Introduction to Mineral Processing
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Lecture – 05
Importance of Mineral Processing (Contd.)

Hello, welcome everybody. So, we are discussing about the separation efficiency in the last lecture and I have talked about the separation efficiency proposed by professor Schulze, which is defined as R m minus R g, where R m is the recovery of the valuable mineral in the concentrate and R g is the recovery of the gangue material into the concentrate.

Now, in this lecture, I will try to show you that how to apply that equation.

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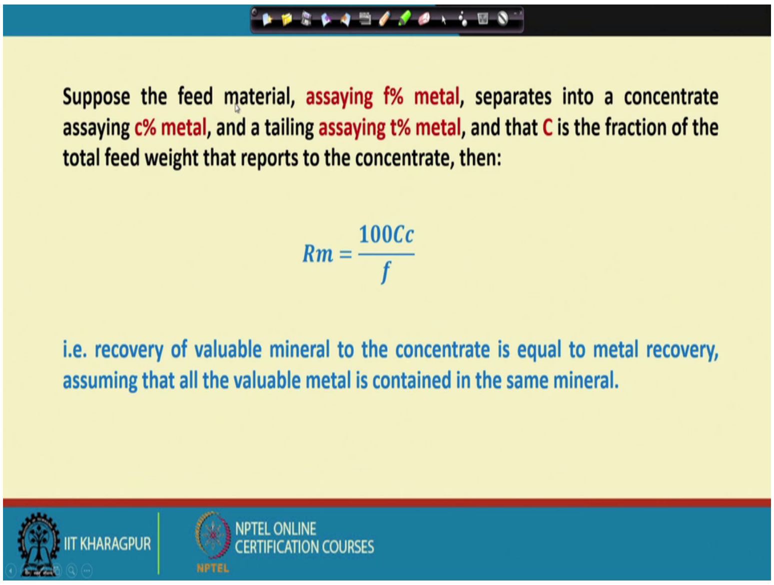

Suppose, the feed material into an unit operation, it has got f percent metal, assaying f percent metal means small f percent metal means the metal grade, that is the grade of that metal into that feed material is f percent and we want to upgrade it to a concentrate and to a tailing we call it tailing; that is a concentrated form of your gangue materials you call it tailings.

So, this feed material, assaying f percent metal, separates into a concentrate assaying c percent metal and a tailing assaying t percent metal, because in tailing also you will have some percentages of that wanted metal. What I try to say, that is, suppose I have got 5 percent of f metal into my feed material and I have upgraded it to a concentrate which contains 20 percent of that metal and you have got 0.2 percent of that metal into your tailings and suppose, so, these are the qualities we are talking, but how much amount has gone where.

So, and if say capital C is the fraction of the total feed weight, that is, if I have a 100 tons of materials in the feed, so, what is the fraction. So, suppose I have got 20 tons in the concentrate, so that is the 0.2 that fraction is 0.2 that reports to the concentrate then. What will be the R m? R m, I said, what is the recovery of your valuable mineral into the concentrate. So, C is the fraction, capital C, so, it is a 0.2, I said that you have got a 100 tons and here you have got 20 tons. So, the basically the fraction is 0.2 multiplied by 100, you get 20 percent and that is the weight distribution and what is the grade of that concentrate I said, that has got small c percent metal. So, how much I have recovered, that is, 100 capital C, multiplied by small c and out of the feed grade that is divided by small f.

So, you have got f percent metal into the feed that has been upgraded to a concentrate grade of small c and what fraction it has been separated that is your capital C. So, that is basically the recovery if I put some numbers I can easily calculate that suppose I have got 100 tons of material we are feeding having 5 percent of this metal. So, that means, I have got your 500, 100 tons and you have got 5 percent of this metal and you have upgraded it to a concentrate grade of 20 percent of this metal, but the volume of that has been reduced to 20 tons. So, in a 100 ton 5 percent means you have what 5 tons of this metal. Now, you have got 20 tons of concentrate which is having 20 percent of that metal. So, 20 percent of 20 tons is 4 tons.

