Introduction to Mineral Processing
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Lecture - 33
Industrial Screening (Contd.)

So, last class I had mentioned that about the Tromp curve, it is popularly known as partition curve. So, what is the beauty of this? Now, imagine that I have got again I am coming back to that example at 1.5 millimetre screen, but even 1 millimetre particle what is the level of difficulty it has faced in getting reported to the undersized material. So, for each particle size class what is the difficulty individually they have faced while getting separated according to their sizes? So, if we take all the size classes together and if we plot them into a form of curve so that is what Tromp has proposed.

Now, here how do we do that?

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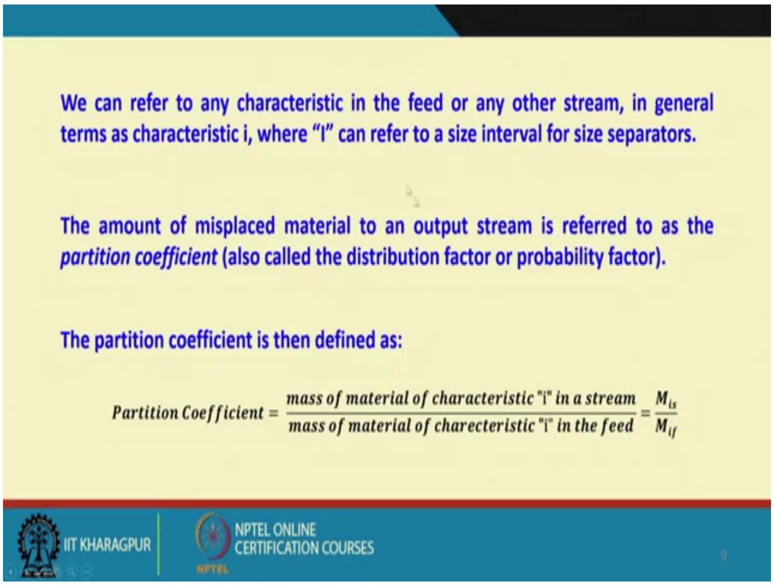

Now, we can refer to any characteristic in the feed or any other stream in general terms as characteristic i or any characteristic size, where i can refer to a size interval for size separators. It may be your say grade for your some mineral separator. So, this is a size separation device. So, here we can refer that i as your, can refer to a size interval for size separators. The amount of misplaced material. What is the meaning of misplace material? That means, if I have an oversized material into the feed ideally this would report to the overflow stream into my screen. If I have undersized material into the feed they should ideally report to the underflow stream. But they may be misreporting that is your some part of my undersized material they are getting reported to the oversize that is called the misplaced particles; that means, they are in the wrong stream.

So, the amount of misplaced material to an output stream is referred to as the partition coefficient. You will get to know it clearly when we solve an example and this is also called the distribution factor or a probability factor. It is simple. Say suppose if I have an aperture of 5 millimetre and if I have a 0.5 millimetre particle, whatever the difficulty it will take it will have to pass through that 5 millimetre will it be similar that if I have a 4.8 millimetre size particle; no, the difficulty levels are different. So, this is what, that what is their distribution of the difficulty they have faced that is what is being quantified as partition coefficient.

So, the partition coefficient is defined as mass of material of characteristic i in a stream divided by mass of material of characteristic i in the feed. So, it is the same concept that is what we have observed, what we have discussed in the oversized material efficiency definition or undersized material definition, but here we are taking into consideration of each particle classes you have in your feed it is not a single oversized or undersized. So, we can report it as M is that is mass of material of characteristic i in a stream and then mass of material of characteristic i in the feed this stream could be overflow or underflow, so that is M if.

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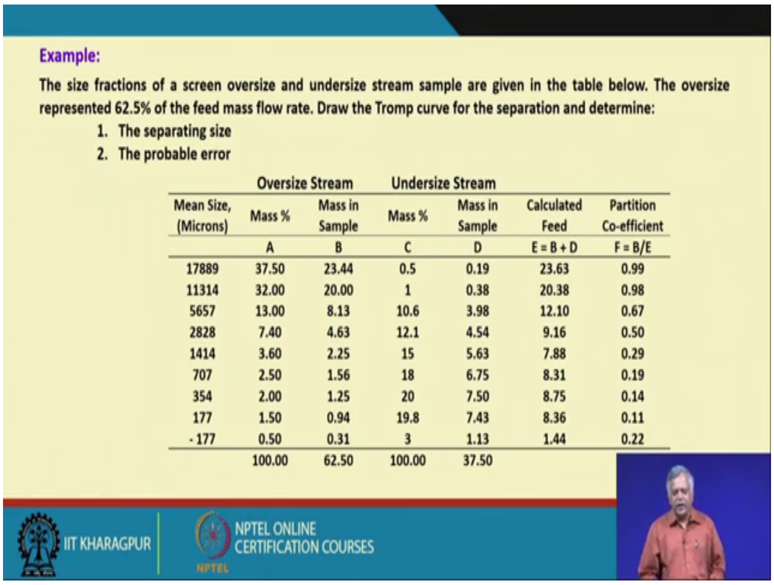

