Introduction to Mineral Processing

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

Lecture – 19
Comminution Fundamentals (Contd.)

So last lecture, we are discussing about the Work Index and I said that, in this lecture I will show you that is, how we can use these useful information, that is your Work Index of a particular material.

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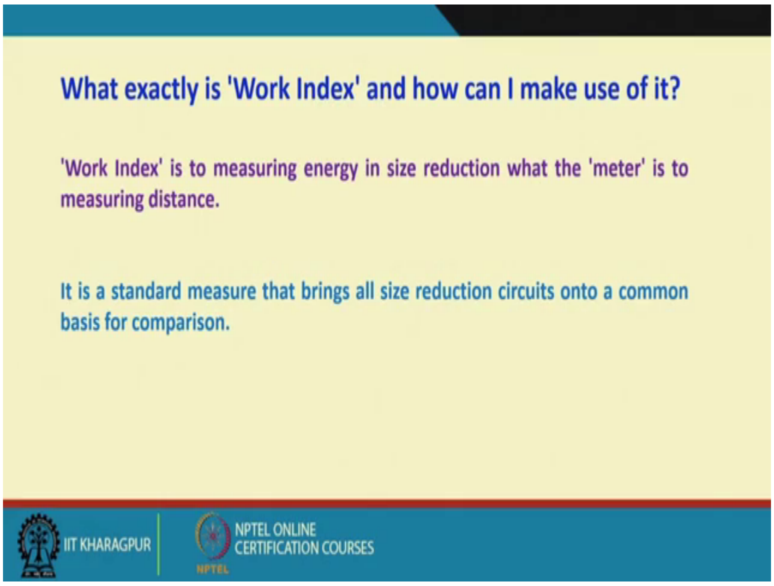

So that is why, I have given this question, that is probably, which is coming to your mind also that, what exactly is Work Index and how can I make use of it. I would say that Work Index is to measuring energy in size reduction. It is similar to what we use a 'meter' to measure distance. That means, it is a almost equivalent to your unit; that means, your work index is the very essential thing you must, we must know to calculate the energy consumption into a combination process.

It is a standard measure that brings all size reduction circuits onto a common basis for comparison. That means, if I perform the test, based on the guideline given, that is we should not alter the machine, we should have a bond meal. It may be a rod meal, it may be a bond grinding mill and we should do the test properly. Then, what will happen, if we have your different equipment and we want to have a particular feed material to be fragmented into a particular product size distribution, we can calculate for comparison purposes that is, which circuit or which machine has consumed the least energy.

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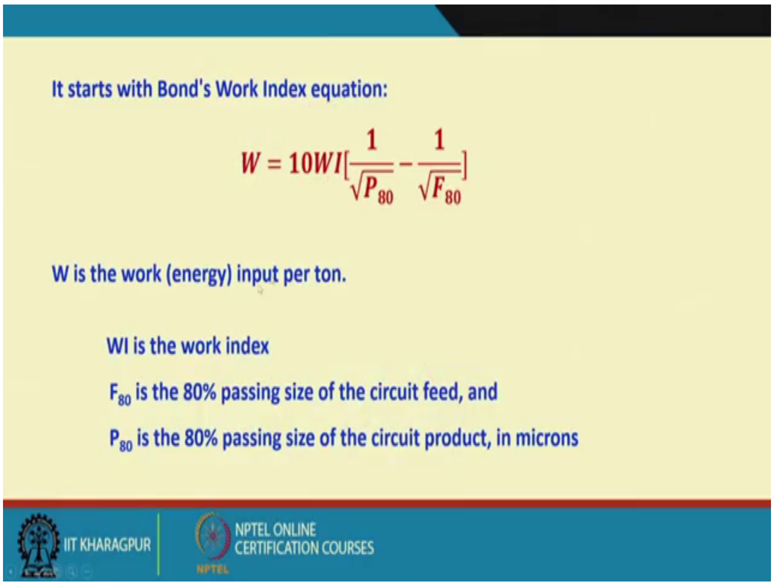

Now let me recapitulate that for giving the example that it is the Bond's Work Index, the equation is that is, when we basically the work input that is, we can write W is equal to 10 WI a 1 by root P 80 minus 1 by root F 80. There we have used that is your here the W is the work or the energy input per ton of material. That means, the if I know the P 80 and F 80 and the Work Index, we can calculate the through this equation, that, what is the how much is the work input required per ton of material or it has consumed per ton of material?

