Mechanical Unit Operation
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Lecture 06
Screening Equipment, Effectiveness and Capacity

Welcome to the mooc course, Mechanical unit operations. The title of this particular lecture is screening equipment, effectiveness and capacity.

Screening equipment

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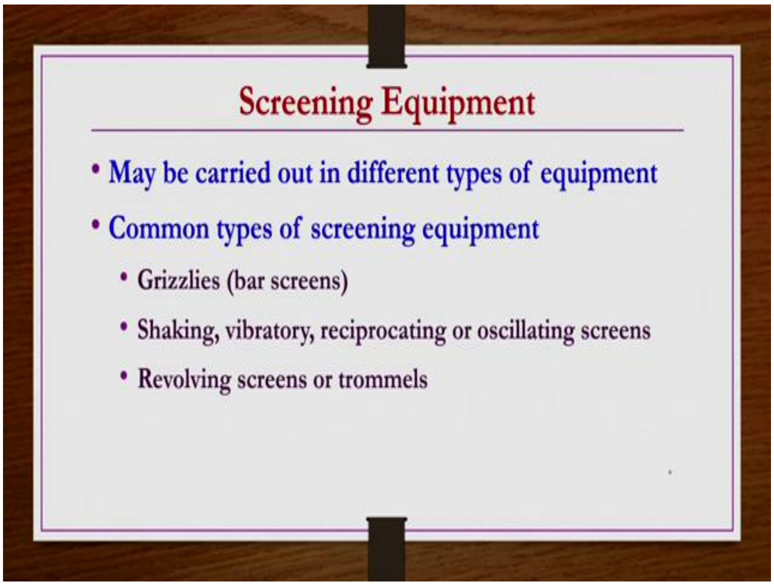

The screening may be carried out in different types of equipment. So it is basically the, you know, design how to handle the material in continuous process and then how to have a kind of higher capacity screens without compromising on their effectiveness as well. So there are many possibilities are available. There are different types of industrial screens are available.

So but here we see the screening equipment based on the type of the motion that has been generated on those kind of basis we will be seeing some kind of a screening equipment, right. So most common type of screening equipment are Grizzlies or bar screen, shaking, vibratory, reciprocating or oscillating screens or revolving screens or trommels also they are being known as. So we see one by one.

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Grizzlies are used for screening larger particles of size greater than 25 millimeters. They consist of parallel bars which space to desired separations as per the requirement and then in general to avoid the clogging or minimize the clogging, bars are often wedge shaped so that the clogging would be minimum and they can be usually horizontally mounted or they can be inclined with an inclination angle up to 60 degrees. Vibrating Grizzlies are also available for the feed material passing over surface in a series of jerks.

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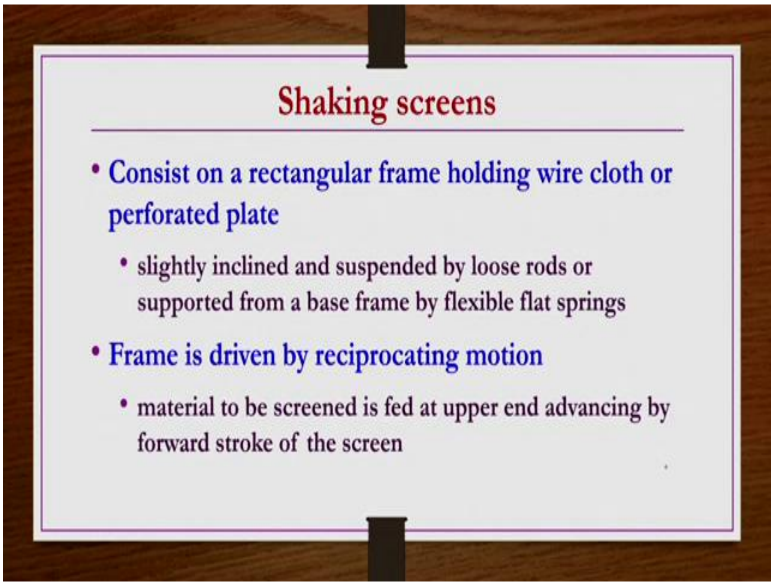

Next one is the vibrating screens. So vibrating screens are used as standard practice when large capacity and high efficiency are required. So in the capacity section we are going to see for some of the oars the capacity is so much high for this vibrating screen compared to another type of screens, the capacity of this vibrating screens is very much high, similarly their effectiveness is also very much high, that is the reason many people use this vibrating screens in their industries.

Their capacity is large especially for handling the finer sizes compared to the other screens and then anyway the capacity is higher and then especially if you wanted to separate out the finer material from the sample then it is better to have a kind of a vibrating screens, because their capacity is very much high if you are you know handling finer size material not bigger lumps sample is you know of having a finer material finer powder kind of thing and then if you wanted to do their fractionation so then this vibrating screens would be better.

Whereas the Grizzlies are better if the samples are having very large particles like you know in few centimeters or few millimeters etc. These vibrating screens can be mounted horizontally or inclined in general they operate at very high frequencies up to 1000 Hz that is very high frequencies in general. It is having the advantage of accuracy of sizing, so and then low maintenance cost and then saving in installation space.

It requires very less installation space and then maintenance cost is also small and then the accuracy of sizing is also very much higher that is the reason these vibrating screens have been used by so many people in the industries. In general vibrating screens are used at a higher degree compared to the other screens.

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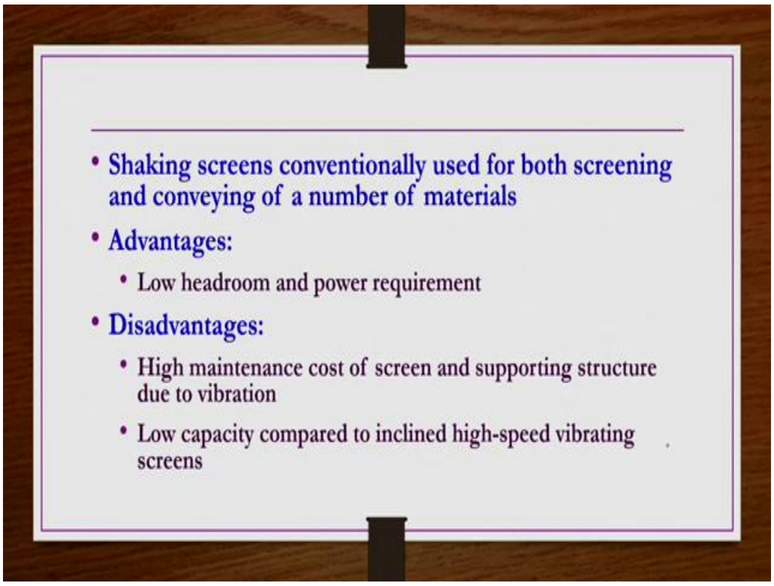

Then shaking screens consists on a rectangular frame holding white cloth or perforated plate. They can be slightly inclined and suspended by loose rods are supported from a base frame by flexible flat springs and then the frame is driven by reciprocating motions. The material to be screened is fed at the upper end advancing by forward stroke of the screens. Then shaking screens conventionally used for both screening and conveying of number of materials.

It is having the advantage of low headroom and power requirement but it is having several disadvantages like high maintenance cost of the screen and supporting structure due to vibration. So this is one of the big disadvantages, as well as the capacity is very low compared to the inclined high speed of vibrating screens. So vibrating screens capacity is anyway high but compared to that one the shaking screens capacity is very much lower.

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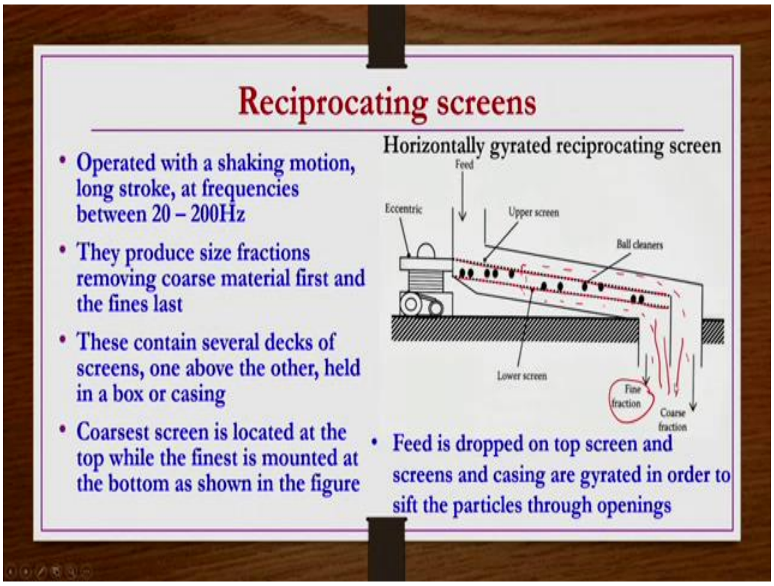

Then reciprocating screens, they operate with a shaking motion long stroke at frequencies between 20 to 200 Hz. They produce size fractions removing coarse material first and then finest materials at the last, that is how these reciprocating screens are designed in general. They contain several decks of screens one above the other held in a box or casing as shown here, let us say we have a box or casing here so there are several screens.

So it only two screens are being shown here the upper screen and lower screen like that but there are the several screens one on to the other such a way that the coarsest opening the largest opening screen is at the top and then the finest opening screen at the bottom. So in that sequential manner they are arranged. In between these screens there are kind of ball cleaners are also provided, okay.

So here what happens the whatever the coarsest material that feed that comes down here and then that passes through the surface, the top surface, whatever the finer material is there that would be passing through the screen of larger openings and then you can get a kind of different fractions in between if you have a kind of large number of screens. Otherwise if you have only two screens you may have a coarse fraction coming at the top and then it is coming first well after passing these screens define fraction is coming from the bottom like a last product.

So coarsest screen is located at the top while the finest is mounted at the bottom are shown in the figure as I already mentioned here. The feed is dropped on top screen and screens and casings are gyrated in order to shift the particles through the openings. Whatever the particles are there they will be passing through the opening something like this and then finer ones may be coming like this the coarsest one would be coming from here if you have the intermediate screens I have not shown in the picture there may be intermediate screens also so then you may be having the middle fractions as well.

