Introduction to Mineral Processing
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Lecture - 32
Industrial Screening (Contd.)

Hello, welcome back to this course. So, we are discussing about screen efficiency.

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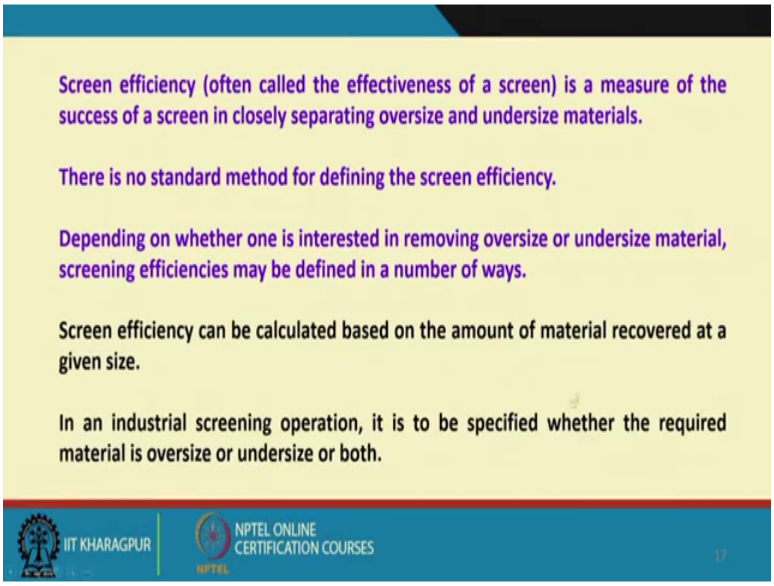

So, screen efficiency often called the effectiveness of a screen is a measure of the success of a screen in closely separating oversized and undersized materials. That is how effectively it has separated the oversized materials available in your feed and undersized materials available in the feed.

There is no standard method for defining the screen efficiency depending on whether one is interested in removing oversized or under size material screening efficiencies may be defined in a number of ways because many at times, he may be interested only in the oversized materials they are not interested that whether you have got the undersized material and along with that you are getting some kind of your oversized materials also. So, what is your objective, based on that that screen efficiency the definition of that also varies.

Screen efficiency can be calculated based on the amount of material recovered at a given size; that means, at a particular size you can say that what is that your amount of material that has been recovered as oversized and undersized material. In an industrial screening operation it is to be specified whether the required material is oversize or undersized or both; that means, whether you are interested in both the oversize and undersized material. Just for example, say suppose we say that there are screens which are used for degrading purposes degrading the grading means you are only interested in removing the oversized material and you want all the under sized material which you want to process similarly there are screens where you want to remove the ultrafine particles. So, when you call them as disliming screen. So that means, you want to make sure that in your oversize material there should be there should not be much of these ultrafine particles.

In some cases you want to grade them. So, that both are your products that is your oversize and undersize. So, depending on that what is your purpose what is your objective the definition of screen efficiency can vary.

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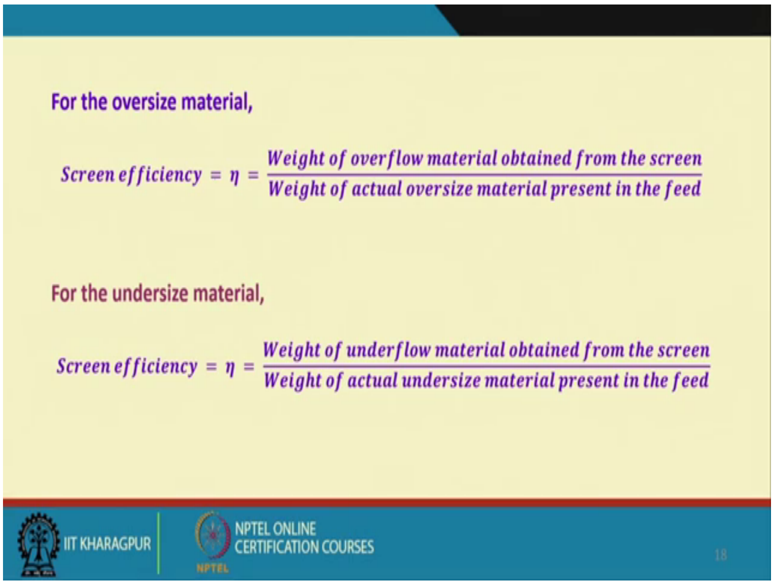

Now, if I define based on the screening efficiency based on the oversize material, so then the screen efficiency is defined as weight of overflow material obtained from the screen; that means, how much of oversize material you have got through the screening operation and weight of actual oversized material present in the feed. How do you know the actual oversize material; that means, you have taken a representative sample from your feed material and you have done it, you have done the sieving operation at a laboratory; that means, at an ideal condition you have done it in a controlled atmosphere you have done it. So, how much actually you have got and how much was there.

