Mechanical Unit Operations
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Lecture 28
Filtration Equipment

Welcome to the MOOCs course Mechanical Unit Operations, the title of this lecture is Filtration Equipment. In previous lectures, we have seen some basics of the filtration processes and also we have developed the working principles of a different types of filtration processes like cake filtration etc. and then also we have developed working principles of a centrifugal filtration processes.

Now, we are going to discuss about the filtration equipment. What we know that that based and the type of the driving force provided for the filtration to occur the filters can be divided into three types of filters that we have already seen that they are pressure filters, vacuum filters and centrifugal filters.

So, under each category of these three types of filters what we are going to do? We are going to see a few basics of the filtration equipment which are most commonly used in industry. We are not going to cover the entire range of filtration equipment there maybe n number of equipment available, n number of designs are available but we are going to discuss only the ones which are very common and the widely used in Industry.

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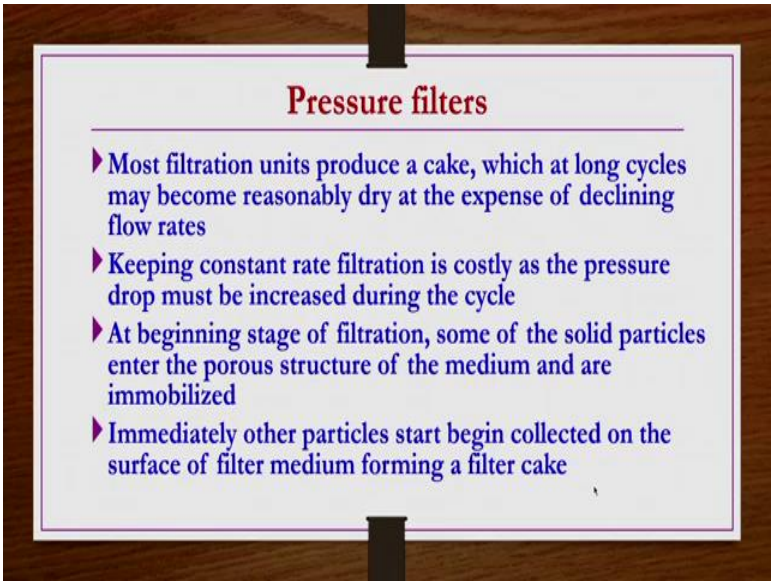

Pressure filters, as we know that most filtration units produce a cake which at long cycles may become reasonably dry at the expense of declining the flow rates. And the under such conditions keeping constant flow rate is going to be very costly because as the filtration time progresses more and more particles are being accumulated as a cake on the surface of the filter mediums who offering more resistance so gradually actually what happens? The filtration the clearance.

In order to maintain the filtration rate constant then what you have to do? With respect to rate time as rate filtration time progresses you have to gradually increase the pressure, pressure differential across the filter medium and then cake that you have to continuously gradually increase in order to maintain the constant flow rate. So, because of that one what happens? Maintaining a kind of constant flow rate filtration process is going to be very costly that is the reason most of the people go for a kind of constant pressure filtration rather going for a constant flow rate filtration processes.

At the beginning stage of the filtration what happens? Some of the solid particles enter in the porous structure of the medium and are immobilized actually what we have in the? We have a kind of filter medium that filter medium is having a kind of porous structure. So, at the initial stage of the filtration process when the slurry comes and interacts with the solid the filter medium surface then some of the particles are being accumulated and the porous structure of the filter and then they become immobilized.

So, because of that one the area that is available for the liquid to flow through the decreases and then gradually what happens? Subsequently more and more particles will come and then start begin to collected on the surface of the filter medium forming a kind of filter cake that is what happens that we have already know.

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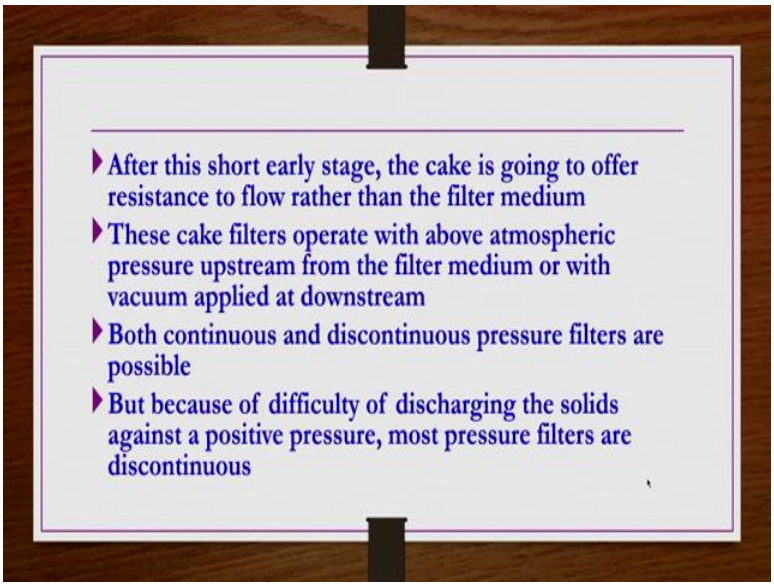

After this short early stage, the cake is going to offer resistance to flow rather than the filter medium. Initially what happens? Initial period of the filtration as we have already discussed there are no solid particles deposited or very few part solid particles deposited on the filter medium. So, the filter medium is going to offer the resistance but that is only for very short period because after that short period or short period of time what happens? More and more number of particles are being accumulated and the solids are on the surface of the filter medium.

So then gradually they build a kind of cake and then that cakes start offering more resistance compare to the filter medium, it offers such high resistance to the flow that the resistance to the flow due to the filter medium is almost negligible, that also we have already seen. These cake filters operate with above atmospheric pressure upstream from the filter medium or with vacuum applied at downstream.

And then both continuous and discontinuous pressure filters are possible in general but because of a difficulty of discharging the solids against a positive pressure, most pressure filters are discontinuous, what happens in discontinuous processes? What we do? We stop the process, the

operation cycle filtration, cycle we stop and between and then try to dislodge the cake that has deposited on the filter medium.

If you can continuously able to if you design such a way that continuously you can able to remove the solids from the filter medium surface then you can have a kind of a continuous filtration process without a interrupting the filtration cycle but removing such kind of a solids or cake that has formed on the solid surface against a positive pressure that has been provided for the filtration to occur is kind of very difficult task because of that one most of the pressure filters are kind of discontinuous of filters though it is passable that we can do for a continuous filtration process also. So, because of difficulty of discharging the solids against a positive pressure most pressure filters are discontinuous rather than continuous.

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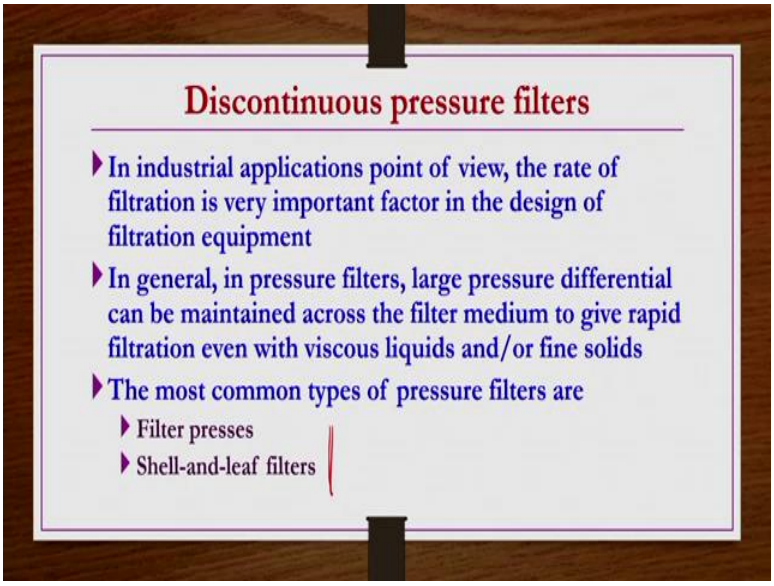

So, let us start with discontinuous pressure filters. In industrial application point of view, the rate of filtration is very important factor in the design of filtration equipment. So, whatever the design equipment, equipment design when you do as per the basic principles that we have seen in the previous class for the cake filtration processes so there are one has to make a kind of give a priority to the filtration rate.

So, based on the filtration rate with the remaining things are need to be supposed to be adjusted because the filtration rate is a kind of very important factor in the design of a filtration equipment. So, in general in pressure filters large pressure differential can be maintain across the filter medium

so that to give rapid filtration even with viscous liquids and or fine solids, why? Because of fine solids because if we have a fine solids in the slurry then what happen?

There may be forming a kind of impervious gel kind of layer and the filter medium and then gradually it may not allow kind of flow it tube a pass through or the decline in the filtration rate is going to be very high which is not going to be acceptable. However, if you apply a large differential pressure differential across the filter medium then it is possible that you can maintain a kind of a rapid filtration even with the viscous liquids and or fine solids.

The most common type of a pressure filters are filter press and shell-and-leaf filters. So, these are the two important type of a filters which are commonly used in industry. There may be other filtration equipment are also available, these are the two very commonly used in a majority of Chemical process industries or Material processing industries. So, now we see some basics how they work and then what are the components they are involving those kinds of details we are going to see one by one now.

