Bulk Material Transport and Handling Systems
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Lecture – 22
Introduction to Bin Bunker and Silo

Welcome back to our discussions. Today, we will be starting another discussion on our storage system. This time we will be talking about closed storage. In our earlier discussion, we have discussed how materials are stored in open space like making with the use of stacking, stacker, reclaimer and there how we had our **(Video Starts: 00:47)** different type of stockpiles, Windrow or Chevron or oblique layers.

But, this we need to store materials in the plants. Like in the processing plants also in bulk material handling in the food industry, in pharmaceuticals, in chemical industry, in many places, you will be using that storage systems where we are storing the bulk material in terms of bin, bunker and silo. This 3 terminology, today, **(Video Ends: 01:28)** we will be introducing this subject of bin, bunker and silo so that after attending this lecture you should be able to explain the differences of this storage systems.

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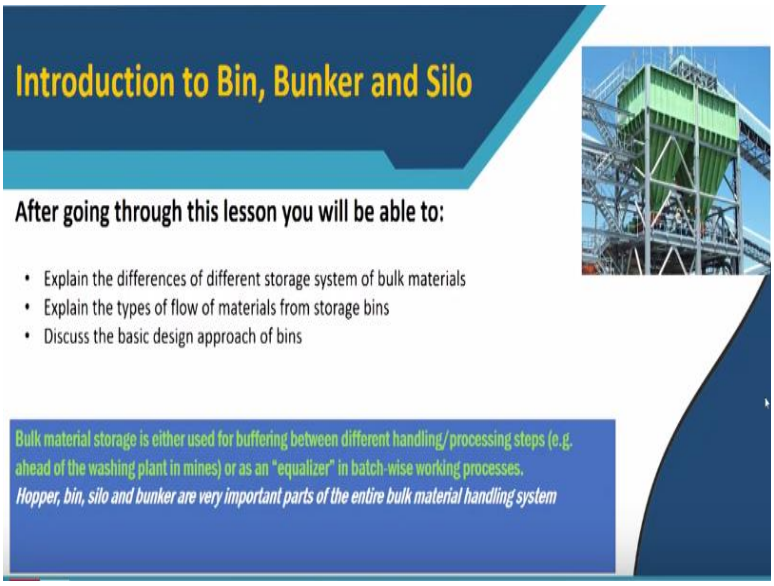

That were, what is a bin? Or, what is a bunker? Or, what is a silo? And then, that how the materials are flown out of it? How the materials are taken from these bins, bunker or silos? What are the different type of flow problems? And also, we will be discussing about the basic design approach that we use for designing a bin. As for example, you can see here in the figure that there is a bin. Now, what are the main components of such type of bins?

And then, we will be discussing. And, they, their main purpose is sometimes they are maintaining a temporary stock as a buffer or in some processes where different materials will have to be there at different timing. They will have to be introduced. All those things are done with the help of this bins. Now, one thing is very important that in any bulk material handling system this temporary storage with bin, bunker and silo are very important.

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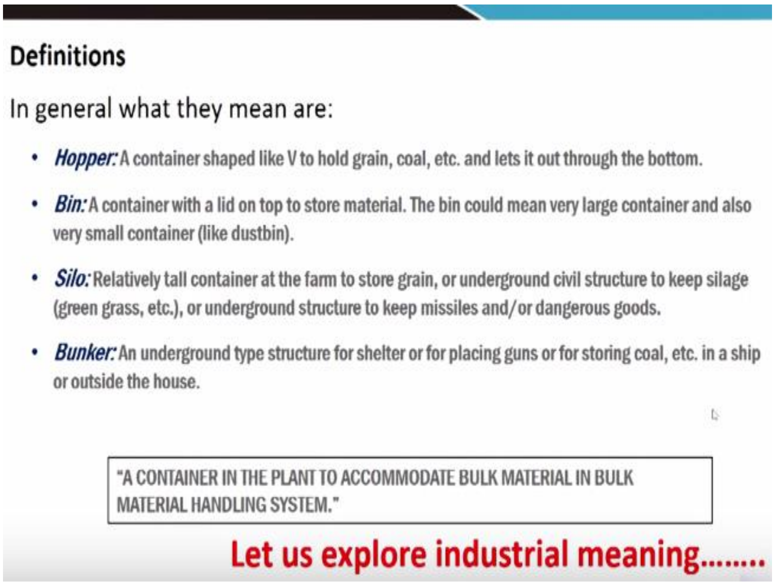

So, coming to some of these definitions that what is a hopper? Hopper, it is a V-shaped container that is exactly it will keep all this loose, dry bulk material. And then, their main job is a hopper you just pour in and it will go out. So, it is just like a both end open. That is a hopper. It is a funnel type of shape storage system. Now, a bin which is having it may have a lid at the top. Or, it may not have any it may be having a open top.

And there, you can keep a large quantity of material as well as very small quantity depending on your design requirement. As a, you might have heard about the dust bin. That is also a bin. We are just keeping it. Only thing is that to clear it we are just taking it out reverse it and then you take it out. But, you can have a bin where the material you can have a gate. Open this, material will go out.

And then, silo, it is basically a very tall bin we can say or a very large bin where it is used in different sector. You may find in some of the foreign countries they just the cattle farm. They get this for their winter season. They store the grass. Cut small chips of this grass and all. They are keeping in a (()) (04:31) bin. Similarly, this bin can be there also in underground mines to keep the material over that to load onto a skip to take it up to the surface.

We can have a temporary storage silo. Or, we can have a bunker. Bunkers in many cases, it is a underground bunker. But, it can be also in open terrace where we are keeping a large area for keeping. And then, all these things, hopper, bin, silo or bunker, this is a normal terminology where your, wherever is a container it is a, some form of a storage vessel in which you are keeping it. But, technically, when we go into it there could be some different industrial meaning.

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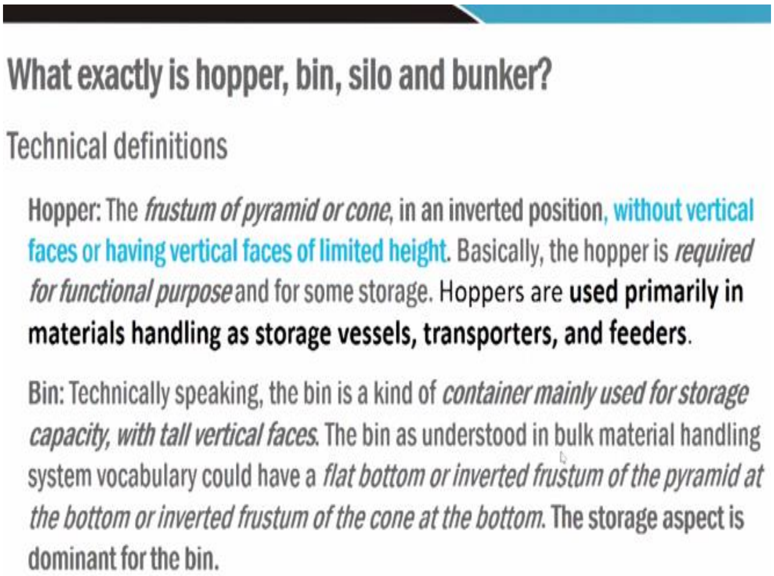

That is, a hopper we can say technically it is a frustum of a pyramid or a cone in an inverted position, without vertical faces or having vertical faces of limited height. That can be a hopper. That hopper, it can be just a, upper like that. Sometimes, you may have a little bit of vertical height so that the material will be coming over there. Now, it is required for this storage purposes as well as it is also a conduit so that from here it can be loaded to other unit of container or a conveying system.

So, it is a storage vessel or it can be a transporter or it can be a feeder. Transporter or it could be rather telling it is a transfer one from one thing to you are transferring to another via a hopper. And the bin, when we say technically it is a kind of container mainly used for storage capacity. That is it has got a vertical faces. In a hopper, you may not have a vertical face or a storage a large storage capacity it may not have. But, a bin will have that.