Similarly for the undersized material the screening efficiency can be defined as weight of underflow material obtained from the screen, how much you have got and how much was the present actual undersized material present in the feed.

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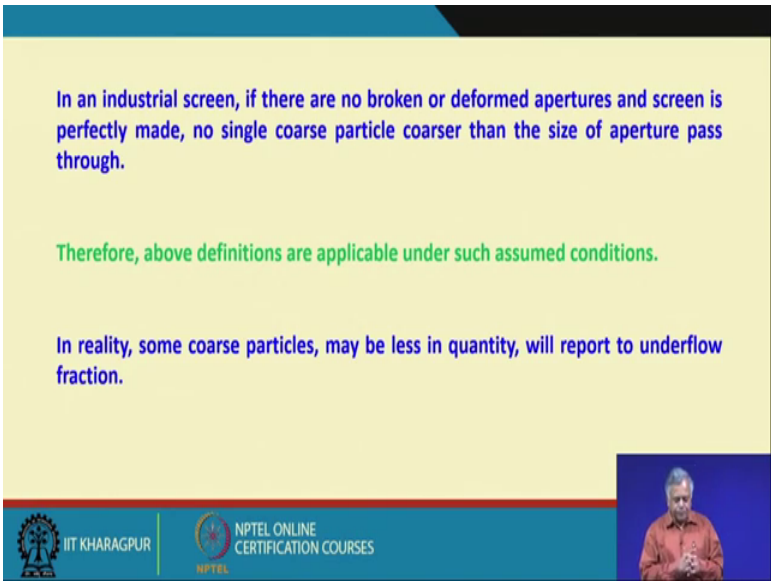

In an industrial screen if there are no broken or deformed apertures and screen is perfectly made; that means, each aperture is the giving you, your say yours perfect dimension what you are say requiring. That is if I say suppose I wanted 2 millimetre sieve aperture all the apertures if they are exactly 2 millimetre and if there are no broken pieces there no single coarse particle coarser than the size of aperture passed through; that means, there is no way that your coarser particle will pass through, but actually what happens there are some say a problem with the deformed apertures and your screen may not be perfectly made then you may get some oversized material into the undersized material.

So, if you want to if you have your precise your screen or say perfectly made screens and the screen maintenance is properly done then you hardly you will no single coarse particle you will get it in the undersized. Therefore, above definitions are applicable under such assumed conditions that there is no miss placement of the your say relatively coarse sizes, coarse sizes then the apertures they will not be reporting into the undersized material. However, in reality some coarse particles may be less in quantity will report to underflow fraction and another reason could be your shape because it may change its orientation and it may pass through that and it may report to the undersized fractions.

So, how do I take into consideration of all this that is the screen efficiency definition we have to think of and there are many definitions as I said, but I would like to show you some of the most popular ways of determining the screen efficiency.

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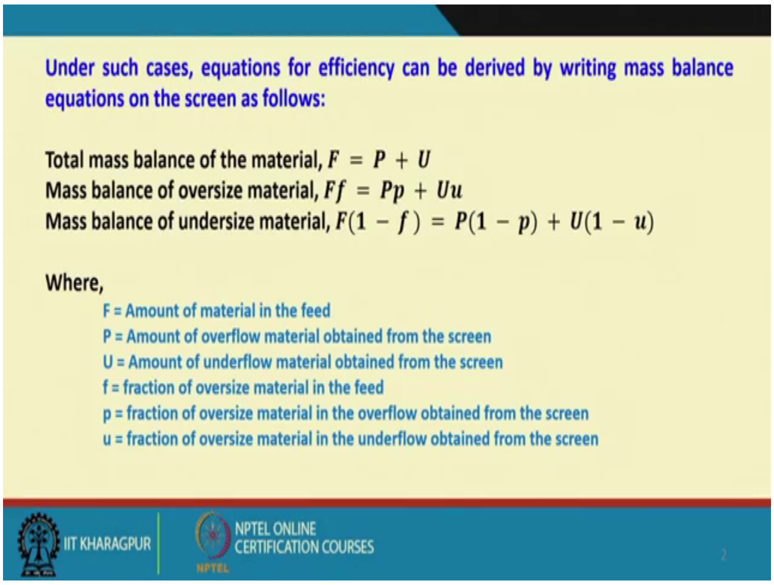

