Bulk Material Transport and Handling System
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Lecture - 30
Screen: Classification and Selection

Welcome back to our discussion on bulk material transportation and handling system. We are now discussing about the mineral processing plant equipment. That is though in the mineral processing the bulk material handling is the most predominant operations but this so far as this particular area screening that size separation. The size separation of bulk material is not only in mineral processing equipment.

It is also required in other industry like pharmaceutical, agriculture, food, technology and all that. So, this screening operations are basically we will be discussing here of two types. That is the large particle separation and small particle separations. The large particle separation we say screening. The small particle separations many times we say sieving. So, we will be discussing this in our mineral processing equipment. As a mineral processing equipment where do the screen stand?

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And what is the present scenario? We will be discussing about it. So, our main objective here first thing we will have to know why do, we go for screening. So, the objective should be clear to us. Then we should be able to name that what are the different type of screening systems or the screen as a machine they are there. And also, we should explain that how the sieving is done. Because the fine particles their separation is very important as we already told.

That when the ore is to be handled and it will have to be beneficiated. Then after that in the process you will find the fines play a big role. And sometimes we will be having some very fine where we cannot separate by sieving and then industrially. So, we need to go there even for another operation called classification that is classifiers are used. Now of course the sieving is necessary of the bulk material sieving is very important.

To do certain laboratory skill studies in the industry as well as in our academic world will have to know the material’s properties. That is why when you go for study of the size separation sieving is very important which is also in the civil engineering as a mining engineering for soil studies environmental engineering there also, they handle those bulk material basically the powder material for sieving. We will be touching upon that also.

And then we should be able to discuss about the different type of screen. So, that we can handle the selection problem.

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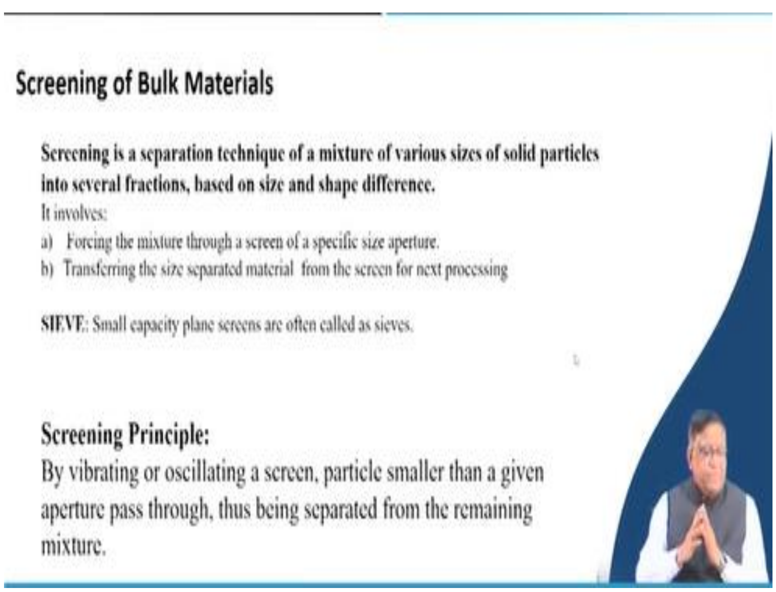

So, let us start discussing about this. So, what is the screening of bulk materials? It is a separation technique because you may be getting a mixture of different material when you blast it will be giving different fragmentations. So, then again when you crush that it will never give a uniform. So, the product of blasting or the product of crushing it will be in a number of different size aggregates will be there. So, we need to screen them that mean to separate them.

Now that separation how it will have to do? You will have to do some standard that is your hole or a square or a rectangular or different shape of some perforations or a perforation plate or there will be some gap through which a particular size will go screening is that just allowing something forcibly to pass through certain or designated gap. And then after that you will have to have the arrangement in the screening system this separated material goes to their next destination.

And then as I said that sieving is basically for the small particles. Now what is the basic principle of this screening? That is, we will have to do either you give a vibration or you give an oscillation. And then sometimes you may give a rotary motion. By that means you are creating a dynamic forces are induced into that. So, that the particle move and they get subjected to the gaps or the screen holes or screen aperture. The word is just aperture.

So, that they can get and then we can do it over there. Now in that the basic design of the screen it will be depending on how the energy is used for giving the vibration or giving that oscillation. The engineering involved is transferring that energy to your screening platform and making your receiving the material to that screening platform and allowing them to move. Now if you are doing a screening operation if you put the material all at a time.

But there is only your screen will be suppose a perforated plate is there. On the perforated plate if you give at a time a lot of material then you make them to vibrate or then move then whatever they are at the top they will not get the chance of going through that hole because it is already blocked by the first layer. So, that means your screening is taking place only at the layer of this that is your one layer of the material only will be getting changed.

So, that is why what will be the retention time of those material on the screen? And then how only a mono layer will be placed on the screen? Those things will be affecting your selection afterwards. So, you will have to know that how the machine has been designed and how it works, what type of layer or how much material it can come or whether you are giving a time so that the material is going jumping like this.

So, then what will happen? Every time the material will be having a chance to fall over there. So, this the mechanism how it will be working will have to be known.

