Industrial Biotechnology
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Module 5
Lecture No 24
Downstream Processing: Solid-Liquid Separators

Welcome back to my course Industrial Biotechnology. Now, I was discussing up till now we are discussing upstream processing and in the upstream processing we cover aid sterilisation and medium sterilisation and how aseptically we can transfer the seed culture in the inoculum vessel. Now the 3 lectures we will be on the downstream processing and downstream processing is a very important aspects in the biochemical industry because I told you that duty of the this of the biochemical process that from simple one, one organic compound we can produce different products but when we market the products.

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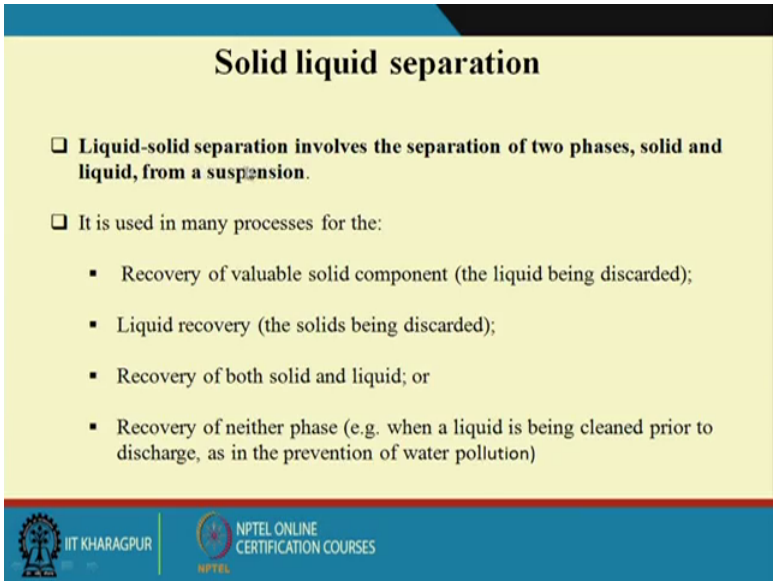

Market products should be in the purified form. The downstream processing deals with the purification of product and question comes how we purify the products, so this couple of lectures we will deal with that. And first I have chosen that solid liquid separation, this is very important aspect in the downstream processing. Now solid liquid separation involves the separation of two phases, solid and liquid from a suspension. So you know that that solid may be of different forms, it may be of chemical it may be of organic it may be different forms.

So it is used for it is used in many process for the recovery of valuable solid components, liquid being discarded, Liquid recovered solid being discarded I can give typical examples.

Suppose when you carry out any fermenter I can take the example of this penicillin industry, suppose we use the penicillium chrysogenum for the production of penicillin. Now in the fermentation broth we get the penicillin in the soluble form in the aqueous media.

So first you have to separate the cell, cell separation the liquid the liquid cannot be discarded, so here the liquid is to be recovered and solid being discarded. Now in case of suppose in case of citric acid industry after citric acid you get it in the liquid form, first you precipitated in terms of calcium citrate. Now when you precipitate with the help of lime then what will happen the citric acid goes in the form of calcium citrate with the solid mass then the recovery of valuable solid components and liquid components does not is little bit discarded, so you have two different things

Recovery of valuable solids then liquid is to be discarded or your liquid is to be recovered and solids being discarded. The recovery of broth both solid and liquid some cases is required or recovery of neither phase or when a liquid is being cleaned prior to discharge as in the prevention of water pollution, so this is how it is done

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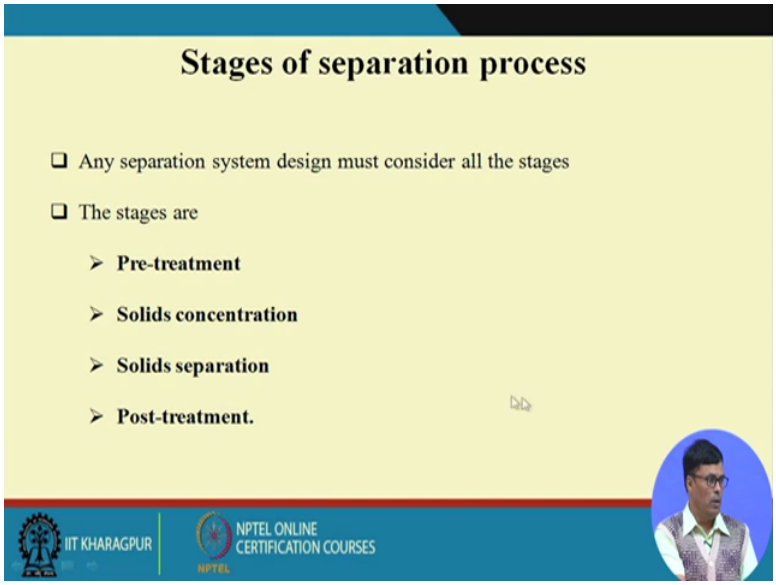

Now stages of separation process, any separation system design must consider in all stages. The stages are there the different stages we can have this separation process, one is called pre treatment then solid concentration then solid separation then post treatment. The different stages we have, so pre treatment solid concentration, solid separation and post treatment (()) (04:28) that we shall have to.

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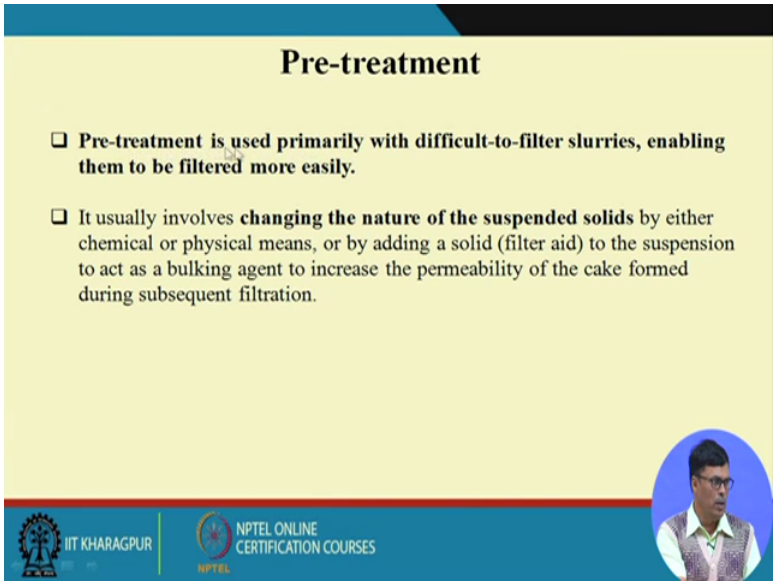

Pre treatment let us talk about little bit on pre treatment is used primarily difficult to filter slurry, enable them to filter more easily. It is it usually involved changing the nature of suspended solids but either chemical or physical means or by adding the filter aid to the suspension to act as the bulking agent to increase the permeability of the cake forming during the subsequent filtration. Let me tell you this that chemical and biochemical industry mostly we use the activated charcoal as a bleaching agent that the common problem that we have chemical and biochemical industry that colour that present in the liquid that if it comes to the product that is not acceptable.