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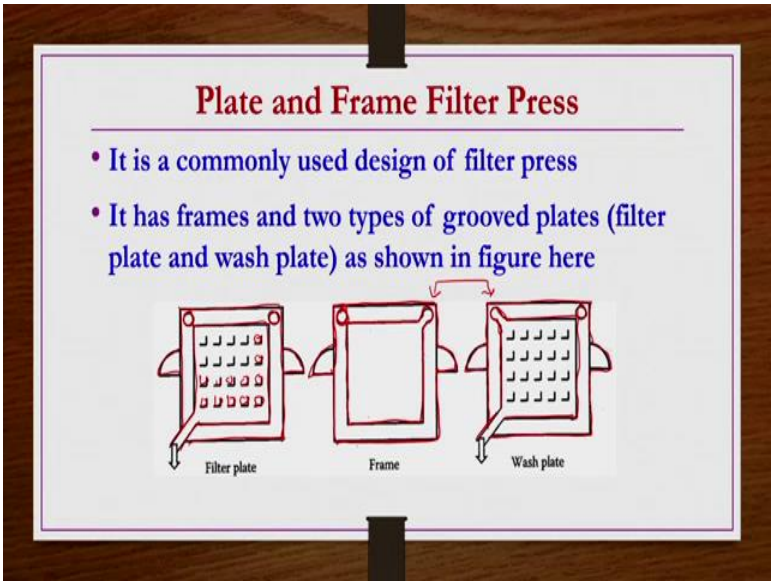

So, let us start with plate and frame filter press. By name what we can understand? It must be having components something like plates and something like frames and then how are they used so that filtration process to take place that is what we seen now. It is very commonly used design of a filter press. It has a frames and two types of grooved plates which are known as the filter plate and wash plates both are there as shown in the figure here.

So, now here we can see this is a kind of frame. So, these frames actually having two openings here one here and then one here like this. So, these openings are provided such that what happens? This either side of the frame we have a kind of filter plate and wash plates. So then it forms a kind of a one unit. So, like that there are several such units as we are going to see pictorially.

So, when these arranged in as kind of one unit these openings are there whatever openings are there they will be available as a kind of a chance to filtrate to pass through as we see subsequently. So, these plates filter plates are having a kind of grooved surface like this as shown in this picture. So, this is the one type of plate so here we can see this kind of grooved kind of surfaces the provided here so these are they are provided here.

So, same is a kind of wash plate also here. So, we can see these openings are different way in wash plate and then filter plate here. So filter plates, so there are both two circles kind of things are there, here wash plate there is a kind of a different kind of opening one side is given here same like a kind of frame like this. So, now these units these things what become they combined as a kind of single unit they we can have a kind of add then together filter plate, frame and then wash plates.

So, that whatever the frame is there frame center will have a kind of a hollow kind of region will be there. So, such kind of filter plate, frame and wash plate and then there is a kind of medium kind of thing like this one unit there are several kind of n number of units one can have and then one can arranged together like this.

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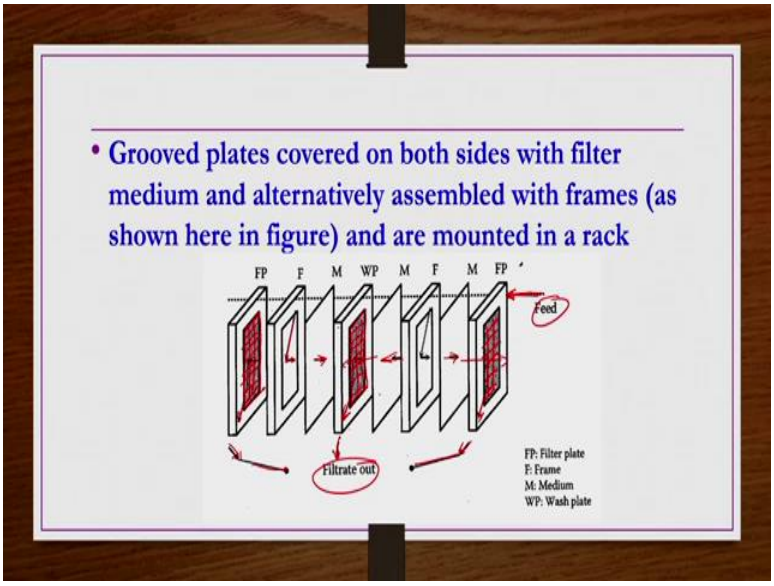

So, grooved plates in general covered on both sides with filter medium because the filtrate is coming through this grooved plate only and alternatively assembled with frames as shown in the picture as I have already mentioned and mounted in rack in a rack like this, . So, now whatever this filter plates are there so grooved plates whatever are there. Now, we can see that they are covered with a kind of a filter cloth.

So, I am showing this gradually pictorially so that it can easily be understood here. So, wash plate also you have a kind of a covered with a kind of a filter cloth or filter medium like this and then frames are like this. So, now these from here from wash plate, medium then frame, medium, filter plate this is a kind of one unit and then like that n number of units we can have and then we can assembled them together and then mount them in a kind of a rack.

So, then what happens? The feed come here and this now as I in the previous picture if you see there are two kind of holes are provided so each hole has having a different purpose. So, here so the feed is coming through that one particular hole from here then that enters a kind of a centre of the frame whatever the frame is there and in that centre of the frame that feed enters there and then from there because of the pressure that the material will be pushed.

And then because of that one the liquid whatever is there that passes through the this filter plate as well as the wash plate here like this and then collected a kind of filtrate through the bottom like this, pictorially it is shown like this here. So, here also the material that is coming here in the

second set let us say, if you take the second set the material is coming into the frame here. So, whatever the material is there that will be pushed towards the either side of the either side of this frame so that either side we are having now plate filter plate and wash plate so that those plates are having a kind of filter cloths.

So, through the filter cloth the material filtrate liquid comes out and then that will be collected out like this. Whatever the solids are there they will be deposited in the hollow centre portion of the press whatever we are having. So, this is how it is a kind of stack you can have at several number of units like filter plate, frame, wash plate, medium one section and then like that you can have a different section and then you can tight them together hydraulically or by manually also and then feed enters through the top like this that feed enters into the frame section of where the material is pushed the either side of the frame because of the pressure.

So, either side of the frame now we are having the plates covered with a filter cloth, so what happens? The plates covered with filter cloth or filter medium they will allow the material only the liquid material to pass through the solid material to be retains whatever the liquid material is pass through this plates both wash plate as well as the filter plate they will be collected as a filtrate from each units and then all these let us say from each unit we are getting filtrate now.

Like this one section like one filter plate, frame, wash plate, medium is a kind of let us say one unit from each unit we are getting the filtrate. So, like that from different units we are having all of those filtrate whatever are coming they will be connected to the one of the opening that is provided at the top of the plate as I shown in the previous picture and then through that openings that material filtrate will come out as a kind of discharge. So, this is what basic principle working methodology of plate and frame filters.

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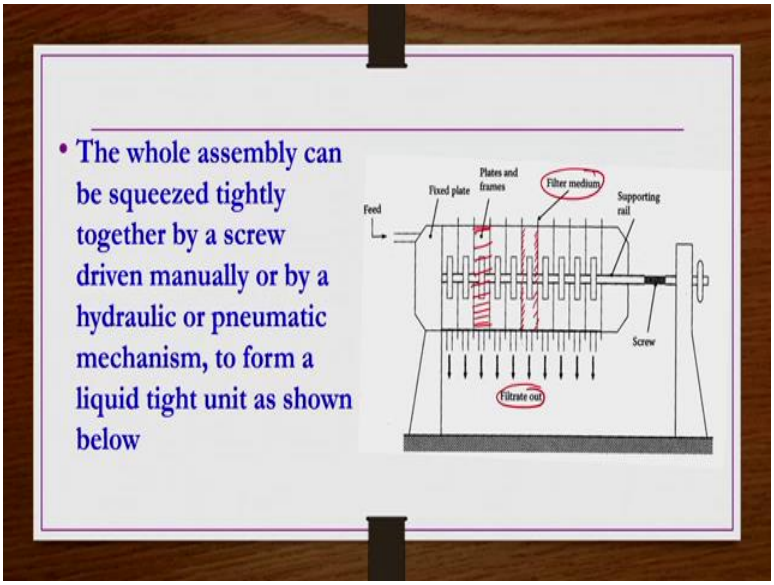

Now, here the whole assembly as I mentioned can be squeezed tightly together by a screw driven manually or by hydraulic or pneumatic mechanism whatever possible then to form a liquid tight unit as shown below. So, that the filtrate should not be leaking from the different other compartments, it should go through to the outside of the units only through the filtrate collection that is whatever available, so like this now as I mentioned.

So, now such there are now earlier in the previous I have shown only two units and now here one unit this is a kind of one plate and frame unit something like this, like this we can have a different plates and frames. So, these whatever the lines are there so they indicate filter medium that there is a plate. So, that plate is covered with a kind of filter cloth kind of thing and then other side kind of may be wash plate.

So, that is also covered a kind of cloth and then whatever the material that comes out here so that material only the filtrate is going out through the filter cloth and then solids are being deposited in the hollow centre portion of the frame. So, like that different n units are put together and then screwed together so that that will form a kind of a liquid tight unit so that liquid should come only through the filtrate outlet units, filtrate outlet pipes only not from the other points.