So, what is the recovery? You have recovered into the concentrate that valuable metal as 4 tons out of your available 5 tons metal. So, it is 4 by 5 into 100, that is, 80 percent. So, though that is the recovery of valuable mineral to the concentrate is equal to metal recovery, but what is the assumption that we have assumed that all the valuable metal is contained in the same mineral, why it is important to mention?

Now, suppose I have got a material where I have got iron content of f percent, but that iron may be coming from Fe2O3, Fe3O4 maybe some pyritic form, so, different sources. So, in the concentrate, what you have separated? The hematite, that is, Fe2O3 or magnetite, Fe3O4 or pyrite, FeS2, but that will become a little bit complicated. So, we have assumed here that all the valuable metal is contained in the same mineral.

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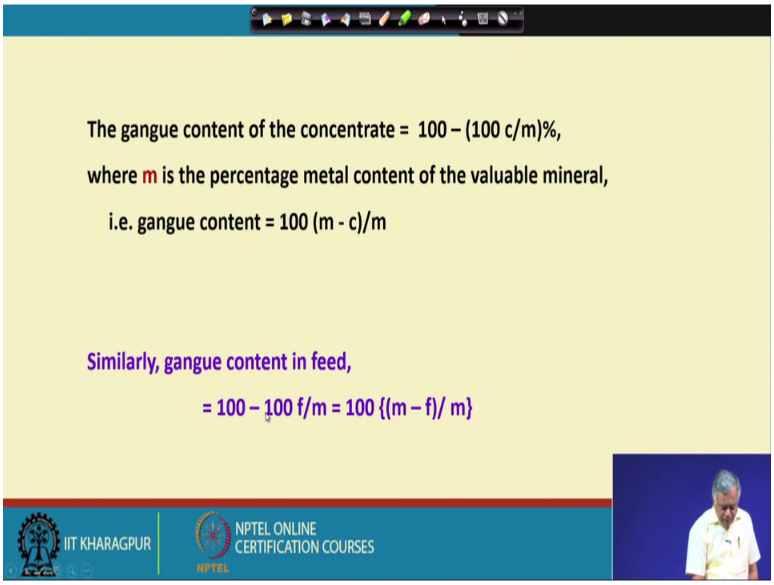

So, what will be the gangue content into the concentrate? That is a 100 minus 100 c by m percent; here, m is the percentage metal content of the valuable mineral. Now, say suppose, what is the meaning of this. So, suppose I have got a hematite ore; hematite is chemically written as Fe2O3. Now, if I look at the stoichiometry, what is the maximum possible Fe you can have in any hematitic ore, how do I calculate it? So, to calculate it I have to know the atomic weight of Fe first. Atomic weight of Fe is 55.85, but our calculations sake, let us say it is 56 and oxygen is 16.

So, Fe2 means 56 into 2, that is, 112 and O 3 is 16 into 3, 48, so we get 160. So, you have got 112 units of Fe out of total 160 units. So, what is the percentage of Fe, 112 by 160 into 100, that is, 70 percent. So, that means, in an any hematite ore deposit I can have a maximum iron content of 70 percent and that is what, this aim is telling that is aim is the percentage metal content of the valuable mineral.

So, what it is comparing with? That is in the purest form of that particular mineral what is the I mean what the assay is. So, if any iron ore if I have 60 percent iron content so; that means, remaining 70 minus 60, that is, 10 percent must be the gangue, must be some other material which is not hematite. So, that is what is calling what is saying the here the gangue content of the concentrate is 100, unit is the total, minus 100 that is a small c is the concentrate grade. So, if your c is equal to m, then the gangue content will be 0, that means, they suppose you have adopted a process where your entire iron ore is broken to a certain size where it is fully liberated and your process was able to give you a concentrate having only pure hematite particles then your recovery of gangue materials into that concentrate is 0.

So, this formula will help us that to know what is the gangue content of the concentrate, that is, 100 minus 100 small c by m percentage. So, when c is equal to m, this becomes 100. So, the gangue content becomes 0. So, if we rearrange it, we can write the gangue content is equal to 100, m minus c divided by m.

Now, similarly, we can also calculate the gangue content in the feed, how do I calculate? Now, gangue content it feed is equal to 100 minus 100, f by m, because the f grade what do we have, that is not pure hematite. It could be pure hematite if it is f is equal to m, and then there is no need for mineral processing. So, we can rewrite it as 100 m minus f by m.