So, under such cases that is in really real cases equations for efficiency can be derived by writing mass balance equations on the screen as follows what is mass balance that is input is equal to output. That means, the screen if it is run in a steady state condition that in a continuous mode where your input is equal to output then you can write that the mass balance of the material that is F is equal to P plus U. What is F? Now, F is the amount of material in the feed that is how much you are feeding, that should be equal to amount of overflow material obtained from the screen and U capital U is equal to amount of underflow material obtained from the screen. Because if I am processing 100 tons of material if F is equal to 100 tons then that should be equal to if it is a perfectly mass balanced, then say suppose I am getting 60 tons in the overflow then I should get the ores are oversize fraction I should get 40 tons in the undersized fraction. So, that is the meaning of F is equal to P plus U.

Now suppose that your 100 tons of material there is a feed that is the mixture of different particle sizes. Now, I want to separate at a size of say suppose I want to separate that entire assemblage a is a aperture size of 5 millimetre; that means, I have got a screen which is having an aperture of 5 millimetre. Now, what I have to do? So, how much a fraction of material in the feed that is out of 100 tons what is the quantity of material what fraction of material are there which are coarser than 5 millimetre. So, if I represent that with small f that is fraction of oversized material in the feed that is say it is 40 percent. So, ever is 40 percent so that means, I have got 40 tonnes of material out of my 100 tonnes of feed which is coarser than a 5 millimetre. So, how much will be the finer than 5 millimetre? Remaining 60 tons, so that will be say that is the f, that is a small f.

And say p small p is it a fraction of oversized material in the overflow obtained from the screen. Now, if I have 100 tales of feed material out of that 40 percent is basically oversized material oversize means when my screen aperture is 5 millimetres say. So, I have got 40 tons of material and I have got 40 tons of total feed material which is reporting into the oversize. Now, what I have to see that how much of are they all are they entire 40 tones is coarser than 5 millimetre, in ideal situation does not happen like that.

So, suppose that is 38 tones. So, remaining 2 tones where it has gone? It has gone to the undersized although they are, they should ideally report to the oversize fraction. So, that is why we are assuming that there is some miss placement, there is some broken part, that is the screen is not properly designed and all this. So, if the small p is the fraction of oversized material in the overflow obtained from the screen and small u is fraction of oversized material that is plus 5 millimetre, particle 5 coarser than 5 millimetre particle how much of that that is what fraction of that is reported into the undersized fraction. So, you have got 40 tonnes of oversized material out of that says suppose 80 percent is your plus 5 millimetre. So, that 0.8 is the small p and you have got 60 tonnes of your u that is your undersize material. So, the remaining 8 tons, are reported here 8 tons of coarser material has reported here. So, what is the fraction of that 8 percent out of 60 tones? That we have to calculate that is around say 13 percent or say 13.5 percent to be precise. So, it will be 0.135. So, that is the small u.

So, in this case for the mass balance for oversize material we can write F capital F multiplied by small f, that is I am doing it for the plus 5 millimetre particles. So, it is P capital P that how much of the total material has come and then what fraction of this p is basically the plus 5 millimetre. So, that is denoted at small p and plus U capital U that is what is that what percentage of total feed has been reported to the undersize fraction and in that undersize fraction what fraction is the plus 5 millimetre particle. So, that is the small u.

Similarly we can do a mass balance for undersized material also because as I said that if I have 100 tons of material that is equal to capital F and if I have 40 percent or plus 5 millimetre. So, that is your 40 ton out of that under ton 40 ton is the plus 5 millimetre particle. So, what is my minus 5 millimetre particle? It is the remaining 60 tons. So, I can write that is there my ideal undersize material. So, F, capital F multiplied by 1 minus f because this that we are writing it in fraction. So, that is equal to P into similarly we can write capital P into 1 minus p plus capital U into 1 minus u because the remaining will be your undersized material.