Now, it can be having a flat bottom bin or it can be having a hopper at the bottom of the bin which could be a circular. It could be a rectangular. It can be a square. Different type of bottom could be there. And also, a bin can be where it may have a, at the bottom the gate is there through which you will be taking the material out. It can be only single gate or there could be a multiple gate. You may have a big vertical wall and then the hopper part.

In between that, there could be number of different type of your, you can have your number of different type of opening can be there that will be coming into those things slowly.

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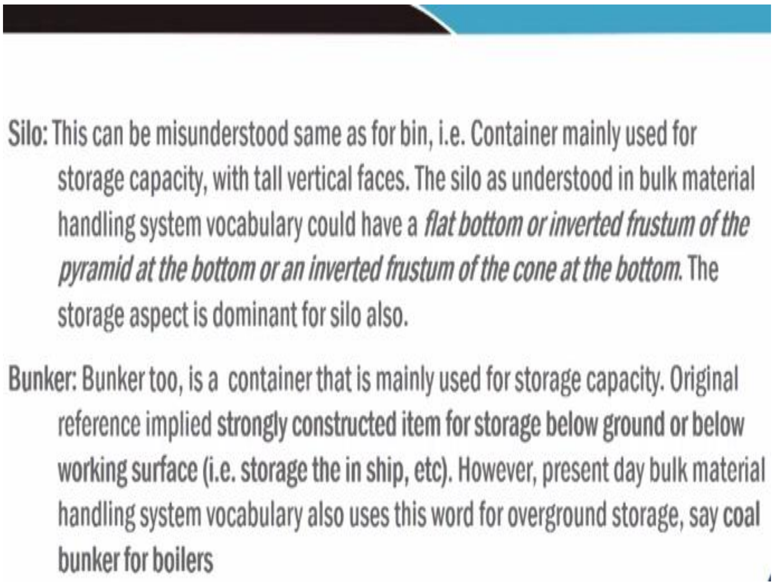

So, we have got now that our next thing is the silo. In a silo, this can be understood as a big bin or a very large bin. And, it is, that is exactly a bin and silo. Their differences will be there in the storage capacity. And, it is, silos are used in a, you can see in many of the grain silo rice silo, coal silo, iron ore silo, like that where you can have 1000s of tonnes of material can be kept over here. And, they also can be having a single discharge double discharge.

It can be flat bottom. It can be a rectangular bottom with gate. That gate can also control differently. It can be even automated. It can be manual. There are different type of silos are there. And, a bunker, it is a container that mainly used for larger storage capacity even larger than silo. And then, they are very strongly constructed for storage below the ground. We have got lot of underground bunker in many of the coal mines.

And also, you might have heard this word in the army. They have got the bunker a camouflaged below that they will be staying. They can that they can have a bunker to store their ammunitions and all that thing. That is also there as a bunker. Now, they can be, the bulk material vocabulary, bulk material storage vocabulary, we will be having sometimes in a overground bunker or underground bunker.

Or, the bunker can be even on the surface with a separate partitions created over there. So, different type of bunkers could be there.

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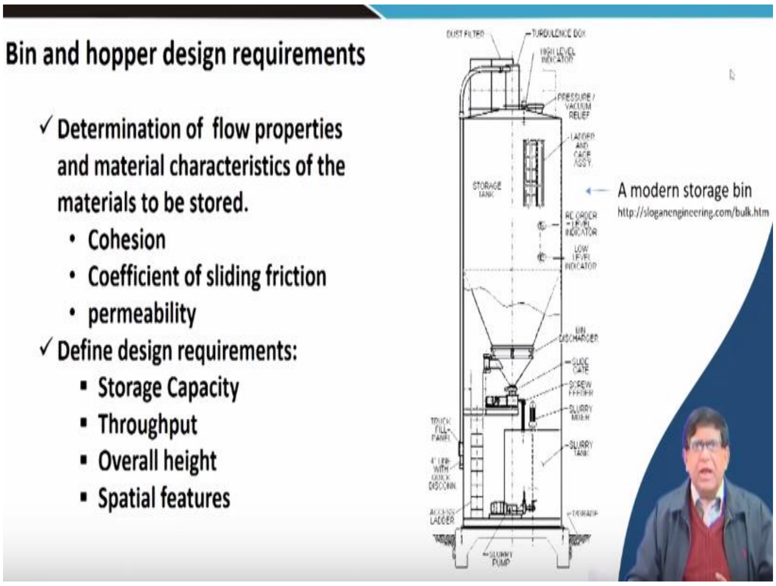

Now, is a, if we see a bin and hopper, what are their main design requirements? You may have that is exactly the whole design will be depending on the material properties because if the materials are having a very high cohesion and at that time they will be having amongst them they will get attract each other and they will be having difficult to flow. Or, then, there how the coefficient of friction with the wall and the material.

Or, the coefficient of internal friction between material to material and also the permeability how exactly the porosity that means the void space in between that material when you stock it up that also will determine how the material will flow. So, that is the material properties which guide their, the flow behavior are very important in designing. And, when we go for designing it, we will have to know that what will be the storage capacity?

Or, then, what will be the throughput? How much you will be taking out of it? The storage capacity may be in some 10,000 20,000 30,000 tonne and your throughput may be say 100 tonne per hour or 1,000 tonne per hour depending on the applications. And also, the height to what height it will be there and then how they will be arranged. Say, sometimes, your height may be restrictions because of the structural the requirements will be there to maintain the stability and all that thing to take the load.

If you are giving a small structure which has very tall height the pressures coming over there at the bottom will be very high. At that time, the material which you have thought may be not suitable. So, and also, then, you will have to do number of such silos or some number of such bins. Then, how do you will be geographically positioned in your plant? Those things are the matter which to be considered in designing. You can see here one modern storage bin.

What they have? This is a bin for giving the feed material to a slurry transport hydraulic transport. You have heard about that what is the slurry transport? You know about that feeding system. By rotary feeder how they were going to feed into that system. Now, if the material is coming over here and then when they are loading, at that time, lot of dust will be generated. So, a dust filter or dust controller will be necessary there.

And then, there is also you have got a level indicator that up to what level the material has come then in which way the flow is there. If there is also called as a turbulence box if anything is happen in a floor that is a lot of gases the dust (()) (12:17) and air is coming out of the bin, at that time, there will be certain indicators over there. There is also the, if the pressure relief will have to be (()) (12:27).

That is, if there is a, if you are having a particularly in a closed type of such type of silo with a high capacity loading point there will have to be kept some of the system for safety. Then, there could be that ladders and the things (()) (12:43) so that the people can go climb up and see what is there. Then, there will be reorder level indicator and the low level indicator. That is you can see from here.

These indicators are all will be say electronic and digitally controlled. Maybe here a laser beam will be going over there. When there will be filled it up then this laser beam will not be getting a say and then from there you can control the error with a gamma ray actuated level indicators are also there. You can have other different type of proximity switches for indicator. There are different way.

You can have a electronic and digital arrangements over here. Then, you can see here there is a hopper type in that this is for the discharge of the material. From here is going from this conical shape as we said it is a hopper. And then, from there, it is going to be giving a feeder. And, from here, the dust which is there it can be collected to a truck. And then, from there, it can go out. So, like that, this is just for an example that these are the different component in a things.

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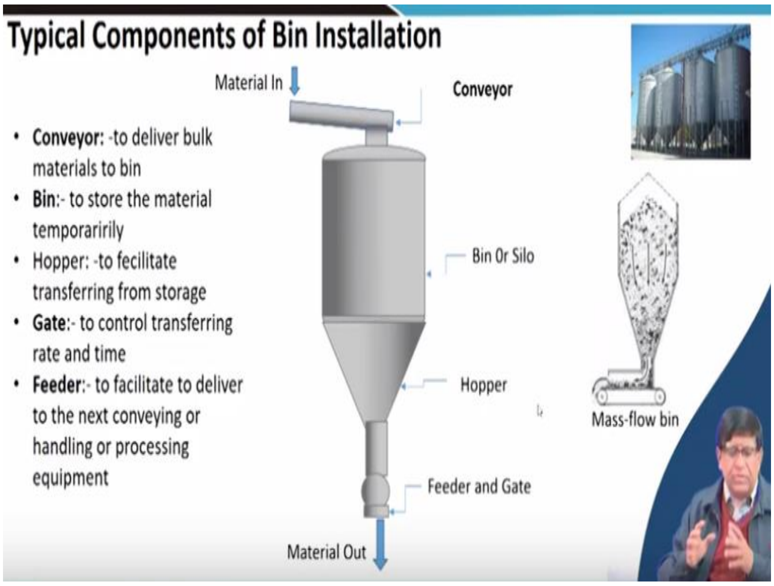

So, let us go little bit more as a schematically what it is. So, that if we talk about a bin, what are its main components? That means your solid material, bulk material will be coming in and bulk material will go out. That is where temporarily you will be storing. So, here, you will be having a gate which will control. Open the gate, material will flow, otherwise not. And, that one, when the material flow it can be giving by a feeder system.