Now, with the example I think that it can be explained in a proper manner. If I put some numbers they need to be easier for explained explanation purposes that is why I have a straight away come to this problem. Example the size fractions of screen over sized an undersized stream sample are given in that table below. That means, the size analysis of the screen over size and under size are given.

So, we have taken representative sample from the screen over size fraction and under size fractions and we have done sieve analysis into a laboratory and that is what is being reported. And then I have to also know that what percentage of the feed was reported to the oversize. So, if I know what percentage so I know that what percentage has reported to the undersized. So, here that value is given the oversize represented 62.5 percent in the feed mass flow rate; that means, remaining 100 minus 62.5 is 37.5 percent as reported to the undersized fraction.

Draw the Tromp curve for the separation and determine the separating size or and the probable error. I will show you how to do it and this is very very important for the performance evaluation not only for screening, but for other separating devices. So, I am not going to discuss separately that how do I evaluate the performance of other mineral possessing separator using the same your set tromp curve based approach.

So, the oversized stream we have got these sizes of the sieves it starts from very coarse size to finest sizes and this oversized stream here at the mass percentage is given. So, suppose I have got 1 kilogram of representative sample from the oversize fraction and that size analysis I have done based on the 1 kilogram and I am reporting that as a percentage of that 1 kilogram for each size fraction what is the mass percentages and a this is the mass percentages of material into the that is the undersized stream this is the size analysis of the undersized stream.

So, what I have to do now, that is when I know the oversize material size distribution when I know the undersized materials distribution and I know what fraction of the feed material has gone to the oversize and then I know automatically that what fraction of the feed has reported to the undersized. So, then I can calculate back that what was the feed size distribution; that means, what does we call it reconstituted feed size distribution there is a debate there many times people say that when we are doing this type of analysis we should do the feed size analysis, over size material size analysis and under size material analysis size analysis and then we should do some kind of your mass balancing based approaches to rectify these numbers. That is a little bit complex.

But my argument is that is it is much better way of doing things that is let us do the reconstituted feed because when you have done the take in the feed maybe that feed has not been actually sized what you are taking it from the oversized and undersized because when it is a mind sample that your feed may be changing and even the my shortest time interval. So, why do I worry about that? So, let me assume let me go back to the reconstituted feed that is at the time of collecting my representative samples from the oversize and under size what was the feed we can get back to that. How do I go back? That is the your some conceptual thing you have to some concept your concept must be clear.

So, this is the percentage of your each fraction. Now, how much of that I have got what fraction of the feed has come to the oversize? Now, say suppose I have got a feed of 100 tons out of that 62.5 tons I have collected into the oversize material and the average size analysis of that 62.5 tons is this. So, if I say that how much of this size was there how much of material out of this 62.5 tons material was there in the oversize material. So, what I have to do that is I have to get back to your actual mass. So, this is the percentage 37.5 percent out of 62.5 percent of my feed material. So, what I have to do? 37.5 multiplied by 0.625 that is the fraction. So, then we get back to this value. So, like that 32 multiplied by 0.625, 13 multiplied by 0.625 like that all the numbers here in this second column we have to multiply it with 0.625 to have a column like this that is the column b that is the mass in sample which is being reported at a discrete sizes into the oversize. So, if I add them together I should get back to this value of 62.5. Hope it is understandable to you or it is clear to you.

Similarly for the undersize fraction what fraction I have got 100 minus 62.5 into the undersized. So, got 37.5 percent of the feed material; that means, if my feed is 100 tons I have got 37.5 tons in the undersized material and if I do the size analysis of this 37.5 tons of material. So, that will be that will bring me back to this that is your 0.5 into 0.375 the that will give you 0.19 like that all the individual numbers which is reported in this column C multiplied by 0.375, I should create a column called D like this.

So, this is very conceptual that first what is the total feed and how they are split. So, 62.5 tons has gone to the overflow remaining 37.5 tons has come to the undersized that 67.5 tons consists of how much of plus 17889 microns. So, that is 23.44 tons like that we are basically discretizing it. So, if I now, go back that how much of that material are plus 17889 micron was there in my feed. So, that will be 23.44 plus 0.19. Now, that means, 23.63. So, the column E is equal to B plus D that is your B plus D. So, you get 23.63 like that if you add column B plus column D you get these numbers. I strongly advise all of you to please to kindly practice this. Even you can practice this with these numbers and best way to practice it is through my excel, power point or maybe you can use a calculator these are all simple arithmetic calculations.