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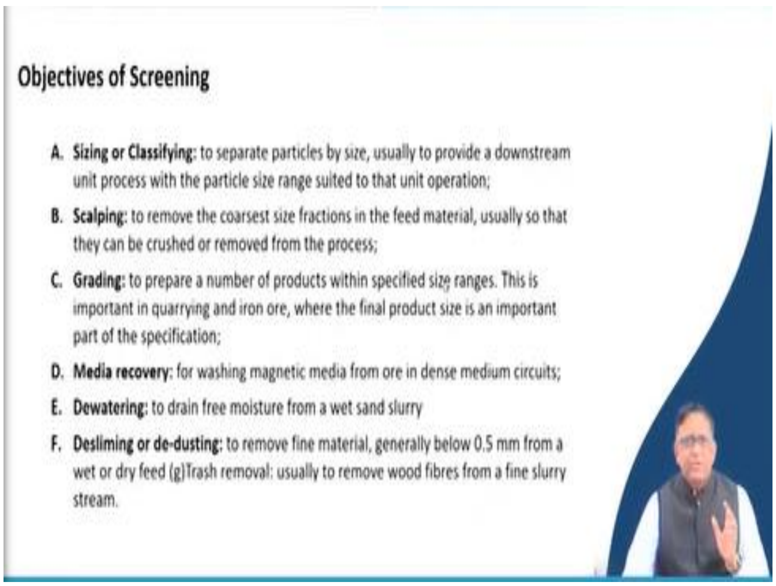

So, as I said that objective of your screening that is exactly your sizing or classifying. Because the people; different people will be requiring a different type depending on that where they are using. So, your separating by size it may also sometimes you allow only the circular things to go of a particular like that in the stepwise also can be screened. Then you need to do a scalping, that is also the removing the coarser fractions of the material.

And then your grading that grading is exactly the metallurgical plants their process they be requiring a particular grade. That is your particular size they will be giving dimensions. So, accordingly you will be grading by the help of this screening system. Then there is a mineral processing where you use that is your magnetic media that is heavy media separation you may be knowing about in the mineral processing.

Because that is you create a heavy media where the particles have been put it over there to make them float. And now that heavy media whatever the particle you have given you need to recover them. There also you will be requiring some separation. And then another thing is there that is also a separation. If you are having a weight, you have processed the mineral is processed by your mixing with water then you will have to separate the water out. That is also a separation.

And some sort of a screening actions that you know how the liquid part is taken in a tea strainer. You are retaining your residue or the tea leaves you keep it on the strainer. The liquid will go. So, that is also a screening what is we can say sometimes at the filtering. Those process is also a separatist. Now sometime that is your de dusting de sliming that fine particle separation different objectives of your screening is there.

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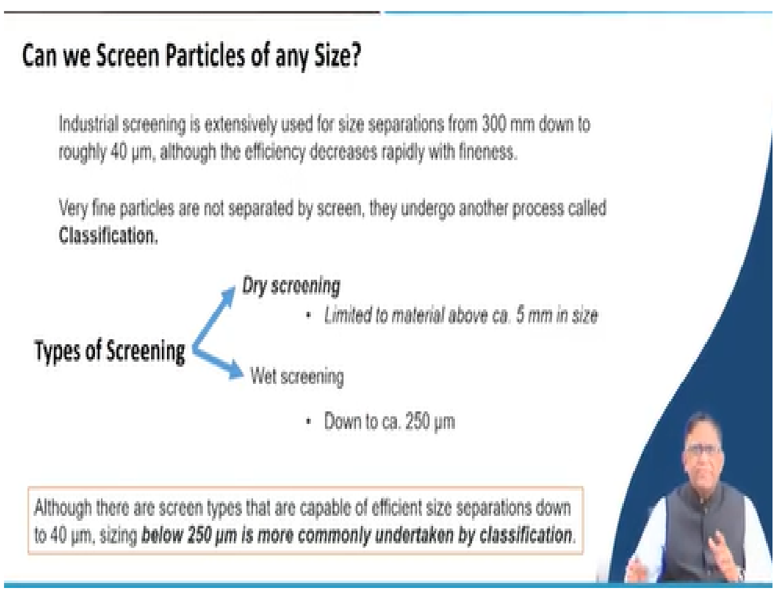

Then in your screening operations in the industry in a mineral processing plant will you take it for all type of materials. Normally it is not. You will be having always working within a range. So, normally that 300 millimetre 30 centimetre and down to 40 micron this is a normal. But depending on that you can have tailor-made machines creation is not at all a problem. Provided if you have got to give a properly whatever you need it can be done.

Then there is as I said a classifier. There is another class of equipment and the system is there where you take out the very fine that is particularly less than 40 micron. If there is a valuable things if you are processing some gold and then in the tailings gold with the effluents very fine gold particles have gone you will have to recover them. That also can be done by process where the classifier can be used and type of screening that can be your dry screening and wet screening.

So, there normally in the wet screening you go with a very small size up to your 250 micron and then in a 5 millimetre size in dry screening it is always done. So, although there are screen types that are capable of efficient size separation up to 40 micron sizing below 250 micron is difficult by this screening system. That is why in the mineral processing they go for those classification.

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Now you may be seeing some of the screening operations of different type of bulk material say in our municipality waste from there when you want to do that is also a screen which is a trommel screen. We also use in the mineral processing sometimes separating some of the coal particles. There also we have got a trommel type and in which the whole crushed coal will be given. The trommel will be rotated and the finer that the small size coal will be taken out.

That is also there. In sometimes the coal breaker and the screen that can be done if you allow a trommel. As you have seen that is a cylindrical one in which there are holes. Now sometimes a crushing and screening can be done for friable minerals or is a coal. If you take them and then allow you feed it from one side and make it to rotate and then this coal or the friable material will go up and then fall down.