So you have to remove the colour and colour removal in the chemical or biochemical industry is mostly done with the help of activated charcoal. Now the the efficiency of the activated charcoal again depends on the surface area, more surface area more it will be, bleaching property will be more so your activated charcoal should be very fine particles. Now activated charcoal as we know it is perfectly black in colour but since it is very fine particles, when you want to separate through the filtration process there is the every possibility that one or two particles some particles comes out with the filtrate so this is undesirable

Now question comes that how you can different, how you can separate this fine particles so what we do we add some kind of filter aid what is filter aid, it is kind of bigger particles it adsorbs the fine particles and this is this particle is very big we can separate it very easily. So this is this is how we can do that by adding the solid or filter aid that we have I can give the

example of (())(06:33) this kind of cellulosic material that is used largely for the separation of activated carbon.

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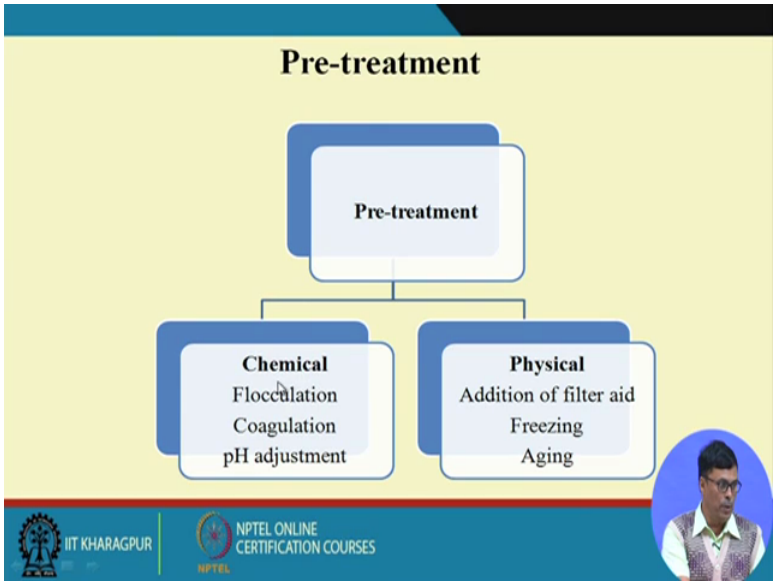

Now pre treatment that can be has two types one is chemical and physical; chemical we have flocculation, Coagulation and pH adjustment, and physical we have addition of filter aid, freezing or ageing. So let me explain that flocculation, flocculation is the float formation that we know the activated sludge process that that how particularly the bacterial culture, the size of bacteria is 0.5 to 2 microns. Since the bacterial size is very small that is very difficult to separate out during the sedimentation process

So it is desirable that they should forms a flock if flow formation then and only then that the cluster of cells will form and particle cells will be bigger then it will be usually settled down, so for doing so the some bacteria I can give the example (())(07:45) this is used in the activated sludge process. This bacteria has the characteristics of producing the polysaccharide gel and since it produce the polysaccharide gel, it has the stitching property because one cell will stick to other cell, so when cells they stick to the other cells then agglomeration of that cells will take place

When the agglomeration of the cells take place then what will happen the particles size will be bigger, when bigger particles is there then it can easily separate that is called flocculation. Now you have similarly we have coagulation, I can give the example of alum that is largely used in the water purification process for the separation of coagulant. Now pH adjustment that is another we can we can also do the pre treatment and physically I already discussed

about filter aid, then freezing that we can freeze that then aging that the aging through aging you allow the material to settle down, so that fine material will settle down and clear things you can take it out.

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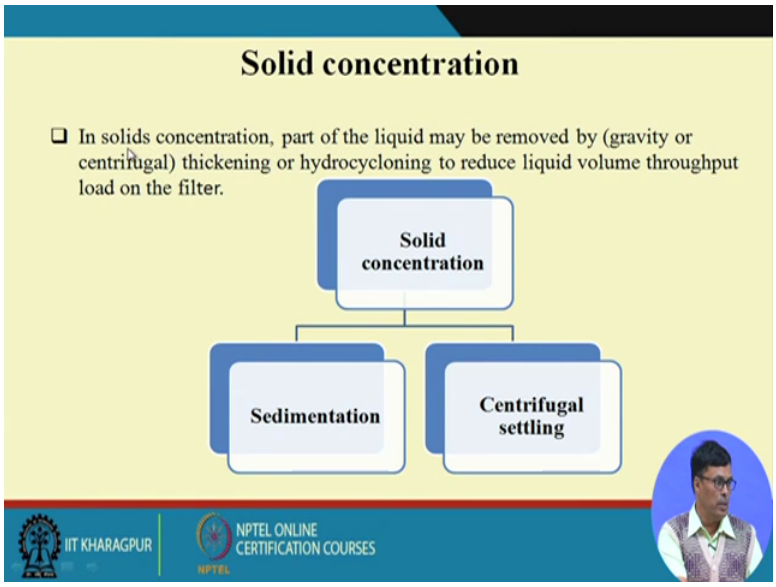

Now there is solid concentration the in solid concentration, part of the liquid maybe removed by gravity or centrifugal thickening or hydrocycloning to reduce the liquid volume throughout throughput load on the filter, the solid concentration this is we can separate do by sedimentation and the centrifugal settling this is the two ways we can do that.