We will be discussing later sometimes, what are the different feeder? And, how they are made compatible with the type of hopper? Now, in that, we have got, this is the bin where we have got a component called hopper component which is exactly a, your conical part of it. So, the material which this bin or that silo depending on, what is the diameter of this? And then, what is the height of it? The capacity will be determined.

As you can see in this figure, there will be number of bins can be placed together in a row getting fed by the same system by which the material is coming to the site. Now, when you are withdrawing from here it may going to a conveyor belt. This is the feeder unit which will be working. Now, as you can see all the materials are flowing down together. We will be talking right now about, what are the different type of flow patterns?

As you can see here, all the mass is flowing at a go and then they are sliding against the wall. This type of flow is called of course the mass flow. If a beam can be designed which will be depending on that this mass flow how it will take place will be depending, how you are discharging? What is this angle of the hopper? All these factors, so, now, you know now that what are the different type of, or, what are the main components of a bin?

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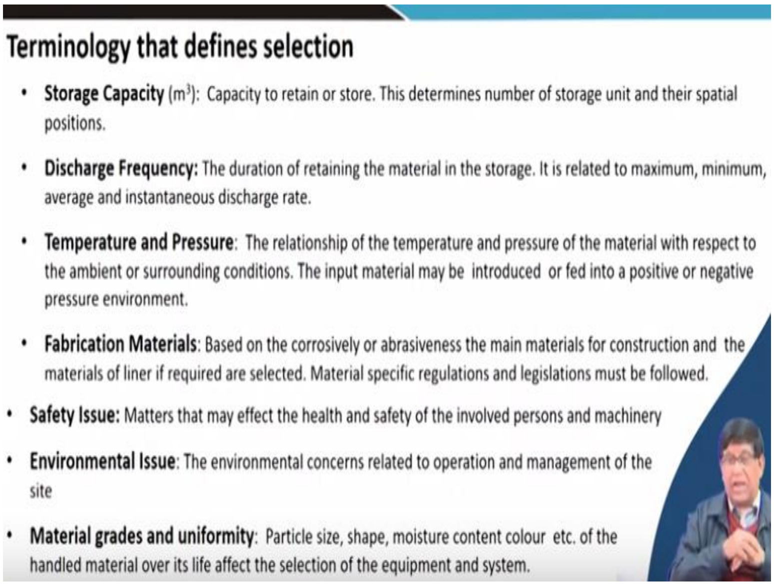

So, we have talked about that bin, hopper, silo. Their different terminology you should know. The terminology in designing a system as I said storage capacity you know that means how much can be stored. Discharge frequency, if you are having a gate, you are opening and closing that giving it, then how many times you will be feeding during the, a shift hour or a 1 hour like that.

So, that frequency is very important depending on what system or what type of process plan it is feeding into. Now, that another important parameter in designing a storage system with silo, bin, bunker, that is what is the temperature and pressure? That means, the, say, for example, you have heard about in the pneumatic conveying that already there could be a high pressure air may be flowing in and then you are maintaining inserting the materials over there.

At that time, as the, as soon as you open up the gate, the high pressure air will be having a tendency to go up over there. And then, this will disturb the downward flowing of the material. So, that means there is a different system. That means from your you are entering or feeding the material into a high pressure system. Or, there could be already you have created a vacuum in the pipe.

And, when you open up the material that is your that vacuum will suck the material from your bin. So, that is a different way. That means you are feeding the material into a pressurized that is a positive pressure system or a negative pressure system. And also, there could be different temperatures. That means when you are adding some material over there in that storage system they can be at a higher elevated temperature.

Or, they could be at a lower temperature. And then, when they were loading it could be the difference of temperature with the ambient temperature or the temperature which that particular processing place where you are feeding in depending on that you will have to design your system. You will have to take care of these factors so that in some cases it may affect adversely if you are not taking care of.

Then, the fabrication materials, the most important thing is you are making this storage bin made of what. There could be your plastic material. There could be alloy material. There could be other metal depending on how much load and how much strength your system will require. While you are storing say rice husk or you are taking this some of the grass feed for the cows cattle’s there your that thing is very lighter. So, only you need a big bin.

The material will be poured in there. So, there you can have a simple corrugated sheet of galvanized steel galvanized sheet that could be made. But, only thing, you will have to manufacture it over there. So, these things are to be taken care of while designing other things. Of course, you know safety issues will be coming. That is when you are storing and taking it out and all they were making different people to work over there.

Their safety as well as while you were loading the material over there it should not affect the other machines. Say, that where you are feeding the conveyor on which you are loading it should not whole the material will be coming out together falling over here and then your conveyor belt will get damaged. So, that is why the safety issue need to be very you careful. You will have to do design it properly.

And, of course, then, environmental issue, as you have said that dust will be generated. So, you will have to control the dust. For controlling the dust, you will have to have a dust collector system the (()) (19:46) whether you are getting electrostatic systems or you are having a vacuum system your (()) (19:51). So, these things are very important. And then, your requirement is what grade of material you must maintain.

Then, whether your particular size uniformity will have to be maintained, depending on that, your storage system and this container design will be different.

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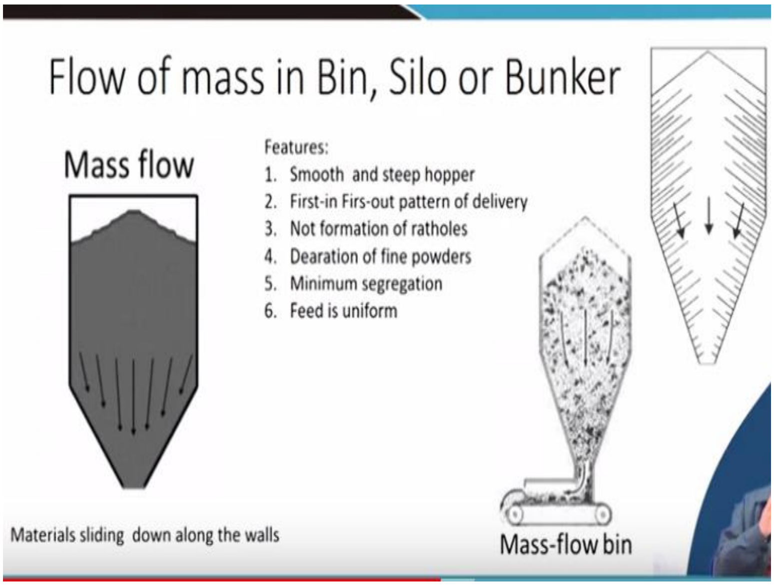

Now, next thing is let us see that how the material flows out of the, this bin. You can see here as we are telling when it is a mass flow there are 2 types of flows. One is called your mass flow. Another is called your funnel flow. Or sometimes, call it is that is your, this flow our mass flow where this whole material is coming down slowly. That means this whole material will be coming down. And then, it will go.

And then, after that, if the material is pouring in over here that same material that will get poured in over here will be just coming the next thing it will be (()) (21:02). That is whatever first-in first-out it is going and there is no dead storage over there in mass flow. So, what is the requirement? Or the, what are the features of this? This type of flow can be achieved when your, this hopper portion it is very, it should be very smooth inside.

And, it should be stiff. You can see here. It is more than 60 degree 70 degree like that. If you make it more flatter at that time that is a 30 degree 40 degree like that. The material may not flow like that. And, we have got a different type of flow. Sometimes, that could be a flow problem also. Now, there is a one terminology is there called rathole. That means if your, this material is not flowing, if you are forming a rathole in between.