And when they are falling down because of these; all perforations through that it can go. You can have a very different size of these particles. So, that in the first sector you will be taking a very fine one separated, next one little bigger size separated, next one very bigger size and then bigger than this size all will be going out. This is done in a trommel type of screen which is used in that as in the coal washing and processing or it is used also in the municipality waste.

In the environmental engineering, your city wastes where there are, your organic and inorganic material both. Then if you use this type of trommel and when you rotate over there because the organic particles, they are not very hard. They can get crushed and then they can be separated out. Then whatever will be coming out? The non-organic material and the things which do not get separated.

So, in this way the organic material which can be used for compost and other preparations are separated out. So, this a trommel screen is one type of screen you are having.

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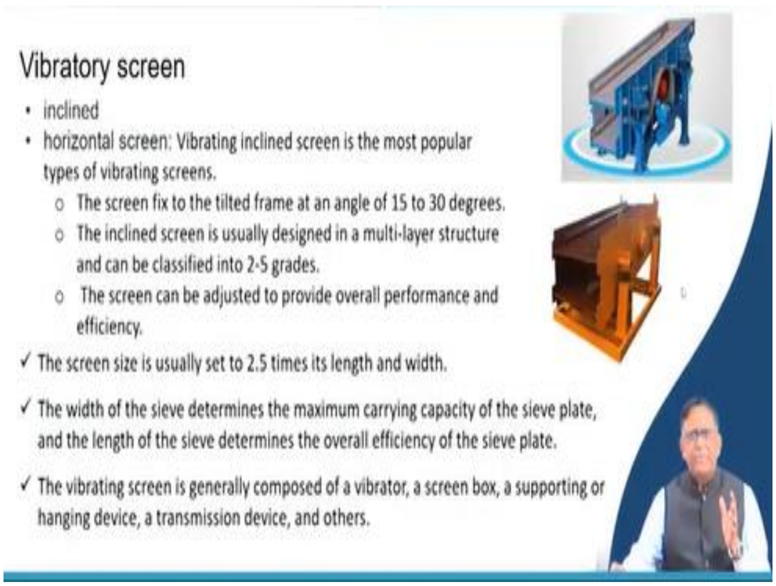

Then the most common type of screen you will be finding this is a vibratory screen. In a vibratory screen can be a single deck can be double deck. That means in a one screen you can separate it out into 2 grid. That means there the screen part where we are having this perforated that is with the holes, we are keeping those plates we say the different mesh size, we will be talking about it. Now there they can be of two types as you can see here.

The deck can be horizontal or it can be inclined. That if it is an inclined up to 2 to 5 degree that type of inclinations can be given over there. And they will be exactly helping you so that the material will be getting screen. That is depending on what type of vibrations you are giving if there they will be moving downward so that your rate of screening can be more. But that will have to be very carefully that what type of feed material is there that will be determining whether you can do it or not.

Now normally you will see that screen it will be below the crusher. Whenever the crushers are there, you have seen gyratory crusher or your jaw crusher after that it will be going to a screen. So, that from the screen it will be again through a feeder will be loading it to the conveyor. So, normally this small unit for the screening it will be having its width and the length ratio that is 2.5 times the width will be the length. So, that a compact unit can be placed over there.

Now that how the width and the length will be determined that as I said that means you will have to make the material at least to go as a layer. They should get exposed to the hole. So, that is why depending on at what speed it is going on. Depending on how vibrations you are giving that you will be designing it. So, the design of this vibrating screen it is an interesting problem. Some of you if you are interested to work on that site.

Or if you want to develop your expertise in the maintaining such system if to be a maintenance engineer you must know the designing so, you will have to study over there. That one thing which will be important for knowing to become a maintenance engineer or if you want to improve the performance of this in the field. How the vibration is given? The vibrations can be given by different method. One you can have number of your shaft eccentric shaft can be there.

They can be giving an eccentric shaft or you may have a spring on which this is moving. And with a spring you can allow the vibrations or you can just drive itself in the motor there will be vibrations coming. So, when you are going for the selections then we will have to see what are the different type of drives that can be given. And then also while selection you will have to know what are the controls available over there.

Because the same machine sometimes if your feed is coming non-uniformly there whether your screen can be adjusted or not. Many a time your screening problem or the shocking problem or that is exactly you are sending more materials in the oversize then sending back it to again in a closed group. This means that is sometimes you are going by that you are making finer then your grade reduced and your performance may go bad.

So, that is why you will have to know that in the design how the drives of this type of vibratory screens are made.

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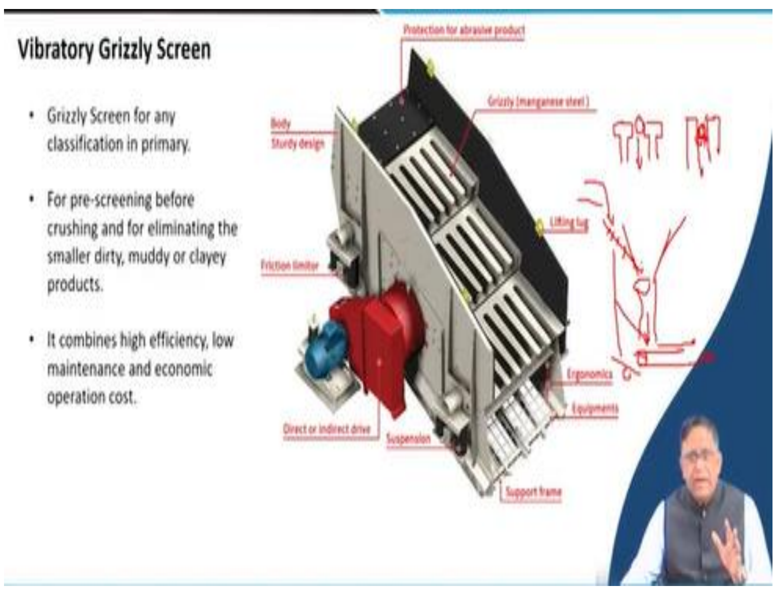

Now, you can see here there is a vibratory screen that can be of a grizzly type. That a grizzly types of screen it can be vibratory or it can be static also. Now what is the grizzly? Grizzly is just you can see here. These are very manganese steel rods. You can see over here which are having it is normally a T section. At the top it is wider and then the below it has got a less thickness. So, that if any rock mass if it go over there.