So, now I have got this feed. Now, according to tromp the partition coefficient for each size fraction is basically if I can do it based on your undersized or maybe I can do it based on oversized. So, if I do it based on oversized material it is B by E that is what percentage what is that total mass I had which is plus 17889 micron then we coarser than that. So, that is I am getting 23.44 tons of material into my oversize fraction. Out of how much? Out of 23.63 available in the feed, so the partition coefficient is F is equal to B by E, I can similarly do it with your say sample your say D by E also for undersized particles. So, that will give you 0.99.

So that means, for the coarser particle the effectiveness of the screen is around 99 percent, but you look at as you are going closer as you are going down. So, similarly for this size it is 0.98. Now, you are getting different values for that. So, this is giving you that what is the difficulty this, your screening operation has faced for each discrete particle sizes.

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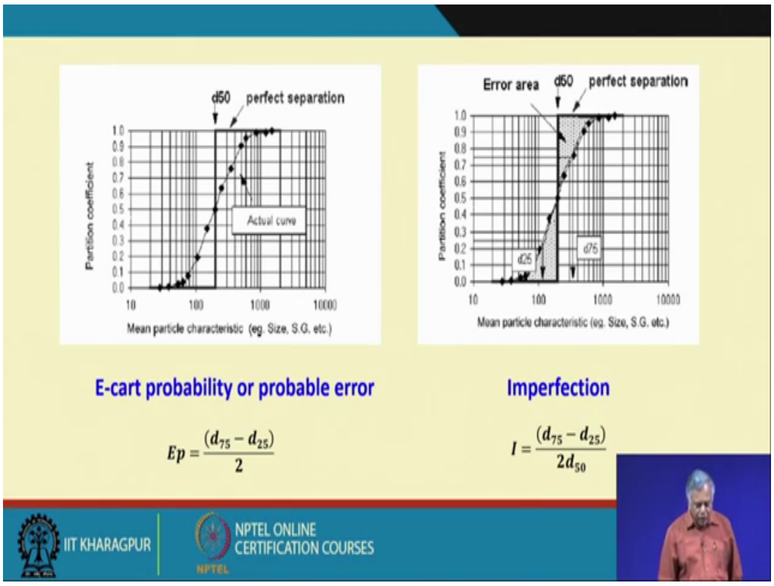

Now, if I plot them, if I plot them that is your mean particle characteristic that is I can plot it based on size this is a sized separator. So, I can plot it based on size and if I have done the discretization based on specific gravity I would have plotted it in the x axis that is your specific gravity that is what we do it for gravity concentration processes.

So, here is the mean particle characteristic here it is the size and we have taken a logarithmic scale so that we can have a spread of the data. And then this is the partition coefficient. So, for each particle sizes what are the difficulties being faced, if I plot them and the difficulty is represented by the partition coefficient we get a plot like this and this is what is showing that is the your coarser particle are having your say less difficulty of separation, but at what size. What size you have separated? So, that is a critical issue that is we have not specified as size. So, here the Tromps suggestion is that you take d 50 size; that means, normally it is a practice.

Now, when I plot this curve which is what got a typical shape. So, then the d 50 is the imaginary size where there is a you have got 50 percent oversized material and that size and you have got 50 percent material into the undersize, so these 50 percent data that imaginary size you are getting it from your partition coefficient data, it is not the actual separation which has given you. So, if I have, if this is my imaginary size. So, suppose this is 200 micrometres and if I have separated if I have obtained this data at an imaginary size of screening at 200 micrometre I would have got 50 percent material into the oversize and remaining 50 percent of the feed material into the undersize.

So now, there is another concept here that is your call E-cart probable error and this is defined as that is if I have an ideal screening at 200 micrometre. I should have a curve like this I should have instead of a curve, I should have a vertical line like this and all my oversized particle should have been having a your partition coefficient of 1 or 100 percent efficiently efficiency of separation and all my under undersized particle should have a efficiency of separation of 100 percent or your partition coefficient of your 0. So that means, I should have a vertical line instead of this curves.