Now, this equations, if these 3 equations if we rearrange it now, what will happen?

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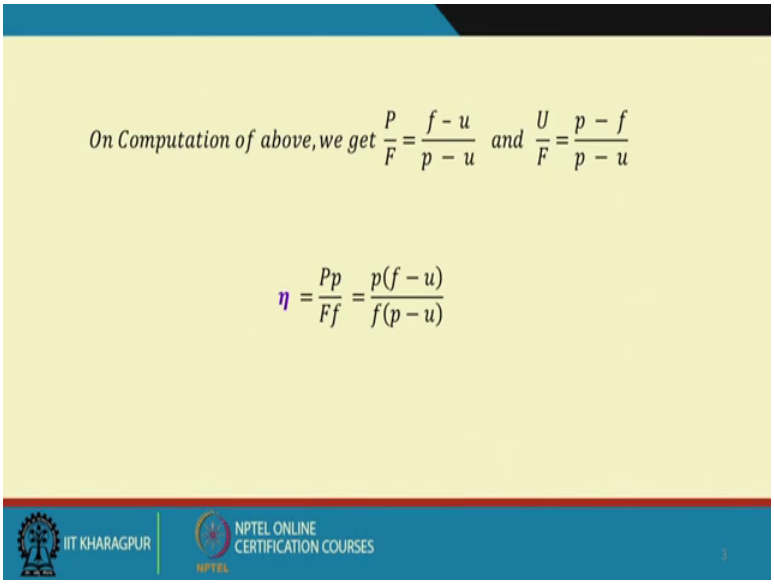

You please try it on your own and what we can do that is I can write p is equal to f minus u and we can place this we can replace this value in this equation or in this equation to derive it like this that is you try to get read of this your capital F and P and U. So, that I get a ratio of that. So, this is a simple calculation you can try it on your own if you have trouble with this just let me know when we having open forum.

So, on competition of above we get. So, capital P by F that is capital F is equal to small f minus small u divided by small p minus small u, that is p is the oversized material relation to feed size material, I can calculate it that what fraction of coarser size material is there in the feed minus what size of that coarser fraction has reported to the underflow divided by what fraction of coarser size has reported to the oversized fraction minus what fraction of that has reported to the undersized fraction. Similarly we can also write u by f capital U by capital F is equal to p minus f small p minus f divided by a small p minus u. Why we are writing this? Because we are trying to write it in the form that we want to calculate that based on that your say definition that of your efficiency in the oversize material or efficiency for the undersized material.

So, now what is the efficiency of oversized material now we can write? That is how much of that oversized material I have recovered into the oversize. I am coming back to that original example that is I have got 100 tons of feed material out of that 40 percent is coarser material or oversized material; that means, I have got total 40 tons of plus 5 millimetre particle. Now, I have recovered in the oversize material I have got total 40 tons. So, that is nothing, but your capital P and out of that your 40 tons we have seen that we have got 90 percent of the material or the 0.9 fraction of that is plus 5 millimetre. So that means, how much we have got? So, we have got 36 tons of that plus 5 material.

So, this efficiency is saying that we have recovered in the oversize material 36 tons of oversize material out of 40 tons available in the feed. So, my efficiency is 36 by 40 is basically 90 percent or if I write it in percentage that is multiplied by 100. So, we get 36 divided by 40 multiplied by 100. So, it is 90 percent efficiency based on oversize material. So, we can also write in this form that is capital P into small p divided by capital F into small f and if I replace this p by f that is f minus u divided by small p minus u and you have got small p by f left here. So, we can write it based on that. So, by doing the size analysis of the oversized and undersized material in the laboratory by taking a representative sample that is only at 5 millimetre and then you can replace this, those values here and we can get to know that what is the efficiency of my oversize material during that screening process.

