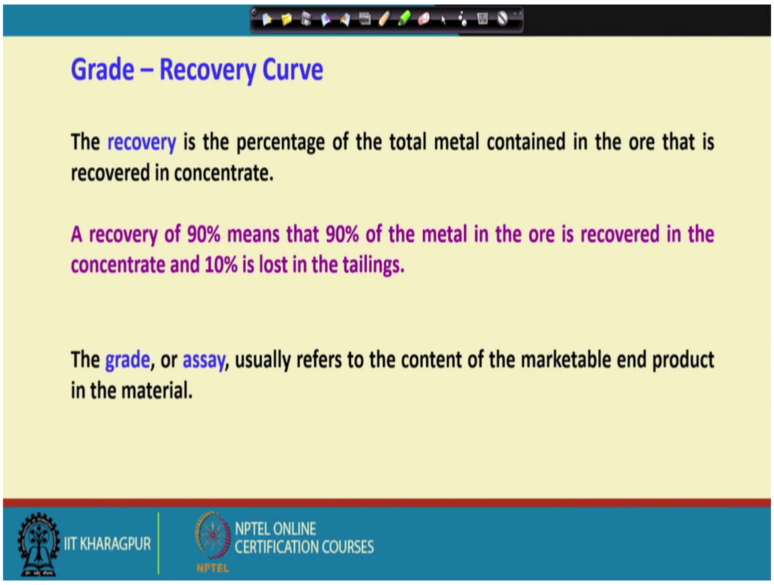
Introduction to Mineral Processing

Prof. Arun Kumar Majumder
Department of Mining Engineering
Indian Institute of Technology, Kharagpur

Lecture - 04
Importance of Mineral Processing (Contd.)

Hello. Welcome back, we are in the forth lecture. Hope so far the journey was enjoyable and meaningful. So, we had discussed that, that there is a compromise solution we have to find out in between the economics and the quality requirement by the metallurgist.

(Refer Slide Time: 00:47)



So how do I do it? So, the basis of a mineral processer to decide on what is the optimum grade we should target, which will give me the maximum profit which essentially is dictated by the ore mineralogy. That is the liberation characteristics.

Now, there is a term we use that is called the recovery. What is the recovery means? The recovery is the percentage of the total metal contained in the ore. That is recovered in concentrate. What is the meaning of that? Now e recovery of 90 percent means, that 90 percent of the metal in the ore, he is recovered in the concentrate therefore, there will be 10 percent lost, 10 percent loss in the tailings. Many times, it is misunderstood that we have to target only high recovery. Suppose I want to suppose this is my spectacle box, and I want to separate out this white part from these entire assemblies.

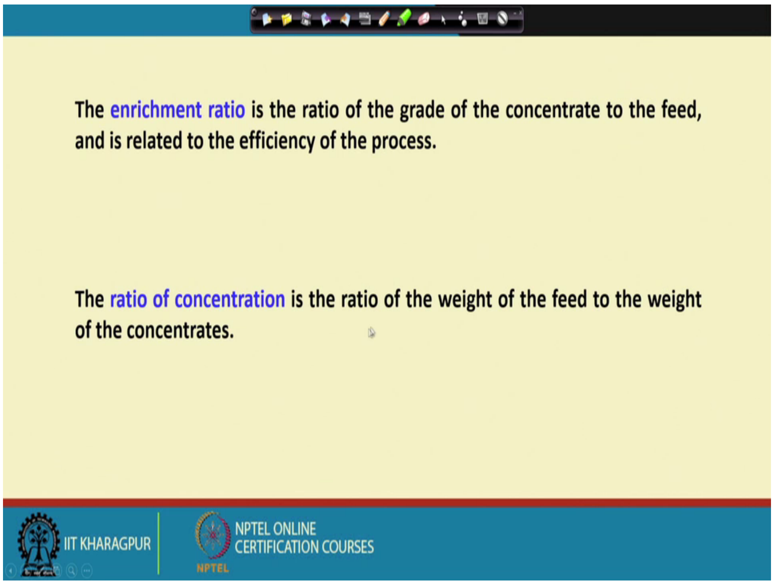
Now, if I just move this material from here to there, the recovery is 100 percent because how much was the available there completely I am recovering that, but what about the quality up gradation, nothing. So, it is not only the single issue that we have to target at optimum recovery. We have to also target at the quality enrichment. So, that is called the grade or the relative percentage. So, that means, in this example what is the percentage of this white part? In this entire assembly that may be your 10 percent. So, the grade of this or is 10 percent, if this is what we assume as an ore. So, if I move it from here to here is still remains 10 percent. So, there is no improvement in the grade. That is not the purpose of mineral processing, in minerals in purpose is to enhance the quality of my grade also, enhance the quality of my material also and an optimum recovery.