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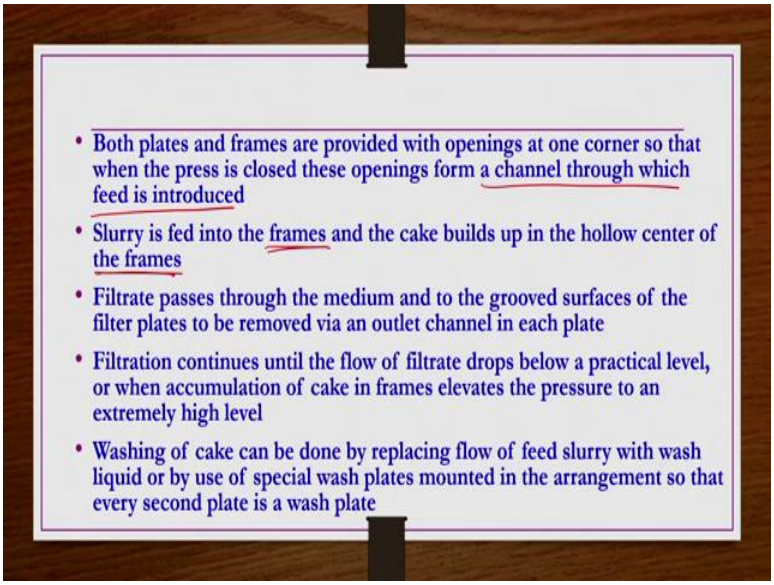

Both plates and frames are provided with openings at one corner so that when the press is closed these openings form a channel as I mentioned through which the feed is introduced. The slurry is fed into the frames and the cake builds up in the hollow center of the frames. So, remember this frame, plate either sides when we have the section and all that so when what happens? This design is such that the frame becomes a kind of hollow one.

So, and then this material feeds material is coming in this hollow frame so the inside the frame hollow sides cakes are being deposited, because the filter medium or filter cloth whatever is covered the either side in the plate that is allowing only liquid to pass and then solids being collected in the hollow center itself only liquids are passing through. Filtrate passes through the medium and to the grooved surface of the filter plates to be removed via an outlet channel in each plate.

And then filtration continuous until the flow of filtrate drops below a practical level or when accumulation of cake in the frames elevates the pressure to earn extremely high level, under such conditions you can understand that the filtration whatever the hollow frame say the whatever is that must be completely occupied by the solids and then further filtration might not be coming properly.

So, then what you have to do? You have to stop the process and then clear the frames by washing process and then you redo the separation once you clear the cakes whatever have been deposited.

Washing of cake can be done by replacing flow of feed slurry with wash liquid or by use of special wash plates mounted in the arrangement so that every second plate is a kind of wash plate.

Remember this, whatever the plates two plates are there one is the filter plate and then another one is the wash plate during the filtration process what happens? Both this filter plate as well as the wash plate both of them are a kind of a acting a kind of a medium filtration medium so that the filtration takes place but in the case of washing only wash plate is acting a kind of filter medium and then the plate is not going to as a kind of wash medium.

So, that is the reason we have seen in the previous figures. So, both through the wash plate as well as the filter plate the liquid is passing through and being collected as a kind of filtrate but as we see in the subsequent figure we are not going to have such kind of process any in a kind of a washing process.

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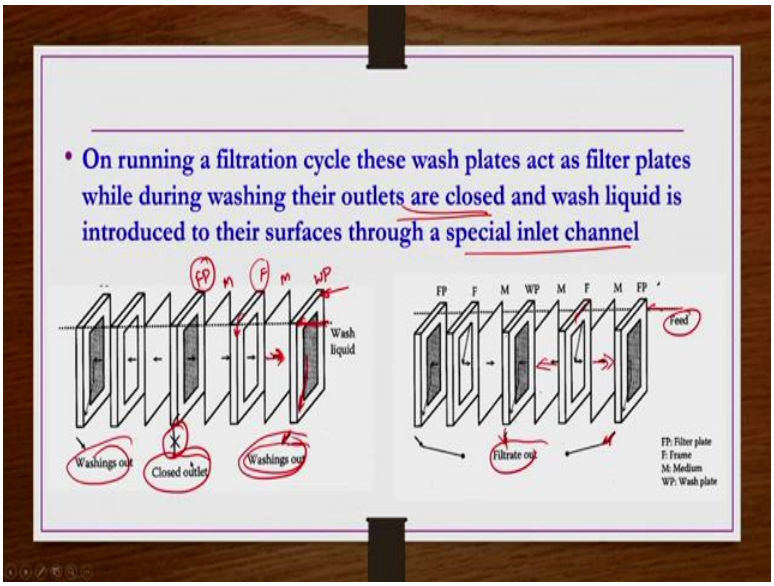

On running a filtration cycle these wash plates act as filter plates while during washing their outlets are closed and wash liquid is introduced to their surfaces through a special inlet channel. The holes whatever provided at that at the top while in the both plates and frames as a shown. So, they are going to act as a kind of channels so that one can used for the special inlet channel for the wash liquids kind of thing.

So, now here wash liquid. So, the same arrangement this is same stack now what we have the previously for the filtration, for filtration whatever the say unit was the same unit is there for the

washing also because indeed in that same unit the cake has been deposited that we are washing it. So, there is a kind of frame, there is a kind of medium, there is a kind of filter plate, there is a kind of a wash plate.

So, now in the previous case when we are doing this slurry introducing the slurry for filtration to occur that was introduced through the other corner other side of the, this plate and frame section. Now, the wash liquid is in enter to this other section but again it also comes to the frame comes into the frame side here and from here because of the pressure that will be pushed towards the wash plate and then whatever the wash liquid is there that will collected back from here like this.

I mean like quite similar the filtration process and then wash process is quite similar but only thing that the, their entry ports are different and then how they are being collected slightly are different, filtrate is collected through the filtrate plate as well as the wash plate but wash liquid is collected only through the wash plate outlet only, that is the one primary difference you can see.

And then in case of washing of the filter surfaces or filter medium surfaces are dislodging the cake by wash liquid. So, then the filter plate outlet whatever is there to collect the filtrate that is closed because now we are doing for a kind of washing. So, now you can compare the previous figure I have redrawn here again. So, now here the feed is coming through the other side, other section of the, these plate, frame and then plate section combination section.

So, here now you can see the frame whatever the material is coming here slurry that is passing through either sides of these frames so that either side it is now having the filter medium so that the separation of the liquid will take place or the separation of solids will take place from the slurry and then liquid pass out the kind of layer filtrate from either sides.

Whereas here what happens? Whatever the material that is coming into the frame so that is going towards only wash plate side only and then through the wash plates whatever the washing after doing whatever the washing after completing whatever the washing requirement the wash liquid is coming out of as a kind of outlet. But it is not going towards the filter plate the whatever the wash liquid coming into the frame that is going towards the wash plate only it is not going towards the filter plate so that should be clearly seen that is the difference.

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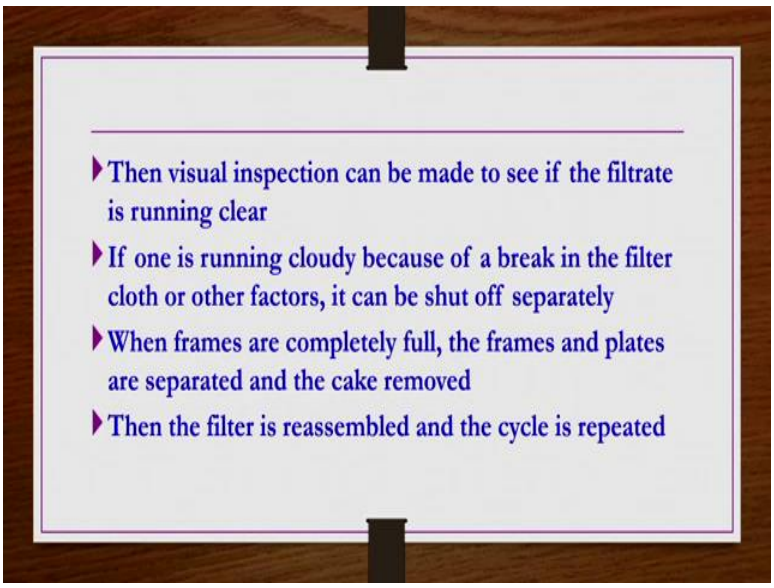

Then visual inspection can be made to see if the filtrate is running clear or not. If one is running cloudy because of a break in the filter cloth or others factors, it can be shut off separately, immediately and then that can be replaced. When frames are completely full, the frames and plates are separated and the cake is removed. Then the filter is reassembled and the cycle is repeated again for the second operation because it is a discontinuous pressure filter process.

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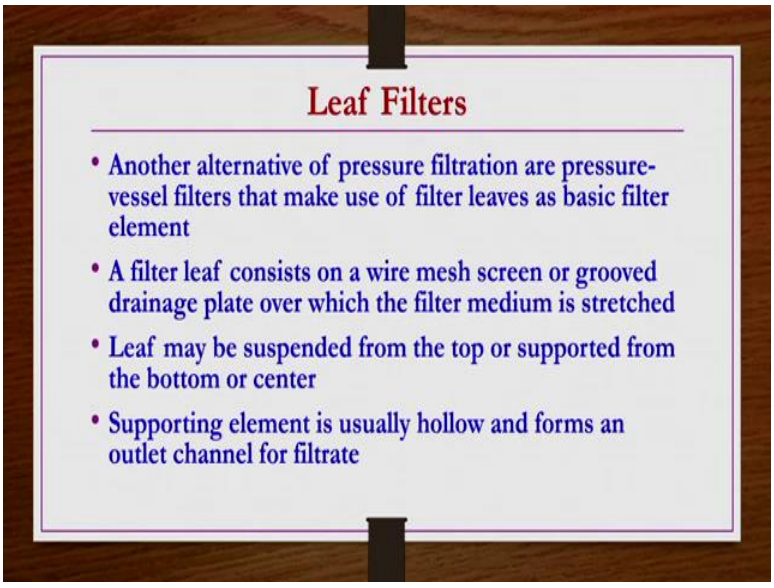

So, other alternative of pressure filters especially discontinuous pressure filters is a leaf filter. So, the process is quite similar here also but there are so there is a kind of pressurized vessel in which

we have a kind of leafs, leafs are as a are kind of hollow mesh or screens kind of things which are covered with a kind of a filter medium or filter cloth, as we see pictorially. Another alternative of pressure filtrations or pressure vessel filters that make use of filter leaves as basic filter element.