How do I do it? So for that, what I have to do? I have to collect the feed material from a circuit. Suppose there is a crusher, so whatever the material going into, as the into the crusher as feed, I need to take a representative sample from there and I must need to do the size analysis of that, based on that size analysis I should get the value of F 80.

Similarly, whatever is getting discharged from that crusher, I should take a representative sample from that crusher product and do the size analysis to estimate the value of P 80 and before that, that ore material that is material which is being fed, I should do the work index calculation, if the value is not known. If it is a common mineral, we should get the WI value from a standard source or from a standard textbook given.

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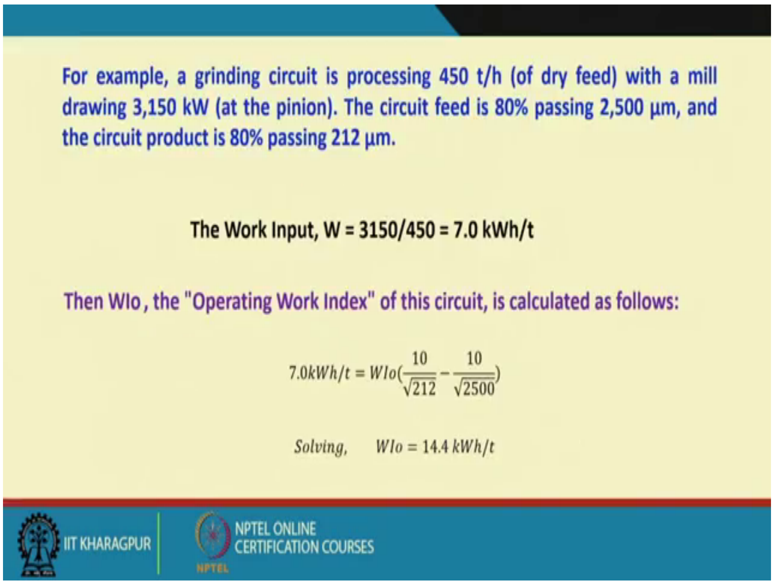

Now, let me give an example, that is, how we can use this work index. Suppose, a grinding circuit is processing 450 tons per hour of dry feed with a mill, that means, a grinding mill, do not worry about that, what mill and all. This we will discuss in due course of time. It is a particle breakage device, with a mill drawing 3150 kilowatt at the pinion. Pinion means at the wire it is waiting basically say getting hooked up, it is that that is called the Pinion you know where it rotates.

So, while processing a 450 tons per hour of dry feed in a mill which draws 3150 kilowatt of energy or the power. The circuit feed is 80 percent passing 2500 micron or micrometer and the circuit product is 80 percent passing 212 micrometer. Now with that what we can do? Know we can calculate the work input. Is therefore, that is we in the input energy is 3150 and we are processing 450 tons per hour. So, that is 7 kilowatt hour per ton. So, that is the work. So, per ton of material to be ground to that particular size from a particular feed size, it is consuming 7 kilowatt of power.

Now, there is a term called WIo which stands for Operating Work Index. So, the Operating Work Index for this circuit is calculated as follows. That is, that is the W and let us say that, your WI I do not know. So, what is that operating work index? That means, when the particle is getting broken, what is that work index of that particle during breakage or say actually, what is that Operating Work Index? So, we can put this value, that is in place of W that is equal to 7 kilo watt hour per ton is equal to WIo instead of

WI. We are writing the WIo, because it is the operating work index. It may not, because your no mineral is a pure mineral. So, it, it will have some kind of your impurities.