We will be just showing you another figure. You will be knowing, what is rathole? So, sometimes, the rathole formation comes or there is a de-aeration of powders. That means here the air and all will not be coming much because whole thing is flowing down. Then, there will not be any segregation. The materials on the basis of the particle size or so like that it will not get separated out. All will be going as it is fed. So, that is why we say the feed is it is giving here uniform fit.

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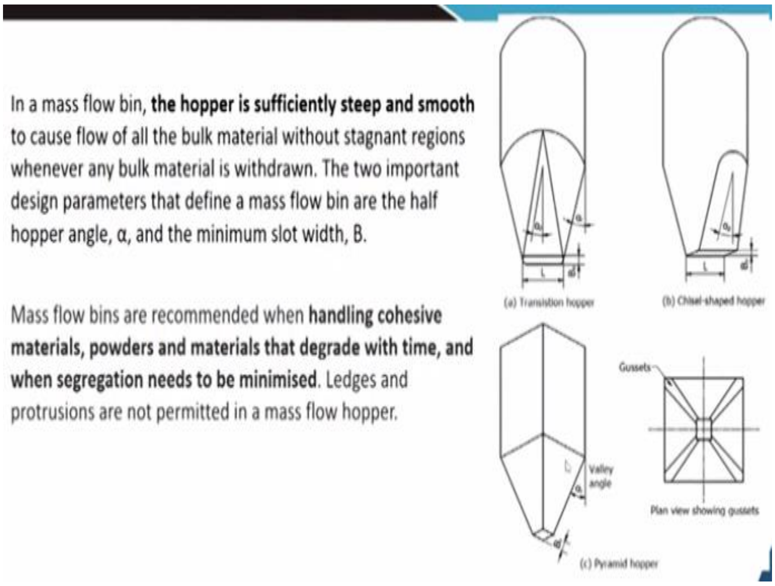

Say, this mass flow, it can be, it is to be sufficiently stiff and smooth. If there is any corrugation, any intrusion, any protrusion in between this, that will not be giving you a better mass flow. So, the most important design parameters are the half hopper angle. This, how it is making its upper angle? And, what is this opening? That is your alpha. And, this your, that b. That is your width. That is very important over here.

Now, as you can see, it could be having a just like a pyramid. You have got pyramidal bottom over here. And, if you see this is a, your rectangular bin or it could be a circular bin. So, depending on that what type of geometric structures you make you will have to make. Now, when you are handling cohesive materials, powders and materials that degrade with time and they when segregation needs to be minimized, there you must design considering mass flow.

That means all will be going like that together. So, this is if the material because you will be saying when it is not a mass flow funnel flow, there may be some storage of the material.

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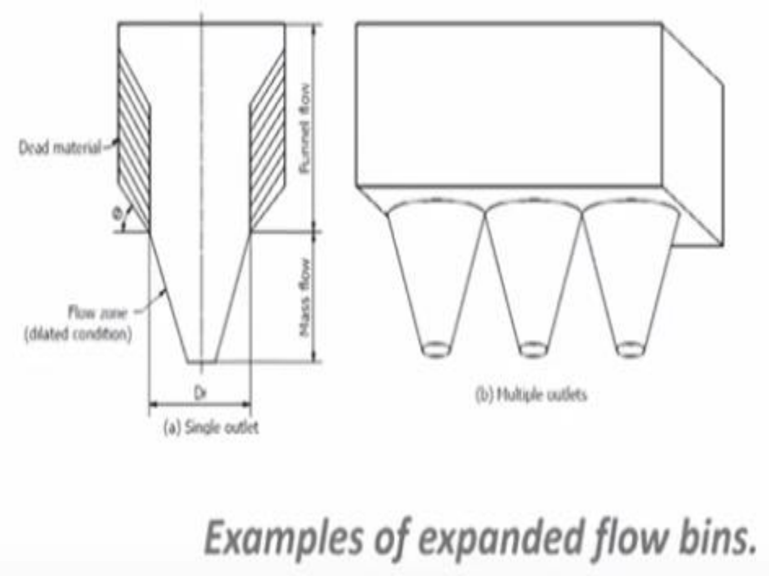

Now, that mass flow bins you can have number of them at the bottom. You are having the storage over here. Now, you are just taking out the material by different gate or by different hopper. This type of things are called expanded flow bins. So, you have learnt now that there are different types of bin.

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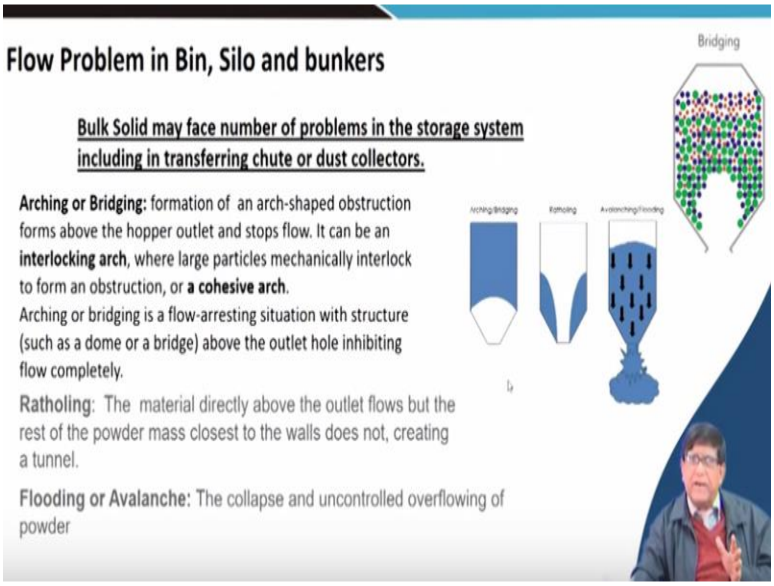

But, this mass flow, it is expected, it can, if it does not happen, it could be a problem. That is called one problem is the arching or bridging that is nothing coming out. Or, another problem is that we are having a, what is called here, a funnel formation. This is called a rathole. A ratholing is there. Or, there is a bridge formed by the exactly we have got a wedge or it is exactly the particle bigger particles smaller particle that together they have form in such a way that nothing flow out.

Or, a problem can be there that whole thing as an avalanche it will come or a flooding whole thing will be coming at a time and it will go. And then, if it is loading onto a conveyor belt that conveyor will get jammed. So, these are the problems of your things comes.

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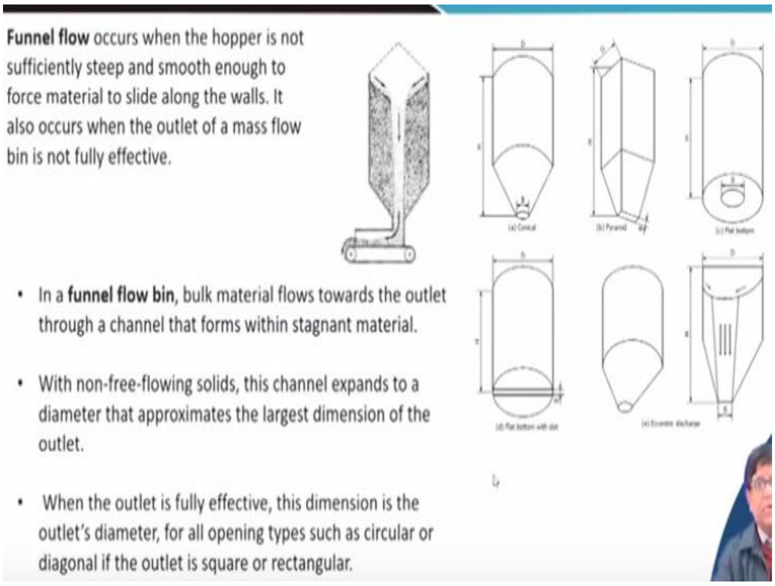

But, this funnel flow, sometimes, in certain case of material, we may wish that let us have a funnel flow. But, the problem here is you can see that the material which is at that up to that hopper level here they are just getting stored there as a dead storage. They are never going out. Whatever the material will be coming above it, it will be falling through this rathole. There you can find that the flow rate here it may be reduced.

