**Fundamentals of Food Process Engineering**
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**Lecture - 48**
**Mixing and Agitation ( Contd. )**

Hello everyone, welcome to the NPTEL online certification course on Fundamentals of Food Process Engineering. We will discuss today Mixing and Agitation and it is a continuation of our last class.

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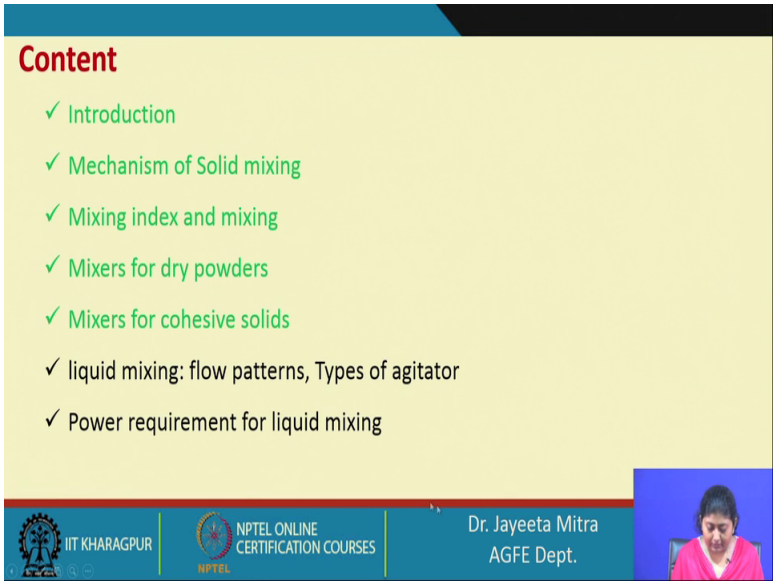


In our last class, an before that also we were discussing about mixing operation mixing and agitation, we have by now completed introduction mechanism of solid mixing index and mixing process mixers for dry powders and we started in the last class the mixture of cohesive solid. So, we will continue with that today also.

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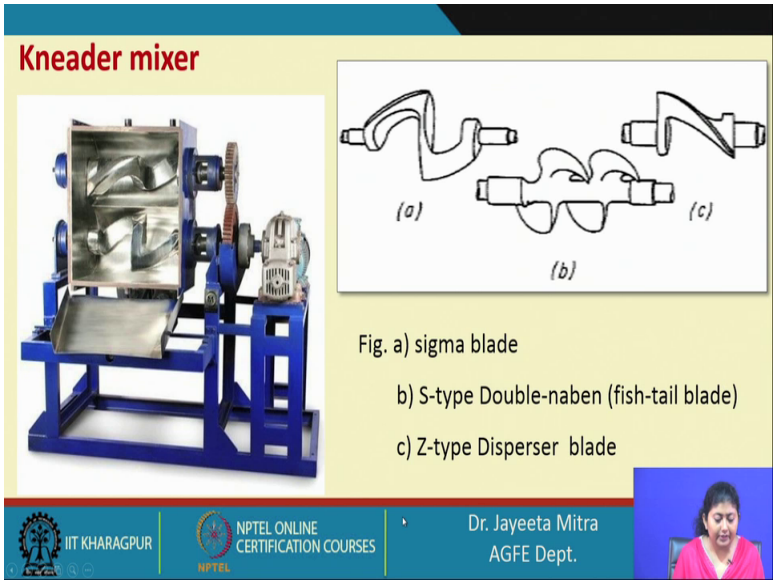


And first, we will see that we have finished here, where we are discussing about the kneader mixer. So, this is one kind of mixer that is used for the cohesive material mixing of the cohesive material and there are 3 different kind of blades as we can see that is used 1 is sigma blade another is the S type double naben fish-tail blade and the third C is the Z type disperser blade ok.

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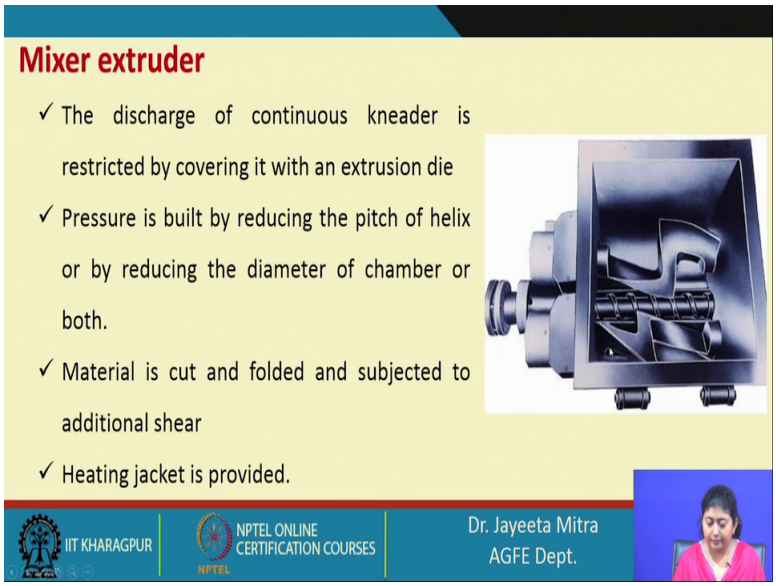