Then it will be just if you see that whenever any material is going your material that much if it is that your grizzly rod are of this type of cross section then what will happen? That if two rods are making like this the material once it is passing through this then it will very freely go through here. But if the grizzly rods are very straight (()) (18:35) then what may happen? That means after passing through this if there is a small one has come.

And then another small also is coming over there both get joined over here. And then they will be shocking over here and then this whole thing will not be moving. So, that is why this type of grizzly screens they must be seen that while in operation they do not give a problem. And then wherever inside that what material will be coming if there is any jam and all for that the ergonomically you will have to see.

That means any maintenance and other operations that can be done well. While selecting or designing an equipment you must see that equipment whether it will be giving any maintenance problem. That is, you are to open up a things or clean it whether the worker can go over there or how quickly it can do it. So, there is another thing that while selecting you must look into what is called maintainability.

In the maintainability and also whether the operator and all it can do easily that is called your ergonomically. Now there will be the supporting frame. You can see the drive is there. Then you have got the friction limiter. So, that means you will be having that your vibrations will be coming. But at the same time on your foundation that vibration should not go. So, that is why others should not have got you need to get only the vibration over there.

And because the vibration is also noise so, how exactly will be doing that. That part need to be seen over there. So, normally where you use a grizzly? You use a grizzly that is before the crushing that means your big particles which need to be crushed. As per the crusher's requirement that only it will go to the crusher. The undersize can be given to your feed and they can join after the crushing where it will go.

If you remember in our crushing we said over there. Now that means why it is given with a manganese steel? That means it will be much wear resistance and it will be very strong. Because when a big rock it will be coming and falling over there, there is a chance of getting its damage. That is why it needs to be very robust. Normally what you can find out that when a truck comes over there that is when your truck is loading onto a hopper that is suppose you are having gyratory crushers over here.

Your gyratory crusher is placed over here. Now when the material which is placed onto this hopper. This hopper is made of your grizzly. So, that what happens that material if the truck is unloading from here this material will be the smaller particle will be going and feed into whatever the conveyor belt is over here. That is from the crusher this material is coming and then on that this material also will be guided to this.

So, that here the material will go for feeding into the next. So, this type of grizzly which is here that is static. That means there the material is coming and falling and they are doing. So, that is why the vibratory grizzly where you are having the processing plan over there in the receiving section you may have also this, what is called your static grizzly.

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This is your static grizzly. Some you will be keeping over here if the material is coming over there that is a conveyor belt or that another apron feeder will be there. This one will be feeding you to the next process. Your material which is falling over here it will come like that and the other side it will go. Similarly, this is what you can see as I was telling the T bar for static grizzly it is working like this.

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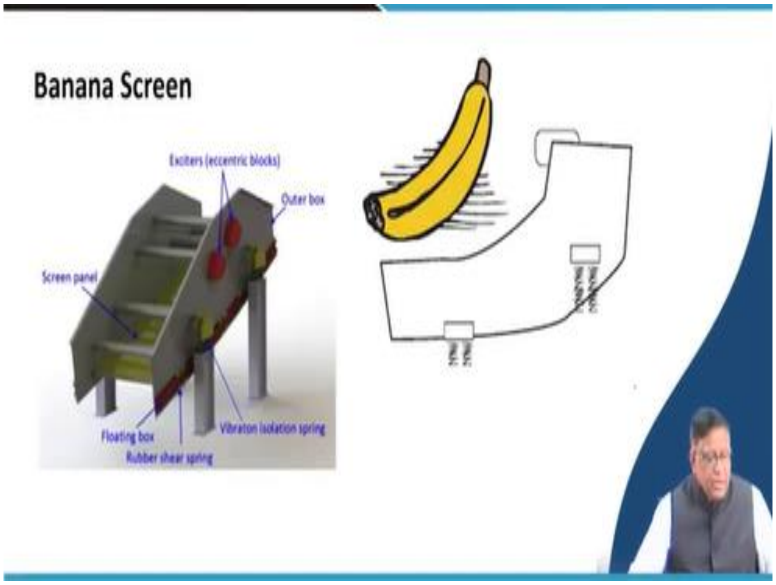

So, next thing is another type of screen is very common. That is our banana screen. In a mining industry wherever you go to a mineral processing plant you will be finding this banana screen. Because the material flow screen is designed just like your shape of a banana. Here they have given like your vibration component is here. So, now they are making it to vibrate the whole skin will be vibrating and the material will be flowing.

The flow is aided by the shape the curvatures given by over there. So, the component wise you have got this floating box that which get vibrations. And then there is a rubber shear spring is provided. So, that it can retain that the shock it can be absorbed. It is not going to get other metal damage. Then there will be the screen plates which are there at the bottom. And then this eccentric block that is your exciter which is exactly making the things system to vibrate. So, these types of banana screens are there.