So, the grade or assay usually refers to the contained of the marketable in product in the material. This is a strong word, marketable in product; that means, suppose my customer is a metallurgist or a metallurgical plant, they have given a specific requirement of a quality, it is we want a copper ore we should have minimum of 28 percent copper, that will buy it from you.

So, the aim of your mineral processing operation is that, that is your mining colleague, you have given you a mined ore which is having 1 percent copper. You are colleague in metallurgies (Refer Time: 04:57) plant they want 28 percent copper. So, you have to first meet the target of 28 percent at now. Another thing is the recovery. So, what is recovery? So, recovery is above also 1 percent. So, that means, in a 100 ton you have got one ton of copper. So, how much of copper you have basically sold to the metallurgical industries having an average metal content of 28 percent copper? So, that is called the recovery

So, essentially what happens, when you want to increase the grade; that means, the quality, you lose some of the materials. That is here you see that 10 percent. So, that means, your recovery general decreases.

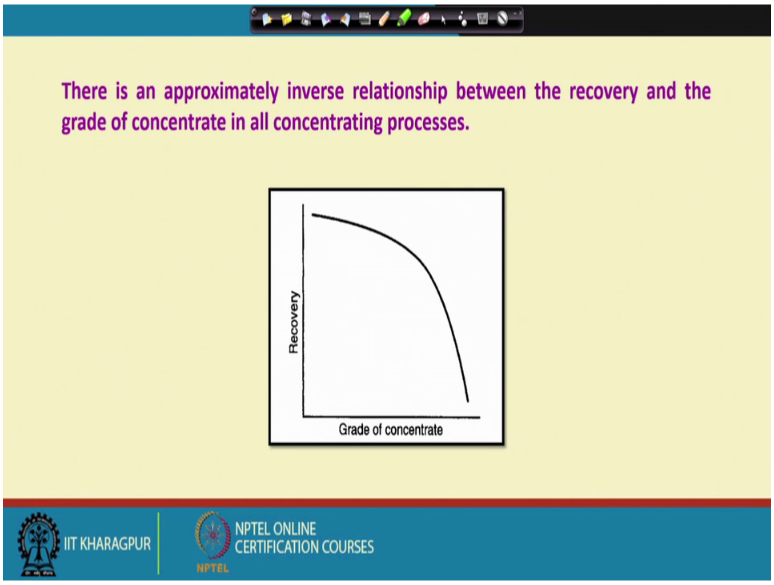
(Refer Slide Time: 06:06)



So, when we plot this grade recovery car we call it a grade recovery car. Before we come to that, car let me explain you some couple of terminologies, which we frequently apply. What is called the enrichment ratio? Sorry, what is the enrichment ratio? It is the ratio of the grade of the concentrate to the feed; that means, feed I have got 1 percent copper and your concentrate you are having 28 percent copper. So, is the ratio of the grade of the concentrate that is 28, and your feed it was 1 percent. So, it is the enrichment ratio is 28. So, it is related to the efficiency of the process.