And then, this storage sometimes it may create a problem. So, this is where exactly you can have a funnel flow or a funnel flow can be there by at the center or it can be also at an edge. So, different type of funnel flow may take place. Or, you can design yourself that we need only. We will be storing the material something over here because if the material is going to give a very high abrasion over there.

Now, the abrasion is coming only in the material to material. So, in that way, that funnel may be helping that your, the, there will not be (()) (26:19) of your silo or bin.

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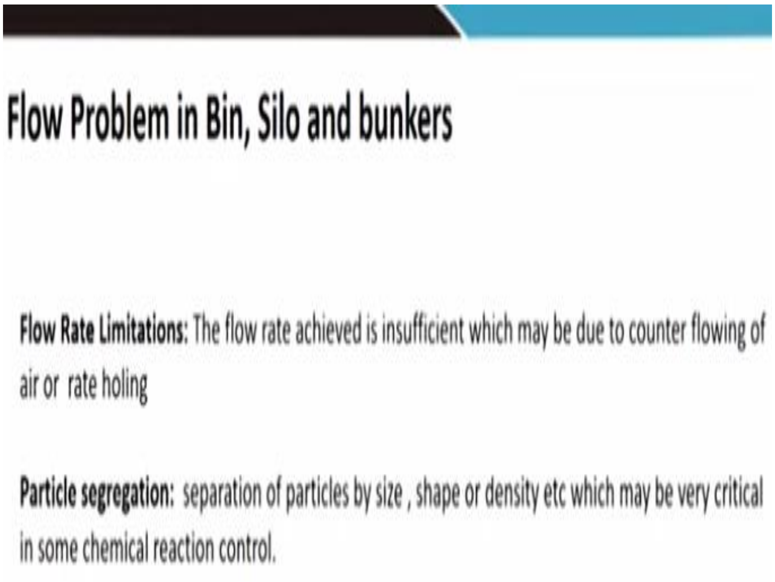

But, this problems are exactly called as a flow rate limitations or the particle segregations. That is flow rate limitation means you are going to give a capacity say 1,000 tonne per hour but you are getting only 5,000 tonne per hour because there is always a constrictions. And then, there is a rathole formations. The materials are not going out. Or, sometimes, it may not go at all. Or, there is a particular segregations takes place.

That means that now if you are feeding to a say in a chemical in this percents it may be necessary that some reactions with a particular size and particular density materials they must be there. Now, if you are giving a segregation and then your material which are flowing are of coming only of a particular size or shape or a particular characteristic density then the reactions may get affected. So, these are the things need to be taken.

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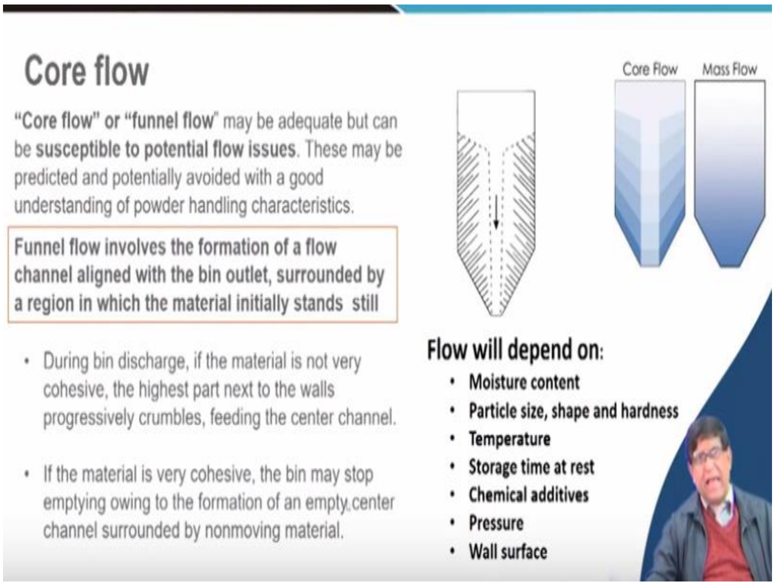

Now, this funnel flow or that we are telling as a core flow sometimes it is a desired. So, what we will have to do? It is a formation of a flow channel. We have to make it. And, it should go smoothly. But, it can be designed. And, or, if it is appearing as a problem, we will have to eliminate that. So, now, we will see that what that flow will depend on your moisture content, particle size, temperature, storage time, chemical additives, pressures and wall surfaces.

And, during the bin discharge, if the material is not very cohesive, the highest part next to the walls progressively crumbles and then feeding the center channel this is. What will happen? After sometimes, if this crumbles and then they coming over there if it is getting solidified over here a big solid piece can come and then it can be (()) (28:17) giving a block over here. So, these type of problems do occur.

So, for very cohesive material, the bin may stop emptying owing to the formation of an empty center channel surrounded by the conveying material. It can totally stop flowing out.

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Mass-flow bins	Funnel-flow bins
1. Particles segregate, but remit on discharge	1. Particles segregate and remain segregated
2. Powders deaerate and do not flood when the system discharges	2. First portion in is last one out
3. Flow is uniform	3. Product can remain in dead zones until complete cleanout of the system
4. Density of flow is constant	4. Product tends to bridge or arch, and then to rat-hole when discharging
5. Level indicators work reliably	5. Flow is erratic
6. Product does not remain in dead zones, where degradation can occur	6. Density can vary
7. Bin can be designed to yield non-segregating storage, or to function as a blender	7. Level indicators must be placed in critical positions so they will work properly
	8. Bins perform satisfactorily with free-flowing, large-particle solids

So, that how you compare the mass flow bin and the funnel flow bin that is your, in case of your mass flow means the particles segregate but remit on discharge. But, the particles segregate but remains segregated in case of funnel flow. And, in a powders de-aerate and do not flood when the system discharges. The first portion is not lost in out. That is your because in a funnel flow, it will get stored. It will that whatever came in the first they are not coming out.

Then, flow is uniform. Here, product can remain in dead zone. So, that is why the flow may not be uniform. Then, density of flow is constant. Here, it may not. That product tends to bridge or arch, and then to rathole when discharging. Now, the level indicators work reliably in a mass flow bin you can easily think of a level indicator and their reliability is ensured. But, that will not be there in the funnel flow.

Then, product does not remain in the dead zone where degradation can occur. But, in case of funnel, it happens. Then, bin can be designed to yield non-segregating storage, or function as a blender. This is what exactly is the main thing.

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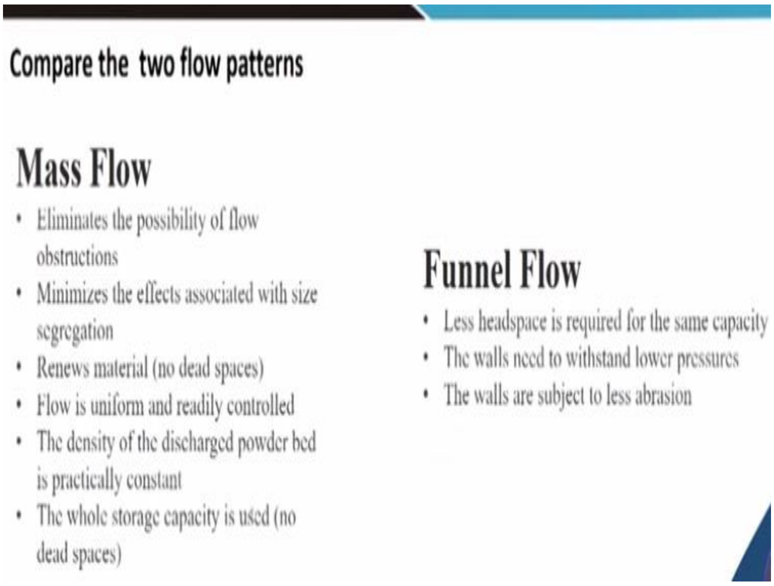

So, in mass flow, it eliminates the possibility of flow obstructions. You minimize the effects associated with size segregation. Reduce material no dead space. Then, flow is uniform. Then, the whole storage capacity is used. So, these are the fissures or advantages of mass flow. That is your mass flow. And, in case of funnel flow, less head space that is it is required for some same capacity in a funnel flow.