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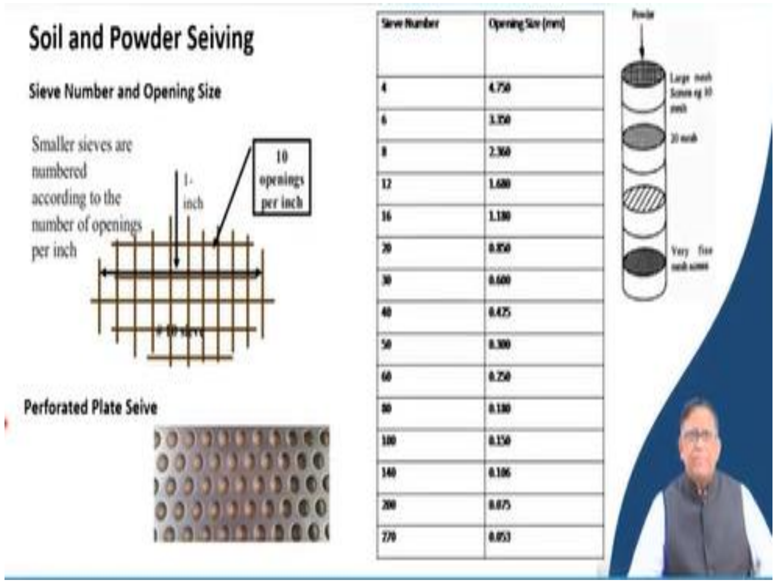

Now coming to the sieving; which are for the finer particle after your things. This is exactly required for your laboratory as well as industrially you will have to do different arrangements there for the classifying. But it is a very important to first know that is how the material characteristics will be there. On the basis of that you will have to do the designing of your classifier. So, this soil or powder sieving that is done by very fine mesh.

Now mesh is how many number of such square is there in one square inch? That is then 1 square is number of holes based on that they give a sieve number. And then if you see the opening size in millimetre for a sieve number 4 that is your 4 holes per square inch. It is 4.75 millimetre and then 270 small holes are there. That is sieving giving your 0.053 millimetre there could be much more. And then that could be that your either it can be a perforated plate or it could be a screen.

And there are number of that your will be from a course to your finer. They can be arranged in a stick.

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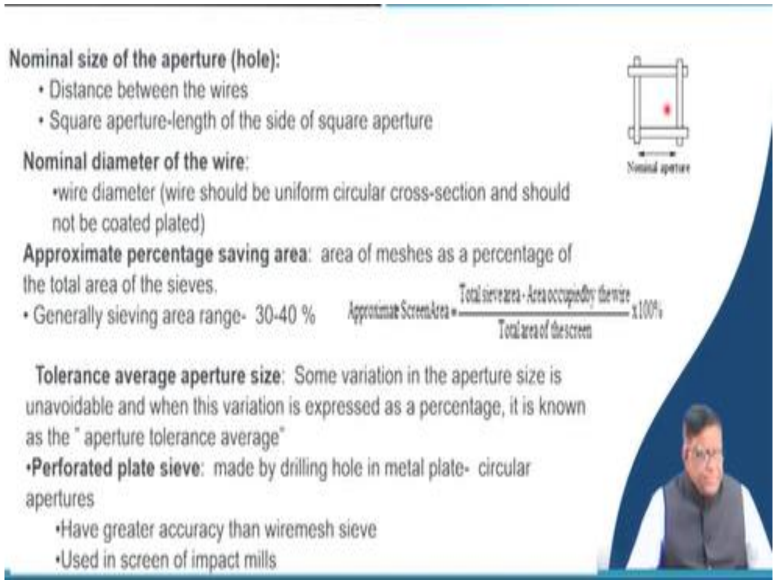

Now what is done in sieving? Your nominal size or aperture of the sieve or the screen shape. This is given by this one. Now the distance between the wires is called the nominal aperture. Now when you will be doing the calculations of how that sieving will be performing because these wires are also occupying some space that will have to be taken care of. Now the nominal diameter of the wire depending on that your screen performance will also change.

Now because what is the approximate percentage of the sieving area that will be calculated by taking out the area taken by the wire. So, that is approximate your screen area it is calculated by the total sieve area - area occupied by the wire and then the total area of the screen and in a percentage. So, this is the way you define that what will be the screening area. So, when you feed the material or screen the material how much that material will be having chance to going through this.

And then there is another thing that tolerance average aperture size. This is your some variation in the aperture size is unavoidable. And when this variation is expressed as a percentage it is known as the aperture tolerance reference. So, this is one of the important things you need to keep in mind whenever you will be doing your laboratory experiment with sieving to find out how the particle size distribution in a things.

Sometimes to know the texture of a soil you will have to do that. Then the perforated plate also same thing the size you will have to calculate out how much material is there?