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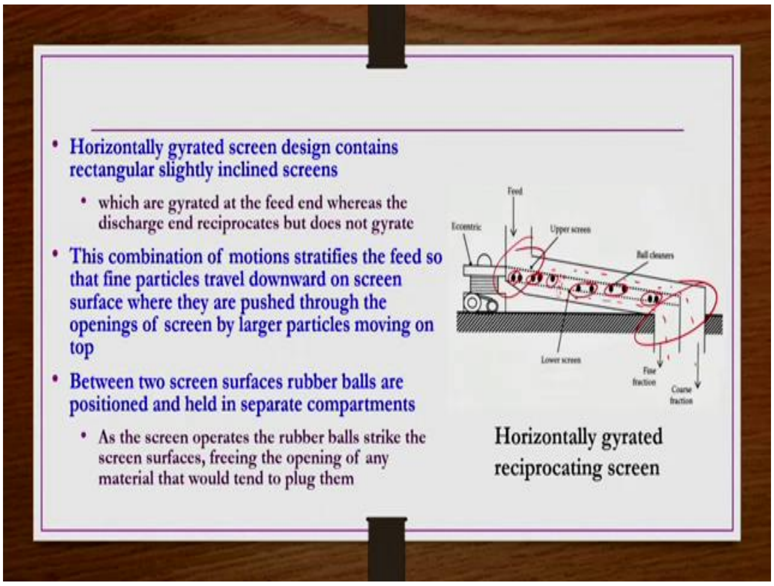

So then horizontally gyrated screen design contents rectangular slightly inclined screens as shown which are gyrated at the feed end whereas the discharge end reciprocate but does not gyrate. So what happens you know the design is such a way that the at the feed end at the top end wherever the feed is coming the that end is gyrated whereas the reciprocation is taking place at the discharging where the material is collected from the bottom as shown in the picture here, right. So because of this combination of motions you know stratification of feed takes place so that the fine particles travel downward on screen surface where they are pushed through the openings of screen by the larger particles moving on top. And then between the screens we have a number of screens so between the screens rubber balls also provided and held in a separate compartment so that to avoid the kind of any possible clogging. All right.

So here you know at this end you know a kind of gyrating motion takes place and then at this end you know kind of a reciprocation motion takes place, okay. So because of this motion you know the particles pass through the surfaces screen opening the finer particles passes through the screen opening like that and then comes out as a fine material, whereas the course material comes first as a kind of you know with the coarse fraction like given here and then between the screen, so these are the rubber balls are provided and they are given in a separate compartment and then they move such a way that as the screen operates the ball strikes this screen surfaces so that whatever the opening of the material is there that is being freed if at all there is a possibility to have a kind of plugging.

If any material is plugging those screens you know when these balls striking those screen surfaces those you know blocking or blinding of surface screen opening whatever is there that will be cleared by removing those particles either moving up and then going on to the surface of the screen or passing through and then coming to the next screen like that. So that is the purpose these rubber balls are provided and they are striking the screen surface in order to avoid the possible clogging that is the very much advantage of this particular reciprocating screens.

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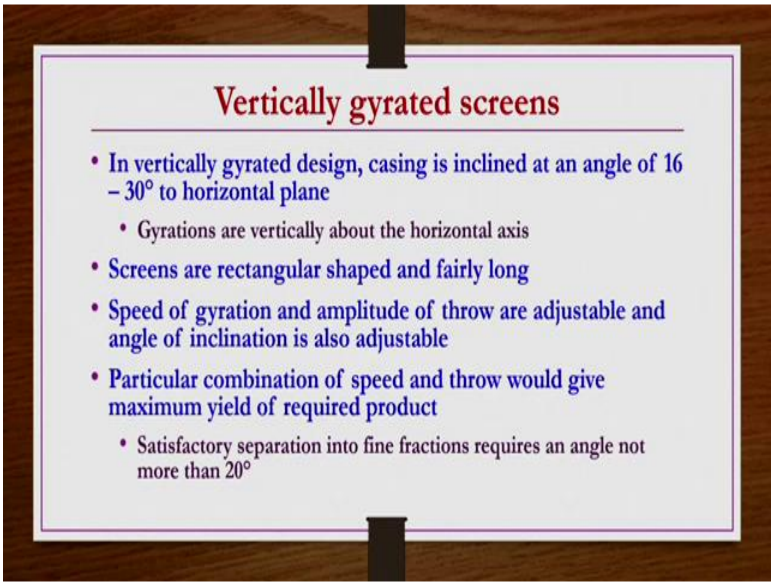

Then vertically generated screens are also possible. They are designed such a way that casing is inclined at an angle between 16 to 30 degrees to horizontal plane, you cannot have a kind of more than 30 degrees. If you have more than 30 degrees inclination the capacity would be very much low as well as the effectiveness would also be very much low. So here gyrations are vertically about the horizontal axis. The principle is quite similar as whatever the horizontally gyrated reciprocating screen whatever we have seen.

The principle is same here in vertically gyrated screens as well but only thing that the casing is inclined at an angle of 16 to 30 degrees to horizontal plane and then gyrations are vertically about the horizontal axis. Screens are rectangular shaped and fairly long. The speed of the gyration and amplitude of throw are adjustable as well as the angle of inclination is also adjustable, that possibility is there in the design. So particular combination of this speed and throw would give a maximum yield of required product.

It has been found that, you know, a satisfactory separation into fine fractions one can get if having the inclination angle less than 20 degrees. If the inclination angle is less than 20 degrees then separation of fine fraction is very much satisfactory by using this vertically gyrated screens.

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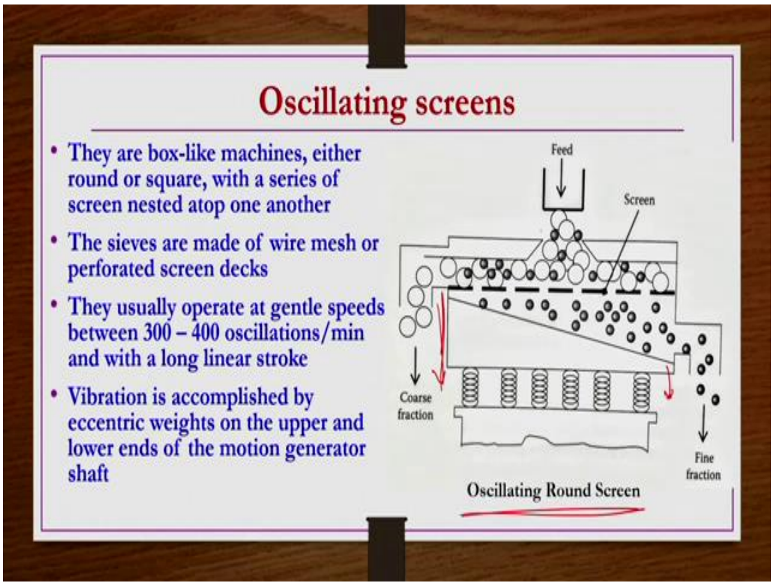

Then oscillating screens, so here oscillating round screen is shown. Actually they can be round or they can be square. In general they are box like machines either round or square with a series of screen nested a top one to the other. So we are shown only one screen here and then there is a motor shaft which is having the elevation higher at one end and then lowers at the other end, high weight at one end and then low weight other end.

So the feed comes here from the top and then through the screens, through the screens it passes through because of the vibration that has cost because of the difference in the weight at the two ends of the motor shafts, okay. So that is the basic principle. The sieves are made of wire mesh or perforated screen decks can also be used depending on the size of the particles you are using, if the size of the particles are having bigger particles like you know in few centimeters or few millimeters then you may prefer to have perforated screen decks which are having more mechanical strength. If the particles are having the more finer material then you know you can go with a kind of a woven wire mesh.

They usually operate gentle speeds between 300 to 400 oscillations per minute with long linear strokes. So vibration is accomplished by eccentric weights on the upper and lower ends of the motion generator shaft. So whatever the motion generator shaft this generator shaft is this. So it is mounted on like you know there are two different weight upper weight and then lower weight so because of this one a kind of you know vibration is generated and then because of that vibration the particle settling is taking place. So the same figure is shown here.

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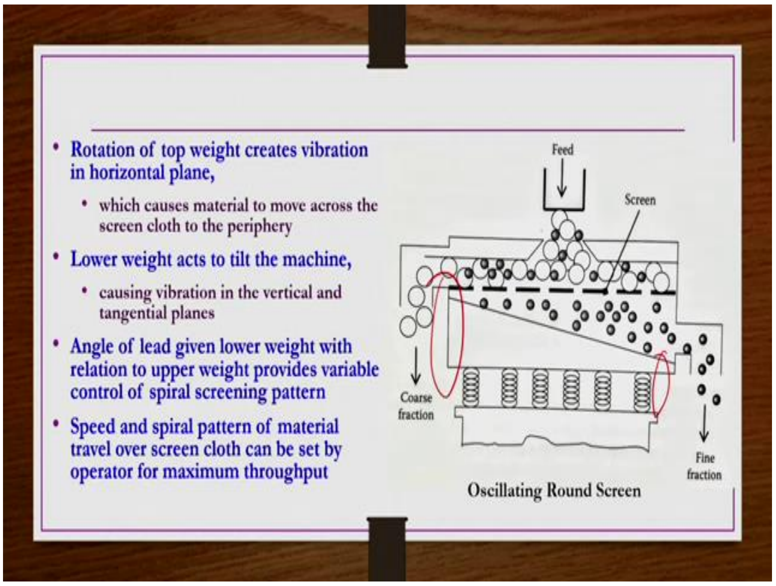

Rotation of top weight whatever the top weight here that creates a kind of a vibrations in a horizontal plane which causes the material to move across the screen cloth to the periphery because of the vibrations are in a kind of horizontal motion in a kind of horizontal direction, okay. Then lower weight here that acts to tilt the machine because of that one vibration is causing in vertical and tangential planes.

So because of this different weight at two ends of the motion generating shaft what we have, We have the vibration both in the horizontal direction as well as the vertical and then inclined tangential directions we have the vibrations, right. So this is very advantageous thing of this particular design here and then the angular lead given between the lower weight and then upper weight it provides the control of spiral screening pattern and in speed and then spiral pattern of material travel over screen cloth can be said by the operator for maximum throughput as per the experience of the process engineer handling this particular equipment so there is nothing kind of generalized one.