A filter leaf consist a wire mesh screen or grooved drainage plate or which the filter medium is stretched. Leaf may be suspended from the top or supported from the bottom or center all three types of designs are possible. Supporting elements is usually hollow and forms an outlet channel for filtrate.

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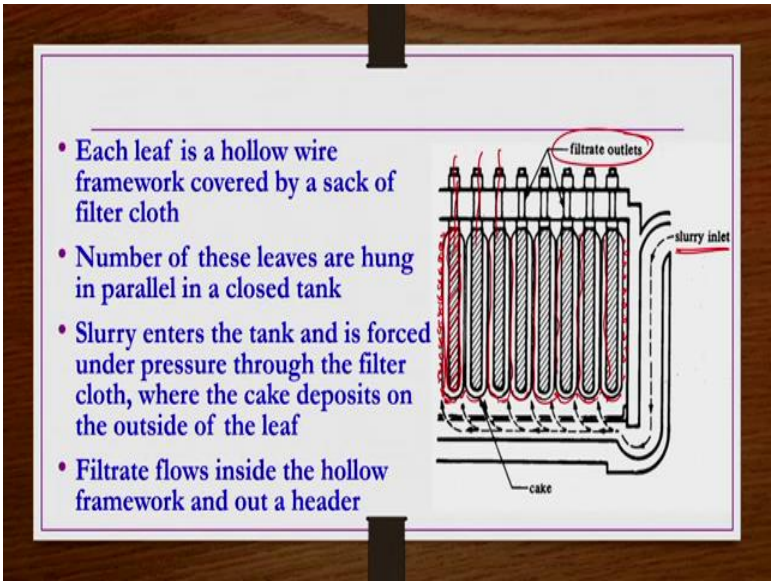

So, pictorially if you see here, as I mentioning so this is a kind of leaf. So, whatever the leaf that is there, leaf in the sense the structure is a kind of leaf structure is this. So, that is the reason they are called as a kind of leaf. So, this filter leaf whatever is there or the hollow mesh whatever is there so now this hollow structure is it is a mesh, and it is having a kind of hollow structure kind of thing, it is covered with a kind of a filter cloth like this and there are n number of leafs like this.

So, they are kept in a kind of pressurized vessel and then slurry comes through the inlet like this here whatever the pressurized because it is in pressurized vessel because of the pressure this material pass through this different n number of leafs so what happens? These whatever the solids are there they are being deposited on the surface of the filter medium, they are deposited on the surface of the filter medium like this.

In the previous case what happen? So, solids were deposited inside the hollow structure of the frames. Now here because there the material was coming inside the hollow structure of the frames and the plate and frames kind of thing but here now the material is coming from the outside because of the pressurized conditions provided in the pressurized vessel the material is coming from the outside of the hollow leafs whatever are there.

So, then whatever the liquid let us say this is the surface this is a kind of a let us say this is a kind of hollow surface, let us say this is a kind of leaf hollow leaf here. So, now the hollow structure is like this here. So, we can see now inside there is a hollow structure. So, the material that is coming slurry that attacks on the surface so solids are being deposited on the filter medium or filter cloth that is being covering these leafs and then whatever the liquid is there that passes through and comes into the hollow structure of the leafs and then pass through as a kind of filtrate.

So, whatever the material that is there filtrate is there that is being collected through filtrate like this so under this section. So, this solids are being deposited on the outside surface of the filter cloth whatever we are having so n number of these things in the intermediate reason also like this. So, all these filtrate outlet from each leaf is there they are connected to one single filtrate outlet and then collected as a single filtrate outlet as to going to the collection vessel.

So, this is what happens here in the leaf filters. So, now how to clean them? So, easier once since the cakes are a kind of deposited on the filter medium surface, what you do now in the reverse direction? You blow with some kind of air to the internal structure filter structure whatever there here. So, internal hollow screens are there whatever forming as a kind of leaf you now you blow a kind of air or some liquids kind of thing and then pressure and some pressurized conditions.

So, whatever the solids are lodged deposited on the surface there will be disclose and then going away then there will they can be removed from the filter medium surface or filter cloth surface. So, that the filter cloth is readily available for the next separation so on because of this one and thus the washing is much easier compare to the kind of a washing in a plate and frame filters. Each leaf is a hollow wire framework covered by a sack of a filter cloth.

Numbers of these leaves are hung in parallel in a closed tank. Slurry enters the tank and is forced under pressure through the filter cloth where the cake deposits on the outside of the leaf. Filtrate

flows inside the hollow framework and out a header to filtrate outlets. Let us so that is what happens.

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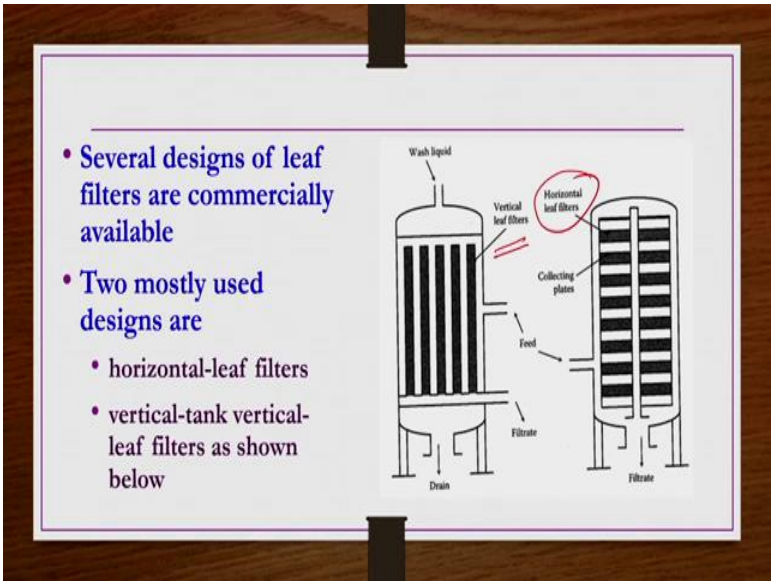

Several designs of leaf filters are commercially available. Two mostly used designs are horizontal-leaf filters and then vertical-tank vertical-leaf filters are shown below here in the figure. So, the working principle is same so they how the leafs are arranged that is the difference only. So, here the previous on whatever we have seen as a kind of vertical leaf filter and then same design is pictorially can be represented like this here also. If you have a kind of horizontal leaf filter then we can have kind of a this kind of pictorially representation.

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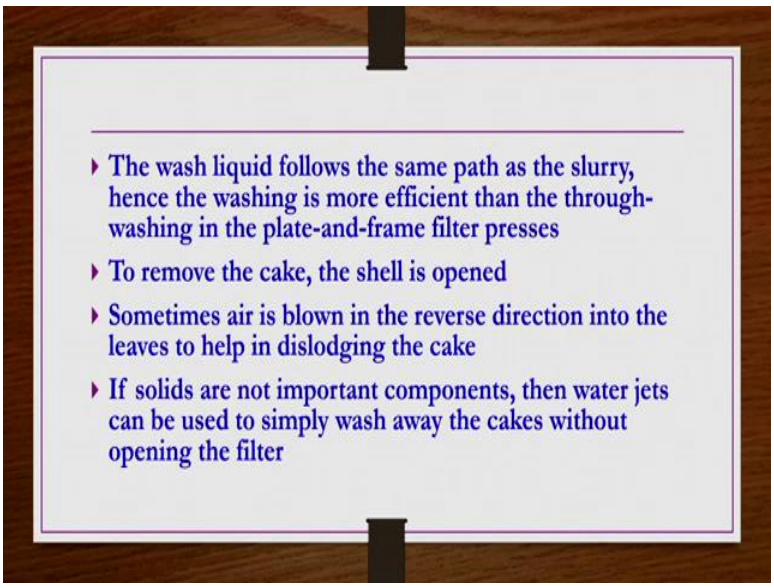

The wash liquid follows the same path as the slurry hence the washing is more efficient then the through washing in plate and frame filter press. To remove the cake the shell is open. Sometimes air is blown in the reverse direction into the leaves to have in dislodging the cake. If solids are not important components then water jets can be used to simply wash away the cakes without opening the filter as well.