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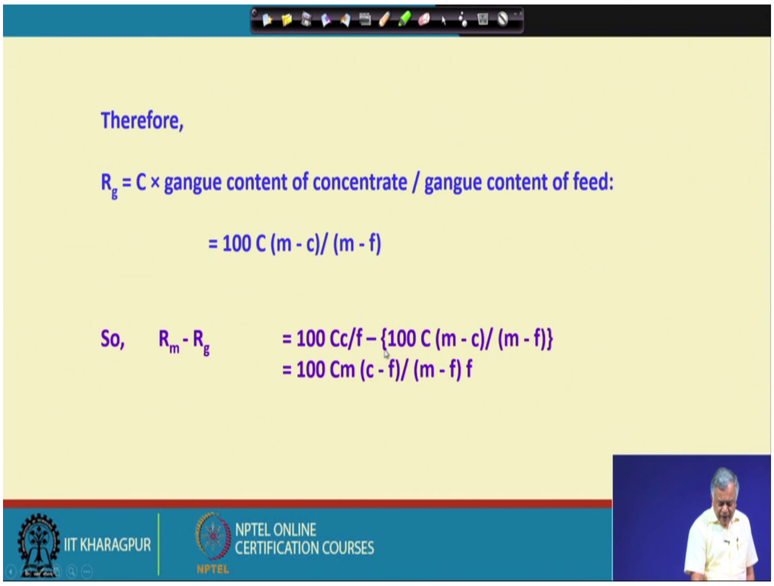

Therefore the R g, that is, what is the recovery of gangue material into the concentrate. So, that is capital C, that is, the fraction weight of the material which is recovered into the concentrate, multiplied by gangue content of concentrate, divide by a gangue content of feed that will give you R g.

So, what we can write that is R g based on these 2 relationships if we just rearrange them then we can say that it is equal to 100 C, capital C, into m minus c divided by m minus f. So, what will be the separation efficiency? So, R m minus R g is equal to 100 Cc by f minus this equation and if we simplify it will take the form in this manner. Please practice it once. It is not a very difficult equation, you can understand this.

Now, let us see that if we apply this, what additional information we get. The example I have given that we have bought 3 parallel circuits and we want to compare their performances.

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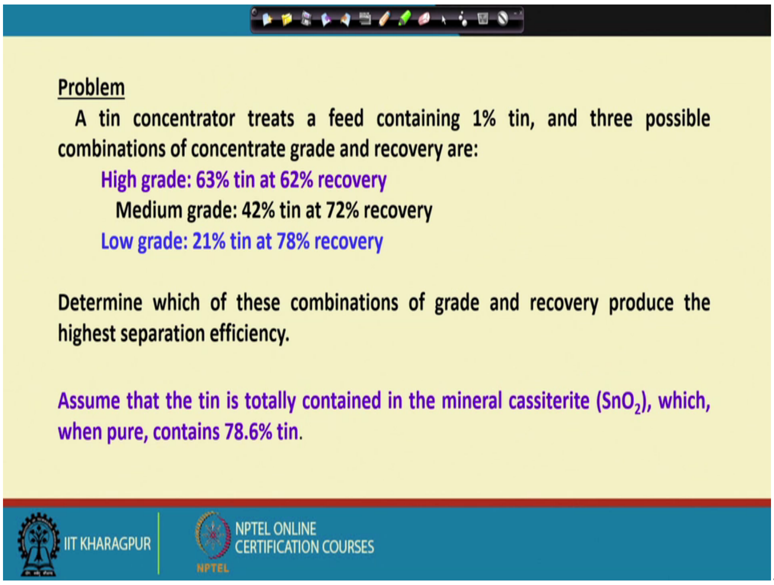

The problem says that a tin concentrator treats a feed containing 1 percent tin and 3 possible combinations of concentrate grade and recovery are; that is, one process you are getting a 63 percent tin and 62 percent recovery, in another process you are getting 42 tin and 72 percent recovery and the third one you are getting 21 percent tin and 78 percent recovery.