So, we want to know, what is the operating work index? So, that is the WIo into 10 by square root of 212, that is coming from your P 80 size and that is the F 80 size is 2500 micrometer. So, solving we are getting WIo is equal to 14.4 kilo watt hour per ton. That is the operating work index for that material, which is being crushed or ground from a 2500 micro meter to 212 micrometer size or 80 percent passing size.

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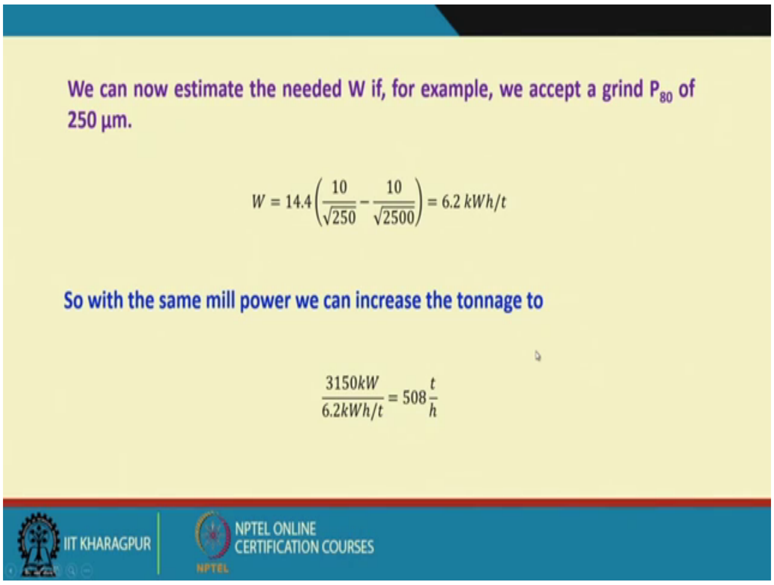

We can now, estimate the needed W if for example, we accept a grind P 80 of 250 micrometer, this is very interesting.

Say here, we are saying that, we are getting a circuit P 80, that is your product 80 percent passing size is 212 micro meter, but if your metallurgist says, when you are having a discussion as a mineral processor with a metallurgist, we say that can you accept a little bit of cores are grained or maybe your mineral processing engineer, who is looking after the downstream processes, you are the in charge of the size reduction processes and your colleague is in charge of your downstream processing circuit. So, you say that, that we are consuming lot of energy in the milling circuit that is your grinding circuit. So, if I increase this 80 percent passing size to 250 micrometer.

First let me discuss with my processing colleague that, to show that how much of energy we essentially will be saving. So, if we accept a grind P 80 of 250 micrometer. Then, what will happen? So, W is equal to 14.4, where from 14.4? You have got it from WIo value. So, that is the WI value. So, that is 14.4 multiplied by 10 by root 250 minus 10 by root over 2500 is equal to 6.2 kilo watt hour per ton. So, you see that, when we are breaking the rock to 212 micron it was consuming 7 kilowatt 7 kilowatt hour for per ton of material to be broken.

If we accept, if you are processing friend, who is in charge of your downstream processing, if you can convince him that ok. Or if he agrees that I would mind, if I get 250 micrometer. Then you see that your, energy requirement will be your 6.2 kilo watt hour per ton, from 7 kilowatt hour per ton or maybe this information you can use it, to say that we will have the fixed energy consumption, but can we increase the capacity of my mill? Yes. So, with the same mill power, we can increase the tonnage to 3150 that means, it was consuming 3150 kilowatt divided by 6.2. So that means, your capacity will be increased to 508 tons per hour from 450 tons per hour.

So, these type of calculations we can do it, as in the very first class, we said that mineral processing operations are basically a compromise between the say how much of money is required to get a desired your separation. So, it is north up your say perfect separation, we look for we look for a between a balance between your economic constraint and your product quality constraint.

So, this example, shows that if we with this WI concept, that is the Work Index concept, we can do all these permutation and combinations, that is keeping the energy consumption fixed. We can increase the your say the capacity of my mill by more than 10 percent by increasing a little bit of your product size distribution from 212 micrometer to 250 micrometer.