So now, the concept here is that that in actual operation I have got this please remember that this definition is based on that d 50 concept. That what is that imaginary size at where the screen has given me a 50 50 split of my oversized and undersized particles. So, similarly from this also I can calculate what is the 75 percent passing size 70 per d 75. So, that is the d 75 I can calculate that is your material where it has got a split in between 75 is to 25 or your 3 is to 1. Similarly I can get a value of d 25 that is at 25 percent here that is your 1 is to 3. Now, why should I take d 75 and d 25, why not other values? If you look at closely that within d 25 and d 75 it is not a curve it is almost a straight line, but it is beyond these two values there is a some deviation in the your say the curve. So, I have got a straight line. So, when I have a straight line. So, basically this concept has come from the slope of this straight line, but I am not getting into that detail.

So, this E-cart probability or probable error is defined as Ep is equal to in short form we write it Ep that is E-cart probability or we call it probable error also the d 75 minus d 25 divided by 2. And there is also another definition it is called the imperfection this is also the same thing what I am saying, but it is showing in the area enclosed under this that how much is the deviation from the ideal curve. So, imperfection is defined as d 75 minus d 25 divided by 2 d 50. So, these are the two basic changes in the definition here you are dividing it also by d 50 sizes.

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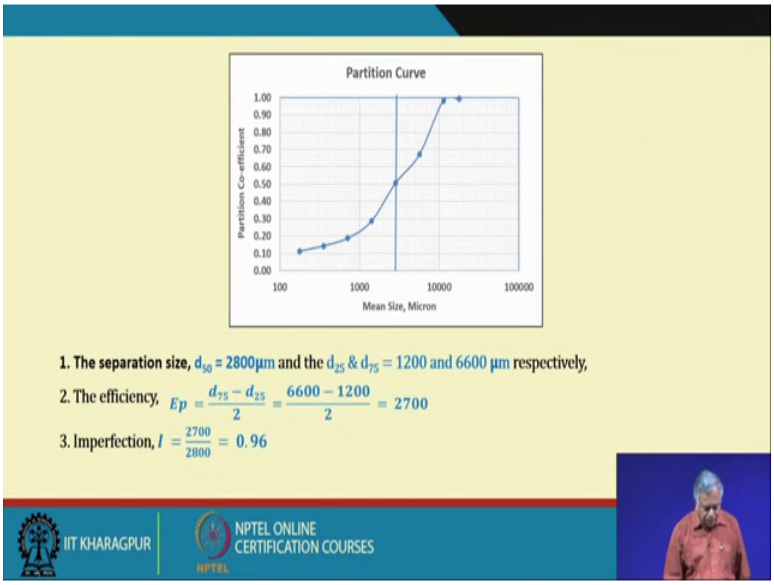

So now, if we go back to that data and if we plot that data. So, we get a curve like this that is with your main size versus your partition coefficient and you get a separation size d 50 is equal to 2800 micron micrometre. So, here the d 50, so the previous curve was not drawn based on the data given this is the curve drawn based on the data given. So, here the d 50 is 2800 micrometre and the d 25, d 25 is somewhere here it is around 1200 micrometres and d 75 is somewhere here which will give you the value of 6600 micrometre.

So now, the efficiency Ep is equal to d 75 minus d 25 divided by 2. So, that is 6600 minus 1200 divided by 2. So, that is 2700. So that means, the it is the E-cart probable at this is 2700, but as because there is no upper limit for this it is very difficult to assess that whether my screen is doing my job in a proper manner or not, but I suggest that for screening this imperfection is a better way of doing that. So, your if I look at that is your imperfection is nothing, but your Ep divided by d 50. So, what is the d 50 value? 2800, because it is d 75 minus d 25 divided by 2 d 50. So, it is 2700 is the d 75 minus d 25 divided by 2 that is Ep by d 50 will give you the imperfection. So, that is 2700 by 2800 is equal to 0.96. So, if it is a perfect separation they say to have been your 2800 by 2800 it should have been the one. So, your Ep your imperfection is 0.96. So, these are the answers to the questions.

Let us look at that what are the other factors, what are the various factors that affect screen performance.

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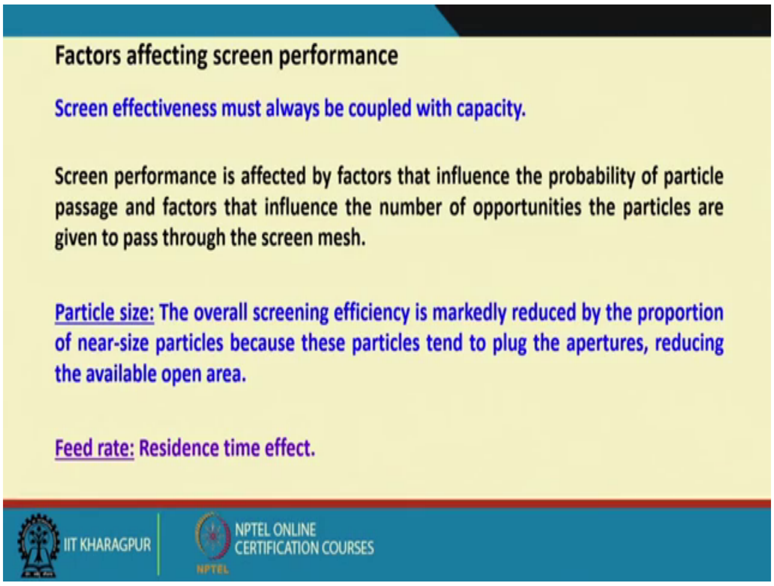