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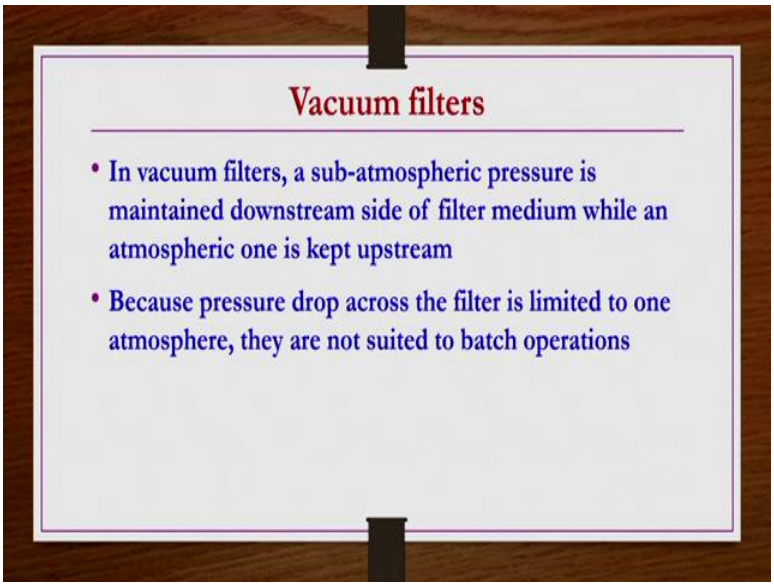

So, next category is the vacuum filters. In vacuum filters, a sub-atmospheric pressure is maintained downstream side of the filter medium while an atmospheric one is or atmospheric pressure is kept

upstream. Because of pressure drop across the filter medium is limited to one atmosphere in this vacuum filters in general they are not suited to batch operations.

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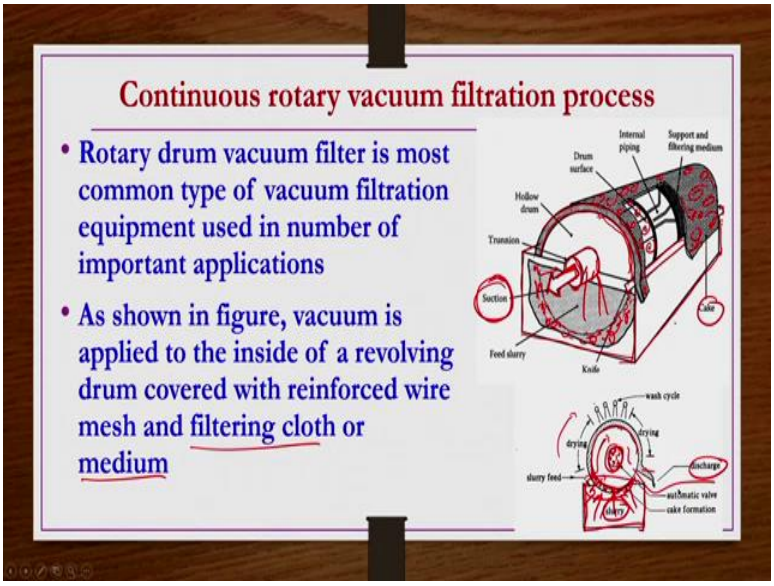

So, let us see what is continuous rotary filters. There are number of continuous type filters are available especially vacuum filters, continuous rotary vacuum drum filter, continuous rotary disc filter, continuous rotary horizontal filter, we see under each category.

Let us start with continuous rotary vacuum filtration process, what happens here. Rotary drum vacuum filter is most common type of vacuum filtration equipment used in number of important applications. As shown in the figure, vacuum is applied to the inside of the revolving drum covered with reinforced wire mesh and filtering cloth or medium. So, pictorially if you see we can understand easily.

So, we have a kind of drum hollow drum, this drum is a kind of hollow one something like this. Now, this drum is covered with a kind of a filter medium or filter cloth. So, this drum surface is also like is having kind of porous structure kind of thing so because whatever this openings are there in the drums through which the material liquid comes through and then passes through the liquid can pass through and then only a kind of solids being deposited.

Here these drum what it is done? It is done it is in must in a kind of a feed slurry tank, there is a feed slurry tank is there. So in this one, in this feed slurry tank this drum is in must to only a some fraction it is not in must completely as. So, let us say 50 percent is in must now. Here now, this

drum whatever the hollow structure is as we have already mentioned this drum is a kind of hollow structure, as a kind of hollow one and then this drum is a kind of out of surface is covered with a kind of filter cloth.

And this arrangement is kept in a kind of a feed slurry tank and then vacuum is applied through this inner hole whatever is there, inner hollow structure of the drum whatever is the through which the vacuum is applied. So, we can see here from here the vacuum is applied, and then this drum is rotating actually it is continuously rotating as much as long as it is processes going on.

So, this drum is rotating and then simultaneously when drum is rotating the vacuum section is applied here in this portion, so what happens? Whatever the liquid is there that would be sucked from the slurry tank whatever the liquid is there that will be sucked through here like this, and then that will be collected as a kind of filtrate. So, when the it is sucking the material slurry then solids it is not that only liquid is being sucked the entire slurry is being sucked but what happens? Because of the filter cloth only liquid is coming out and then solids are being deposited on the filter cloth.

So, this and it is continuously rotating so it rotation continuously goes on. So, solids are being continuously deposited on the surface of filter medium that is covering the drum. So, they will have a kind of cake something like this the whatever this material is there that cake formation is taking place. So, when this portion when it is rotating so sometimes some portion is a kind of in a kind of slurry tank and rotations takes place so then the it come when the that part comes to the top so on the top it is having some kind of solids.

So, these solids are continuously removed by this knife there is a kind of knife is provided so that will be scrapping the solids when this drum comes out to the upper side like this. So, then whatever this material is there that comes out and then the cake is collected like this here. This is the simple working principle here. So, the same thing if you see so there in other representation other way representation there is a kind of slurry tank here.

So, into this we have a kind of hollow drum. So, this is a kind of hollow drum which is having a kind of outlets are porous structure like this. Now, what happens? Here in this through this hollow structure you apply the so called vacuum as sucked the material. So, that whatever the material is there from the slurry so that will be select out of that slurry that is being sucked only the liquid is

passing through the filter medium of which is covering the drum and then that is being collected as a kind of a filtrate that is being collected as a kind of filtrate.

So, then when it is sucking the material slurry so solids are being deposited on the surface only, . Whereas the liquid is being taken out by through the suction by because of the suction whatever the pressure variant is developed because of that one the liquid is being separated through the filter medium and then solids are being deposited and then when because it is rotating when this rotates here something like this, this portion this bottom portion when it comes up here like that there is a kind of knife that knife will be discharging the cakes like this.

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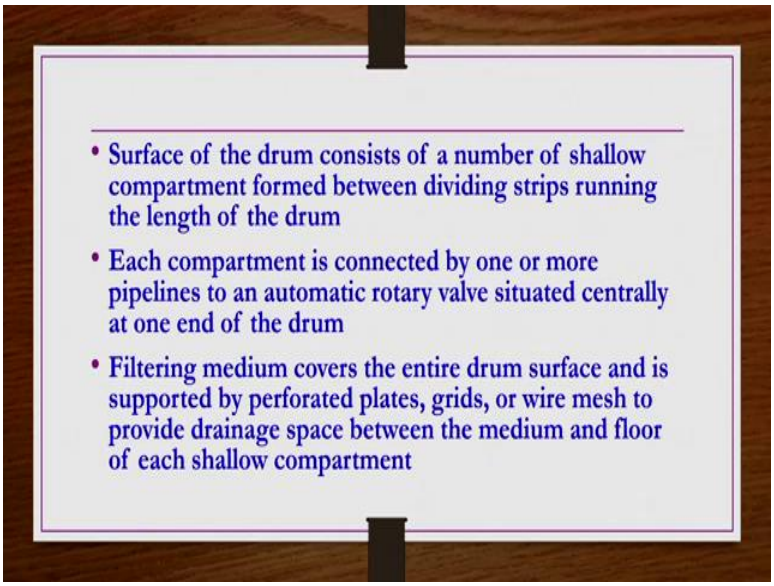

So, surface of the drum consist of a number of shallow compartment formed between dividing strips running the length of the drums we can have a kind of different compartments in general. Each compartment is connected to another by one another or more pipelines to an automatic rotary valve situated centrally at one end of the drums. So, all of these compartments of the they are in general connected by one or more pipelines to an automatic rotary valves situated centrally at one end of the drum.

Filtering medium covers the entire drum surface and is supported by perforated plates, grids or wire mesh to provide drainage space between the medium and the floor of each shallow compartment.

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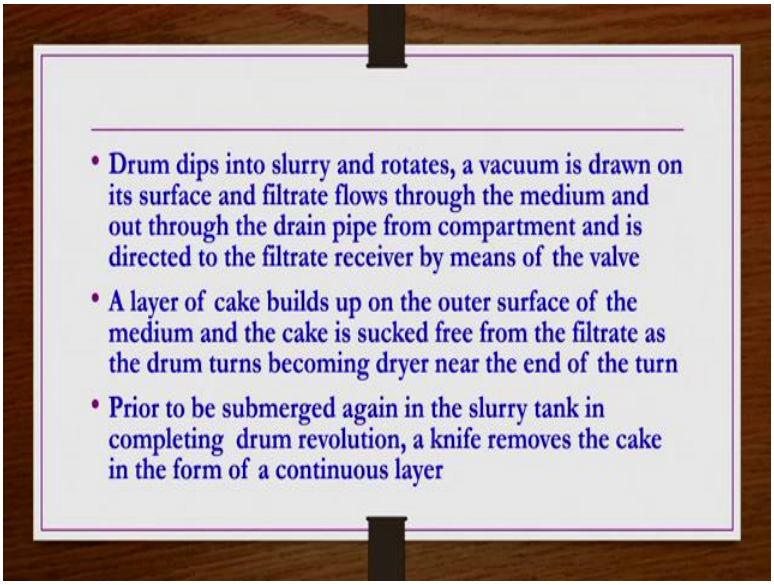

Drum dips into slurry and rotates, a vacuum is drawn on it is surface and filtrate flows through the medium and out through the drain pipe from compartment and it is directed to the filtrate receiver by means of the valve. A layer of cake builds upon the outer surface of the medium and then cake is sucked free from the filtrate as the drum turns becoming dryer near the end of the turn.