So, basically your process efficiency, we will be able to assess based on this value of enrichment ratio. Suppose enrichment ratio is thousand in some case. So, that means, the process is very, very efficient. So, that type of assessment we can have. Another one term we use it that is called the ratio of concentration. What is the ratio of concentration? Now it is the ratio of the weight of the feed to the weight of the concentrates. Why it is required? Now how much of material; we will be able to sell out of my feed material, which compounds to the quality requirement by a metallurgist. How much is the material because he will be selling your ore in terms of weight. You will be getting paid based on the tonnages, or maybe kilograms or maybe some other units, but it is definitely based on the weight. That is why this is being used.

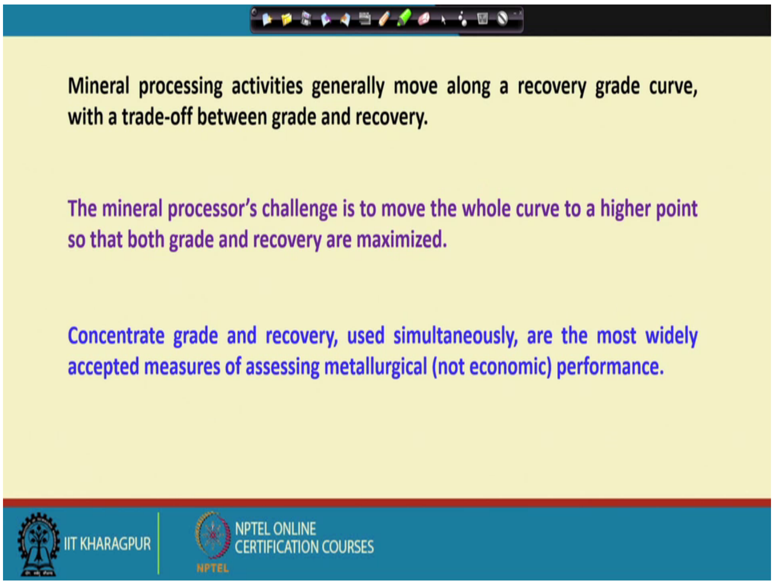
(Refer Slide Time: 08:22)



Now, see that that there is an approximately inverse relationship. As I said earlier also between the recovery and that grade of concentrate in all concentrating processes, because when I want to upgrade the quality is a relative percentage. So, you are throwing out your gangue materials; and because of the liberation behavior, because not all the particles are in freely liberated states. So, you will be losing some of your wanted materials along with your gangue materials. So, that means your recovery will be lower. So, what do we do? We plot this grade up concentrate and recovery to see that; what is the pattern of this curve.

So, as a mineral processor, we always tried to seep this curve towards this region, because and a particular grade if my recovery is more; that means, my losses are less. So, that means, I am getting more value out of my mind ore. And that is the challenge of any mineral processor. That is, how do I shift the grade recovery cop towards from this region to this region. That is whether it can become like this. So, that is the challenge of the mineral processors.

(Refer Slide Time: 10:18)