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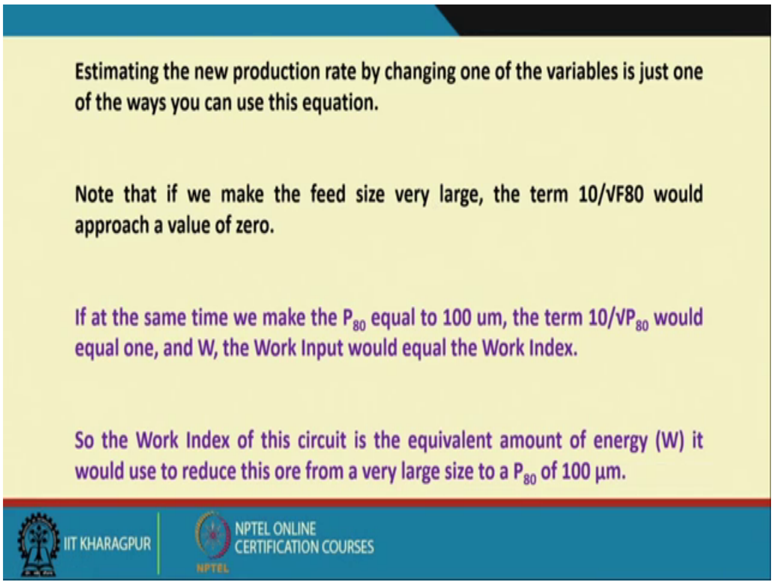

Estimating the new production rate by changing one of the variables it just one of the ways you can use this equation. It is one of the applications. So, if we make the feed size very large, now let me explain you, that what exactly this WI, when we say that it is coming from infinite size to below your 100 micrometer size. See that if we have this 10 by root F 80, if your feed size is very large. So what will happen? That it would approach a value of 0, because your F 80 could be very large in relation to 10.

So, it is 0.00000 or like that. So, it would approach a value of 0. If at the same time, we make the P 80 equal to 100 micrometer. So, what will happen? Sorry this is not you, this is the micron. So, the term 10 by root P 80 would be equal to 1 and W that is the Work Input would equal the Work Index. So, what I try to say that here, say suppose this test value is very high. So then, what will happen? This 10 by this value will become almost 0 and if this is 100 microns. So, 10 by 10, it will become 1. So, this will nothing, but your Work Input is equal to your Work Index. So, that is that WI.

So, that is why the Work Index of this circuit is the equivalent amount of energy. It would use to reduce this ore from a very large size to a P 80 of 100 micrometer. Hope now, this is clear that, what did I want to mean that is, when I said that WI stands for Bond Work Index which is basically that, how much of work you require to break a particle from a infinite size to below 100 micrometer.

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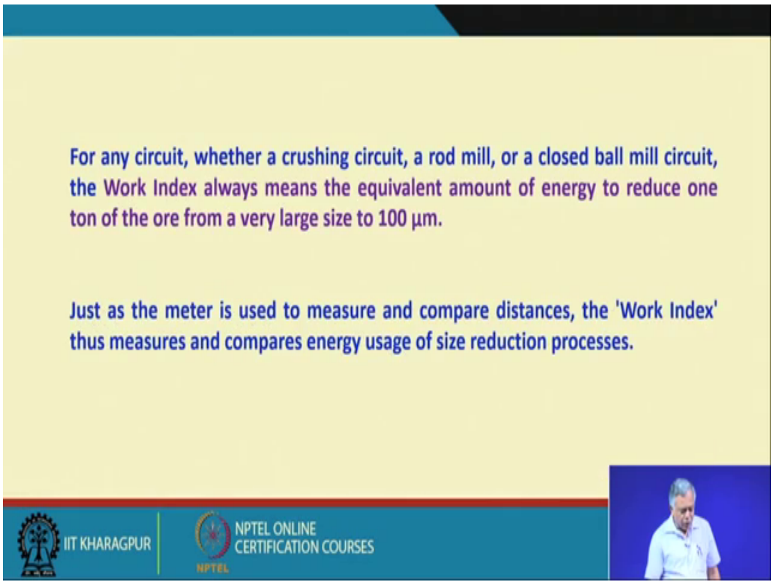