And, the walls need to withstand lower pressures. That is because as I said this is coming the pressure is coming on to the, that is your ratholes only.

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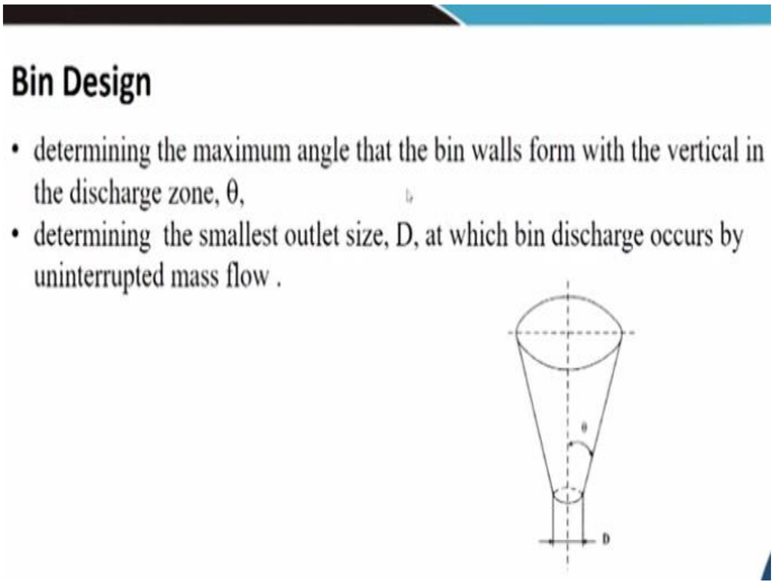

So, while designing of a bin, you will have to take care of that what should be this angle? What should be this height? And, what should be this width? This is the most important in designing.

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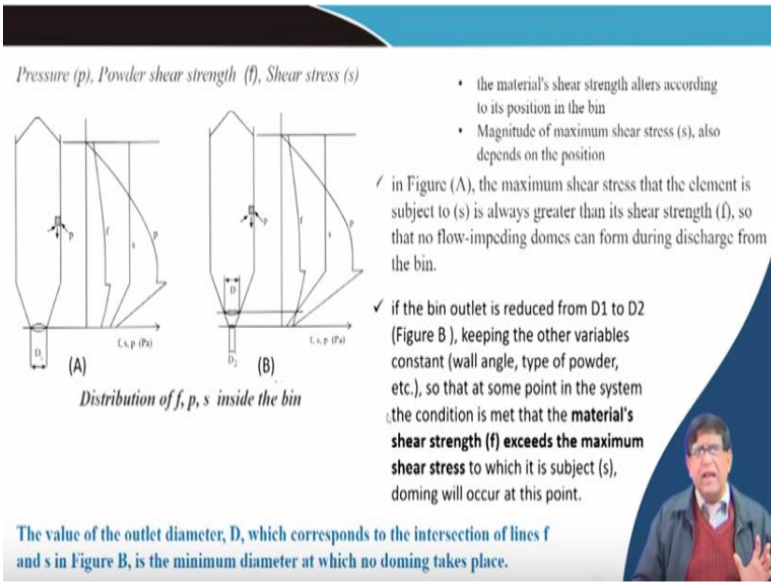

Now, that design will be depending on if you consider a small portion of element of material wherever at any particular place it will be having a pressure on it because of the material above it. And, due to that pressure, it will get compacted or its density will change. As a result, it will be having a different shear strength and a shear stress that what is there is a relationship of this your shear strength and shear stress.

How along with the depth it will happen. Now, you can see here. This, your shear stress and this, your shear strength, they are changing. If you consider for a particular diameter D1, your, this pressure it was going up to that vertical portion. It has gone increasing over there. At that part portion, it has got your, this pressure increased over there. And then, during the next part, it got decreased.

Similarly, the powder shear strength, it was going on in this pattern. As the depth is increasing, it is increasing. Same thing with the, your shear stress, it is happening like it is going constant shear stress. Only here, it has got also constantly reduced. Now, if this diameter D2 is very small here, what is happening? You see. Now, there is a one point in which your this shear stress it is exactly crossing your, this shear strength.

So, at that point, this is the critical point. Now, whatever be the diameter at this space, this D should be the evacuation diameter. Otherwise, there will be the problem of your, that is you will not get the mass flow. This is how it was decided. And, this is the science started in 67 or so with the Jenkins work on this flow behavior. And, now, it is established with that. But thing is that how this behavior will take place.

That will have to be every material will be doing differently. Even in coal, if you are having a very finely (()) (33:07) or whether it is your very powdery coal or if it were having a cross coal with a different lump sizes this pattern will vary. So, that is why when you are thinking of a particular installation, you will have to undergo certain experimentations. We should have a proper bulk material handling laboratory in which we can do this test.

There are certain places I think in the some laboratory in Jamshedpur, some laboratory in our this (()) (33:39), we have got this material. The mineral processing sections mineral processing laboratories they have some of this type of arrangement by which they can do in a large scale real life experimentations can be done.

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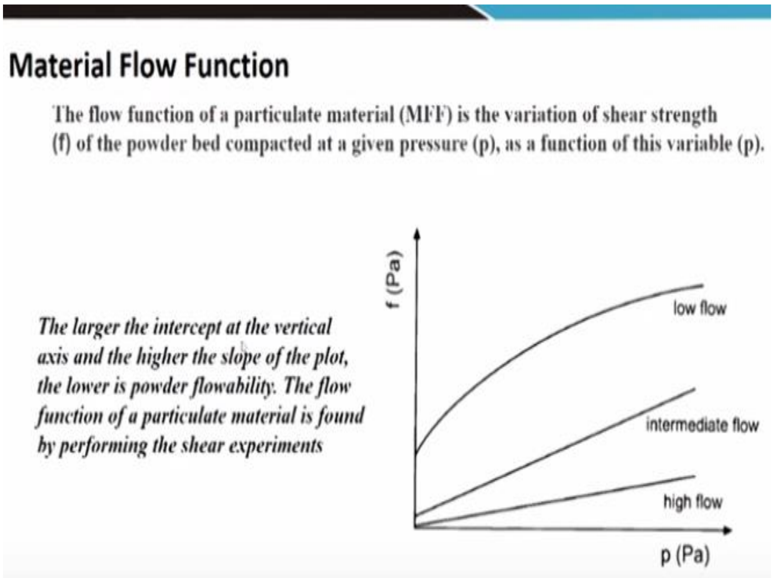

Now, there are one very important thing is to be known there. That is your material flow function. That is the relationship of your that when you take the shear strength and your this pressure their relationship if this is (()) (34:14) at a that interception is high if that intersection goes higher that is a low flow behavior. And then, if it is near to the zero that is a high flow behavior. And then, in between, there will be intermediate flow behavior.

This mass flow behavior is experimentally determined. And, that is necessary for doing a proper design of it.

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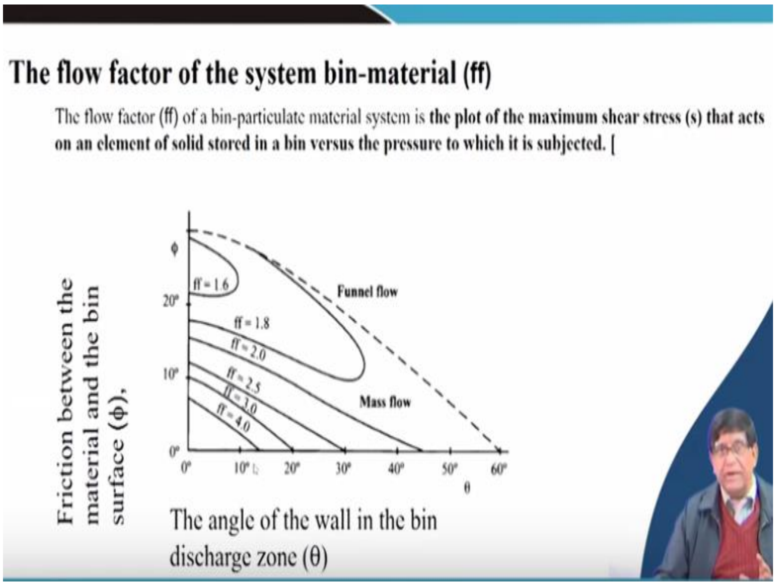

Then, there is also a flow factor which is exactly they find out by that putting this, your internal angle of friction and that your angle of the wall that theta you have seen in the diagram their relationship is found, and, on that, different flow behavior having a different type of your flow factor. Now, this flow factor can again that your theoretically there are different equations are derived by Jenkins in a mineral processing. And, that your mineral handling, this is very important.