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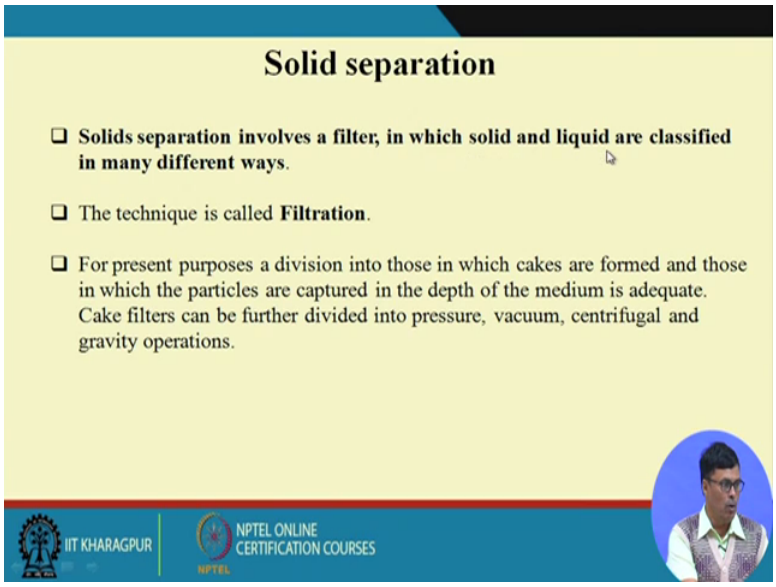

Now solid separation involves the filter in which the solid liquids are classified in many different ways, technique is called the filtration, for present purpose purposes a division into those in which the cakes are formed and those in which the particles are captured in the depth of the media is adequate. The cake filters can further be divided into pressure, vacuum and centrifugal and gravitational operation.

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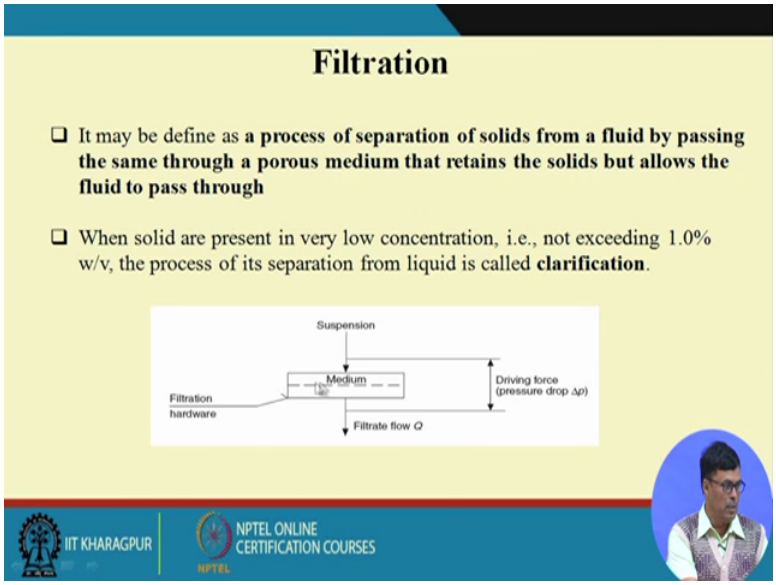

So I can that you know that filtration basically this is a media and this is the filtration hardware and this is the suspended particles is comes and this is the driving force that the pressure across the membrane and we get the filtered out. It may be defined as a process of separation of solid from a fluid by passing through the same through a porous media that retain the solid but allowed the fluid to pass through. When solid are present in very low concentration that is not exceeding 1 per cent weight by volume, the process of its separation from the liquid is called clarification, so clarification means also that clarification means the separation of solid from the liquid.

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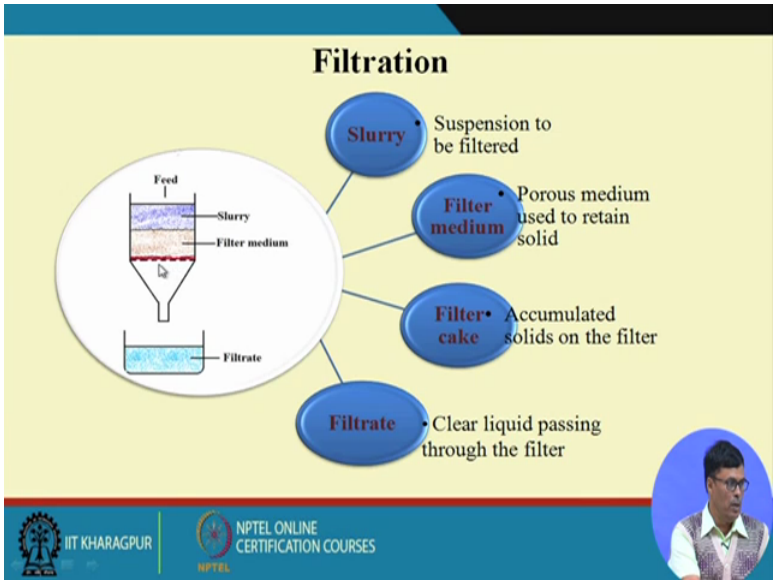

Now filtration you can have that we have slurry we have filter media we have kind of sieving that we have then we get filtrate, so slurry that the suspension of the filtrate filter and then this is materials we put the slurry in combination of solid and liquid. Then filter media, that porous media is used to retain the solid this will retain the solid particles. The filter cake accumulate the solid in the filter this is cake formation is there and clearly if it passing through the filter then it comes out like this.

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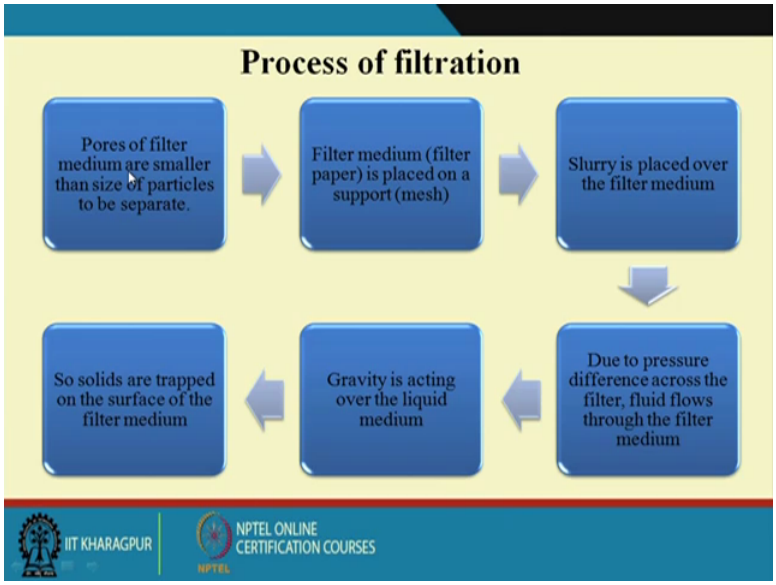

Now process of filtration is this pore of filter media pores of filter media are smaller than size of the particles to be separated. Obviously I told you that if the size of the particles is 1 micron to be separated, the pore size would be little bit more than that, the filter media or media paper is placed on a supportive mesh because this is very much required because we

know that when you use the membrane, membrane is a flexible material so we cannot keep the flexible as such like this.