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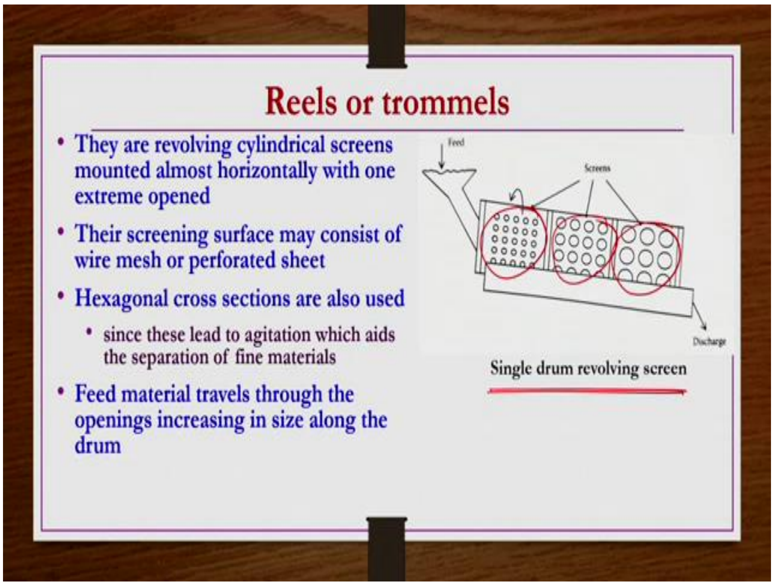

Next one is reels or trommels. So they are usually revolving cylindrical screens mounted almost horizontally with one extreme open as shown here. So we have a single drum revolving screen here. We can have the multiple drum revolving screens also, here one particular drum we have you know the different screens are covered, right. You know finer one then medium and then the coarsest one like that.

So the feed is coming from here and then accordingly you know based on the screen opening the material is being collected and then taken as a kind of discharge. The screen surface may consist of wire mesh or perforated sheets hexagonal cross-sections are also used in general since these lead to agitation which age the separation of fine materials then feed material travels through the openings increasing in size, so the we can see the size here increasing is a smaller one, then the middle one, then the larger opening kind of thing. So the feed material travels through the openings increasing in size along the drum then discharged by a chute on the lower extreme of the equipment.

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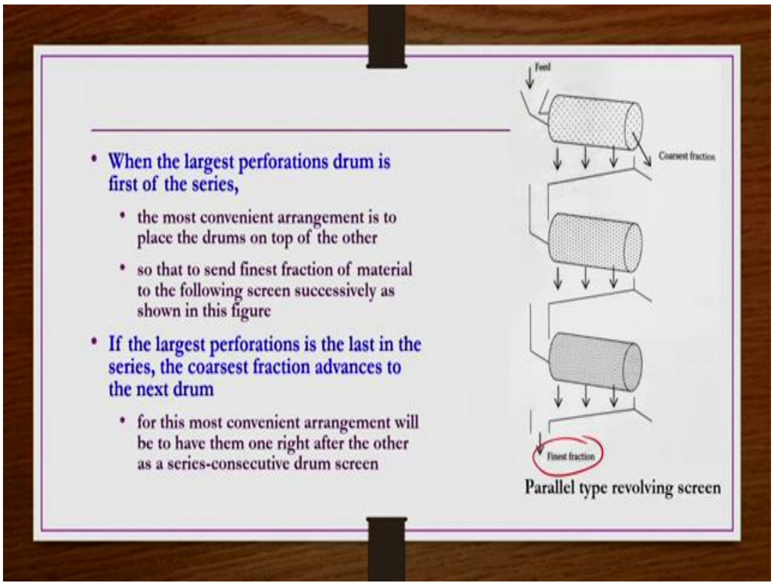

We can have multiple drums revolving screen so several arrangements of trommels can be possible. Two of them are discussed here, one is the parallel type revolving screen and then other one is the concentric type revolving screen. In the parallel type revolving screen we have shown here pictorial representation is given here, right. Simplest one is shown here, when the drum perforations are uniform all over the surface here what we can see? Now let us say only three drums are shown, we can have ‘n’ number of drums with different openings but the thing is that the openings in each drum they are uniform.

Here you can see the first one you know the coarsest opening is there and then here the medium opening is there and then bottom most one is a kind very much smaller opening is there, but within each drum the uniformity of screen openings is there, okay. And then they are arranged such a way that you know maybe the largest opening screen drum that particular drum having the largest opening is at the top and then the drum having the smallest opening is at the bottom that sequence we can order, we can arrange in other way also.

So to separate different fractions of a given material drums are mounted in series as shown here in parallel type revolving screen. So obviously two alternatives are possible depending on the largest perforation drum is located at the first of the series or at the top of the series or at the last of this series in what way they have been arranged. Let us say if you arrange the largest perforation drum first of the series like at the top as I shown here in the picture, then the most convenient arrangement is to place the drums on top of the other so that the finest fraction of material can be flowing to the subsequent following screen successively and then finest can be collected at the bottom.

If the largest perforation is the last one in the series then the coarsest fraction advances to the next drum and then convenient arrangement for this purpose would be having them one right after the other as a series consecutive drums screen.

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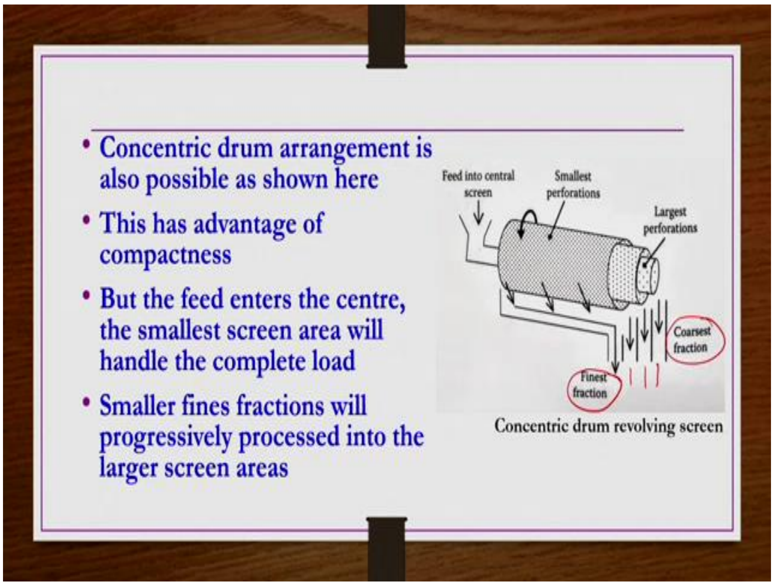

We can also have the concentric drum arrangement as shown here. So we have a concentric arrangement of drum one into the other kind of concentric arrangement is there. The advantage of this particular design is that they compact mix you have a kind of compactness, but the problem is that you know the concentric drum or concentric arrangement is made such a way that the largest opening drum is at the center and then the smallest opening drum is at the outer of the surface,I mean like you know last one the largest opening screen at the center and then smallest perforation screen is forming the outer periphery because of this one what happens. The feed enters at the center so the smaller screen area will handle the complete load that is the kind of problem. However smaller finds fraction will progressively processed into the larger screen areas and then collected as the finest fraction. Let us say you have a several concentric drums of different openings in a successive, in a sequence manner they are arranged such a way that the largest perforation is at the center and then finest one is at the end.

So from the center you get the coarsest fraction like this, from this particular section you get the finest fraction in between you can get the medium ones also medial product also you can get. So these are the common types of screen equipment we have seen. There may be many other different types of designs available industries also, so we are not getting into those details of industrial screens one can go through the book by Brown et al as one of the reference I have given are there is a book by Fost et al so that also gives many details about this industrial screens.

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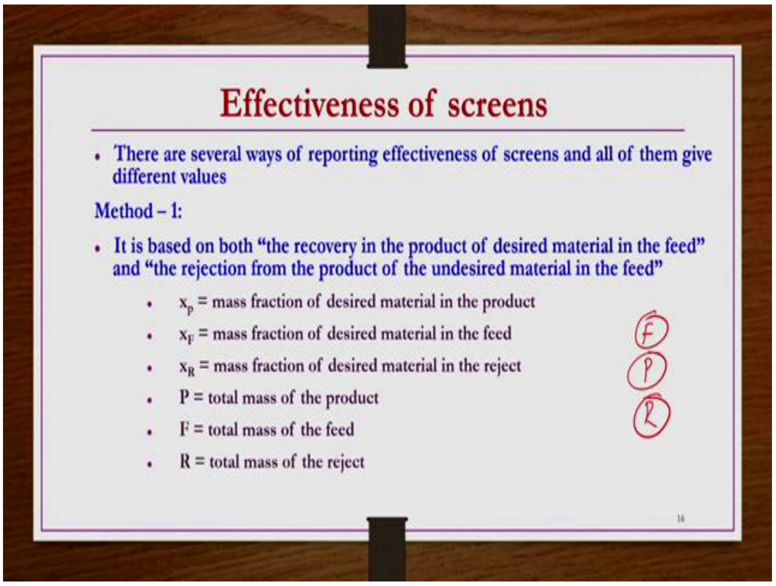

Now what we do we see the effectiveness of the screens. So there are several ways of reporting effectiveness of screens and all of them give different values, so one should be careful when using these numbers, so we take three different methods first method, first method it is based on the recovery in the product of desired material in the feed and the rejection from the product of the undesired material in the feed. So this is the basis for the defining the effectiveness in this particular method one. So let us say Xp is the mass fraction of desired material in the product, let us say F is the feed and then P is the product material and then R is the rejection material. So in the feed product material, what is the mass fraction of desired material? It is true that you know when we do the screening the effectiveness is not 100% so in oversize material there may be some kind of undersized material also present and then because of this screen tearing a touring of the train etc or kind of breaking of the screens you can have undersized material also sometimes have the oversize material.

So it is not possible that you know if you have the product that only the required size material will be there. It is not true that in the rejection only the rejected size material will be there. In any fraction if you take feed product or the rejection fractions you take all the materials will be there, desired, undesired materials will be there. Here in this context of the screen effectiveness desired-undesired are in terms of the size, let us say for your obligation the size 400 to 500 micron is a kind of desired one, so whatever the material that you know from 400 to 500 microns is still that is taken as a kind of a desired material.