That is why do you think that the screen is not industrial screens they do not operate at a in a perfect manner. So, I must know what are the governing for what are the different factors. So, screen effectiveness must always be coupled with capacity that is at what rate we are separating. So, screen performance is affected by factors that influence the probability of particle passage that is how much a passage you have given, what is the probability of that particle I keep on hammering this that how many times the each particle class has got the opportunity to interact with the aperture to finally, decide that whether I am finer or coarser than that aperture.

So, and the factors that influence the number of opportunities the particles are given to pass through the screen mesh. So, what is particle size? So, I have already given that demonstration with the straight screen I have shown you the different particles and how do they behave. So, the overall screening efficiency is markedly reduced by the proportion of near sized particles, that is from 0.75 to 1.5 times your size of the screen. Because these particles tend to plug the apertures sometimes because of the some projected your areas they may get just stuck into the screen surface. So, they will not only they will not only create problem your mass balancing because they are not reporting neither in the oversized fraction nor the undersized fraction, but the passage is also blocked. So, with time the your entire effective surface area of the screen will be reduced and naturally your screen efficiency will be reduced.

Feed rate that is what we have already discussed a depth that is your overcrowding. That is the residence time effect that is how much of time you are giving and what is the bed depth you are creating. So, if you are feeding at a very high rate, so the some of the particles at different layers they may not have any opportunity to have this your interaction with my aperture to finally, decide that whether I should report to the which stream.

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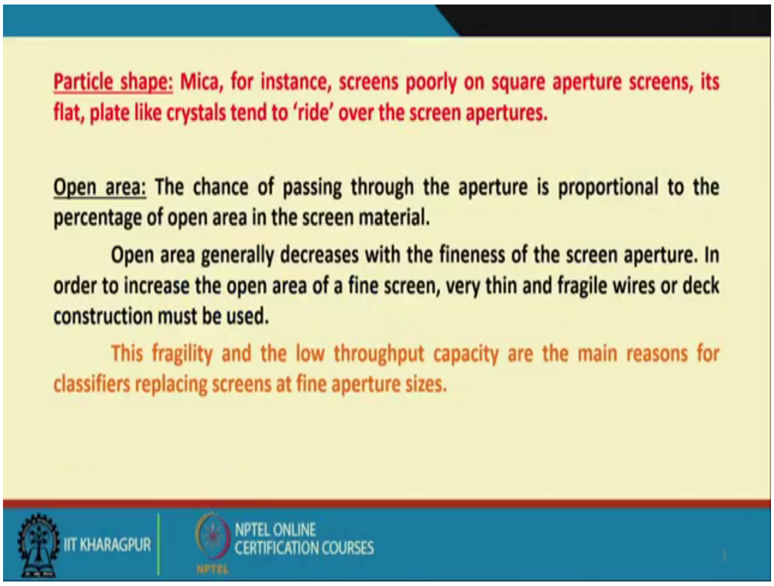

The next is the particle shape I had shown you that if I have elongated particle, it depends on what is that your basically the orientation. So, that will decide finally, that whether it will finer or coarser than that.

So, mica for instance screens poorly on square aperture screens because if I have a mica is a like your say flatter particles like your lentils or may be flatter than that. So, on a square aperture screens they get flat. It is flat plate like crystals tend to ride over the screen aperture; that means, they will just sit over, it will not move even. So, it will block the passage.

Then the open area how much is the percentage open area you have given in the screen and that is the challenge to the screen manufacturers that is how much of opening area you can give. That means, we one example I have given that is if you can minimize the wire thickness you can create more open area, but not at the expense of your maintenance or your say damage to your screen. So, you have to give prolong life as well as maximum aperture area. So, the material scientists they play a huge role here. So, the chance of passing through the aperture is proportional to the percentage of open area in the screen material.

So, we have already derived this we have shown you that what is the open area how we can calculate it. Open area generally decreases with the fineness of the screen aperture. Why? Now, the material gets choked, material blocks because you have got more near size materials and the fine particles and the very fine sizes have apertures they are very difficult to pass through. So, they plug your openings.