Now, based on that definition, which circuit is most efficient in terms of metallurgical efficiency? So, we will try to apply that, but before that to get the value of m, that is, the maximum metal content, that is the maximum tin content into the mineral which is the common mineral for tin is cassiterite, it is SnO2 which when pure contains 78.6 percent tin. If you put the values of Sn and O2 their atomic weights you can get this value. So, this value is given that when it contains the maximum when it is pure contain 78.6 percent tin and this example you will get it under the book of Wills' Mineral Processing book you can get it and I borrowed it from there. So, I acknowledge that Wills' Mineral Processing book for helping me to explain you this equation.

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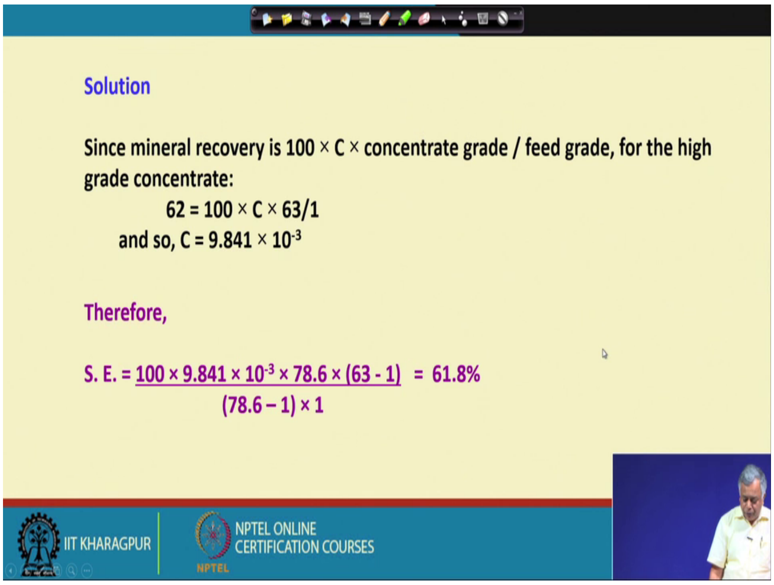

Now, since mineral recovery is 100 into capital C; capital C is nothing, but what is the fractional weight, you have recovered, multiplied by concentrate grade by feed grade. So, for the high grade concentrate is. So, what you have seen that it is the 62 percent recovery and 63 percent tin. So, that is the 62 percent that is the recovery is equal to hundred into capital C, I do not know what fractions, I have been recovered multiplied by grade that is 63 in relation to your say what is that equation 100 capital C by c that is your what is that percentage of metal that is recovered into the concentrate.

So, it is the tin content in the feed is 1 percent, so, 63 percent is your concentrate grade, 62 percent is your recovery, I will calculate the C as 9.841 into 10 to the power minus 3. So, that fraction has been recovered into the concentrate. Now, it is a metal of simply putting all these values. The m value we have already given 78.6 and if you put all the values into the equation of separation efficiency that is R m minus R g this one, then you can easily calculate that your separation efficiency is 61.8 percent for the high grade O.

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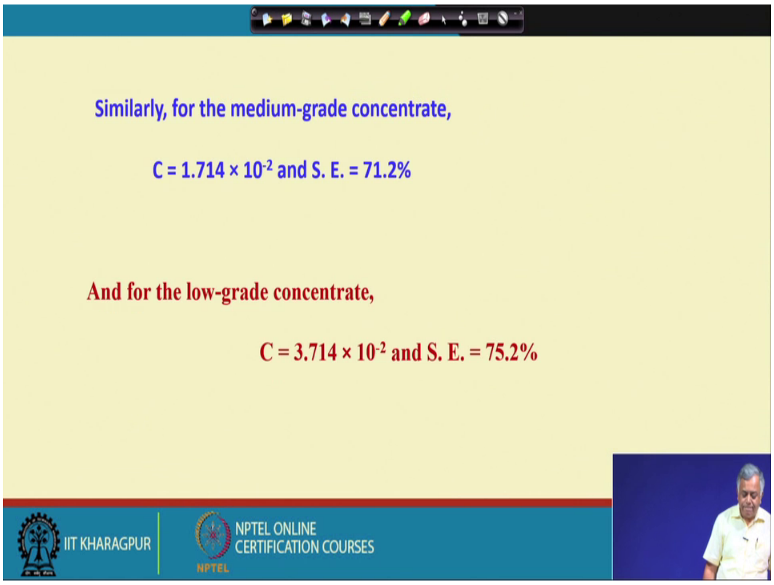