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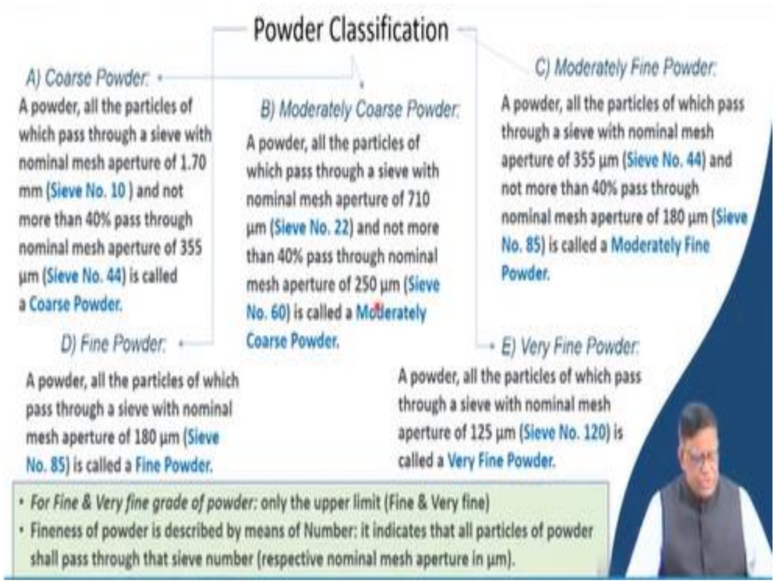

So, these powder classifications it can be done because there could be a coarse powder. There could be moderately coarse powder. There would be moderately fine powder. So, particularly this type of things will be coming in pharmaceuticals or in some food industry also in mineral processing. Sometimes, you may get some very fine powder and very fine powder. Now this powder can be where it is a coarse powder there exactly with a sieve number10.

And then in between the sieve number 10 and sieve number 44 whatever is written that is your coarse size. Similarly, for moderately coarse powder they are retained between your 22 size and the 60 size and moderately fine powder 44 size to 85 number depending on the number. As the number increasing the aperture size decreasing because that many number of your holes per square inch. So, then when it is a fine powder, they do not stay between 2 range.

It is whatever will be going through that is your 180 millimetre size. And for very fine powder they are going sieve number 120. So, this is the way these are classified. And accordingly, we can get the sieves.

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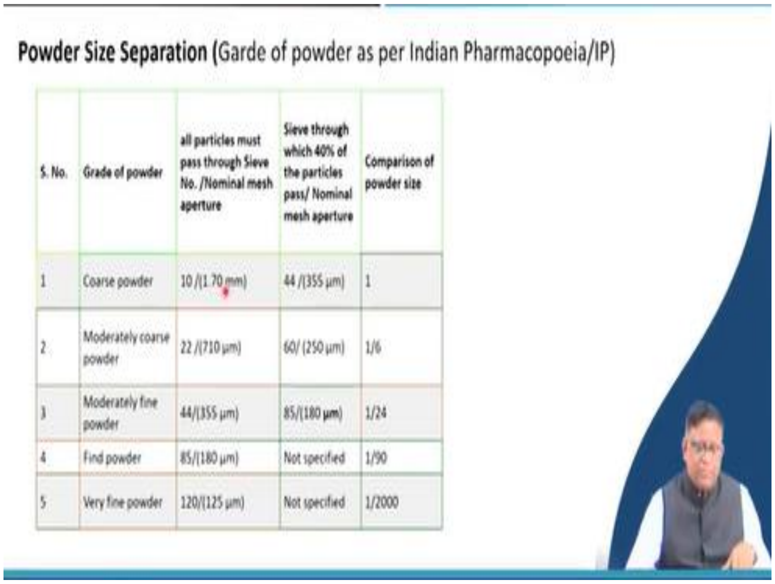

Powder Size Separation (Garde of powder as per Indian Pharmacopoeia/IP)

S. No.	Grade of powder	all particles must pass through Sieve No. /Nominal mesh aperture	Sieve through which 40% of the particles pass/ Nominal mesh aperture	Comparison of powder size
1	Coarse powder	10 /(1.70 mm)	44 /(355 µm)	1
2	Moderately coarse powder	22 /(710 µm)	60/ (250 µm)	1/6
3	Moderately fine powder	44/(355 µm)	85/(180 µm)	1/24
4	Find powder	85/(180 µm)	Not specified	1/90
5	Very fine powder	120/(125 µm)	Not specified	1/2000

So, this sieves you can see they are different. That means if your 10 size means your size is 1.7 millimetre. And then for your very fine powder 120 means 125 things like that.

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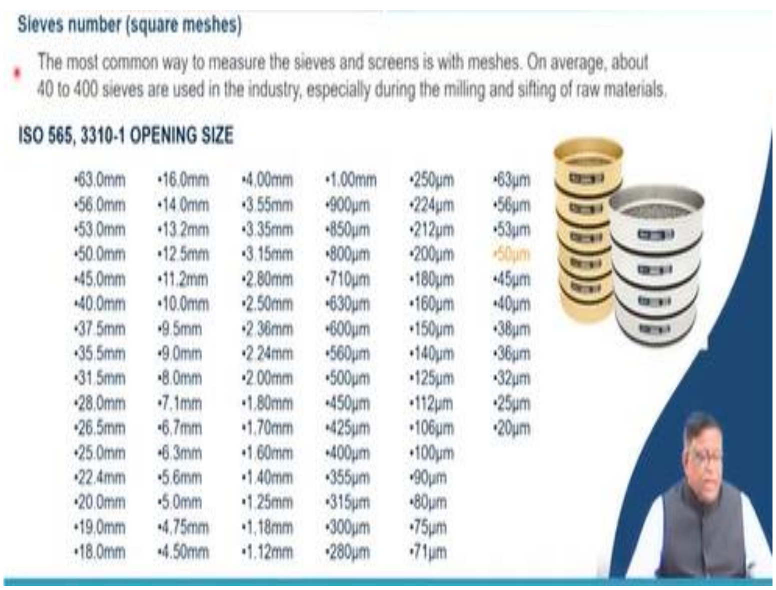

So, there is ISO standards are there. Whenever you will be doing the studies for standardization purposes there are so many different number of sieves are available. Under the standard manufacturer they will be giving the sieves in this form. But if sometimes you are doing the laboratory work with weight one there will be a little bit of design will be having. So, that we can retain the water there will be a little bit of bigger size.