So how much fraction of material in the product is having 400 to 500 micron size that is X_{P}, okay. So similarly how much fraction of material is having size 400 to 500 microns in feed is X_{F}. Likewise how much fraction of the material having size 400 to 500 microns in the reject is X_{R}., this 400 to 500 microns I have taken as a reference in order to explain it can be any number, the desired size of the particle could be anything, right.

So now here P is the total mass of the product and then F is the total mass of the feed and then R is the total mass of the reject.

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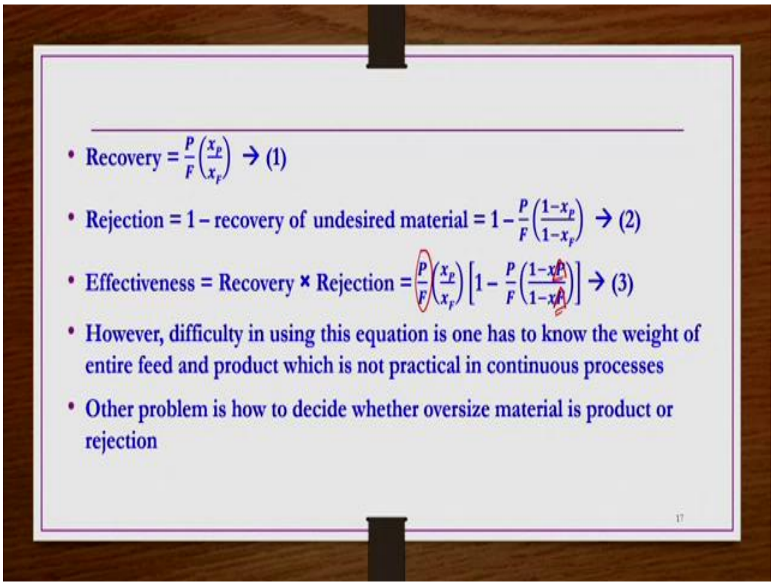

So recovery should be $\frac{P}{F}\left(\frac{x_P}{x_F}\right)$. Then rejection should be 1 – (recovery of undesired material) so that should be $1-\frac{P}{F}\left(\frac{1-x_P}{1-x_F}\right)$. , okay. Then effectiveness is nothing but the product of these two so when we when you multiply them you get, $\frac{P}{F}\left(\frac{x_P}{x_F}\right)\left[1-\frac{P}{F}\left(\frac{1-x_P}{1-x_F}\right)\right]$. This P, F, R kind of suffix they are not multiplication this is X_P and then this is X_F.

However, difficulty in using this equation is one has to know the weight of entire feed and product which is not practical in continuous process. We have seen several screening equipment, we have a kind of you know they are continuous mode operations. In industries you prefer to have a continuous mode operation so that you can handle large amount of material in a lesser time, right. So though in a laboratory screens you can have the metal stakes with the individual metal pans having screens at the bottom you can arrange and then do the things and then you can find out the what is the feed wait, what is the product weight like that you can do; but in industry that is not possible in general, okay.

So that is the one of the important drawback of this method that is you should know what is P what is F otherwise you cannot use this equation, right. Another thing is that how to decide whether the oversize is product or the undersized is product? That is again a problem with this method.

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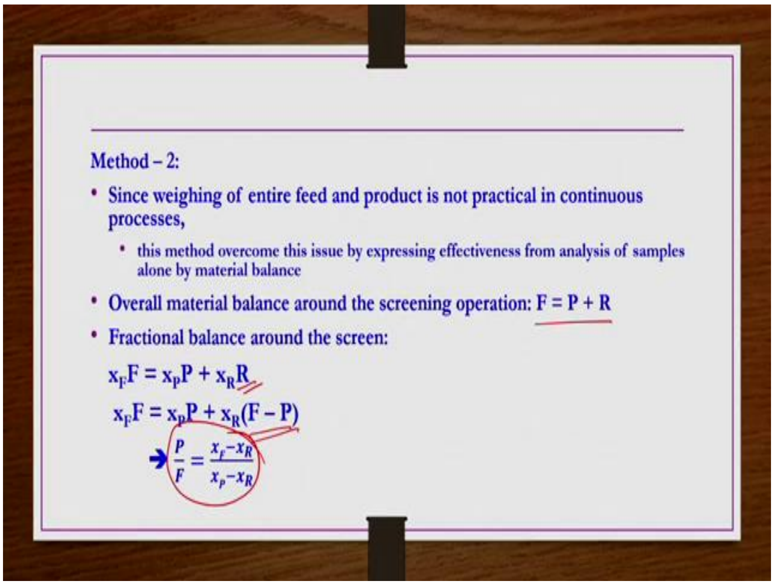

So now we go to the second method where it overcomes the requirement of knowing the feed and product weights in continuous process, right. So that is what we do here. So how we do here, We do a by a simple material balance, so if you do a overall material balance let us say feed whatever is coming that is being separated into the product and rejected, right. Then if you do the fractional balance for the materials around the screen then you have $x_F F = x_p P + x_R R$ Now here you can write R = F - P like this.

Then you can rearrange these equations so you get, $\frac{P}{F} = \frac{x_F - x_R}{x_P - x_R}$ that is it. Simply this P/F you substitute in the previous equation number 3 of method 1 so you will get the effectiveness by this method to where you do not need to know the weight of the feed or weight of the product or weight of the rejectanant. You can know only based on the mass fraction alone obtained by the screening method.

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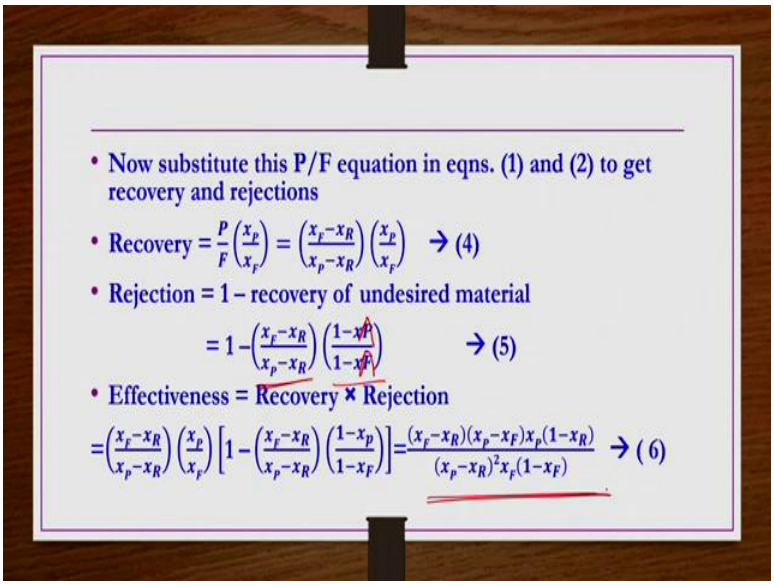

So when you substitute this P/F in equations 1 & 2 you get recovery as, $\frac{P}{F}\left(\frac{x_P}{x_F}\right) = \left(\frac{x_F - x_R}{x_P - x_R}\right)\left(\frac{x_P}{x_F}\right)$ Same is rejection is 1 – (recovery of undesired material) so that comes out to be $1 - \left(\frac{x_F - x_R}{x_P - x_R}\right)$. So this supposed to be you know whatever the P/F that we get and then multiplied by $\left(\frac{1 - x_P}{1 - x_F}\right)$

That is the mass fraction of the desired material in the product and then mass fraction of the desired material in the feed, okay. Then effectiveness would be the multiplication of these two, so you will get this one after simplification so this is by the second method.

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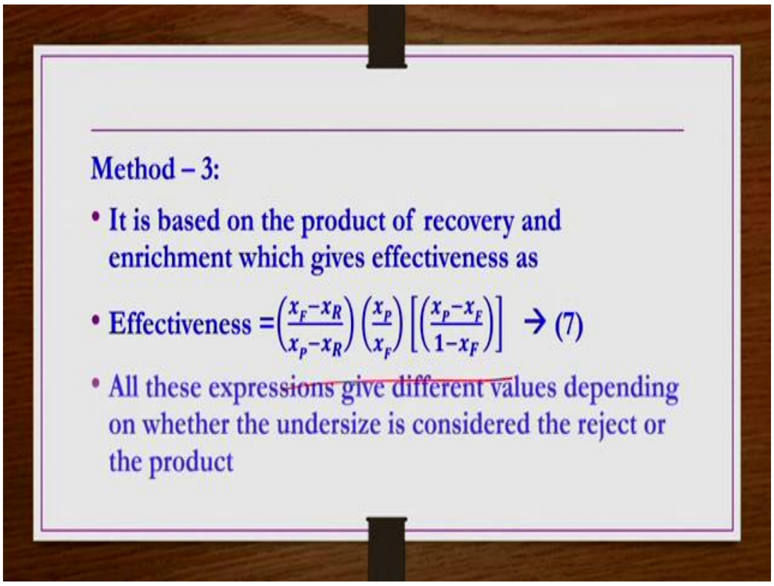

Another method, method 3 it is based on the product of recovery and enrichment which gives the effectiveness as this one, equation number 7. We take couple of problems and then try to calculate effectiveness by these different methods and then see how different numbers we get by three different methods.

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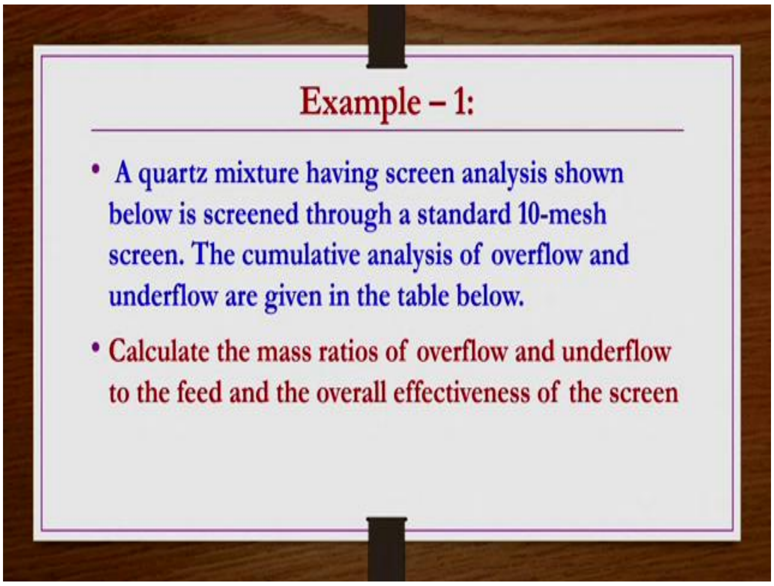

Example 1: So let us say a quartz mixer having screen analysis shown below in table is screened through a standard 10-mesh screen. The cumulative analysis of overflow and underflow are given in the table, right. Calculate the mass ratios of the overflow and underflow to the feed

and the overall effectiveness of the screen. That is P /F, R/F you need to calculate and then you need to calculate what is the effectiveness.