Similarly, for the second situation, if you calculate in the similar way you get the capital C value of 1.714 multiplied by 10 to the power minus 2 and you will arrive at a value of separation efficiency of 71.2 percent. Please practice this, please derive the equations and try this on your own. If you face any difficulty, just let us discuss it when we have an opportunity to discuss.

Similarly, for the low grade concentrate you get a capital C is equal to 3.714 into 10 to the power minus 2 and separation efficiency you get 75.2 percent. So, where you have the lowest grade, now, you compare the separation efficiency is 61.8 percent, 71.2 percent and 75.2 percent. So, that means, it is the lowest grade ore from a metallurgical efficiency point of view based on the formula proposed by professor Schulze, it appears to be more efficient. But, please do remember that we have only discussed about the metallurgical efficiency.

Now, what can happen? So, that means, this process looks to be more efficient, but does it guarantee the best economically efficient process. First thing I have to look at that whether there will be any client who will accept this grade of tin, who will buy this 20 one percent tin and what you have to look at that how much of money you are being paid for that. You may be having the best efficient process and you are having the highest recovery also, but what is the payment for this quality you will be getting and likewise you have to look at the payment and that ultimately what is the NSR, that is, what is the Net Smelter Return. So, that you have to look at and then you have to look at the other losses also.

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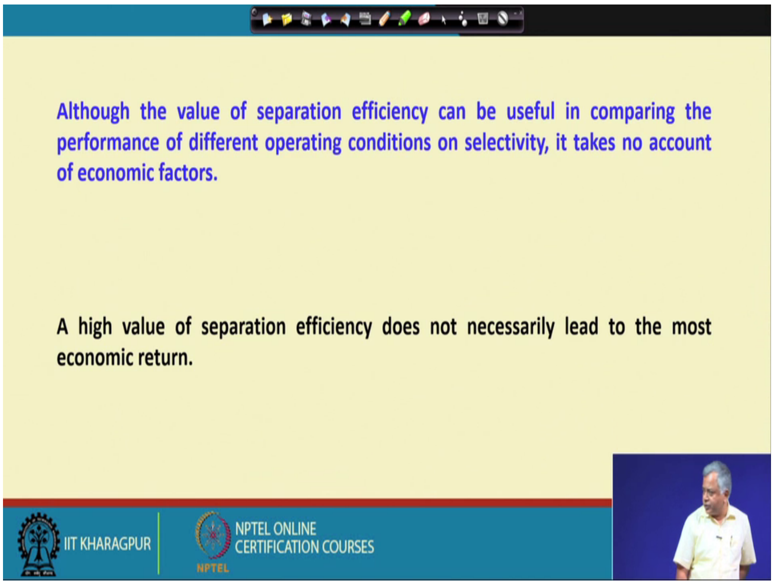

So, although the value of separation efficiency can be useful in comparing the performance of different operating conditions on selectivity; that is, say suppose, I have got 3 parallel processes and I have used a chemical for a process-1, I have not used any chemical for the process-2 and in the third process, it is entirely different process than the other 2. So, which one is more selective, which one will be which one from a metallurgical efficiency point of view is more attractable, actually more attractive? It is not telling more nothing more than that because it takes no account of economic factors. Because, in that case I do not know that if we say, here also I need 60 percent tin content, I do not know what will be the recovery of that, recovery will definitely go down.

So, friends this is what we should do. So, that is why we are summarizing it that it does not talk about the economic efficiency, but it is only talking about the metallurgical efficiency and these operating conditions will only tell you about the selectivity of the processes that whether that chemical has really worked or not, whether we need to add that chemical or not or whether that new process is really looking promising or not. We get that information when we apply this formula. A high value of separation efficiency does not necessarily lead to the most economic return.