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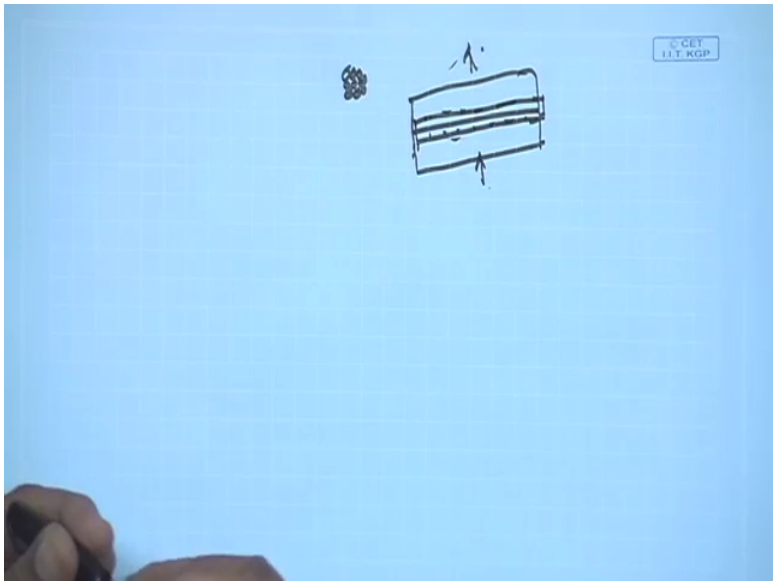

So it should have a supporting disk and this supporting disk should be perforated this will be perforated and then it is put it in a casing and then if you pass air like this and then puts in a envelop like this and then we pass media or you know liquid or whatever you pass then your solid will retain there and it goes like this. So slurry is placed over the filter media and then due to pressure difference across the filter fluid flows through the filter media and gravity is acting over the liquid media. So solids are trapped on the surface of the filter media, this is the process how the filtration takes place.

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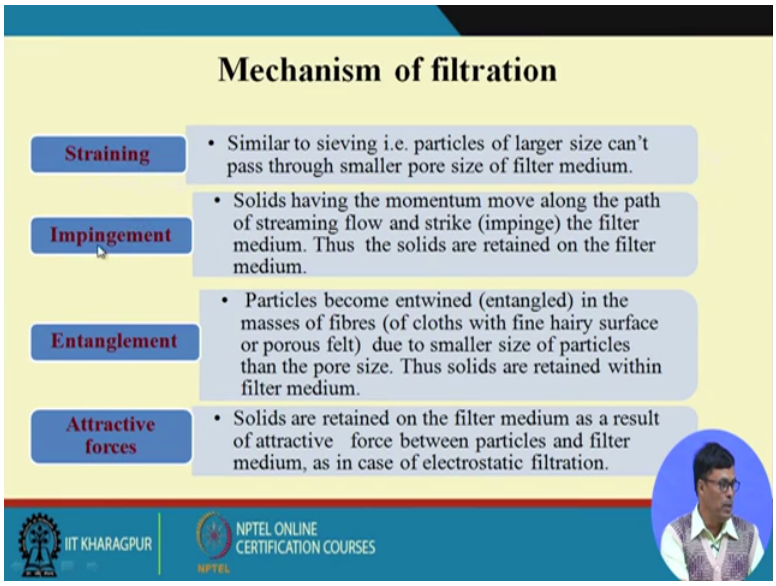

Now mechanisms of filtrations are straining, impingement and entanglement and the attractive forces. Now straining that similar to sieving or that is the particular large size

cannot pass through smaller size, I think in the in some lecture I tried to mention that sieving like 10 to 10 oblique 20 mesh 30, 20 oblique 30 mesh so we have different spore size, so if we if we have sieving mills kind of perforated the disk that we have so you pass particles of larger size cannot pass smaller size can pass that is your strain. Then impingement is that solids having the momentum move along the path of a streaming flow and strike the strike of impinge the filter media and thus the solids are returned on the filter media.

So this is the entanglement is the particles become entwined entangled in the mass fibre due to the small size of the particle than the pore size thus the solids are retained within the filter media. Attractive forces solids are retained on the filter media as a result of attractive force between the particles and filter media as in case of electrostatic filtration because if your particles has opposite side then we can easily separate it by the attract the opposite side and other things will be filtered out.

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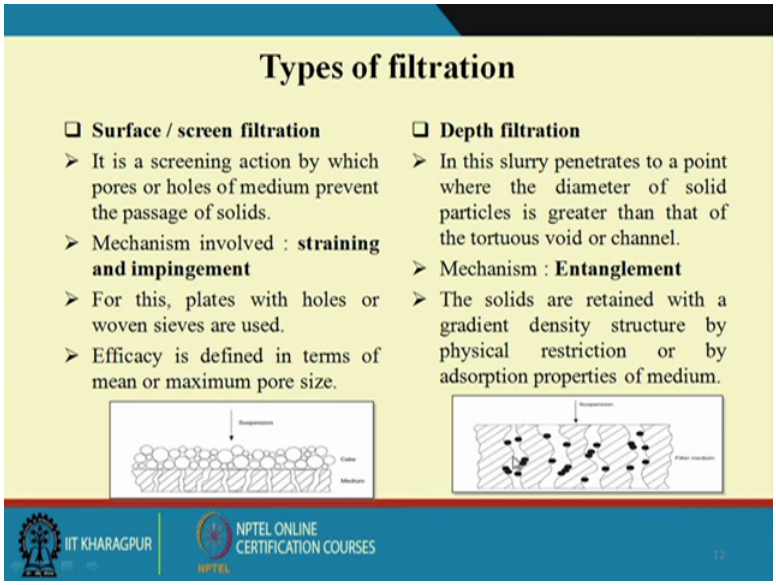

Now we have typical filter that filtration surface screen filter and depth filter, so here you can you can see that in the surface the suspended particles they accumulated and in case of depth filter this is accumulating inside this new filter media, this is the how it the different this is called straining or impingement and this is called entanglement.