So, in order to increase the open area of a fine screen very thin and fragile wires or deck construction must be used and we use also weight screening so that they are basically the water also tries to say frost that those particles. So, this fragility and the low throughput capacity are the main reasons for classifiers replacing screens at fine aperture sizes. This is the reason that is below a particular size the screen effectiveness reduces drastically and that is why we have to switch over to other mechanism that is called classifiers where we use the principles of movement of solids in fluids to separate them and, but these days there are some developments happening in the even with the say fine screening.

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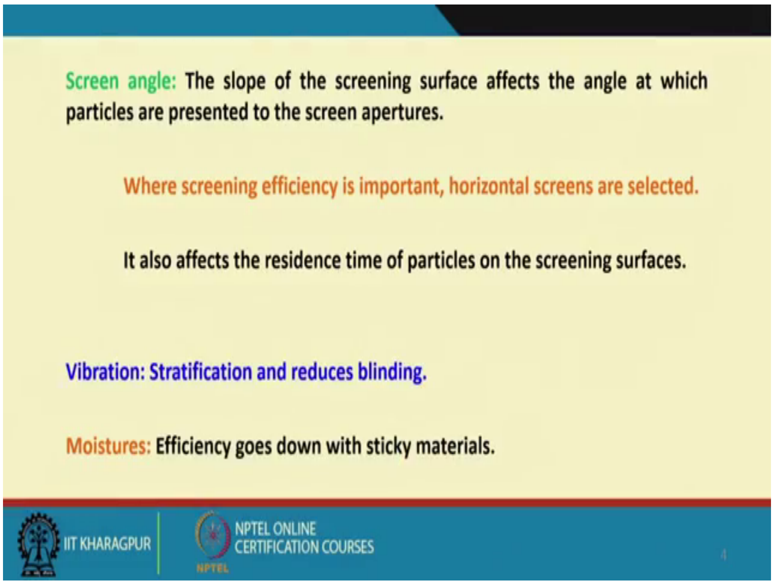

Screen angle, that is the slope of the screening surface affects the angle at which particles are presented to the screen apertures because if they are inclined you know the apertures at different locations they will be different, so that also affects the screen performance. Were screening efficiency is important that is I want higher screening efficiency horizontal screens are selected because the particle movement is slow through that. It also affects the residence time of particles on the screening surfaces that is your capacity will be less.

Vibration you can use vibration, where a stratification because it helps in stratification and reduces blinding because the particles are always in mobile. So, you are reducing the blinding miss choking of the passages of your apertures.

Moisture because if I have more moisture into my material. So, the efficiency goes down with sticky materials.

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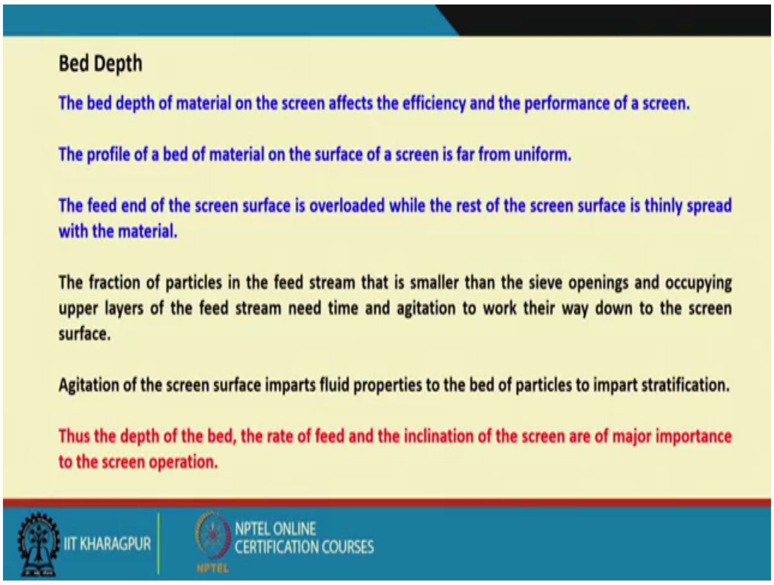

Bed depth we have discussed it the bed depth means your how many layers you have got so that means, if the screen surface is it does not have any aperture suppose if you have a plate and if I am feeding that rate what is the depth of that material.

So, if the bed depth increases means the less chances of that top layer of particles to have interaction with the apertures. So, your capacity will be reduced. So, in that case the bed depth of material on the screen affects the efficiency and the performance of the screen and the fraction of particles in the feed stream that is smaller than the sieve openings and occupying upper layers we have already discussed that.