Now, for any circuit, whether a crossing circuit, a rod will circuit which will discussed in due course of time or a closed ball mill circuit the Work Index always means the equivalent amount of energy to reduce 1 ton of the ore from a very large size to 100 micrometer. So that means, it is the independent of the machine or you can say, that Work Index is basically telling that, in any machine from a infinite amount of certain infinite size, to a size of 100 micrometer and if you want to process, 1 ton of material from that size, to this size then, it will remain constant. So, that is the equivalent amount of energy irrespective of that.

So, that is why I repeat it again, just as the meter is used to measure and compare distances, the Work Index thus, measures and compares energy uses of size reduction processes.

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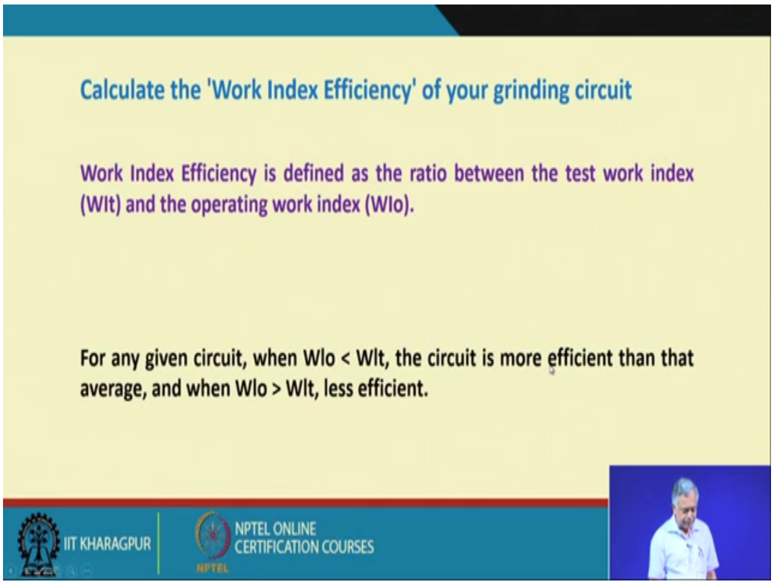

Now, if I ask you to calculate the Work Index efficiency. I will define it, what is Work Index Efficiency of your grinding circuit? Work index efficiency is defined as the ratio between the test Work Index that is represented as now, WIt to distinguish between the 2 work indexes, we are discussing and the operating work index.

That means in the laboratory in a control environment, when you have done the test, that is the tests prescribed by Mister Bond, what is that WI you got and while operating the machine for a particular size reduction or say particular specified size reduction, what is the operating work index you got? So, it is the ratio between the 2. So, for any given circuit when WIo that is your Operating Work Index is less than the, your Test Work Index. So that means, the circuit is more efficient than that average and when WIo is greater than WIt it is less efficient.

That means in a standard condition, if I break a particular rock from a particular specified size, to another particular product size. How much of energy essentially it would consume? So, that is the laboratory test. Now you have got a different circuit, you have got a different feeding arrangement; you have got different types of your say breakage mechanisms, which we briefly discussed in the previous lectures. Now what is the Operating Work Index? So, if the Operating Work Index is less than the Test Work Index, so that means, your process is very efficient and if it is vice versa, so that means, it is less efficient; let us see that.

