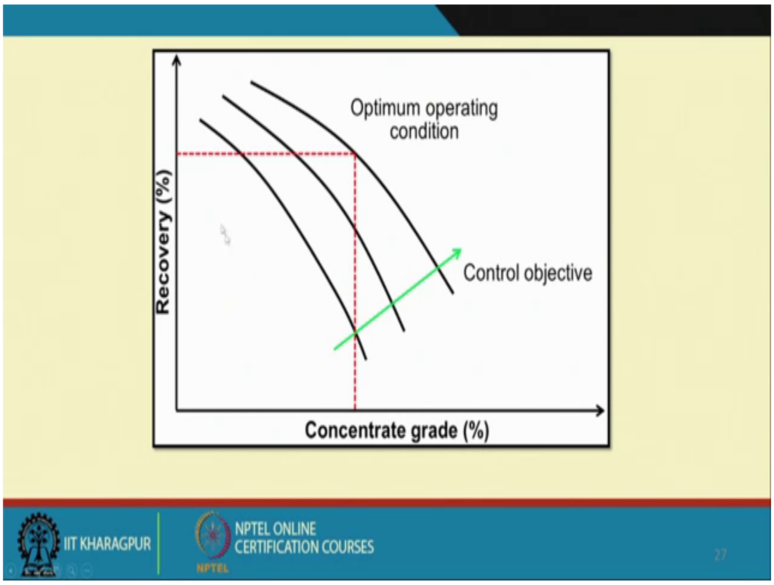

So, what is the ultimate aim of the entire process that is your; you have to select an optimum operating condition, as we had started with this course saying that my grade recovery curve should be pushed towards the right side in this way. So, that is the control objective is that your, concentrate grade recovery curve that is grade may satisfy, but your recovery curve; recovery should be at the best can best possible condition.

So, the optimum operating condition of the flotation process, because you are getting your final concentrate most of the mineral processing operation, you are getting your final concentrate through the flotation process. So, the optimum operating condition of a flotation process, that is whether I should have a rougher scavenger cleaner circuit or I have a rougher; then your cleaner and then your regrinding circuit and then your scavenging and then you got re cleaner circuit and all this whatever we have discussed; whether we use a costly chemical or a cheap chemical; everything will depends on will depend on, what is that your grade recovery curve and based on the recovery what is the value of that.

So, I am coming back again, what is the; your contained value of your; what is that or say what is the net smelter return nsr. So, that is your grade recovery curve should be plotted with the different operating conditions, and then we should try to achieve this condition to arrive at a decision that to achieve this optimum operating condition what is the cost and what is the benefit. So, that is that should be the control objective of the flotation process; not only froth flotation process your entire mineral processing circuit the control objective should be guided based on these your grade recovery curve and the economics based on that.

So, please keep this thing in mind, and if you keep this thing in mind you can design a flowsheet in such a way that my grade recovery curve is at it is optimum condition and what is the cost I have to bear for that; and what will be the net smelter return I will get. So, next class we will I will discuss briefly about two other topics, two other separators, which are having amines importance also in certain specific minerals call it magnetic separation or electrical separation. Then we will wind up the course by briefly discussing, that how do I develop a process flowsheet for a mineral processing plant.

Thank you very much.