And agitation of the screen surface inputs fluid properties to the bed particles to impart stratification because when you are bed particles and when you are trying to vibrate or lift them up so you are increasing the volume occupied volume occupied by the particles. So, the particles have got more space or the more void spaces to say to pass through that and they decide or you are trying to give more probability or opportunities for the particles to have interaction with the aperture. This thing will discuss more that is the fluidation when we discuss about one separator that is called a jigging operation. So, the depth of the bed, the rate of feed rate and the inclination of the screen are of major importance to the screen operation.

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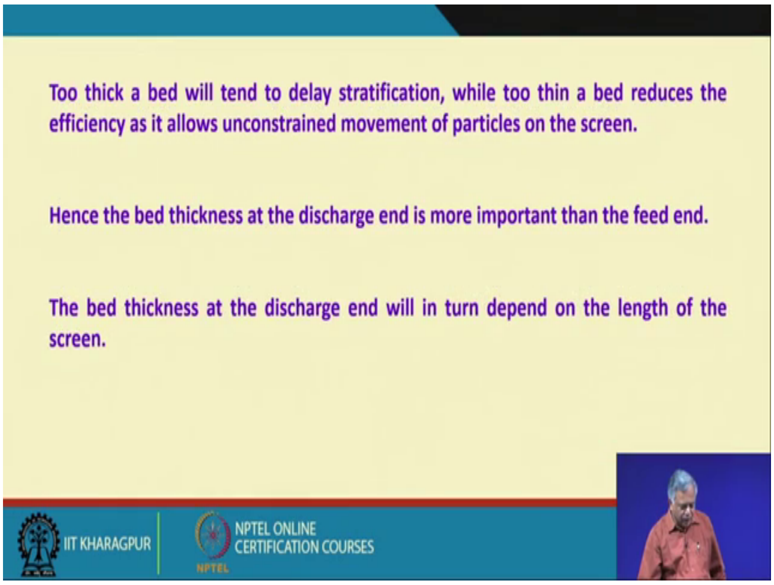

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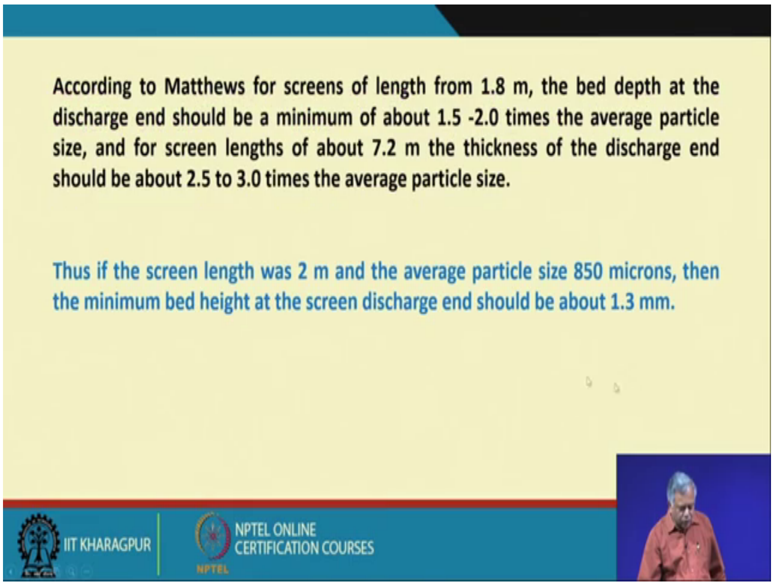

So, how much of bed depth I should have? According to Matthews for screens of length from 1.8 meter the bed depth at the discharging should be a minimum of about 1.5 to 2 times the average particle size. These are some of the proposed rules and you have to verify that whether it works well with your material.

And for string length of about 7.2 meter the thickness of the discharges should be about 2.5 to 3 times the average particle sizes, but that is not a fixed rule I am repeating it again you have to verify this with your material. So, if the screen length was 2 meter and the average particle size is 850 microns then the minimum bed height at the screen discharging should be about 1.3 millimetre.