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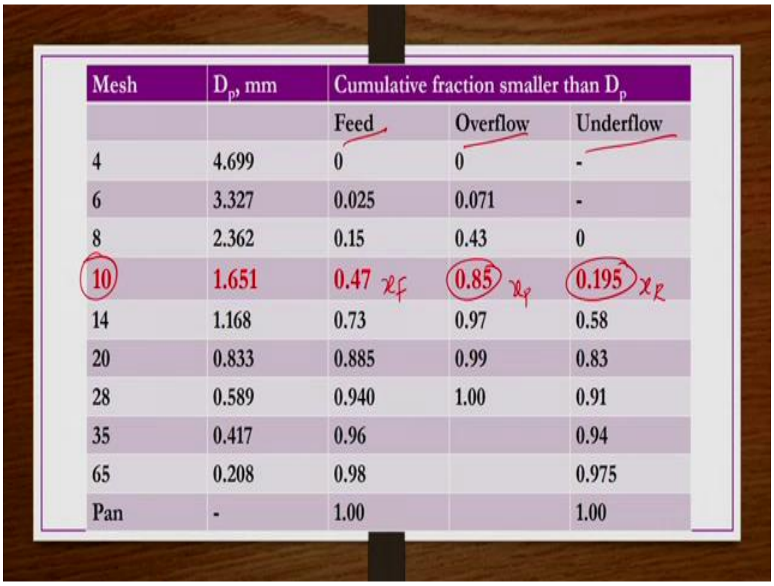

Mesh	D_p, mm	Cumulative fraction smaller than D_p		
		Feed	Overflow	Underflow
4	4.699	0	0	-
6	3.327	0.025	0.071	-
8	2.362	0.15	0.43	0
10	1.651	0.47	0.85	0.195
14	1.168	0.73	0.97	0.58
20	0.833	0.885	0.99	0.83
28	0.589	0.940	1.00	0.91
35	0.417	0.96		0.94
65	0.208	0.98		0.975
Pan	-	1.00		1.00

So this is the information is given a table it is given in the problem mesh verses Dp information for a feed overflow and then under flow is given under the cumulative fraction smaller than Dp information. 4 to 65 mesh and then pan have been used and then the reference screen is 10 mesh screen so from here what we get? This should be your X_F and then this should be your X_P and this should be your $X_{R,}$ right? So you know $X_{F,}$ $X_{P,}$ $X_{R.}$ So you can calculate recovery, you can calculate rejection, you can calculate you know even the effectiveness.

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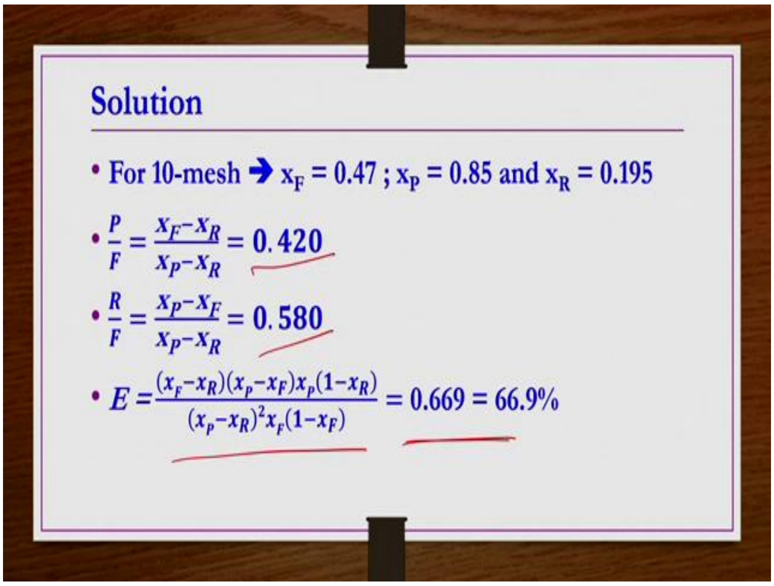

So we use method 1 for 10 mesh. Why are we taking 10 mesh? Because that has been screened through 10 mesh, that is the problem statement is given. So that is the reason we need to take these numbers $X_{F,}$ X_P, X_R corresponding to 10 mesh. okay. So for that only we need to calculate the recovery and the rejection. So $\frac{P}{F} = \frac{x_F - x_R}{x_P - x_R}$when you substitute you get 0.42, rejection is $\frac{R}{F} = \frac{x_P - x_F}{x_P - x_R}$ when you substitute these numbers you get 0.58.

Then effectiveness this expression by method 1 if you substitute you will get 66.9 % effectiveness.

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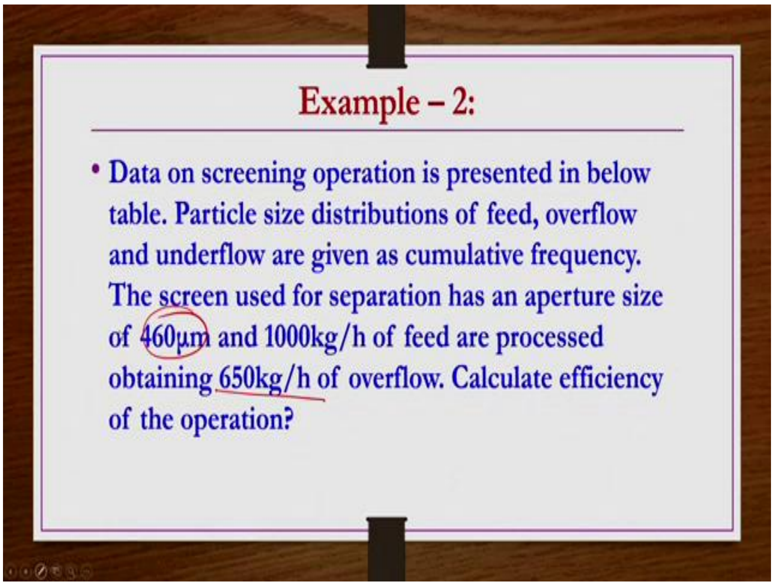

We will take another example-2: Data on screening operation is presented in below table. Particle size distributions of feed, overflow and underflow are given as cumulative frequency. The screen used for separation has an aperture size of 460 micron and 100 kg/hour of feed and processed obtaining 650 kg/hour of overflow calculate the efficiency of the operation.

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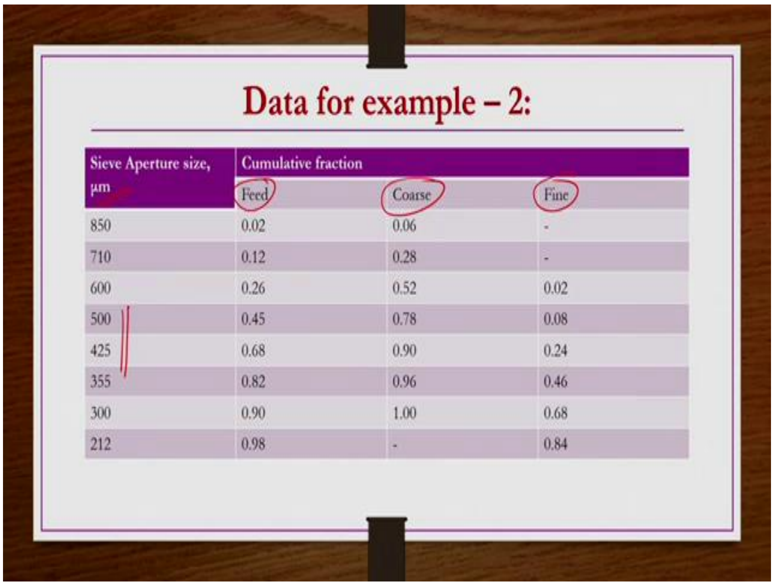

So here data for the table is given. Sieve aperture size in microns is given and then cumulative fraction for the feed, coarse and fine material are given. But here you know the screen used for separation has an aperture size of 460 micron that is what it is mentioned. So corresponding to 460 microns we have to take X_F, X_P, X_R. So but here for 60 micron opening the information directly it is not given and then you cannot interpolate also because you know you cannot know what the trend between the sizes and fractions etc .

So for that what you do? You plot this cumulative fraction of feed, coarse and fine with respect to the sieve aperture opening or particle diameter or opening of the sieve then corresponding to 460 microns from the graph you can take the $X_{F,}$ $X_{P,}$ X_R.

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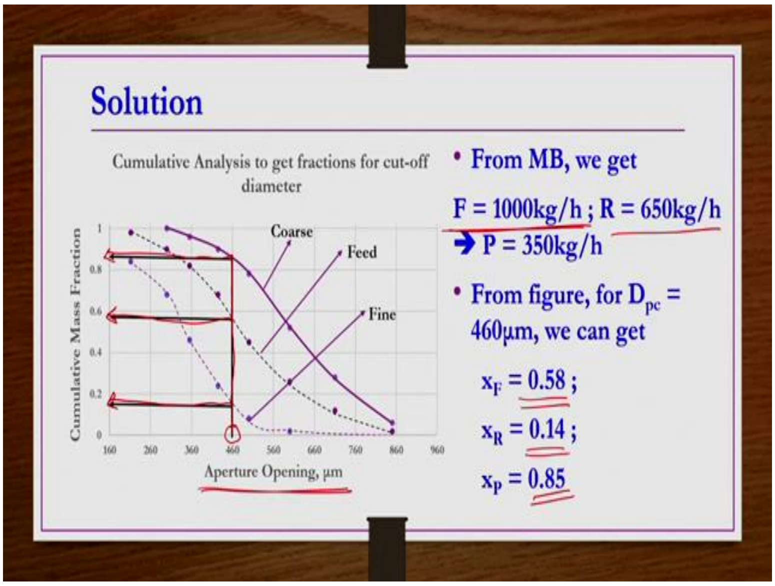

So first we do the cumulative analysis. Cumulative mass fraction verses aperture opening in microns we wave plotted. The middle is kind of feed and then the upper one is kind of course material and then bottom one is kind of fine material. So the screen that has been used for separation is 460 microns, so you draw a kind of vertical line at 460 like this, and then whatever the corresponding that values are there, let us say feed curve wherever it is intersecting that you take us X_F so that is 0.58 then similarly the coarse one is coming as a kind of you know 0.85 and then the fine one is coming as 0. 14. From material balance the feed is given as 1000 kg per hour R is also given as 650 kg/hour so P you get as 350 kg per hour. From here from this graph for D_{pc} for 60 microns we can get that X_F as 0.58 whichever is let us say when you have this vertical line at the point where it is intersecting the feed curve the corresponding value mass fraction in the y-axis that should be taken as X_F that is 0.58. Similarly X_R at 460 when you draw a vertical line wherever it is intersecting the fines and then corresponding Y axis value that should be taken as X_R that is 0.14 likewise X_P is 0.85.