Prior to be submerged again in the slurry tank in completing the drum revolution, a knife removes the cakes in the form of continuous layer. So, that the fresh surface of the filter medium is explodes for the further separation when that particular portion goes inside the slurry tank while the rotation of the drum is taking place.

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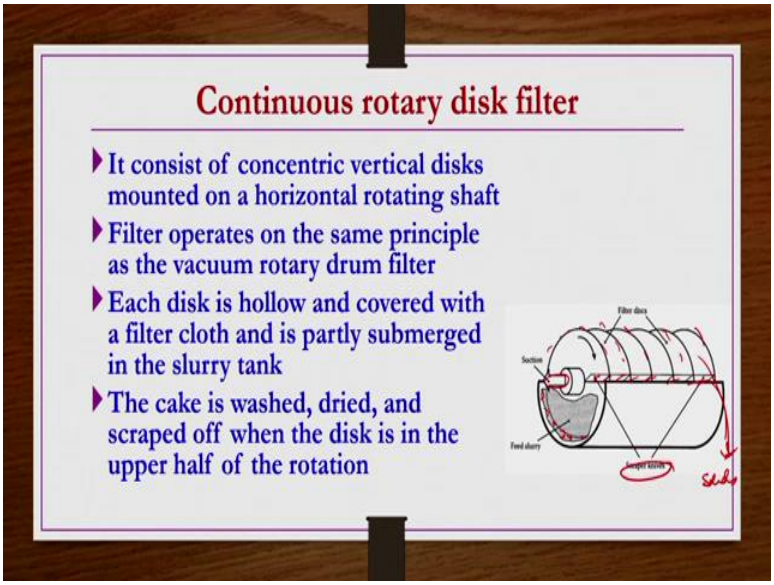

So, the other one is continuous rotary disc filter. It consists of concentric vertical disk mounted on a horizontal rotating shaft. Filter operates on the same principle as the vacuum rotary drum filter. Each disk is a hollow and covered with a filter cloth and it is partially submerged in the slurry tank. The cake is washed, dried and scrapped off when the disk is in the upper half of the rotation.

So, the exactly the same working principle as the rotary drum filter but here what we have? We have a hollow disc rather than the drums, drums with the different compartments as in the previous case. Now, we have several n number of hollow discs which are covered with a kind of filter medium and then in must in a kind of a slurry tank and then exactly the same process is done as in the kind of rotary drum that is sucking through the medium whatever the liquid is there that can be sucked through the medium to this enter shown here like this and then whatever the solids are there they are being deposited on the kind of surface when the rotation takes place, when the solids comes on to the top surface like this.

So, there will be a kind of scrapper or knife kind of thing will be there so that will be discharging the cakes continuously. So, that the surface of the hollow the surface of the filter medium that is covering this hollow disc is free from the solids it not possible to have completely free but more surface is definitely available for the filtration to occur in the second subsequent rotations. Because partially we are removing the solids and then these removal of the solids is a continuous.

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Then, this third category centrifugal filters. So, pressure filters, vacuum filters we have seen now we see centrifugal filters. By using centrifuge, solids that form a porous cake can be separated from liquids the principle is very straightforward and simple here. Slurry is fed to a rotating basket having a slotted or perforated wall covered with a filter medium such as canvas or metal cloth.

Pressure resulting from the centrifugal action forces the liquor through the filter medium leaving the solids behind. If the feed to the basket is then shut off and then cake of solids spun for a short time much of the liquid in the cake drains off the particles leaving the solids a much drier than those of those from a filter press or a vacuum filter. When the filter material must be subsequently dried by thermal means then considerable savings may result from use of a centrifuge.

So, what happens here actually basically principle we have a kind of a centrifugal bowl. So the, this bowl is a kind of a having a kind of a perforated structure. So, it is not a kind of solid container while it is a kind of perforated structure it is having and then this bowls is rotating now you can make use of rotation of this bowl either from the top by using some kind of sharps or motor something like that or you can rotate from the bottom.

So, when the solid slurry comes here at the feed slurry that comes here that is being pushed towards the wall of this bowl because of the centrifugal action because it is rotating at high speeds,. Now, this surface whatever the basket walls are there which are perforated they are also covered with a kind of filter medium. So, the solids are being deposited on the filter medium they are not able to

pass through because the perforated plate whatever is there bowl surface is whatever is there that is being covered by the filter medium.

So, only the liquid is coming out only the liquid is coming out and then solids are being deposited. So, these kind of walls are in general arranged in a kind of casing something like this. So, from here whatever the liquids there coming out through this wall of the bowls because of the centrifugal action. So, they are in general collected as a kind of liquid from the bottom here.

So, whatever the solids are there they have provisions are made for removing the solids also in the design so that changes from one design to the other design. So, this is the basic principle, Now, further what happens? Sometimes if you need to drive the solids let us say you have taken the feed slurry you separated both the solids and then liquid into phases by applying the centrifugal force in the centrifugal bowls.

Now, obviously that cake that is being deposited on the solid surface is a kind of having a wet nature because it is also having some liquid whatever the interstitial spaces between the particles solid particles are there they are in general occupied by the liquid. So, then after completion of the filtration process you can take those solids are led them be inside the filter symbol and then spun it at a kind of much higher speed then the filtration speeds.

So, that whatever the liquid that is there in the interstitial spaces of the wet cake they will also be drain out, they will also be drain out because of the higher centrifugal action arising because of the higher rotational speed and then almost kind of a semi dried or a partially dried solids you can get. So, let us say if you suppose to dry the solids after the filtration process then it is better to go for this kind of centrifugal filters because partial draining can be done in the filtration process itself, or at the end of the filtration process using the same equipment of partially drying of the solids can be done so that is going to be economical anyway.

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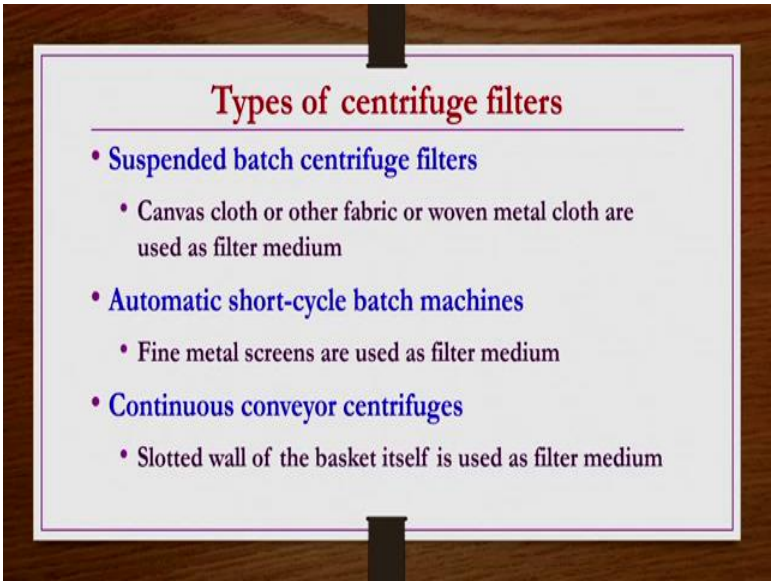

So, there are different types of centrifugal filters are available. Suspended batch centrifuge filters, automatic short-cycle batch machines, continuous conveyor centrifuges working principle is same but how are they operating that is the only one slight changing is there. And the suspended batch interface, one can have the canvas cloth or other fabric or woven metal cloth are used as filter medium. In automatic short-cycle batch machines, fine metal screens are used as a filter medium. In continuous conveyor centrifuge, slotted wall of the basket itself is used as a kind of a filter medium in general.

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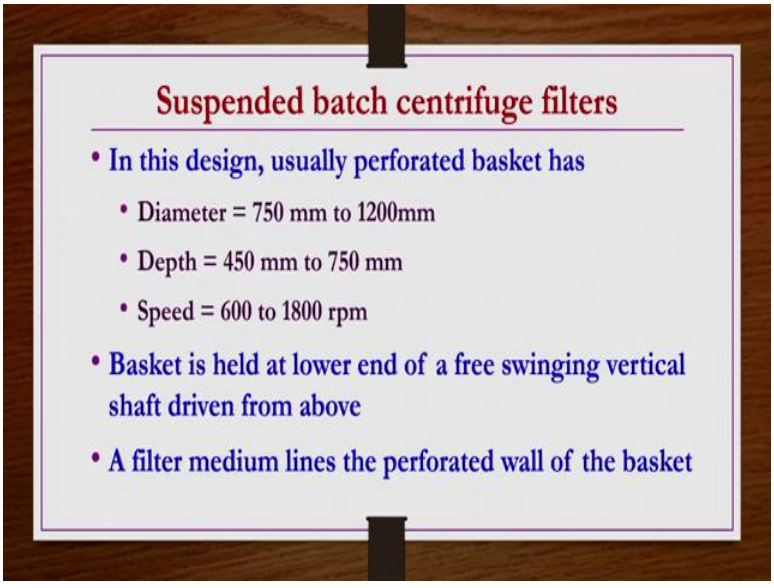

Now, we see each of them. Suspended batch centrifuge filters, in this design usually perforated basket has a diameter 750 to 1200 mm, depth of 450 to 750 mm and then speed at which they rotate is in general 600 to 1800 rpm. Basket is held at lower end of free swinging vertical shaft driven from the above. A filter medium lines the perforated wall of the basket.