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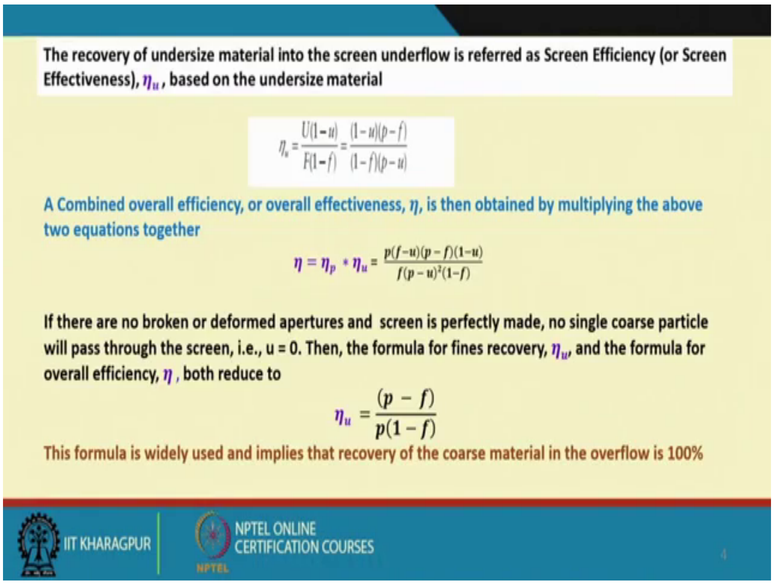

Similarly, the recovery of undersized material, so you have got 40 tons of oversize material, now I am interested in over undersized material. So, how much of undersized material was there out of 100 tons? So, we have got 60 tons. Now, I have to see that how much of that material out of the 60 ton available how much we could recover it into the underflow. So, that is the available. So, that is the 60 tons now how much I have got. What is the u? u into 1 minus u. So, because whatever the percentage of oversize material I have calculated into the undersized. So, remaining, suppose 40 tons has gone there, remaining 60 tons are basically in the undersized out of that 10 tons is now basically your oversize material. So, remaining 50 tons is your undersized material you have got out of 60 tons available in the feed.

So, the recovery of undersized material into the screen under flow is referred as screen efficiency or screen effectiveness based on the undersized material eta u. So, that is defined as U, capital U multiplied by 1 minus u; that is 1 minus u means it is the undersized material oversize material you have got u small u. So, 1 minus u will be the fraction what is the undersized material you have got in the underflow and how much of that was available undersized material that is 1 minus small f multiplied by capital F. And if you replace this u by f value what we have written here that is p minus f divided by p minus u and then you can write this equation as 1 minus u divided by 1 minus f multiplied by p minus f divided by p minus u.

So, when you are interested in both of your material that is if you are interested in only knowing that what is the effectiveness of generating undersized material I can use this formula, if you are interested in oversize material I can use the previous formula. But if I am interested in both oversize and undersize material, so a combined overall efficiency or the overall effectiveness is then obtained by multiplying the above two equations together. That is your oversize material effectiveness multiplied by undersized material effectiveness and it is simply by multiplying this undersized and oversize effectiveness that is this equation multiplied by this equation we get an equation in this form.

But if you ensure if you are maintaining your screen on a regular basis and if you have bought it from your standard manufacturing agencies, you can, if you can assure that there are no broken or deformed apertures and the screen is perfectly made then as I said that no single coarse particle will pass through the screen. So that means, that small u is equal to 0; that means, the your that is no chance that your any coarse particle then your aperture will report to your undersized fraction. So, then what will happen if I put u is equal to 0 in this equation. So, this becomes p f multiplied by p minus f and divided by f into p square into 1 minus f. So, I can write p minus f these are all in small divided by small p into 1 minus f. So, then the formula for fines recovery and the formula for overall efficiency both reduced to these form. So, whether it is the overall if it recovery or overall efficiency or the underflow undersize efficiency they get into this form. So, these formula is widely used and implies the recovery of the course material in the overflow is 100 percent.

Now, if you maybe wondering that if the screen is perfectly made how come the undersized material they report to the oversize fraction. As I said that you have got many layers of particles. So, if your screen is overcrowded, if you have multiple layers of that. So, the undersized particles may be having no chance to have your interaction with the aperture and they may report to the oversize fraction there are many mechanism it may be adhered to the coarser particle size surfaces. Suppose imagine that I have got one micron or two micron type of sizes of clay particles they may be added to the coarse particle surfaces and even with they may, even if you give them an opportunity to the tube to interact with the apertures, but still as because they are not dislodged from the your coarses size fraction your skin of that, your the surfaces of that. So, these particles will be carried and will report to the oversized fraction.