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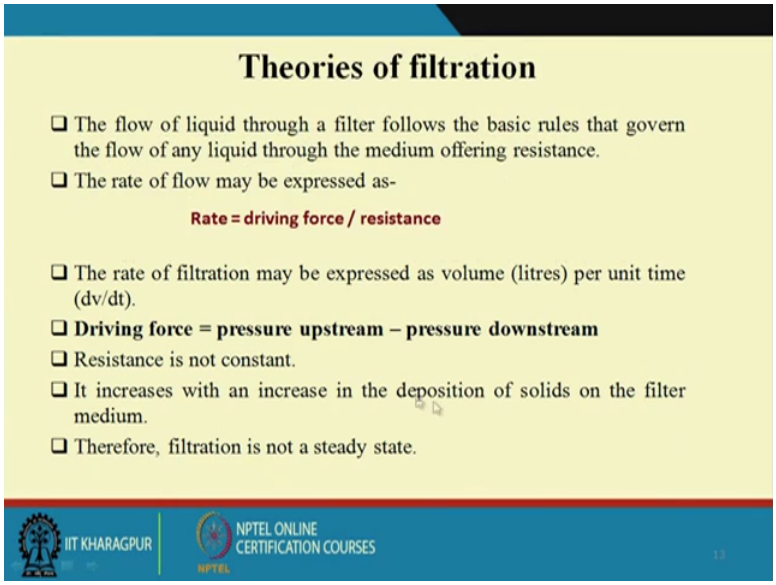

Now theory of filtration is that the flow of liquid through the filter follows the basic rules that govern the flow of any liquid through the media offering the resistance. Rate of flow may be expressed as the driving force by resistance, the rate of filtration may be expressed the volume per unit time that is dv by dt. Driving force is the pressure of upstream – pressure of downstream. Resistance is not constant, it increases with the increase of deposition of the solid on the on the on the filter media because let me explain that because suppose this is the filter media and if the particles that deposited on the surface and if the close the pore of the filter naturally the that you know pressure difference will be more. It increases the resistance will increase with the deposition of solid on the filter media therefore, filtration is not a steady state.

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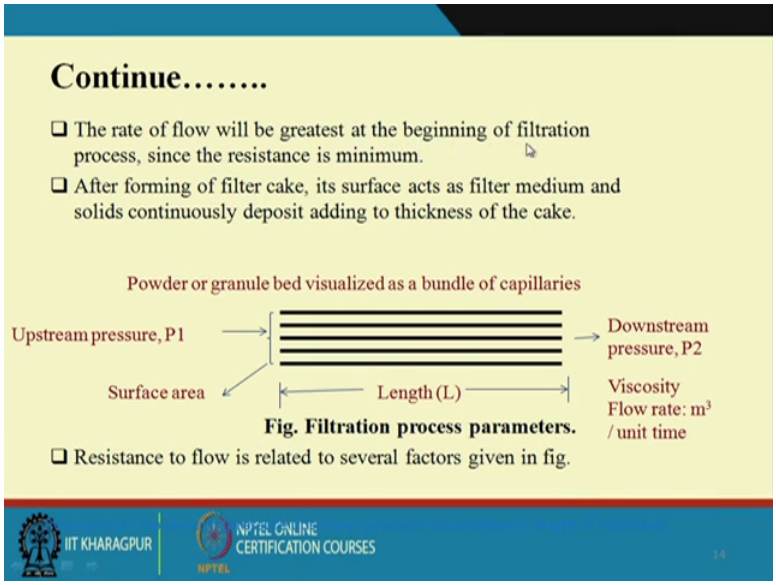

Now the rate of flow will be the greatest at the beginning of the filtration process since the resistance is minimum. After forming the filtered cake, its surface acts as a filter media and solid continuously deposited adding the thickness of the cake that is the normally that is the that is the resistance of related to the several factors given in figure. This is the different factors that we have in the in the in the difference of the surface area upstream processing the upstream pressure, the downstream pressure, viscosity flow everything is it depends on that.

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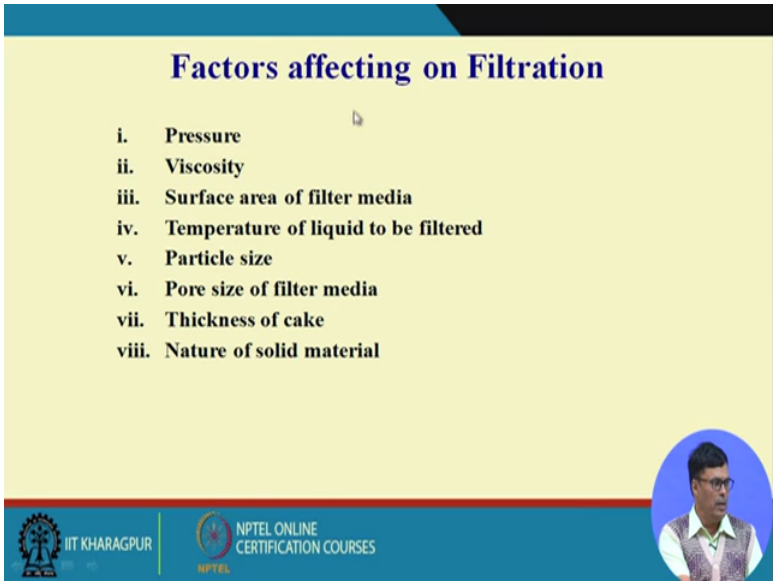

Now factors affecting the filtration is the pressure, viscosity, surface area, temperature of the liquid to be filtered, the particle size, pore size of the filter media, thickness of the cake and nature of the solid media. So different factors that affect the filtration process, the pressure

drops across the filter depends on gravity, vacuum, pressure and centrifugal force so different factors that affects the that you know pressure drops of this process. I can give the example the pressure difference could be obtained by maintaining the head of slurry of the filter just more head the pressure drop will be, pressure difference will be more and pressure develop will depend on the density of the slurry.