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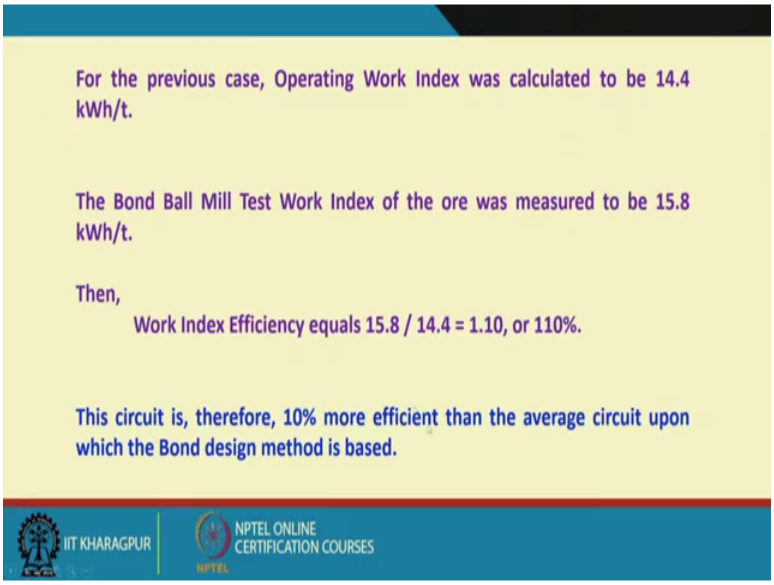

Now, for the previous case, that is the numbers where I have given. We have calculated that index was calculated to be 14.4 kilowatt hour per ton. Now if we have performed the Bond Mill Test, suppose that you have performed the Ball Mill Test prescribed by the Bond and you have got a value of work index of 15.8 kilo watt hour per ton for that particular material. So, in this case your work index efficiency is 15.8 that is the work index WI t divided by WIo that is 14.4. So, it is 1.1 or it is 110 percent.

So that means, your circuit is 10 percent more efficient than the average circuit, upon which the bond design method is best, because the Bond Mill that test work index is proposed because there is no theory in that, that is also an experiment. So, you have got a circuit that you will feed this material like this. They will have this type of configuration of your, say your balls that you will make it or you will try to break your particles from a particular feed size to product size of less than 100 micrometer and that is an ideal test condition. So, you have got a machine, you have got a circuit and you are saying that that my circuit is 10 percent more efficient than the average circuit upon which the bond design method is best.

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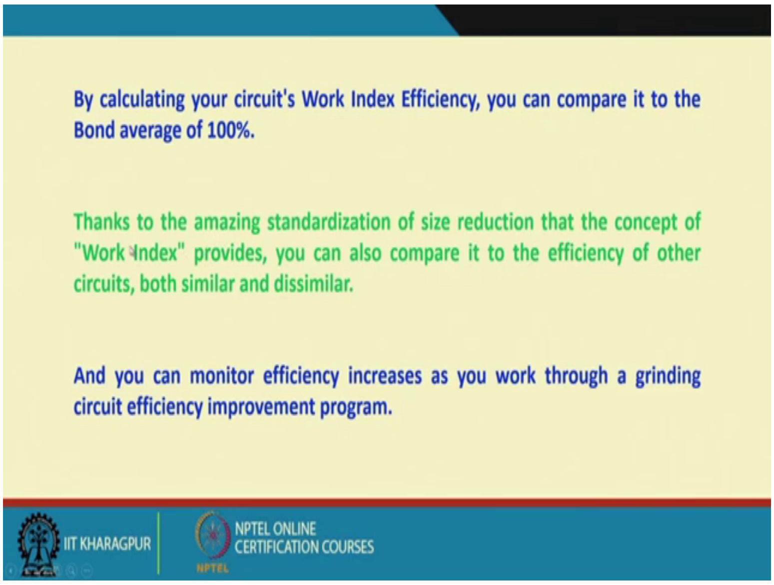

By calculating your circuits Work Index Efficiency, you can compare it to the bond average of 100 percent; that means, the bond average you can assume that this is equivalent to 100 percent. So now, the same material, as suppose is broken into 4 parallel circuits. So, each circuit the operating efficiency, work index efficiency you can calculate, based on the how many tons of materials are processing per unit per hour and then how much of energy is being consumed?

Based on that, you can calculate, what is the operating work index for all the 4 parallel circuits? And you can compare it, the Work Index Efficiency and then, you may say that the circuit 3 is the most efficient and maybe your circuit 4 is the least efficient. Then, as a plant engineer you should take some kind of your corrective measures. That is what is going wrong into my circuit 4 and then how do I improve the energy efficiency of that circuit?