So, it is very common to observe that your relatively finer particles they report to your oversized fraction, but if your screen is perfectly made and if your maintenance schedule is proper you can guarantee you can ensure that your recovery of oversized material into the on to the screening surface is 100 percent.

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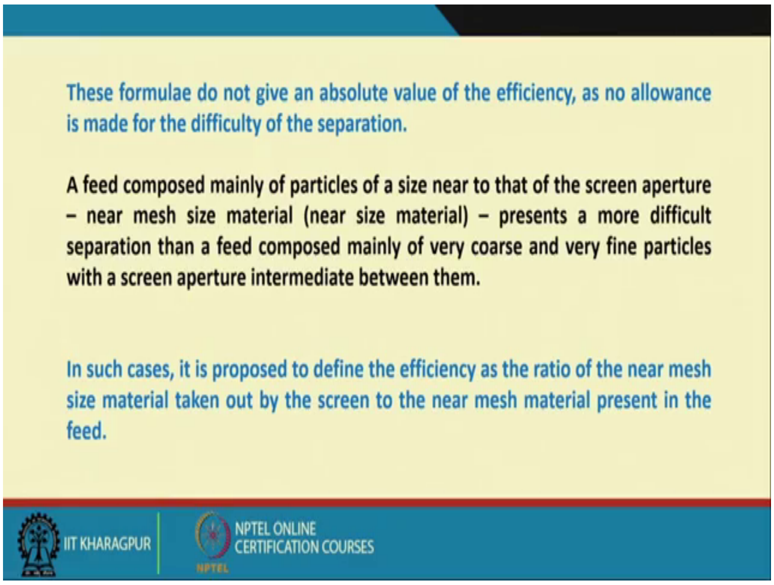

So, but these formula do not give an absolute value of the screen efficiency of the efficiency as no allowance is made for the difficulty of the separation. And as we discussed about the near size material, here we are thinking of only two particle classes that is coarser than your aperture and finer than the aperture, what will happen to the near size particles, and how did you ensure that your screen is properly maintained and the screen surface apertures are properly made and then you have what is the feeding system, what is the material flow characteristics. So, how difficult is that whether the material the material is sticky, then you have got a separate difficulty. If your material consists of the relatively larger fractions of your near size materials then how much of residence time is required have you given that. So, there is no allowance is made for the difficulty of the separation.

A feed composed mainly of particles of a size near to that of the screen aperture we call it near mesh or near size particle presence a more difficult separation than if feed composed mainly of very coarse and very fine particles with a screen aperture intermediate between them. Like when you are getting a mind sample you have got a size distribution. So, definitely you will be having some near sized materials and this formula does not take into account of that that is how effectively the screen has separated the near size materials. So, in such cases it is proposed to define the efficiency as the ratio of the near mesh part material taken out by the screen to the near mesh material present in the feed. So, there are various definitions of screen efficiencies and depending on your what for your objective of screening you use different formula for screen efficiencies.

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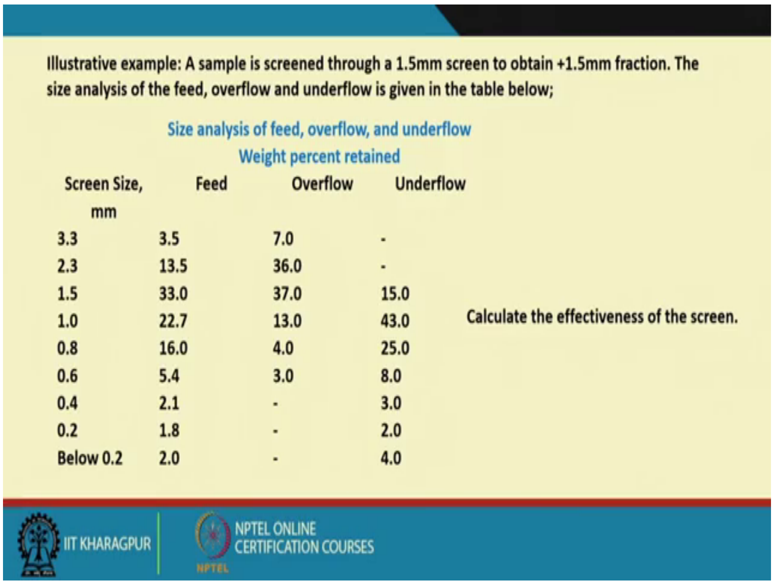

Now, how do we use this formula? Let me show you an example a sample is screened through a 1.5 millimetre screen to obtain plus 1.5 millimetre fraction. The size analysis of the feed that is suppose I have got screening operation and the screen was having 1.5 millimetre aperture. So, we have got a sample screen through a 1.5 millimetres screen to obtain plus 1.5 millimetre fraction. So, you have got oversized material from the actual screen.