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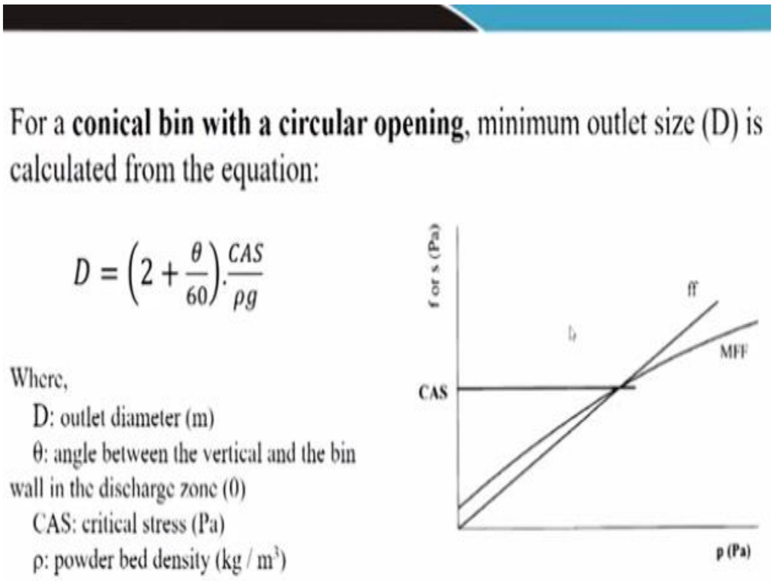

There, of course, you will have to do a lot of this. Work is a done mostly by that case specific research. That means they will be doing the experiment. Finding it out, then take it validations. And, they will establish over there. Now, while designing that diameter that minimum outlet size, they can be calculated by this type of equations which Jenkins found over there.

That is our, that outlet diameter will be depending on the theta that angle of the vertical wall and the bin wall and then the critical stress. And then, if you put this our shear strength and the pressure diagram where they this, your flow factor and material flow pattern that meet. This point taken as a, your critical and then you put the value over here you get this thing. This is one way of designing it.

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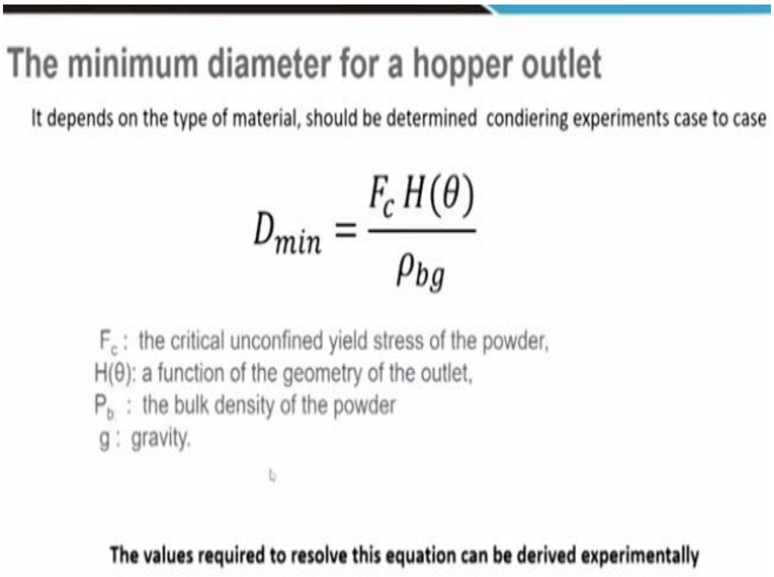

But, the other way, it is given also in literature, you can find it out. That is your D min. That is a minimum diameter for getting a good flow is depending on your critical unconfined yield stress. And then, you are getting the function or geometry of the outlet that function derived by experimentally and then for different angle for that. When you are having the different hopper angle, your, the D diameter will be changing.

And then, it depends on your bulk density of the powder material. This is exactly for the powder handling. This type of equations are there. So, you your normally in any bulk material handling laboratory as it is there in our laboratory if you happened to (()) (37:03) you can do this experiment with different type of hopper angle and we keeping a different material you take the flow rate and then you optimize that what will be the things. There many studies are empirically done.

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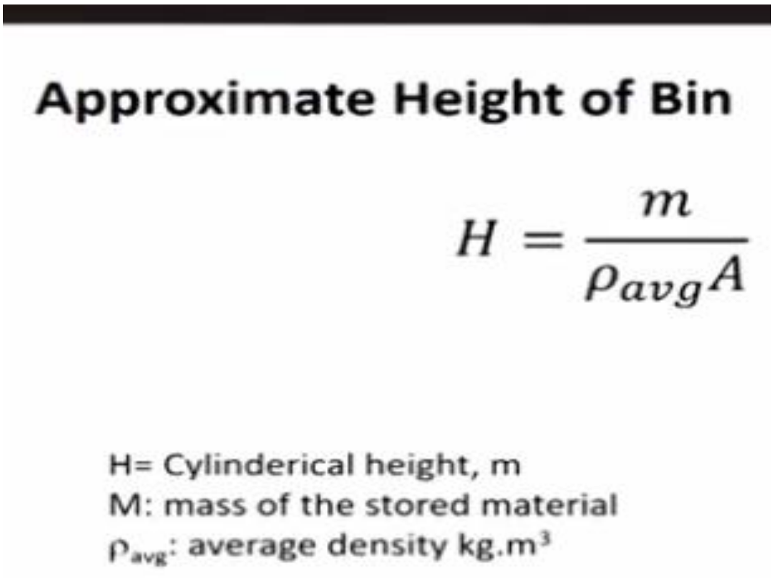

So, then, the question of that higher height portions, how much will be there? What should be the bin height? That is the cylindrical portions it depends on that whatever the capacity you want to keep over there which depends on the mass storage capacity as well as the density. Now, once you that will whole thing if you are making more height your pressures variations will be there. Your diameter will be again changing.

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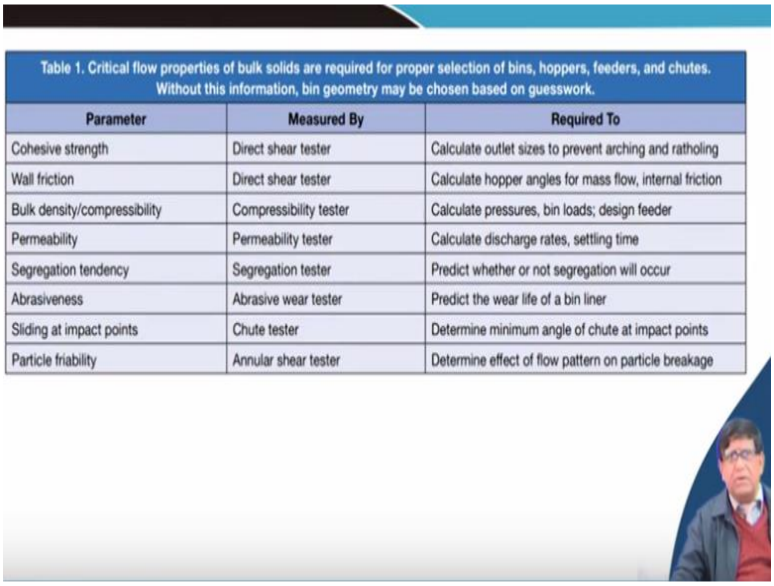

Table 1. Critical flow properties of bulk solids are required for proper selection of bins, hoppers, feeders, and chutes. Without this information, bin geometry may be chosen based on guesswork.