Height of this sieve will be more. But this type of sieves will be used you can see in any material handling laboratory that sieving operations for different testings you will have to have.

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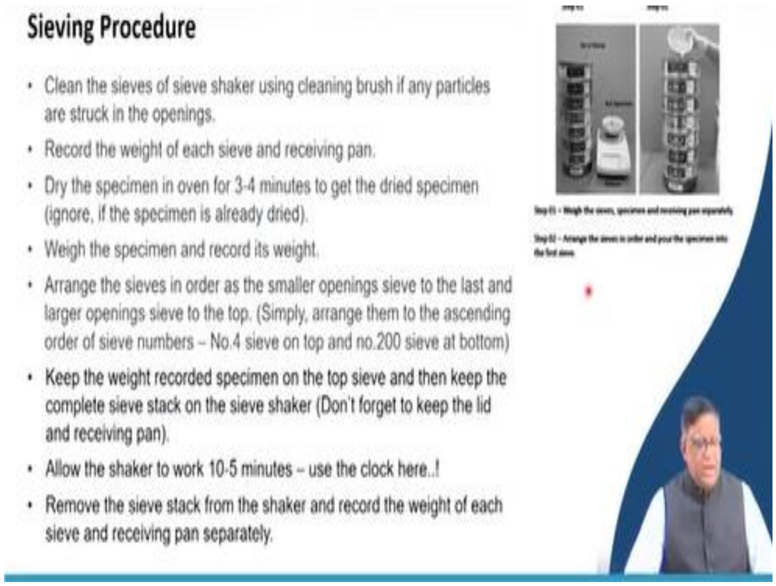

Now you know that the procedure is first you stack this whole material, you put them, weight them that is all. First you will have to when you are going for taking you have got sieve rack that how many times how many different sizes you will be separating. Depending on that you will be selecting okay, I will do it 5 sieves, 6 sieves, or 7 sieves you will be deciding. Then you will have to clean it properly. Why? Because the cleaning is very important.

Because whole sieving how much percentage weight you are retaining that will be determined by measuring gravimetrically. So, the cleaning of all powder whatever is left from the previous experiment should be removed. Then you will have to weigh it. After that use your specimen one which one you want to get separated that will be in a first in oven it will be dried. The dried powder will be placed over there.

And putting all one above another you will be putting in some vibration or shaking things or arrangements. And after some time, what will happen? That in each of them there will be certain particle will be retaining. And then rest of the things will be coming and getting at the bottom.

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Sample Calculation of Sieving

Sieve Number	Sieve Size (mm)	Mass of each sieve (g) (M1)	Mass of each sieve + soil retained (M2)	Mass of soil (M2-M1)	Percentage retained on each sieve $\left(\frac{M2 - M1}{M}\right) X 100$	Cumulative % retained	Percent finer
4	4.750	765.5	786.5	021	4.2	4.2	95.8
10	2.360	738.25	764.25	026	5.2	9.4	90.6
16	1.180	672	716.5	044.5	8.9	18.3	81.7
30	0.600	602.5	649	046.5	9.3	27.6	72.4
40	0.425	572	684	112	22.4	50	50
60	0.300	554.5	701.5	147	29.4	79.4	20.6
100	0.150	523.5	585.5	062	12.4	91.8	8.2
200	0.075	509.5	530.5	021	4.2	96	4
Receiving pan		485	505	020	4	100	0
Total				500 (M)			

M --> Mass of specimen	M2 - M1 --> Mass of soil
M1 --> Sieve Size	Σr --> Cumulative % retained
M2 --> Mass of each sieve + soil retained	Σr - 100 --> Percent finer

So, you will have to do that sample that is you are having here say sieve number 4. That is a 4 holes per square inch up to 200 holes. We have taken these many sieves. And then their size we know and then after that you have taken the material. This total material mass of each sieve that is your first one retained 765 gram and then the lower one it gave 509 gram the total material they have. And the finally where you find less than 200 is coming 485 gram.

Then you do the weight of the sieve and the soil retained. And then mass of the soil you can find it out. Just minus then you can find out what is the percent retained in that particular one. Because this percent then you can find out the cumulative retained. Then you can find out exactly what is the final fractions over here. Now these things then they will be putting that your sieve analysis graph. They will be putting sometimes in your graph of (()) (32:12).

They will be putting over here. And then they will be finding that exactly how that what percentage what is the size? And then how much percent is going through this? And then how much is there? By saying this type of your sieve analysis graph, you will be knowing how the particle size is separated by this.

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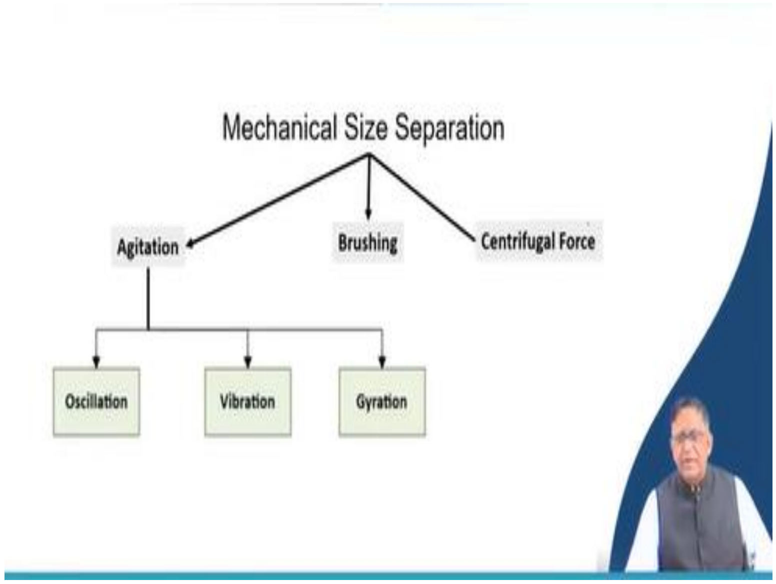