So, in literature in a website, we have seen this amazing your say, actually this sentence which I liked it. So that is, why I could not prevent myself in telling you this sentence that thanks to the amazing standardization of size reduction that the concept of work index provides, you can also compare it to the efficiency of other circuits both similar and dissimilar, that means, I can have a your plant auditing, like I can have the your circuit your energy estimations and even the most efficient circuit, we can do the your say detail analysis like we can do post mortem and we can find out that why this circuit is most efficient and then, why cannot we implement or say reproduce this circuit into the another parallel circuits.

So, that my overall energy consumption is list and you can also monitor efficiency, you can also monitor efficiency increases, as you walk through a grinding circuit efficiency improvement program. Even based on this logic, you can have some all stream, your analyzer, which will give you the basically the work index efficiency or say operating efficiency of your circuit and then, you can pinpoint that, which circuit I should act to modify it.

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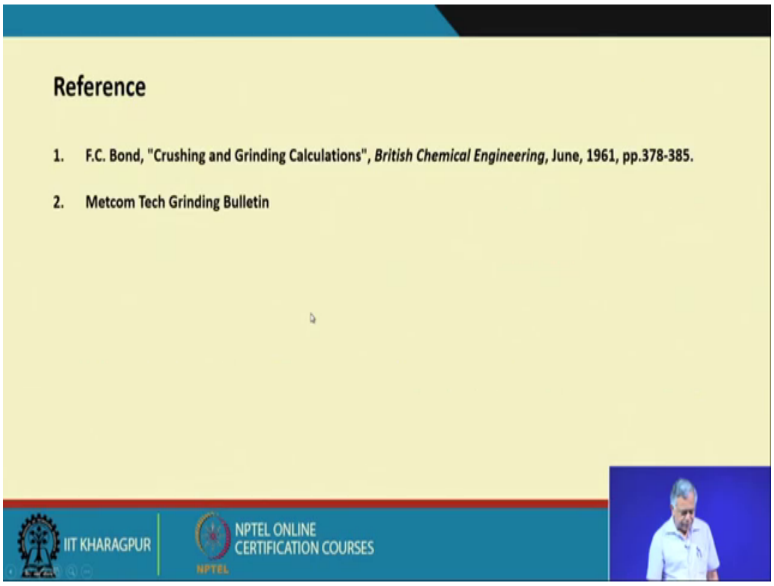

So, for this lecture actually I have consulted this 2 literature. One is by, Freight Bond, that is the crossing and grinding calculations; it was published it has got the 2 parts, part 1 and part 2. It was published in British Chemical Engineering in June 1961.

And there is a basically, if you google it that Metcom Tech Grinding Bulletin, you can get all this interesting your feature related to this work indices. So, if I summarize it, the combination fundamentals, that we have we should know that why, what is the fundamental difference between your blasting and combination coalition; we want a progressive size reduction, not and a blasting you are having a size reduction in one go. So, you do not have much control on the product size distribution. But as a mineral processing engineer or as a combination engineer, you should know that how do I control the sizes at each stages. So, that I do not generate much of finer product than what is required.

So, it is a progressive breakage of particles and for that, we must know, why the particles are broken, what are the characteristics of that your ore, which actually say promotes the process of size reduction or which inhibits the process of size reduction, what are the parameters and then, what are the various ways we can break a particle. That also we should know and then, what are the different machines which are available. So, that we will discuss in the next successive lectures, but how much of energy is being consumed, that means, energy consumption as a very vital parameter for your size reduction processes. So, what is the concept of WI that is the Work Index?

And then, we have also discussed, we have through examples that is how do we use this WI value for calculating the your capacity of a plant and if we manipulate the product size distribution, can we increase the capacity of my plant by manipulating a little bit of your coarser product size and we have also discussed through examples, we have shown that how we can compare the performances of different combination circuits, through this unique parameter called WI. So, that is the Work Index and we have also discussed about the Operating Work Index Efficiency and the Laboratory Work Index that is called a Bond Work Index.

So, next class we will start with the different machines. So, till then.

Thank you very much.