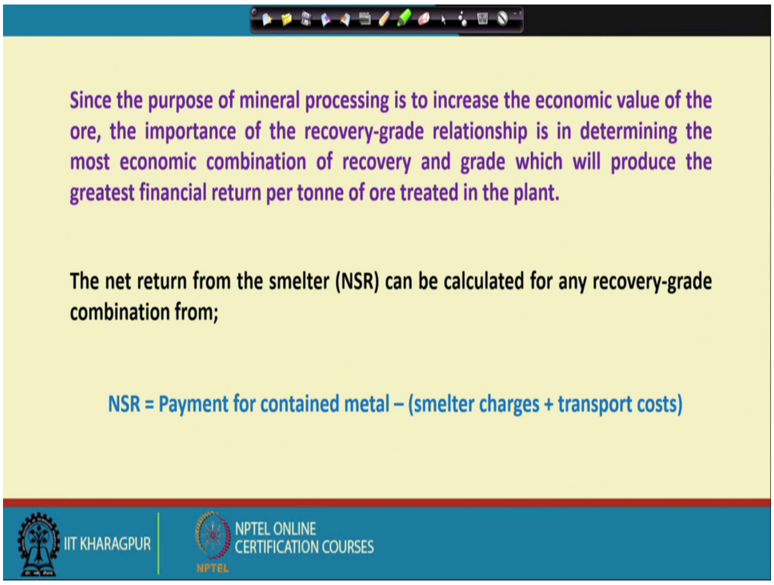
So, mineral processing activities generally move along a recovery grade car with a tradeoff between grade and recovery; that means, I have to find out the optimum grade and the optimum recovery as I explained you earlier, where I get maximum return on my investment. So, what will happen when my ore grade is very low? And what will happen when my or grade is relatively high? That is an interesting scenario which will be discuss very soon, but before that let me reiterate this that the mineral processors challenge is to move the whole curve to a higher point. So, that both grade and recovery are maximized. That is the challenge.

So, how do we overcome these challenges? That is what is the optimum grinding size or the particle size you have to break them with minimal input energy in the breakage. And then what is the most efficient process than I have to adapt to have the most efficient separation between the wanted and unwanted materials? And for that the process that technologies related to your feeding system to your product removal system separation vessel designs and all this they play a huge role. And my dear friends, please remember that here we are talking about large volume of materials to be processed per unit time.

So, even and 1 percent increase in your recovery and a particular grade will be able to bring you lot of dollars for your investment. So, that is where the continuous need for research is required on process optimization new process developments. But to be an effective researcher in this field your basic understanding of them different techniques or existing techniques, and the different challenges in mineral processing, you must be having thorough understanding.

So, concentrate grade and discovery you simultaneously are the most widely accepted measures of assessing metallurgical performance. It is not the related to economic performance. So now, the question naturally comes, what is the optimum grade and optimum recovering for a particular operation. That is the question. We will try to answer it in due course of time.

(Refer Slide Time: 14:04)

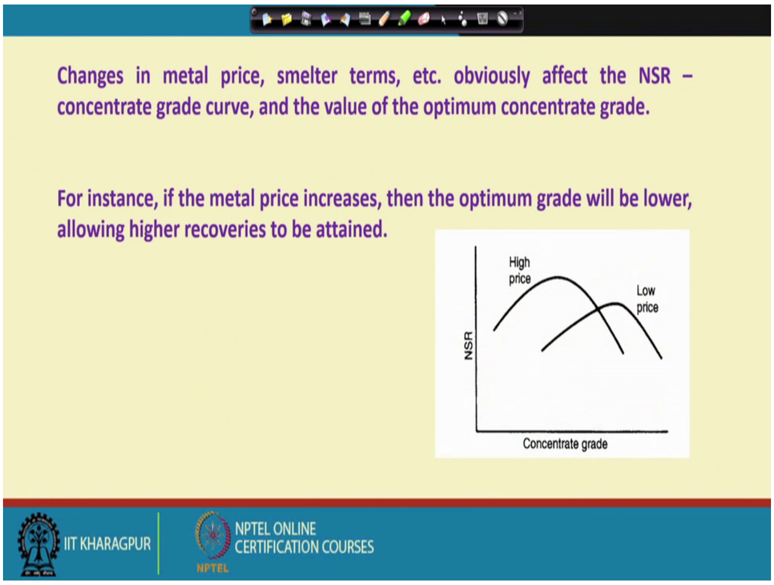


So, the purpose of mineral processing is to increase the economic value of the ore the importance of the recovery grade relationship is in determining the most economic combination of recovery and grade, which will produce the greatest financial return per ton of ore treated in the plant. What I try to say that that one is metallurgical efficiency, but ultimately from a business point of view, we are more interested in looking at your economic efficiency of the entire process.