So, this will be very interesting when you will be working in the laboratory. Normally in the bulk material handling laboratory you do this analysis. Now it is exactly that how you can do these separations? That can be by agitation, brushing and centrifugal force for the finer particles. That vibration or that agitations for screening it can be given by oscillation, vibration or by gyration. For the sieve analysis also, you will have to have this system and that can be done over there.

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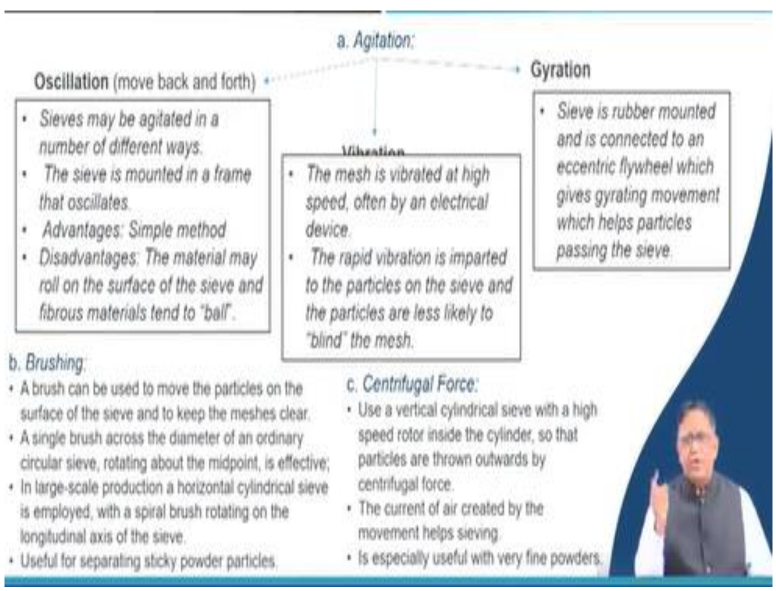

Oscillations that is your sieve will be giving all the time oscillating like that. In a vibration sieve will be given a vibration like this. Then the gyration sieve will be rotated like that. Brushing means with a brush you will be going on handling over there. And then in a centrifugal force what happens within the sieve it will be rotating. So, this type of arrangements are there in a different type of systems.

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So, we will be continuing one more class on screening to tell you about that. How the screening principles and then the basic things in the mineral processing sections. But you are advised to go through these books of mineral processing by B. Wills. And then there is a very good old book but very good book that is your handbook of mineral processing by Taggart. Though I do not know whether the new editions have come or not.

But the old edition for understanding the basic principles are important. But what is most important today is? You please go through the websites of different screen manufacturers because nowadays lot of new developments have come. So, once you know from the textbook that what is the basic principle but what design coming out of it? It will give you an idea that where exactly the advancements are taking place and you will have to do that.

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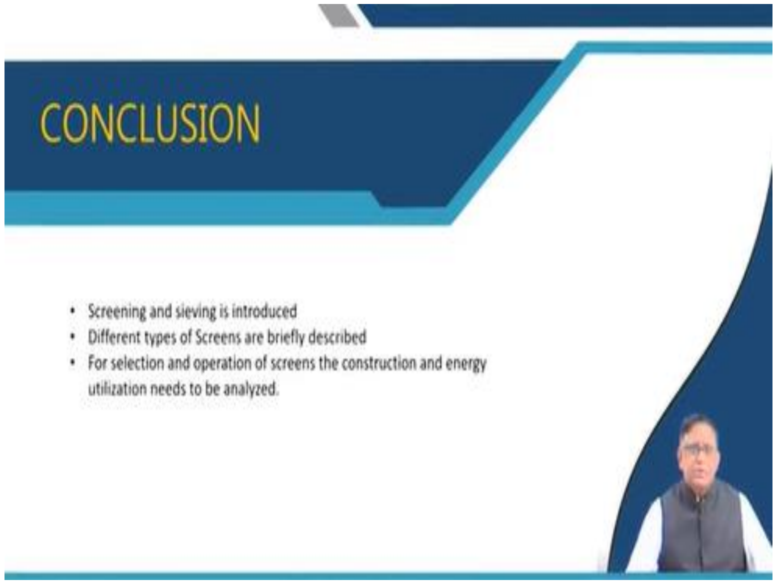

So, coming to the conclusions screening and sieving I have introduced here very briefly. The different type of screens are also just specified. So, that you should be able to tell what are exactly their vibratory screen? What is a static screen? What is a trommel? And then what are the different type of sieves. And basically, what is a multi-deck? What is a single deck? And then how they are constructed? What is the banana sieve? What is a trommel sieve?

These things you should be able to explain. So, make a study report of what you have learned of the screen and try to do it. Then one more thing I would like to tell you here that you will be given a model link. So, that whatever, we are studying that you can once again study over there and take some lesson. So, an email will be sent to you in which there will be a password given and, in that site, you will get all this material as well as some of the reference notes for knowing more.

And you can submit some of your work also if you wish any special attention by us. Thank you very much.