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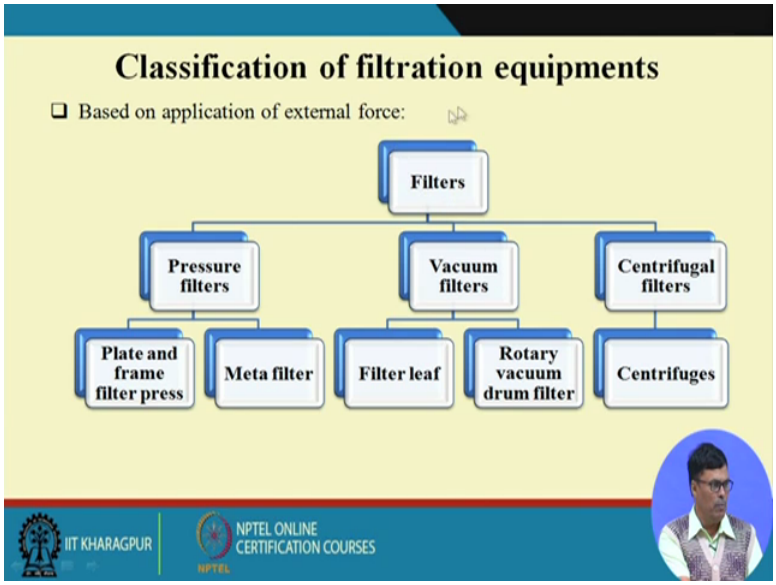

Classification of filtration equipment we have pressure filter we have vacuum filter we have centrifugal filter. Now in the biochemical industries we are interested for the plate and frame filter press is largely in practise and then we also use rotary vacuum filter largely in practise and centrifuge, so I shall mostly concentrate on this three that filtration process because which are in practise in the biochemical industries.

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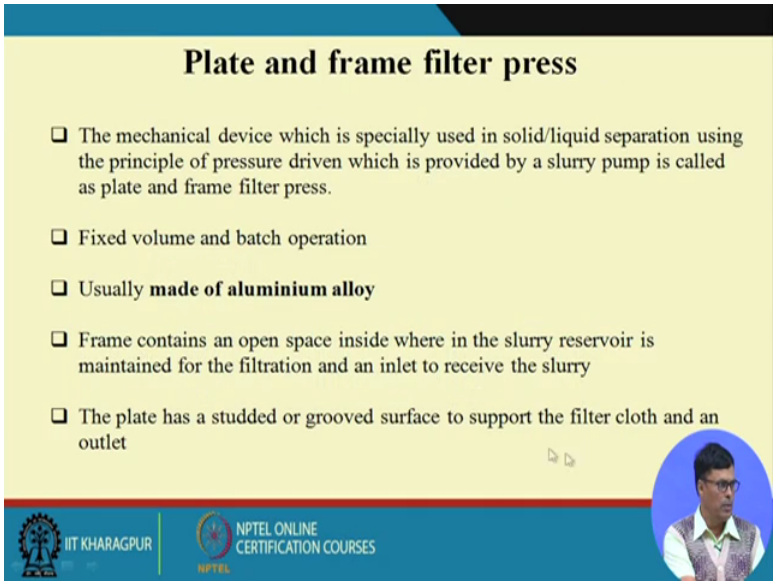

Now as for example, the plate and frame filter press that mechanical device which is specially used in solid-liquid separation using the principle of pressure driven which is provided by a slurry pump is called the as the plate and frame filter press. Now here I want to point out like this that how what do you mean by the plate and frame filter plate and frame, frame we understand that the frame we have in our door you know in the door we can have the frame like this.

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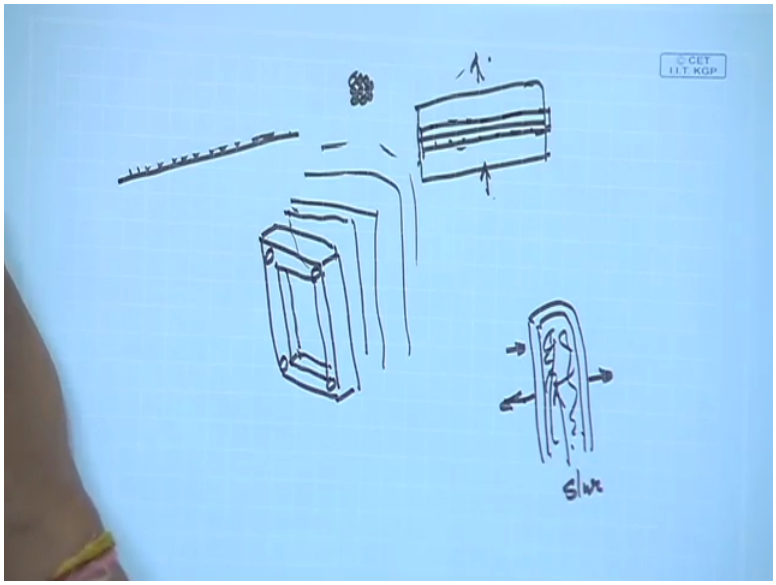

So this is the frame that we have you know that we can have the frame like this. So we can find out this how frame is looks, this is in the door we have the wooden frame like this so this is the frame that we have and so what we do that you know this frame that we wrap with

thick cotton pad and you know then we the number of frame we bunch together because this is usually made of wooden and we can easily make hole here.

So if you make it hole we can with the help of nut and bolt we can make it a fix all together so we can have number of such you know that that frame we can we can bunch together, so it is the mechanical device we specially use solid liquid separation using the principle of pressure driven provides the slurry form so how it is done. Suppose this is the frame here and we put the cotton thick cotton here and when you when you pass suppose thick cotton pad is here and if we pass this is the thick cotton pad like this and we pass the slurry then what will happen with the pressure liquid will comes out like this and solid material that accumulate inside this the thick cotton pad.

And when it is cool then you stop the operation and take this out, so fix volume and batch operation this is usually the batch operation usually made of aluminium alloy. The frame contains an open space inside where the slurry reservoir is maintain for the filtration and inlet to receive the slurry, the plate is studded or grooved surface to support the filter cloth and outlet. So I told you the wooden thing, it can be made up of aluminium also this is in practise because then what is the principles the mechanisms is surface filtration that slurry enters into the frame by pressure and flow through the filter media.