So now you have 0.58, 0.24, 0,85 as X_F, X_R and X_P. So all three are known, so then you can calculate the effectiveness.

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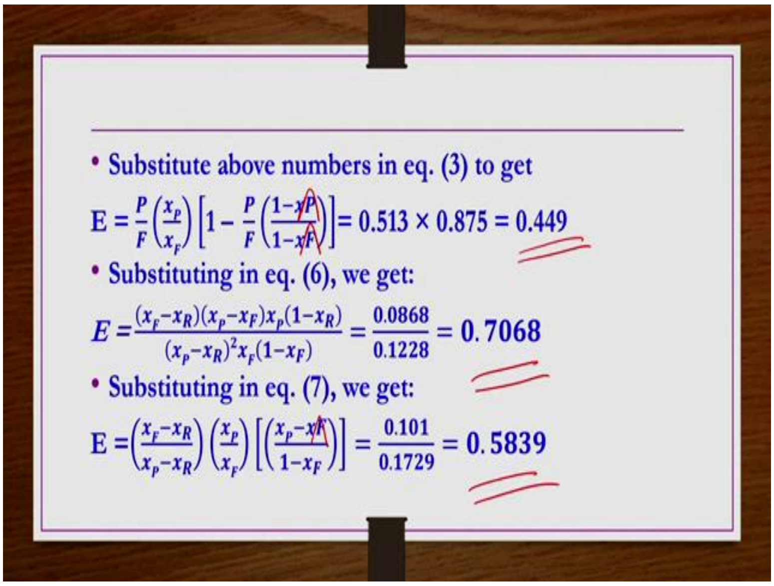

We calculate using all three methods, method 1 that is equation 3 if you substitute you get E =0.449, method 2- equation 6 if you substitute this Xp, X_R, X_F values then you get E =0.7068, method 3- if you substitute these values in equation number 7 you get these values are you know 0.5839. So here this X_F is suffix here also Xp is Xp and then X of X_F. So now you can see all three methods are giving three different values of the effectiveness.

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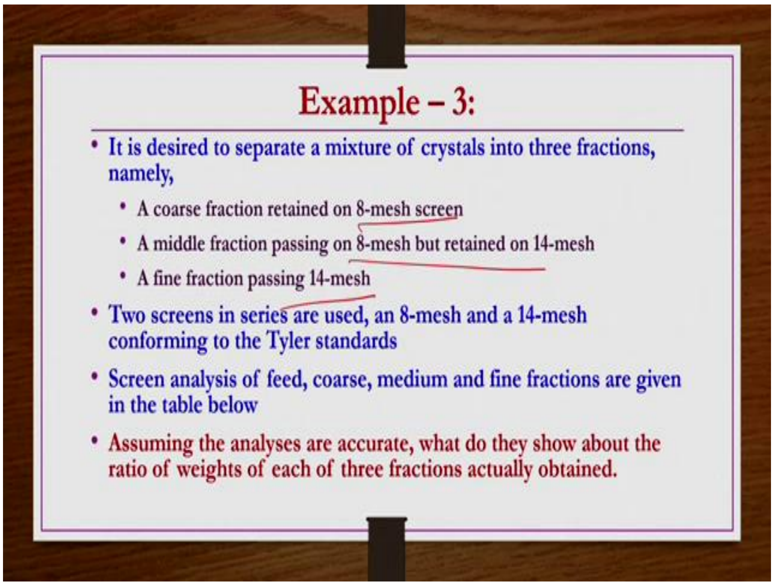

Last example, it is desired to separate a mixture of crystals into three fractions. Let us have a coarse fraction retained on 8-mesh screen and in fine fraction passing through 14 mesh whatever the middle fraction is there that is passed through 8 mesh but retain on 14 mesh. Two screens in series are used and eight mesh and 14 mesh conforming to the tailor standards that is whatever the mesh opening for the eight mesh instead from the tailor series that is that should be taken as the D_{pi}.

Similarly for 14 in mesh whatever the tailor screen opening is there that should be taken as the Dpi for the 14 mesh. Screen analysis of feed, coarse, medium and fine fractions are given in the table below. Assuming the analysis are accurate what do they show about the ratio of weights of each of three fractions actually obtained. So how much of course material is obtained? How much is the medium obtained? How much is the fine fraction is obtained? That we have to calculate with respect to the feed.

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Screen	Feed	Coarse fraction, A	Middle fraction, B	Fine fraction, C
3/4	3.5	14	-	-
4/6	15	50	4.2	-
6/8	27.5	24	35.8	-
8/10	23.5	8	30.8	20
10/14	16	4	18.3	26.7
14/20	9.1	-	10.2	20.2
20/28	3.4	-	0.7	19.6
28/35	1.3	-	-	8.9
35/48	0.7	-	-	4.6
Total	100	100	100	100

So let us take feed as a kind of 100 Kg basis. So this is the table is given. The screen versus feed and then coarse fraction, middle fraction and in fine fraction their corresponding mass fractions are given here they are not cumulative one but they are differential one. So when you add them together for all four cases you get, you know kind of 100.

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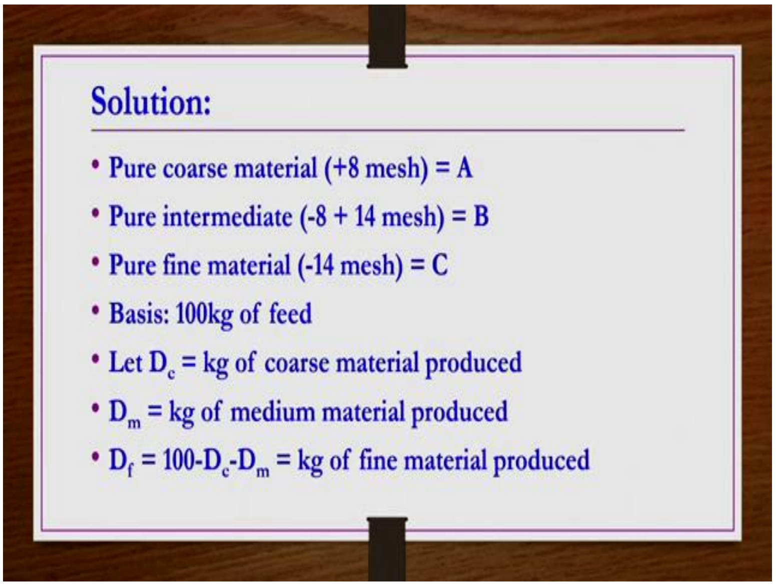

Now let us have a designation whatever the course material that is retained on 8 mesh you take it as A. Then whatever the intermediate material that is passed through 8-mesh but retained on 14- mesh you take it as B. Similarly whatever the fine material that is passing through the 14 mesh you take it as C. So this is labeling this is not the weights A, B, C are a kind of labeling they are not the weights.

Now coming to the weights you know take 100 kg of feed then let D_C is the coarse material produced. How many kgs of course material produced that you take D_C., how many Kgs of media material produced that you take D_m, how many cases of fine material produced that you take D_f, which is nothing but 100 - D_C - D_M. Now from the screen analysis we just get back to the screen analysis one here.

So the feed is containing all three material similarly coarse fraction is also containing all materials. It may be having coarse material, it may be having medium material, it may be having fine material also. Because 100 percent separation is not taking place in by any types of screens, right. Same is true for the middle fraction, same is true for the fine fraction also. So what we do first we take how much fraction of what is the material of fine fraction present in the feed, coarse fraction in the feed and then medium fraction in the feed that you take.

Similarly in coarse fraction what is the amount of fine, what is the amount of coarse, what is the amount of medium that you take in this fraction also. Likewise in middle fractions, fine fractions also all three types of materials may be there, right. So that we are going to see now here.

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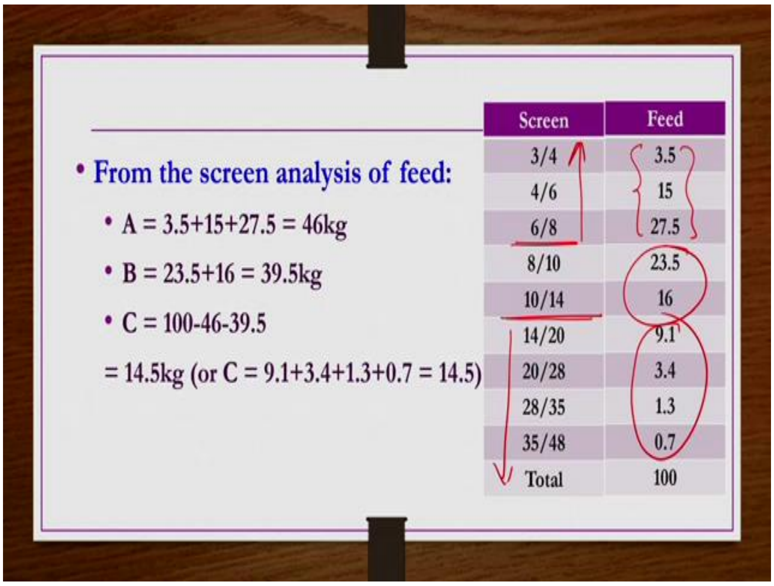

First what we do? We take a feed from the screen analysis of feed you know what is the coarse material that is being retained on 8-mesh, okay. So whatever the corresponding mass fractions are there larger than 8-mesh opening are the smaller mesh numbers. So that is 3, 4, 6, 8-mesh numbers whatever are there. Whatever the material retained on that particular up to 8 screen that is all should be taken as A.