So, the net return from the smelter, we call it NSR ultimately, why you have mine and iron ore, because we want to sell a product in the form of some steel, or maybe some other alloys. So, that is my final product in the entire chain. Even between we are having businesses mining engineers they are sending into mineral processing engineers, for further upgradation mineral processing engineers they are selling it to metallurgical industries. So, there is some there are some transactions, but if you look at the totality of the process, what for we are mining the iron ore, in an integrated steel plant, you are mining the iron ore to sell some specific product.

So, that is why we call it the net smelter return. So, that is the net smelter return is equal to payment for contain metal minus payment for contained metal means? How much of money I have ultimately could get by selling that product, which I have started from the mining operation. Minus, what are the cost? Smelter charges smelter charges include everything right from your geological exploration to mining to processing to extraction processes, refining processes and all this. Plus, your transport cost. So, that is the net smelter return.

(Refer Slide Time: 16:50)



Now, what happens? When you are in this business as a metallurgist or as a metal processing engineer or as a geologist or as a mining engineer, it is not you who are regulating the metal prices. Someone else is regulating the metal prices globally. So, what happens when the metal prices changes fluctuate? Meaning of many such operations become highly profitable sometimes, and sometimes they become unprofitable at large. And if this continues for a while you may have to stop the entire mining operation and even you have to close your smelting operations.

So, when you are deciding about this, that is whether we should mine whether we should process whether we should have a extraction plant, you should take into consideration this metal price likely metal price fluctuations. You should also be careful about the smelted terms, that is based on your local government laws, and your environmental clauses, and other clauses and these are; obviously, affect the NSR. But most importantly it is the concentrate grade recovery car. That is what is the value of the optimum concentrate grade, because as we have explained that directly most of the cases the as mined ore, you cannot directly charge into furnaces in between.

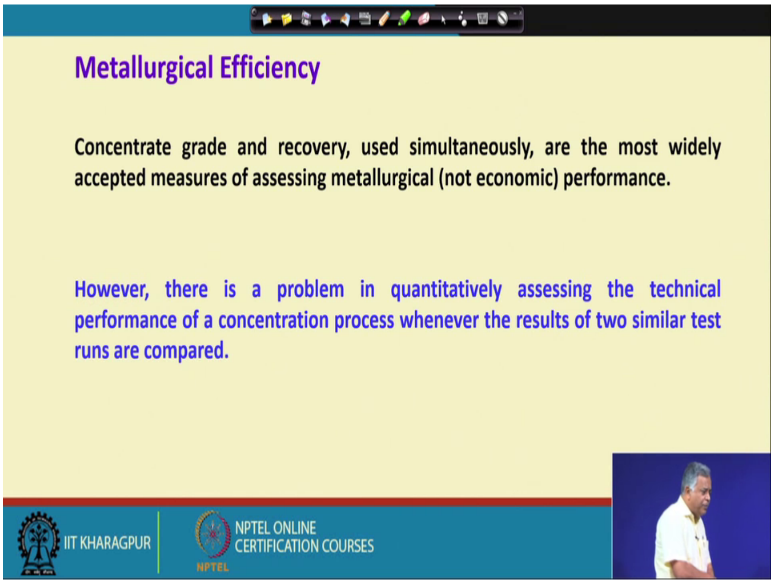
There has to be a quality up lipid by the mineral processing engineer. And many a times you will find that it is the operation at mineral processing based on how you have upgraded the quality of your raw material, they had basically contributes in havoc in this entire value chain. For instance, if the metal price increases, then your strategies for concentrated recovery curve is different what you tried to do? The metal price increases means, I want to recover as much as metal of that metal as much as possible.