Now, you have done the size analysis also of the feed and over oversized material overflow and underflow overflow means I have got a screen whatever is retained that we call it overflow whatever it is passed that is called we under flow. So, you have done the size analysis of the feed overflow and underflow which is given in the table below. So, I am not worried about what is the flow rate and all this, how much you have got in this because you have seen that effectiveness can be calculated based on the quality of your product. So, this is the size analysis of feed overflow and underflow.

So, these are the screen sizes this is the feed weight percent retained that is in feed, we have reported that what are the different weight percent retained at different sieves you remember the sieve analysis I believe that. The overflow fraction whatever you have collected that also you have done size analysis with the identical sieves and you have got these numbers. Now, in the underflow also you have done the size analysis with the identical sieves and you got these numbers. You see that in the overflow fraction you do not have much of finder fraction below your 0.6 millimetre and you see that in the underflow fraction you do not have much of coarser material than 1.5 millimetre.

But you see that there are certain particle in the feed which are basically coarser than 1.5 millimetre steel they report into the under flow. So, now, I want to calculate the effectiveness of the screen based on this data given. How can I do that?

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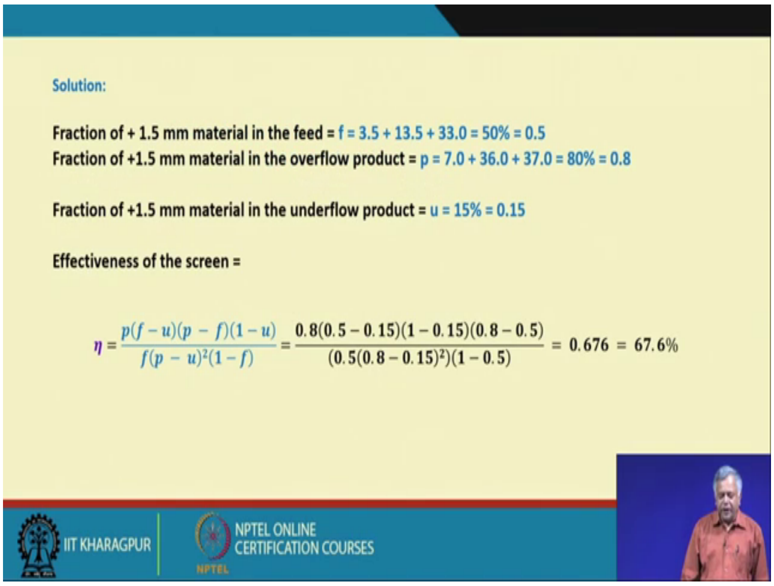

So, let me use this formula. So, fraction of 1.5 material in the feed because your screening operation is at 1.5 millimetre, you have got a 1.5 millimetre aperture screen. So, what is the small f? That is how much of material in the feed present. So, if we go back to this. So, here that is a 1.5. So, that is 33 plus 13.5 plus 3.5. So, this becomes 17 and this is 33, it should become 50. So, that is giving you small f is equal to 50 percent or in fraction because it has to be written in fraction, so that becomes 0.5.

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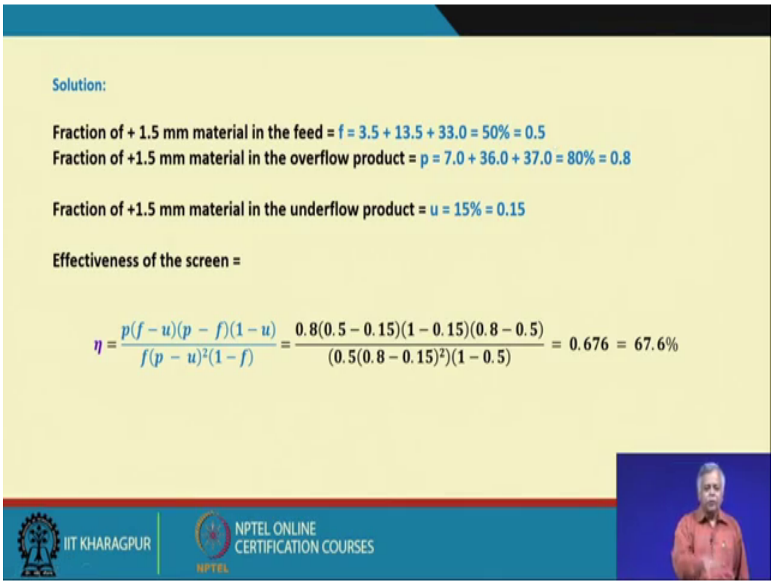