So coarse material is you know how much coarse material from here from the in the feed it is 46 kg, that is 3.5 + 15 + 27.5. Similarly that is the medium one that is passing through 8 but retaining on 14, so that should be the summation of 23.5 + 16 that is 39.5 kgs, and then what is the fine it is all the remaining that is passing through the 14 that is all remaining is a kind of you know sieve fine material that is 100 - 46 - 39.5 so that is 14.5 kgs

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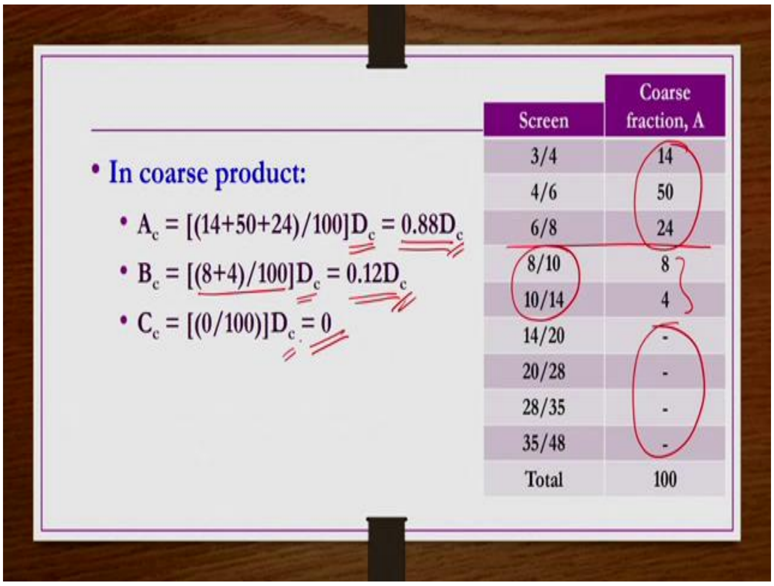

Similarly in coarse product also we can have A_C that is up to eight mesh whatever is there that is the coarse so that is [(14 + 50 + 24) / 100]D_C is nothing but 0. 88 D_C. Similarly medium one is that between these two that is 8/10 and 10/14. So corresponding goes fractions are [(8 + 4)/100] D_C that is 0.12 D_C.

And then fine fraction here passing through 14 mesh is not there in this coarse fraction at all. So at least in the coarse fraction the fine material is not there only coarse and then medium material are there. So here you can see all the D_C's are there we are doing balance for the D_C's in the course product.

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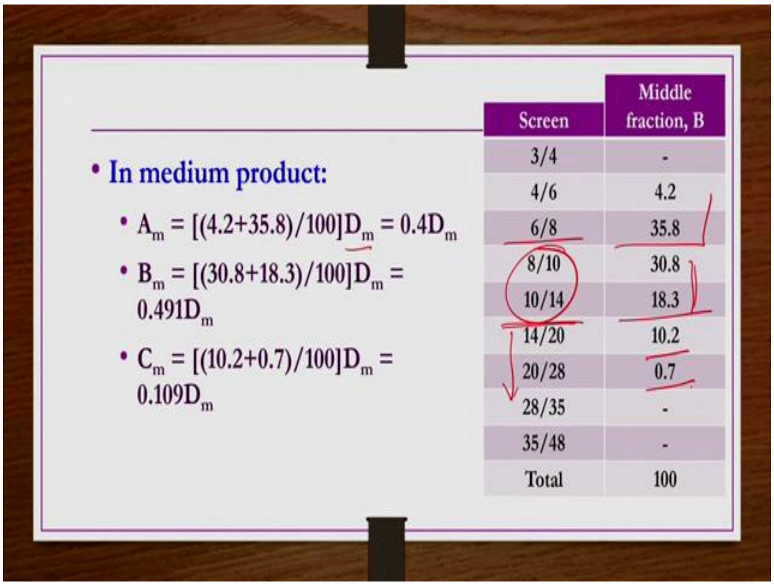

Similarly, middle fraction also if you do in the middle product you have what is the coarse fraction in the middle product that is up to 8-mesh that is $[(4.2 + 35.8)/100]D_m$ that is 0.4 D_m.. Similarly what is the medium fraction in this middle product is $B_m = [(30.8 + 18.3)/100]\ D_m$ because that is passing through 8 and then retaining on 14 is designated as a kind of medium one.

So $= [(30.8 + 18.3)/100]\ D_m = 0.491\ D_m$ and then what is the finer ones in this middle fraction whatever that is passing through 14 mesh all should be considered in the kind of finer, so that is $C_m = [10.2+0.7)/100]\ D_m = 0.109\ D_m$.

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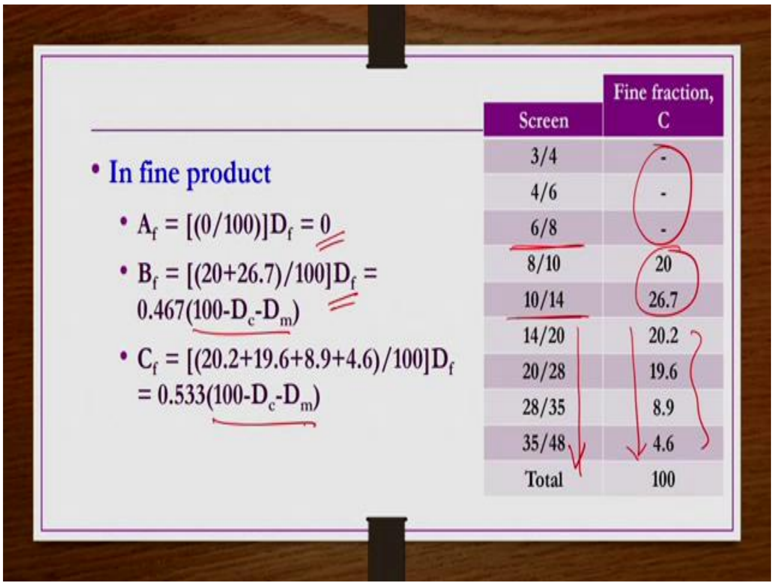

Similarly in the fine product the material retained on up to 8's on 8 screen there is nothing so that is 0. A_f is equals to 0 and in medium fraction that is passing through 8 but retaining on 14 is having $[(20 + 26.7)/100]D_f$ so that is coming as you know 0.467 D_f we can write $(100 - D_c - D_m)$ because $D_c + D_m + D_f$ is equal to 100 that is feed, okay.

Similarly C_f is that define fraction fraction what is the finer material is there. All that passing through 14 mesh is all counted as a finer material. So $[(20.2 + 19.6 + 8.9 + 4.6) / 100]\ D_f$ that is 0.533, again D_f we can write $100 - D_C - D_m$.

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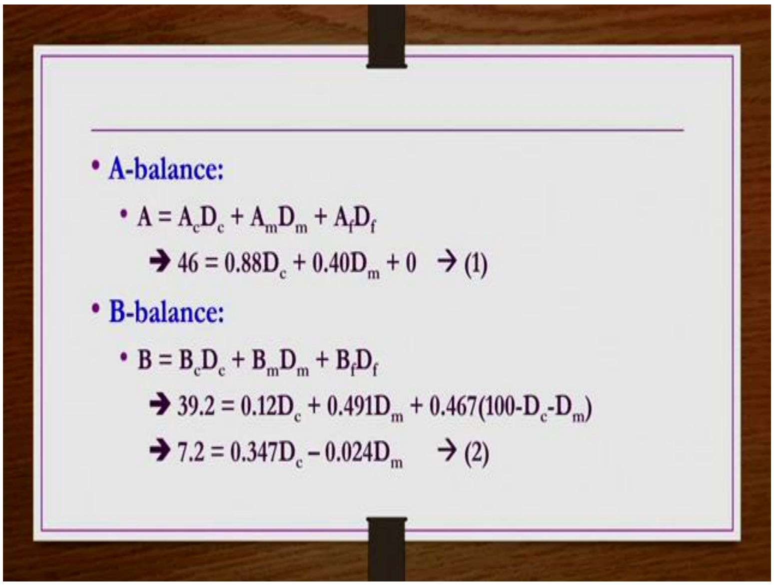

So now if you write the A balance, A should be, $A = A_c D_c + A_m D_m + A_f D_f$. So when you substitute this you will get this equation, and then B balance should be $B = B_C D_C + B_m D_m + B_f D_f$ so you get this equation.

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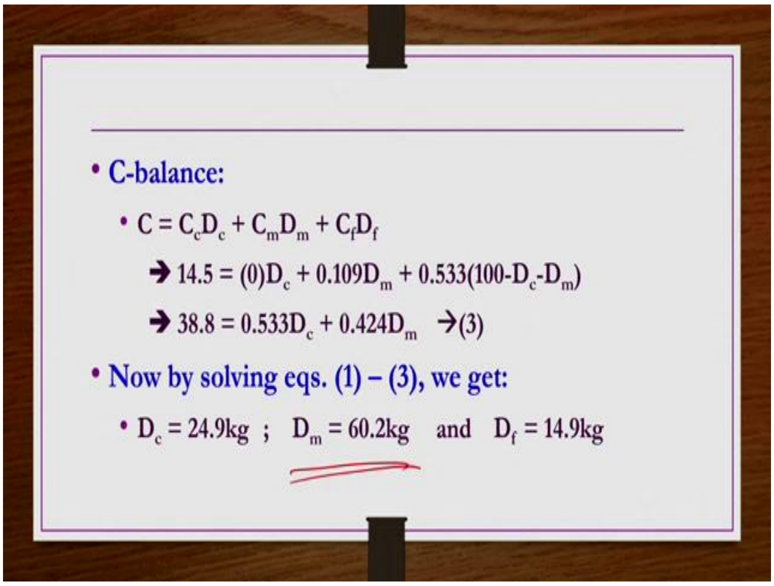

Then similarly C balance is nothing but $C = C_c D_c + C_m D_m + C_f D_f$ so you get this equation. So if you solve equation one, two, three you get D_C is equals to 24.9 Kg, D_m is equals to 60.2 Kg and D_f is equals to 14.9 Kg. So we can understand from this operation it is doing such a way that you know 60.2 Kg medium fraction is there and then 14.9 Kg of final fraction is there:

whereas the coarse fraction is 24.9Kg. So this is how we have to solve the problems using these screen analysis.