Parameter	Measured By	Required To
Cohesive strength	Direct shear tester	Calculate outlet sizes to prevent arching and ratholing
Wall friction	Direct shear tester	Calculate hopper angles for mass flow, internal friction
Bulk density/compressibility	Compressibility tester	Calculate pressures, bin loads; design feeder
Permeability	Permeability tester	Calculate discharge rates, settling time
Segregation tendency	Segregation tester	Predict whether or not segregation will occur
Abrasiveness	Abrasive wear tester	Predict the wear life of a bin liner
Sliding at impact points	Chute tester	Determine minimum angle of chute at impact points
Particle friability	Annular shear tester	Determine effect of flow pattern on particle breakage

So, these are one related to other. Now, that while you will have to make the different parameters of full design where that is your cohesive strength, wall friction, bulk density, permeability, segregation tendency, abrasiveness, sliding at impact points and particle friability. These can be measured by different type of laboratory test. And they are required for designing it.

Such type of things you will have to do when you want to do a real life work for a particular things.

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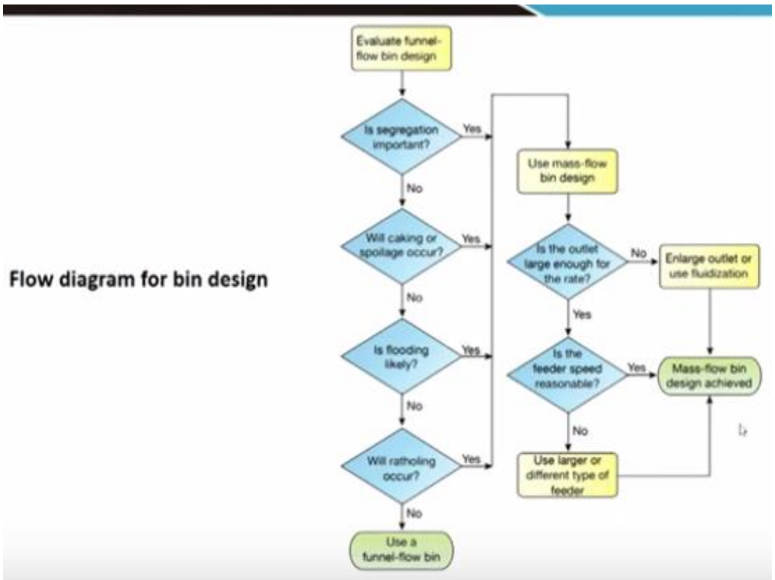

And, as a result, you can determine a flow diagram. This is one flow diagram you can use by which you exactly determine that for what type of flow, what type of diameter and what type of angle or what is the capacity you will be using it. If this is just an example, it will vary depending on the particular things which you are going to use it.

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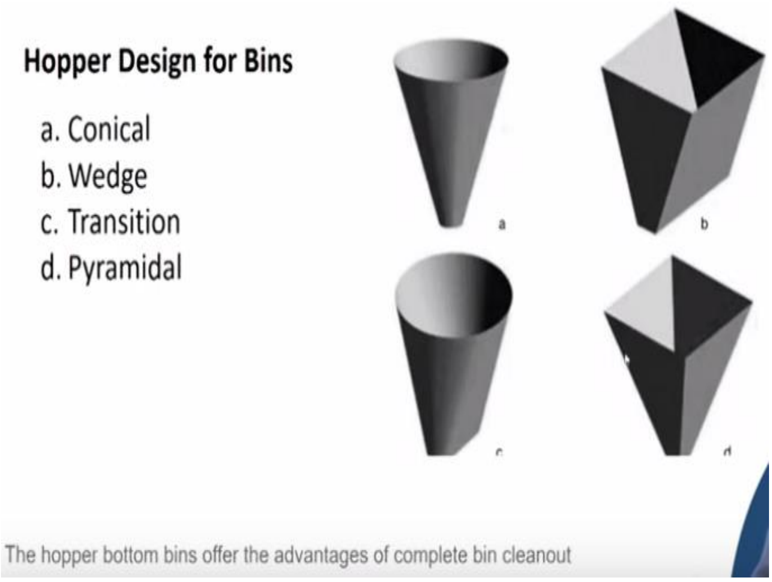

And, that the hopper portion below, it can be also conical, wedge shape, transition or pyramidal. Different way the hopper may come.

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And, you can see that how that hopper in a real life it will be coming like that. This is exactly feeding over here. And then, we are having a gate from this conical hopper. You can see the diameter and all. If these are not properly designed that the whole system performance its availability it's everything will be very difficult.

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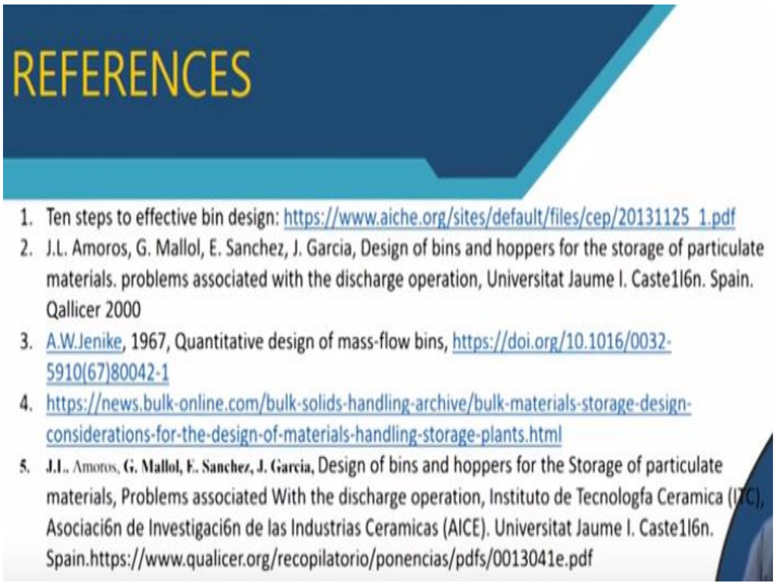

So, there are a number of research work has been done in the past. If you are interested to take any project on this, you can start doing over here.

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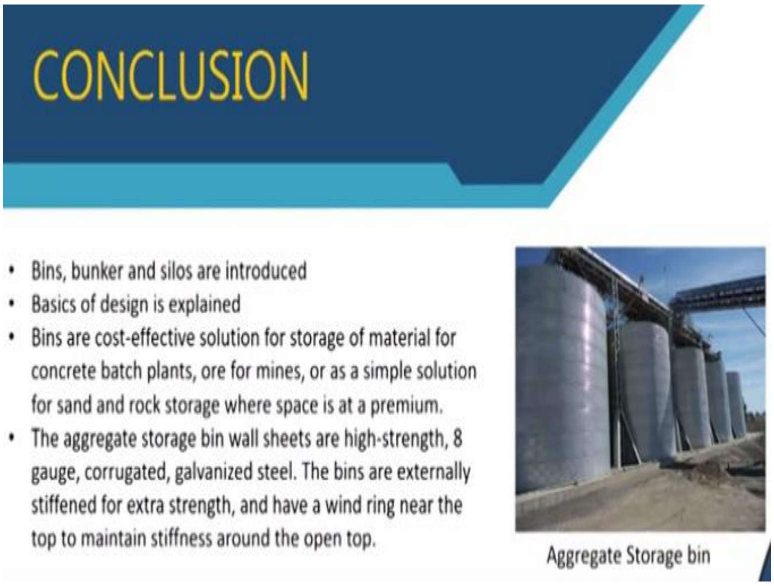

And ultimately, your, what we have just today I introduced it. We may be doing coming 2, 3 lectures on this. And then, we should be able to understand, how in a bulk material handling these are designed and what are their importance? So, this is a, you can see even the aggregate storage bins are there nowadays because these are environmentally friendly. Your, this particles are not kept outside so that the wind and all they cannot create any environmental damage.

So, closed storage in many industries particularly in the mineral industries also we need to think of. But, at the same time, it is investment. And then, if you do not do it properly, design it properly you may get a problem in your system. So, that is why this requires well studied and then done very nicely. So, thank you very much.