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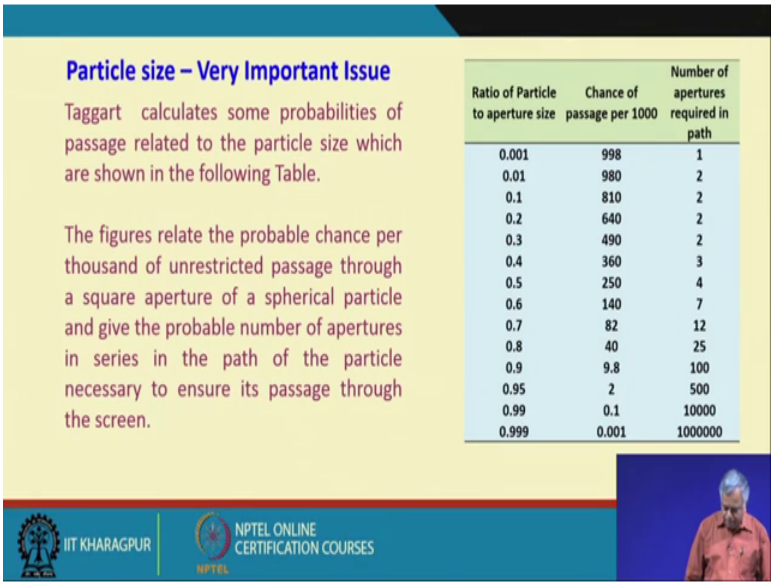

So, this is the chart where I am giving the ratio of particle to aperture sizes. That means, when your aperture size is suppose your 1000 micron and your particle is one micron. So, the ratio of particle to aperture is 1 by 1000 that is 0.001 and chance of passage per 1000 is 998. So, this is number of apertures required in path only 1; that means, 1, 1 passage, 1 chance it has got 998 times out of 1000 times it will pass through.

So, this is like your probability calculations. So, whosoever is more interested to know about this you can go through this and this is what is showing that when the particle to aperture size goes down that is your probability that is your number of apertures required in path increases; that means, you have to increase the residence time of the particles, many many folds.

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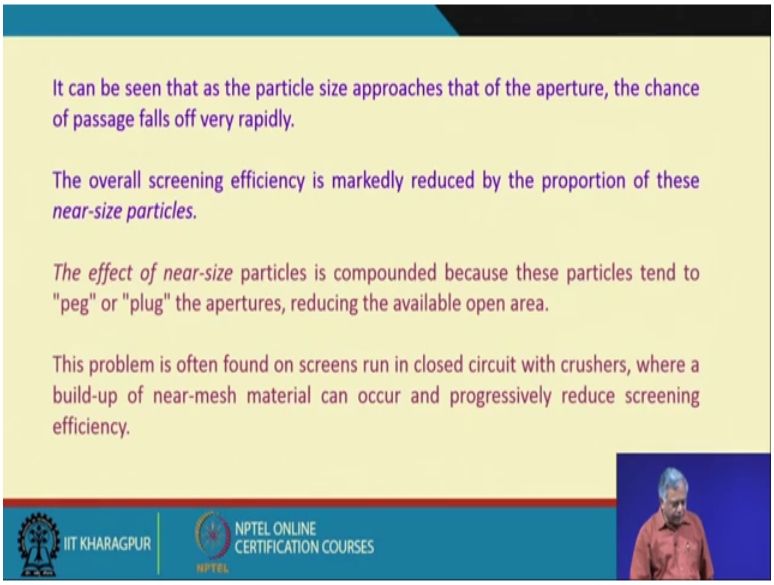

So, the effect of near sized particles we have discussed, over all screen efficiency we have we have discussed that is the proportion of the near size materials and the problem is often found on screens run in closed circuit with crossers a build up of near mesh material can occur and progressively reduce screening of efficiency.

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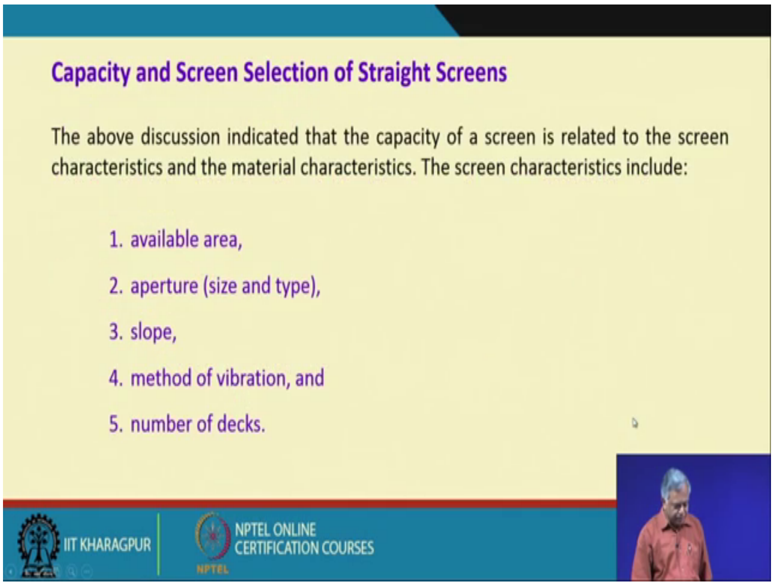

So, we will continue this in the next lecture.

Till then, thank you very much.