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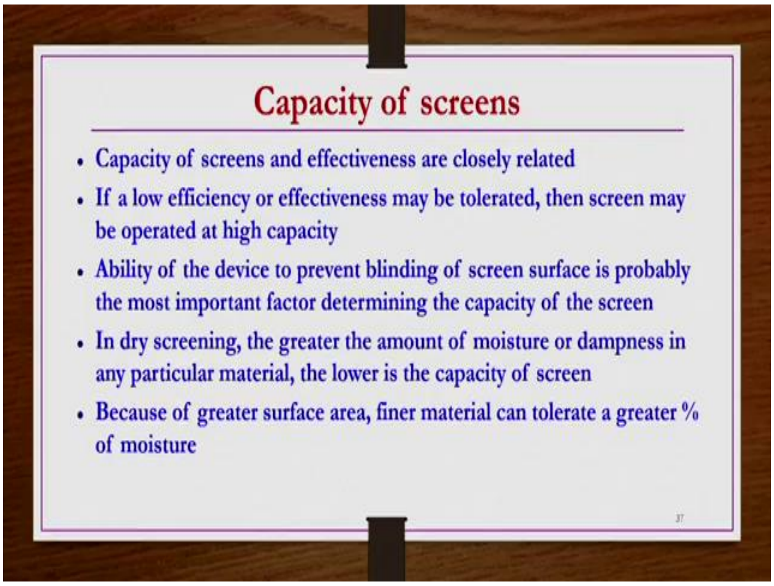

Capacity of screens capacity of screens and effectiveness are very much closely related. If a low efficiency or effectiveness may be tolerated then screen may be operated at high capacity, right. So you it is very difficult to have both high capacity and then high effectiveness simultaneously. So if you wanted to handle high capacity material, the large amount of material then you must be compromising in the effectiveness.

Ability of the device to prevent blinding of screen surface is probably the most important factor determining the capacity of the screen. So in general you know blinding is a very important problem that one come across in the screening. So sometimes you know whatever the screen opening is there that may be blocked by the particles of you know larger size or something like that so that, that particular effective area that is available for the passing of the material now that is reduced. So because of that one you know the effectiveness you know decreases so the capacities of the screen also decreases. So in the dry screening if the moisture or the dampness is more than the capacity would be very small, because in the dry screening we not necessarily dry the material but whatever they naturally available material we get so that must be having some moisture if that moisture is more than permissible limit then the capacity would be very much lesser and then because of greater surface area finer material can tolerate a greater percent of the moisture in general.

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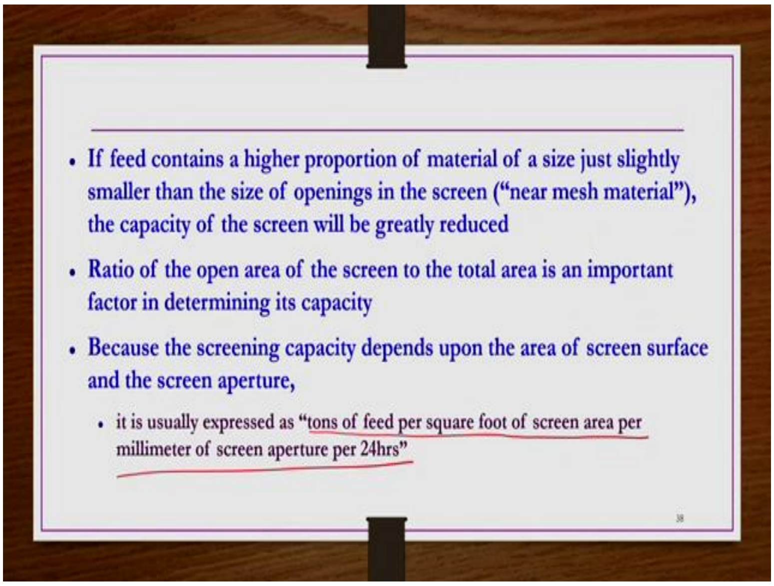

If feed contains a higher proportion of material of a size just slightly smaller than the size of the opening in the screen, that is near mesh material we call it. Let us say mesh opening is 0.05mm but if you have some material like 0.049 mm or 0.048 mm material then it is possible that those maybe you know blocking the pores in general so then capacity of those screen would be very much reduced because of those kinds of materials.

So it is not advantageous to having near mesh material when you do these separations. The ratio of the open area of the screen to the total area is an important factor in determining its capacity. So whatever the individual square apertures are there here like you know like this you know those square aperture areas and then all of the area that is effective area of the entire area total area of the screen so the ratio whatever the ratio is there that ratio of open area of the screen to the total area is also going to determine its capacity. Then because the screening capacity depends upon the area of the screen surface and then screen aperture the capacity is usually expressed as the tons of feed per square foot of screen area per millimeter of screen aperture per 24 hours.

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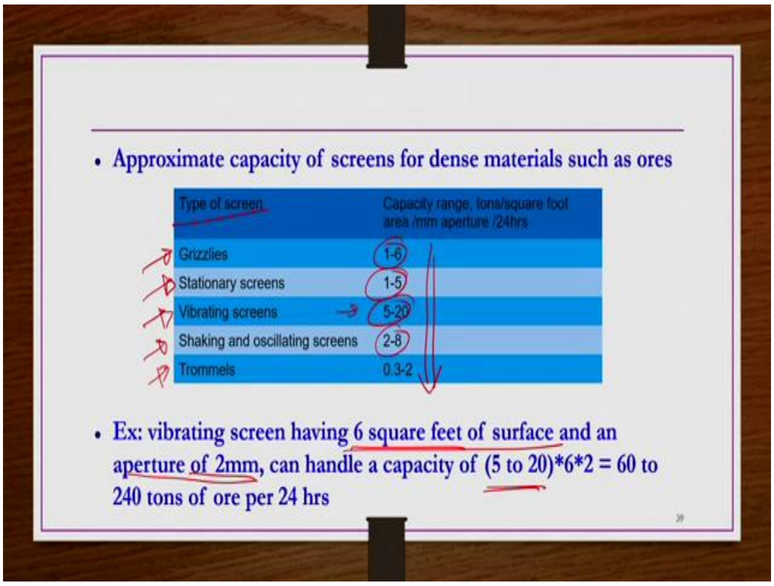

Approximate capacity of screens for dense materials such as ores are given here in this table, type of screen and there the capacity range in tons per square foot area per mm aperture for 24 hours it is given. So the Grizzlies we have seen so they have the lowest capacity of 1 to 6 stationary screens in general they have for this ores 1 to 5, whereas the vibrating screens as we already discussed having the high capacity and in high effectiveness we can see here also for this ores 5 to 20 and then shaking and in oscillating screens to 2 to 8 whereas the trommel's have the lowest capacity of 0.3 to 2.

How to convert them into the number? How much of weight can be handled per hour or per day is something like that. That is let us say now vibrating screens is having you know 6 square feet of the surface and an aperture of 2 mm that is you take a vibrating screen which is having six feet squares of area surface area and then opening of aperture whatever the screen opening is there for that vibrating screen is only 2 mm, Then according to this one the capacity should be (5 to 20)*6*2 so that you get 60 to 240 tons of ores per 24 hours it can handle. So it can handle 60 to 240 tons of ores per 24 hours.

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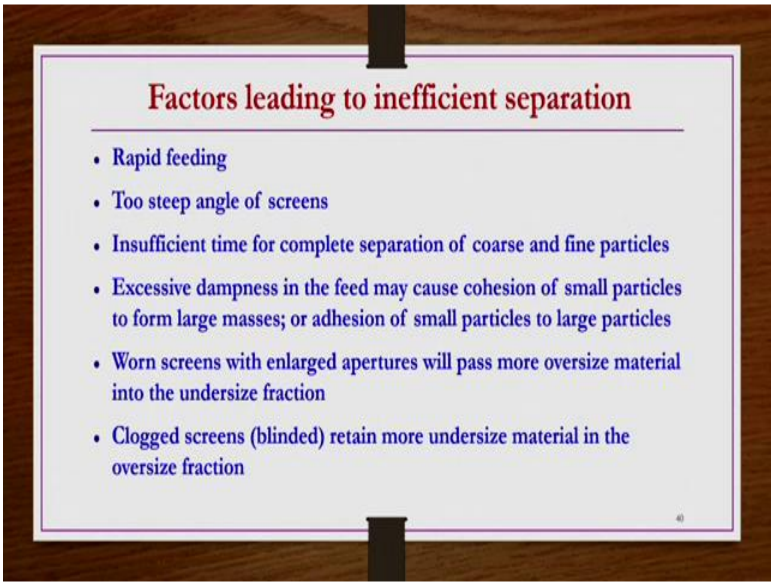

Factors leading to inefficient separation, rapid feeding:- Rapid feeding is a kind of problem we have seen a kind of continuous screen so where we do a kind of feeding continuously if you feed rapidly so then also inefficient separation may take place and then steep angle of screens we have seen that the mounting can be inclined also if you take the angle too steeper angle then also the separation may not be efficient. Then you one must provide the sufficient time for the complete separation otherwise you know if you provide insufficient time this operation may not be efficient and then excessive dampness in the feed may cause cohesion of small particles to form large masses or adhesion of small particles to larger particles.

So in such cases also efficient is very poor. Sometimes worn screens with enlarged apertures may pass oversized material into the undersized fractions also that is also causes inefficient separation and then sometimes blinding or clogging of screens takes place because of the blockage of the screen openings then they may retain more undersized material in the over sized fractions, so then also in a inefficient separation would take place.

So this is about the screen analysis, screening screen analysis, screen equipment and then effectiveness and then capacity of the screens all the details required at the UG level about the screen processes have been discussed in this particular module through lectures 4, 5 & 6.

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The references that have used have given here. McCabe Smith, Ortega Rivas, Richardson Harker Geankoplis, Brown et al, Badger and Banchero. The some of the schematics and problems are taken for this lecture from this unit operations of particulate solid theory and practice by Ortega Rivas likewise some problems are also taken from the Richardson Harker and then McCabe and Smith. Thank you.