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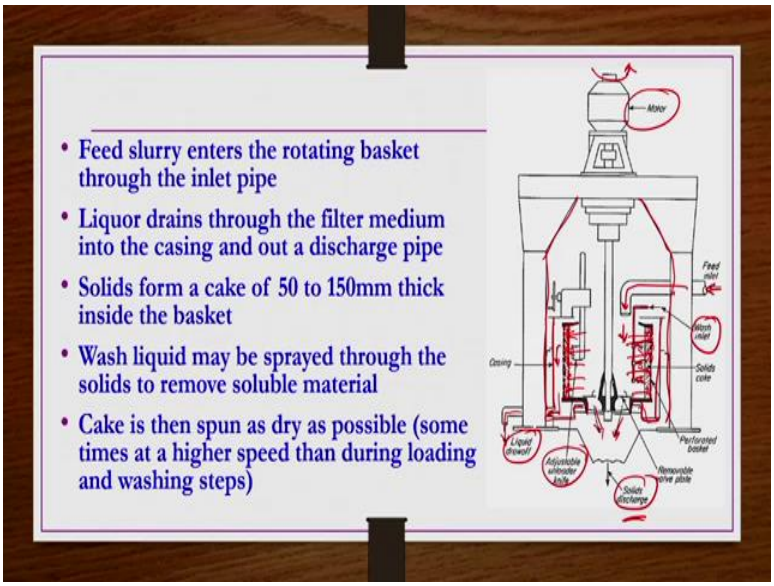

So, as shown in the picture here. So, now whatever is there this is a kind of a bowl perforated centrifugal bowl which is having a kind of perforated wall like this. These walls are covered are line with a kind of filter medium. And then feed slurry comes in here deposited here, entering the filtering bowl at this location. And now it is rotating, this is rotating by a motor which is having here at the top.

So, because of this motor this bowl is rotating, this entire setup is kept in a kind of a case in like this whatever we have seen like this, this kind of casing we are having like this. So, now because of the centrifugal action when the ball is rotating so the material is thrown towards the wall of the bowl.

So, but this material is having solids and liquids, liquids can pass through because the filter medium is having such kind of porous structure only liquid can pass through because of the pressure difference developed because of the centrifugal action but solids will not able to pass through they will be return on the surface like this as a kind of cake whatever the filtrate liquid that is passing through that will be collected through the liquid valve out drain out like this.

The solids whatever are deposited so these solids are removed with a kind of adjustable unloader knife it moves up and down to the left and as well so that whatever when it moves up and down. So, the whatever the solids are there, they will be dislodged from the filter cloth or the or from the valve of the bowl whatever the bowl valve perforated wall is there from there this solids are, would be dislodged and then there will be collected as a kind of solid discharge when this adjustable knife is moving up and down the solids are being dislodged from the basket valve which is having a kind of filter medium.

These solids discharged dislodged solids are taken as a kind of solid discharge like this. This is the simple working principle and then it is same for all kind of model but how it is operated semi batch, continuous or automatic kind of things that is what we are having. So, let us say if you want to have a kind of washing of the cake then there is a kind of separate washing layer is provided where it provides the kind of a spring of the liquid for washing of the cake.

And then the required washing or discharging of this whatever the solids that are deposited on the bowl valves are perforated valves of the bowl whatever the solids are deposited which are not being removed even after playing this adjustable knife. Then you have to wash the filter medium surface by these wash liquids as provided this here. So, feed slurry enters the rotating basket through the inlet pipe.

Liquor drains through the filter medium into the casing and out a discharge pipe. Solids form a cake of approximately 50 to 150 mm thick inside the basket. Wash liquid may be sprayed through the solids through remove soluble materials. Cake is then spun as dry as possible if required and sometimes at higher speed than during the loading and washing steps itself. Higher speed if you spun that solids will become more and more dry, they are the liquid more and more liquid can be drained off through this cake.

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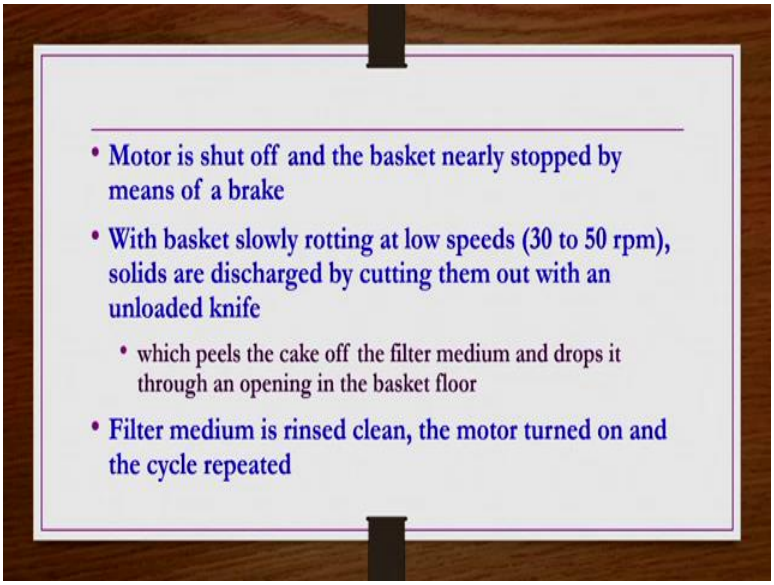

Motor is shut off and then basket is nearly stopped by means of a brake. With basket slowly rotating at low space 30 to 50 rpm solids are discharged by cutting them out with an unloaded knife which peels the cake of the filter medium and drops it through an opening in the basket floor. Filter medium is rinsed clean, the motor turned on and the cycle repeated again for the subsequent operation so this is what happens suspended batch centrifuge filter.

Working principle is same but only the design how the bowl is rotating and all those things or how the materials are being collected whether continuous or batch those are the kind of things are only different, design or only different but working principles of a separation is only because of the centrifugal action because of the centrifugal action whatever the pressure gradient is developed that is going to make this slurry to separate into a kind of a liquids and solids when the slurry is passing through the filter medium within the centrifugal bowl or are the filter medium which is attached to the perforated valve of the centrifugal bowl.

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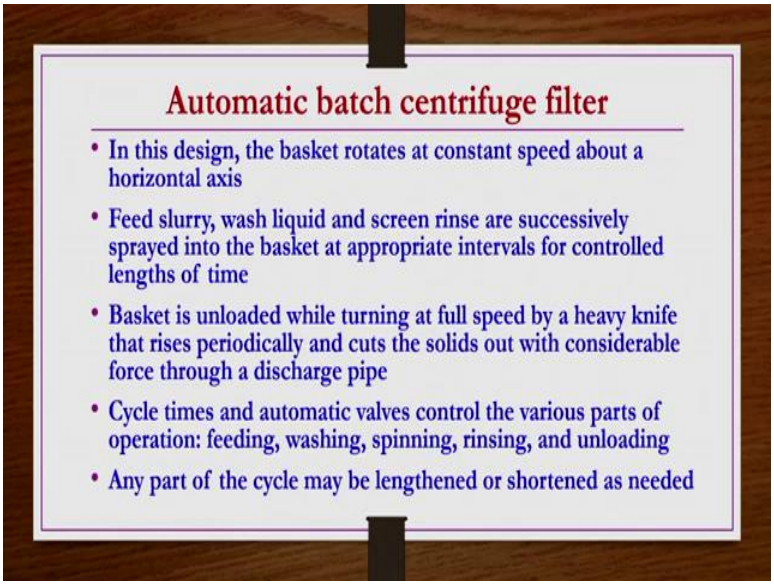

Now, automatic batch centrifuge filter. In this design, the basket rotates at constant speed about horizontal axis. Feed slurry, wash liquid and screen rinse are successively sprayed into the basket at appropriate intervals for controlled lengths of time. Basket is unloaded while turning at full speed by heavy knife that rises periodically and cuts the solids out with considerable force through a discharge pipe. Cycle times and automatic valves control the various parts of operation like feeding, washing, spinning, rinsing and unloading. Any part of the cycle may be lengthened or shortened as needed.

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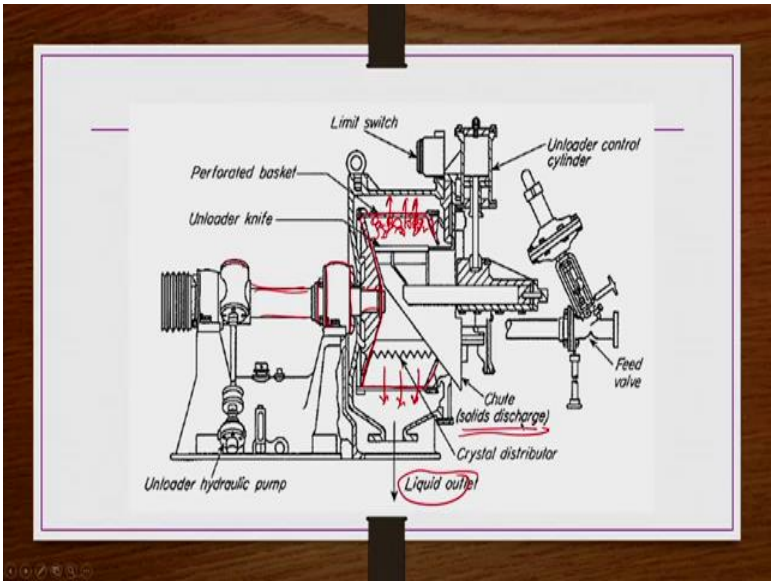

So, the process is same here. So, we have a kind of horizontal rotation, what we have? We have a kind of perforated plate here like this. Now, but this is rotating through an horizontal axis because of this motor is provided like this. So, as in the previous case it was rotating from the top it is possible anyway. So, whatever the material that comes here the same working principle is there.