We may sacrifice a little bit upgrade. Because, my metallurgies, then they will say that with the same furnace maybe we have to increase the delta x amount of input energy, but we could produce 10 delta x of this metal. And your return and your so payment what will get for that 10-delta x is much higher than your delta x input in it. So, that means, you are trying to make more profit. So, to sum up that that is if the metal price increases then the optimum grade will be lower allowing higher recoveries to be attained. That is the strategy. Similarly, when the metal price drops; that means, they are not getting much of return on your investment, because your metal price has dropped. So, what do you try to do? Then now you are trying to have the maximum grade that is the optimum grade. So, that my extraction cost is lowered. Then when the relative percentage of your metal contained in your ore what you are charging into a furnace increases your extraction cost because lowered.

So, when the metal price decreases, you have to save that money somewhere, and that is at the smelter. So, what will happen? So, this is the plot which shows that concentrate grade versus NSR; that is when you have a very high metal price, we try to sweep the curve towards the higher side, but towards the up left, and when the metal price is lower than we try to shift it towards the right. So, that we get we target for optimum grade by sacrificing some recovery. This is the guiding tool for any mineral processor; that is, what should be my optimum recovery what should be my optimum grade that is dictated by the present market prices of that particular metal.

Now so, can we not have an index, because here you have got 2 variables grade and recovery. Can we not combine them with a single parameter which will tell me that this is what you should target? That is called the metallurgical efficiency.

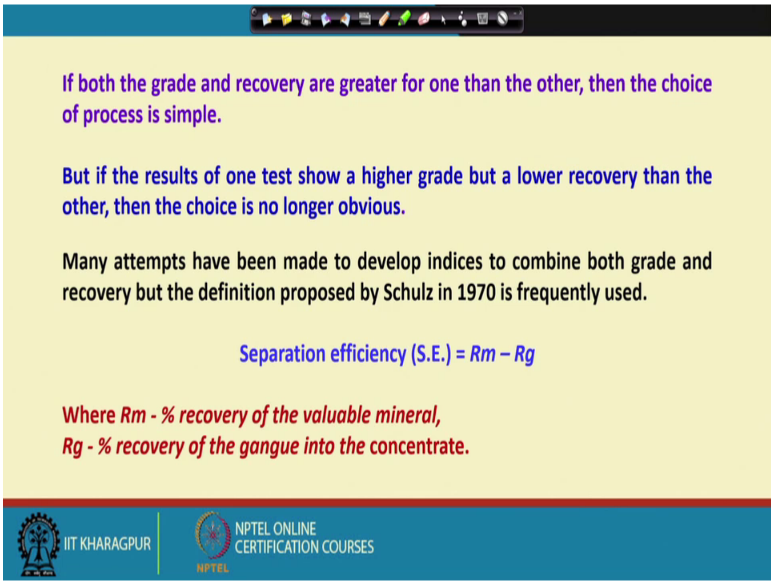
(Refer Slide Time: 23:18)



And there many attempts were made to evaluate theseefficiency metallurgical efficiencies by utilizing the concentrate grade recovery values. Now say suppose, if I have 3 parallel circuits or processing the singular middles. Now if I want to compare this 3-parallel circuit that which one is more efficient.

The decision will be very easy if one circuit gives me the maximum recovery as well as the maximum grade, but say suppose, in circuit a you get the highest grade and the lowest recovery. Circuit b you get some kind of you are in between grade and recovery. And in the circuit c you get maximum recovery by the minimum grade. Then how do I compare them? What are the metallurgical efficiencies?

(Refer Slide Time: 24:46)



Now, to answer this question as it is understood that it there is no obvious answer, attempts were made to come out with a index. So, one index proposed long back in 1970 by Professor Schulz and which is being used frequently in the industry. So, he proposed that, that separation efficiency is equal to Rm minus Rg where Rm is the percentage recovery of the valuable mineral percentage recovery of the valuable mineral into the concentrate. And Rg is the percentage recovery of the gangue into the concentrate. So, Rm is the percentage recovery of the valuable mineral in the concentrate, and Rg is the percentage recovery of the can into the concentrate.

In my next lecture, I will show you that how to apply this this equation to compare some parallel processes, or say it is compared some processes to evaluate the metallurgical efficiency of a plant.

Thank you very much.