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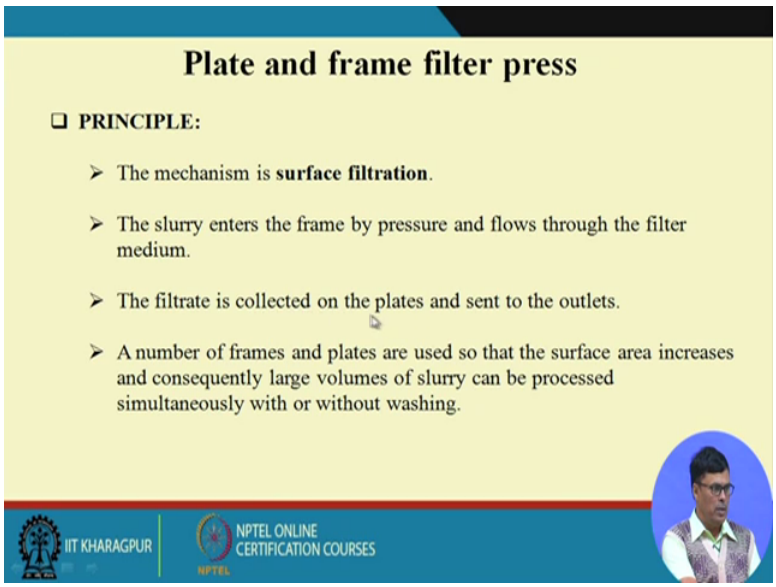

The filtrate is collected on the plates and sent to the outlets, the number of frames and plates are used so that the surface area increases and consequently large volumes of slurry can be

processed simultaneously with or without washing, this is largely in practise in the Baker's yeast industry.

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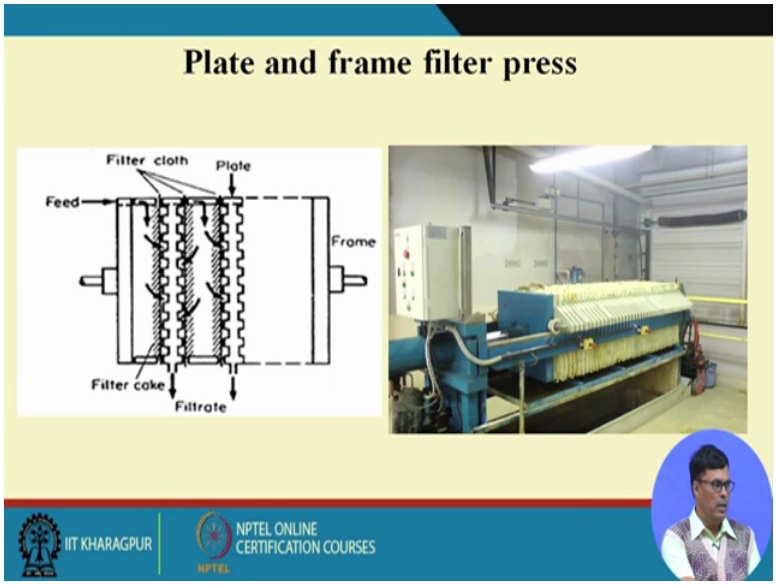

Now if you if you look it here that plate and frame that what I was telling this is your cloth am I right, this is your cloth and here the filtrate is coming out and here you do (())(22:11) the feed when you feed is coming and this is the filter cloth filter and the liquid will comes here and filtrate is going out like this. This is the channel through which the filter is going out and this is how this plate they are bunched together and question comes how one understand that you know when you find out that this cloth is totally filled with the cell mass?

How you can find out because this is usually connected with a nanometre with the slurry, if the pressure drop is maximum then that indicate that it is totally filled with the solid particles then we have to stop the operation means open this plate and take out the cell out from the from the plate and frame filter press, this is largely in practise in the industry. The application of the filter press is used variety of different application, food industry I told you Baker's yeast industry, mining industry, pharmaceutical industry, chemical industry, wastewater treatment process.

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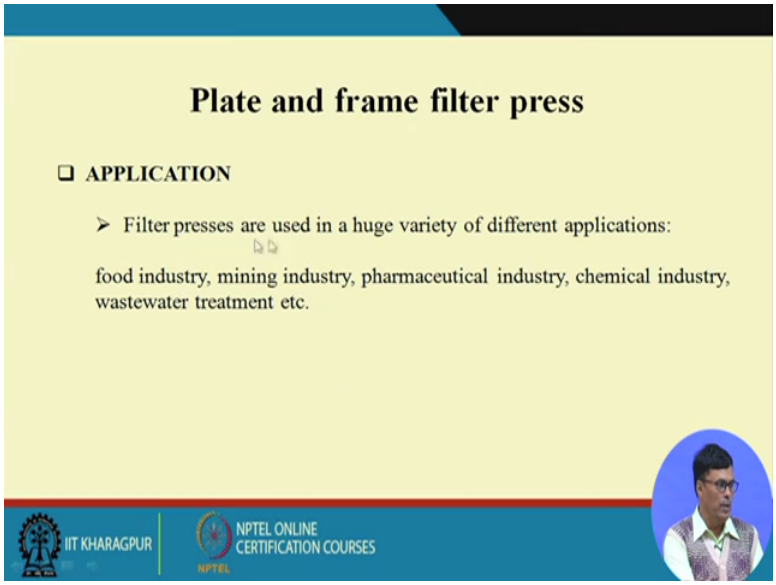

Then rotary vacuum filter this is another very important filter that is used for the separation of the cell mass particularly I want to mention that most of the antibiotics is produced with the help of fungi, I can give the example of penicillin industry. Penicillin is produced by penicillium chrysogenum the streptomycin is produces by streptomyces griseus so they are all fungi and this fungi are the bigger particles that can be removed with the help of this rotary vacuum filter.

Rotary vacuum filter consist of drum rotating in a tub of liquid to be filtered. The technique is well suited to slurry or liquid with high solid content which could clog other form of filters. The drum may be of 3 metre in diameter and 3.5 metre in length, given a surface area of 20 metre square.

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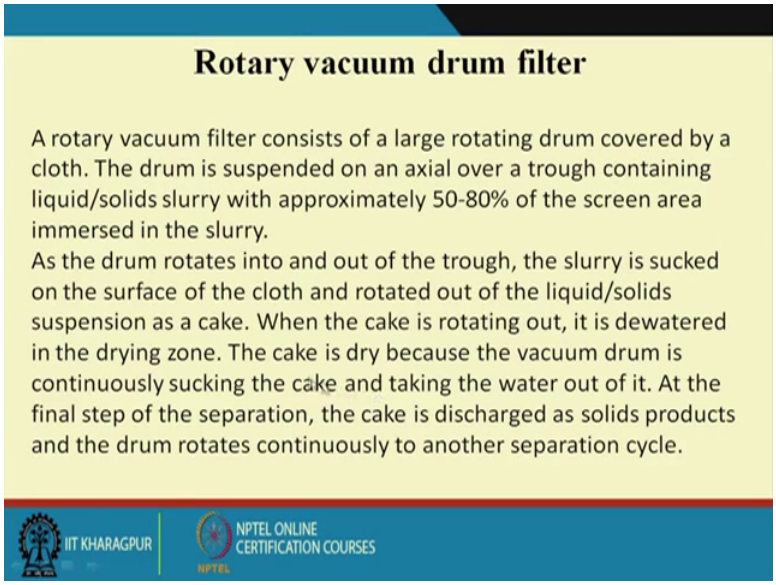

So this is now a rotary vacuum filter consists of large rotating drum covered by a cloth and drum is suspended on an axial over trough containing the liquid-solid slurry with approximately 50 to 80 percent of the screen area immersed in the slurry. As the drum rotates into and out the trough the slurry is sucked on the surface of the cloth and rotates out of the liquids and solids suspension as the cake.