Similarly I have to look at how much of oversize material present into your overflow. So, let us look at the oversize material. So, overflow, in the overflow how much of material which is coarser than 1.5? So, this is a 37 plus 36 is 73 plus 7. So, that is 80 percent or this fraction will be 0.8. So, this is the fraction or plus 1.5 millimetre material in the overflow product that is reported as small p that is equal to 80 percent or equal to 0.8.

Now, similarly I have to look at what is the small u that is your how much of plus 1.5 material is there into the undersized product ok. So, let me go back to this. So, let us see that at 1.5 it is only 15 percent so that will be equal to 0.15. Now, effectiveness of the screen is written as because you cannot make u is equal to 0 because here you have got 0.15. So, I have to use the whole equation, so the f is effectiveness of the screen is equal to they using this formula if you have to remember this formula or maybe you have to derive this if you do not remember and if I put all these values. So, that is p f and you are u we get a value of 0.676 or is equal to 67.6 percent. So that means, the effectiveness of this screen at that operating condition is 67.6 percent. If you want to improve it you have to think of that how do I improve it or if you are fine with this then that is ok.

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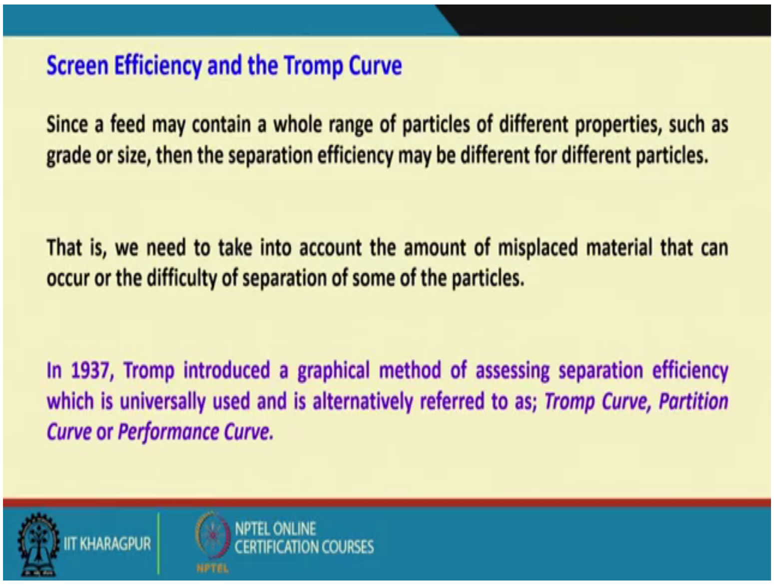

There are also other ways of looking at the screen efficiency. So, it is called the screen efficiency and the tromp curve because a feed may contain a whole range of particles of different properties such as grade or size, then the separation efficiency may be different for different particles.

Now, I have done it with 1.5 millimetre particles. Now, if I say that if I have a 2 millimetre size your screen 2 millimetre aperture of screen that efficiency may be different, for that effectively of that same size material of same material with the identical say operating conditions, but only the apertures we have changed. So, in that case we need to take into account the amount of misplaced material that can occur or the difficulty of separation of some of the particles.

So, this is what in 1937 Tromp introduced a graphical method of assessing separation efficiency which is universally used and this tromp efficiency calculation is not only used for assessing screen efficiency, but for other separating devices which we use in mineral processing. So, this requires your entire another class to explain you because this Tromp efficiency curve we use it for assessing the effectiveness or the performance evaluation of almost all the separating devices. So, we will deal with this with some kind of numerical examples and till then, say in the next class.

Till then, thank you very much.