So, whatever the liquid is there that will be passing through this perforated valve of the centrifugal bowl and the collected as a liquid outlet, whatever the solids are being deposited on the surface of the bowl valve which is covered with a filter cloth so they are removed by unloader knife and then taken as a kind of solid discharge exactly the same way but the thing is that in this one cycle times and automatic valves control the various parts of the operation that is the only difference so that is the reason it is known as the automatic batch centrifuge.

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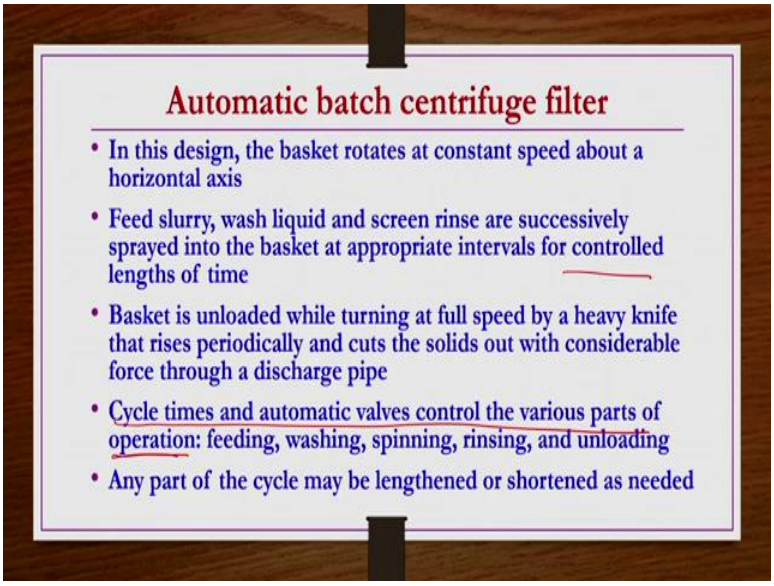

Suspended batch centrifuge and then this automatic batch centrifuge the difference is that the previous one the rotation of was taking place from the top now here it is taking along the same horizontal axis and then in this case the control cycle time and then controlling of the operation is done automatically so that is the reason it is known as automatic batch centrifuge filter.

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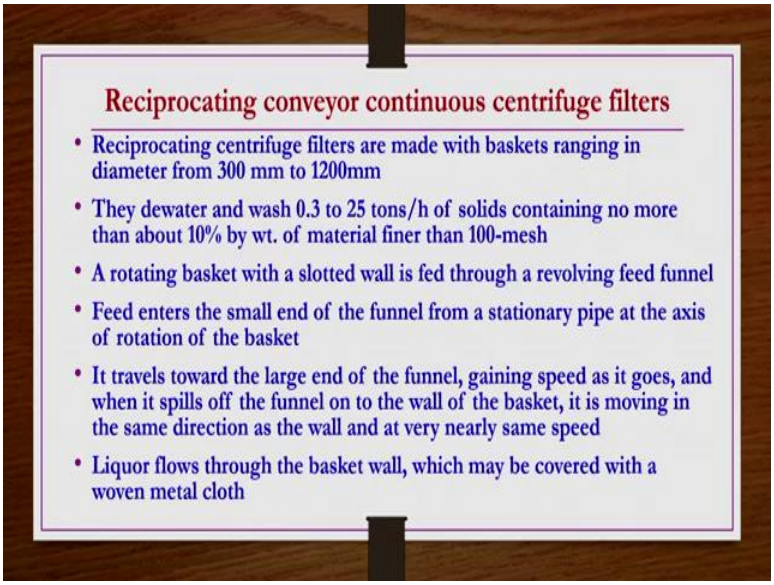

The last one is reciprocating conveyor continuous centrifuge filters. So, reciprocating centrifuge filters are made with baskets ranging in diameter from 300 mm to 1200 mm. They dewater and wash 0.3 to 25 tons/h of solids containing no more than about 10 weight % of material finer than 100 mesh. A rotating basket with a slotted wall is fed through a revolving feed funnel.

Feed enters this small end of the funnel from a stationary pipe at the axis of rotation of the basket. It travels toward the large end of the funnel, gaining speed as it goes and when it spills of the funnel on to the wall of the basket it is moving in the same direction as the wall and at a very nearly same speed. Liquor flows through the basket wall which may be covered with a woven metal cloth. The exactly the same thing we can see pictorially anyway.

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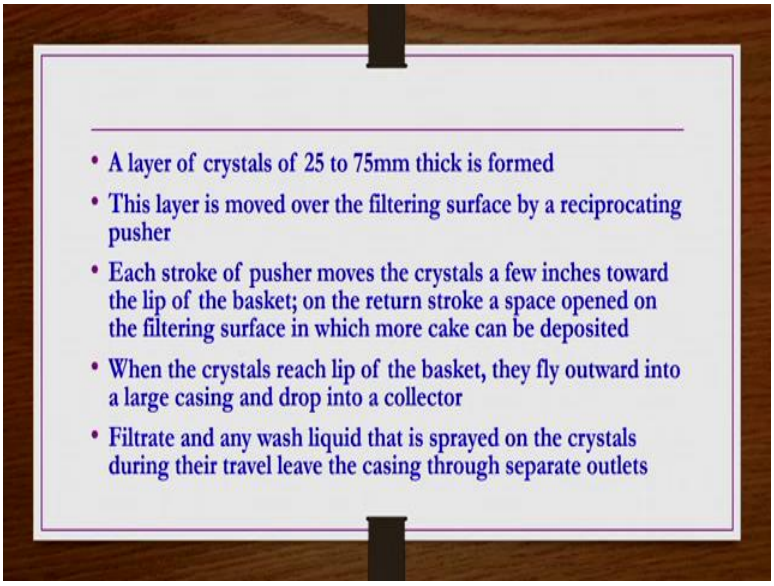

A layer of crystals of 25 to 75 mm thickness is formed. This layer is moved over the filtering surface by reciprocating pushers is there. Each stroke of pusher moves the crystals a few inches toward the lip of the basket; on the return stroke a space opened on the filtering surface in which more cake can be deposited. When the crystals reach lip of the basket, they fly outward into a large casing and drop into a collector. Filtrate and any wash liquid that is sprayed on the crystals during their travel leave the casing through separate outlets.

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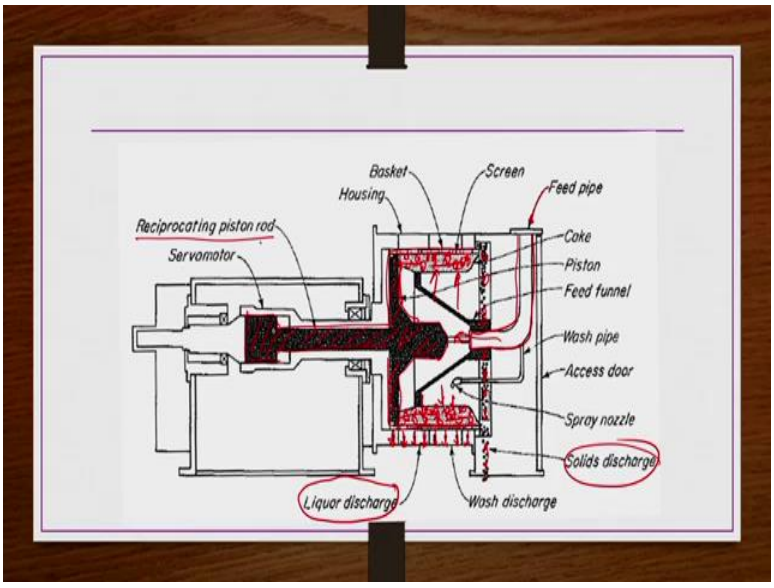

So, pictorially if you see the process is exactly the same thing but only thing that in the previous case there is a there is no kind of reciprocating pusher kind of thing. So, let us say we have this bowl here centrifugal bowl valve is here. So, now which is rotating and then it can also be reciprocated by a kind of a reciprocating piston rod here so this is what provided. Now, the feed pipe there is a kind of feed pipe here, the feed material comes in here.

Comes in, when it comes here and then this bowl is rotating because of the rotation what happen? The centrifugal action will develop and then pressure will build up so because of that one this material would be pushed towards the basket wall which is perforated and covered with a filter cloth so what happens? This perforated basket wall will allow only liquid to pass through and then solids will be deposited because of the bigger sizes and also because this basket valves are covered with a kind of or lined with a kind of a filter medium.

So, there is a kind of a depositing of the cake kind of thing is this so that is there and then whatever the liquid is drained out here are passing through this perforated valve of the bowl whatever the liquid that passes through that will be collected from here as a liquor discharge, as a liquor discharge they will be collected from here. The solids what happens now? This is having a kind of reciprocating pusher.

So, it moves as it moves it push the materials when it moves goes forward in this direction it pushes the material whatever range here there the solid materials and then those solids will be dislodged or discharged from the surface of the filter cloth and then they will be collected as a kind of solid discharge, here and then when it goes back so obviously the solid seat has removed certain amount of solids more space it will create, more space it will regenerate once again to have more separation to take place, so that is the process.

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We have a several references for this course, all of them should be providing some amount of information on this filtration equipment but primarily these two references are going to be very important especially from the notes point of view of this lecture, thank you.