When the cake is rotate out it is dewatered in the drying zone. The cake is dry become vacuum drum vacuum drum and is continuously sucking the cake and taking the water out. At the final step of separation cake is discharged as solid products and drum rotates continuous to the another separation cycle.

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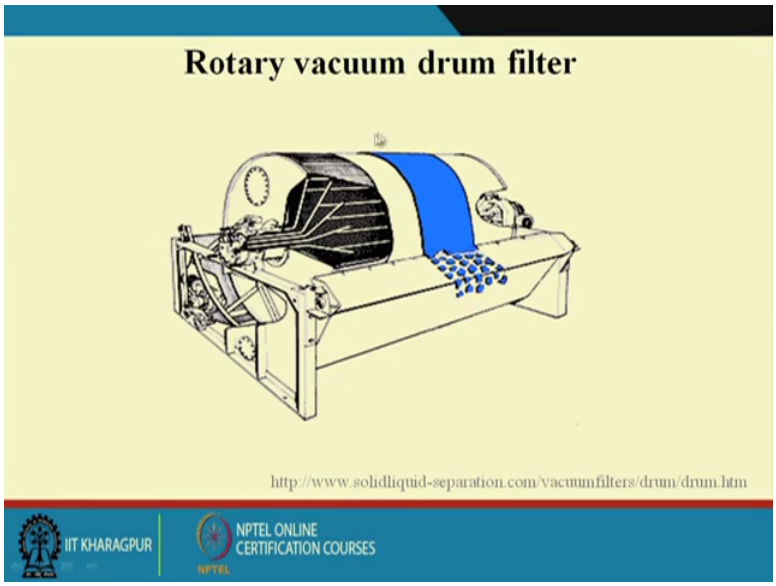

Now this is like this is the drum this is rotating and this is the muslin cloth that is on the and inside we have different pipelines. We applied the vacuum here and this is inverse in a trough this is a trough, where your fermentation liquid comes and it is rotating at very low rpm, 1rpm one revolution per minute, so here we have a fine knife so when it rotates since we applying the vacuum this cell mass will be dry and then when it touch this plate this fine cloth muslin cloth here we have wrap with most fine muslin cloth and liquid comes out like this.

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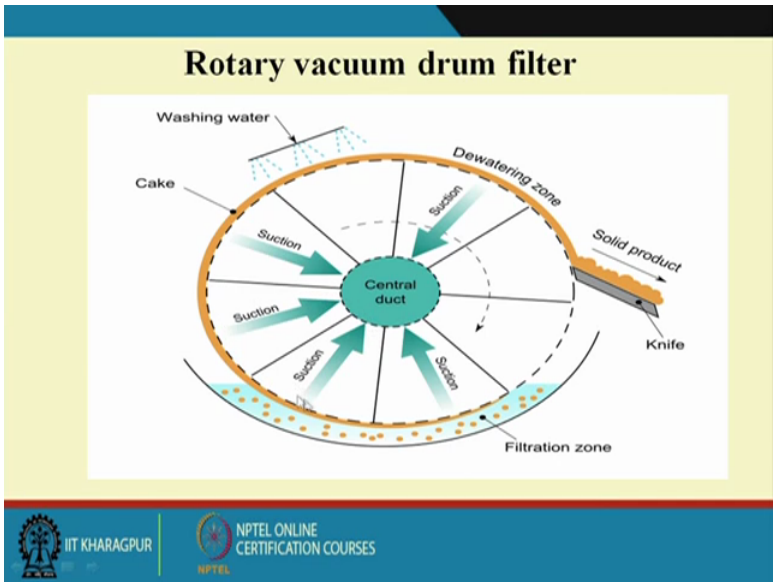

And this is actually that is that is the cartography that we have, this is the trough where this is suspended solid that we have and here this the pipeline where we apply the vacuum, we can apply the vacuum here and when you this rotates in this direction so when it rotates like this it suck the liquid on the surface solid in the surface and you can wash with the washing water this is the washing water, and this is the dewatered zone and this is the fine knife touch the muslin cloth and take the solid out.

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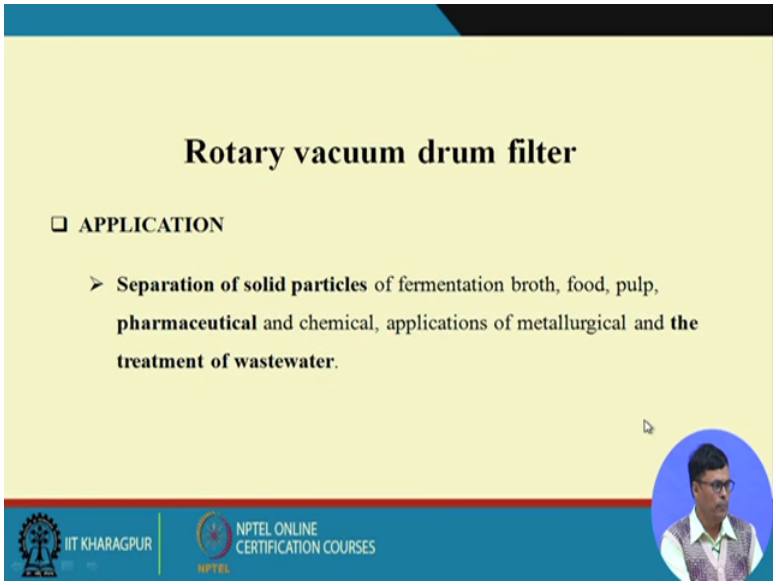

Rotary drum dryer is separate the solid particles of the fermentation broth to pulp and pharmaceuticals, chemical and applications of metallurgical and treatment process, now let me close here because next lecture I shall cover the centrifugal filter and other downstream process. Thank you.