Now, next is mixer extruder; so, here the picture of an mixer extruder. So, mixture extruder in the sense that, they are not only mixing, but extruder extruding that is also one operation that will be there and here also there is a central shaft is there, which is again grooved and 2 blades are there, 2 Z type blades are there. So, the discharge of

continues kneader is restricted by covering it with an extrusion die ok. So, we have fixed die so, that the otherwise the because of this motion the continues discharge will takes place. So, by fixing a die we are restricting that movement. So, pressure is built by reducing the pitch of helix or by reducing the diameter of chamber or both.

So, we can see that there is a pitch in the screw that is the that central screw so, we can change the pitch ok. So, pitch is from one all the grooves are there. So, from ok so, you are not having that colour pen here, but any way we will just inform, you that if you see the grooves different grooves are there. So, from one top of one screw top of one rotation to the other top end that whole length is called the pitch and that pitch can be adjustable, it is you can change the screw in such a way.

So, that the pitch will be lowered or highered and because of that the pressure will build up and also what we can do is we can reduce the size of the chamber as it is mentioned or both the thing can be done that is change of pitch as well as change of the chamber size. So, that we can get the high pressure built in the inside of the chamber, material is cut and folded and subjected to additional shear. So, because in the small zone along with that pressure development and the kneader blade will also will move in the you know cohesive material.

So, because of this special shape as we have mentioned in the z shape blades so, they will cut and fold and shear it ok. So, additional force will be exerted on that and heating jacket is also provided. So, because of all this action that is a movement of the barrel movement of the blades, they will be high pressure development. So, because of all that the heat energy will be generated and that should be neutralized by circulating the chill water around the casing. And if you require some cooking effect to this then, we can use some heating jacket ok. So, in that case it will add some extra heat to the material.

So, that partial cooking will also be done along with the shearing or mixing action. So, then it is call the mixture extruder, because in extruder along with the mixing many operation happened that is the shearing, kneading, mixing, cooking and then finally, the product will come out their expansion or puffing all things will be there. So, in such kind of a system thereby we provide the heating jacket as well, because in extrusion we generally need a very high temperature.

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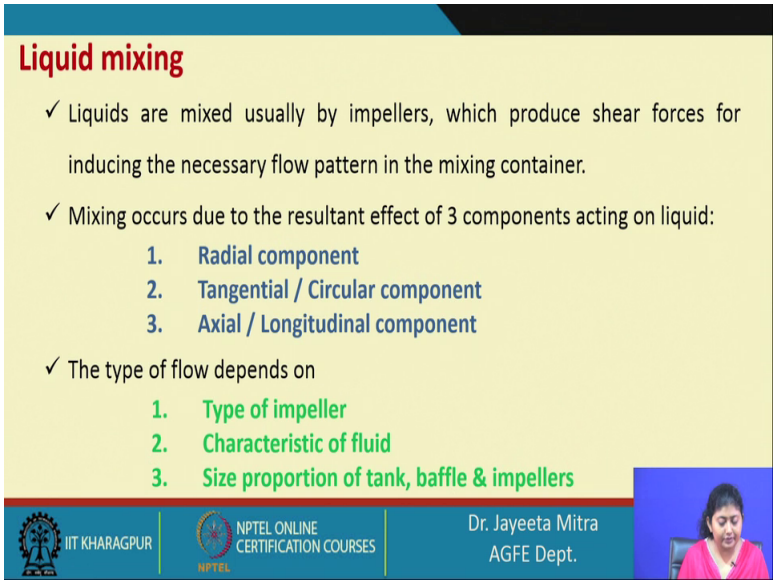


Now, liquid mixing; so, here we have by now discussing about the solid mixing and the cohesive solid mixing ok. Now next, we will jump into the liquid mixing. So, the nature of the liquid mixing is totally different from what we have seen in the solid mixing, because also the power requirement in the liquid mixing is quit lesser then the solid or cohesive material mixing and the mechanism is also very different.

So, liquids are mixed usually by impellers, we have seen that in case of dry powder we have used the tumbler mixture or double cone mixtures kind of then horizontal mixture barrel kind of mixture. Now, when we have seen the cohesive material, we have used blades because, the high shear force is to be applied there. Now for the liquid mixing we use the impellers ok. So, the impeller those are mounted on a central shaft or a centrally mounted impellers are there in the tank or barrel were the liquid is kept. So, these are the liquid mixing liquids are mixed usually by impellers, which produces shear force for inducing the necessary flow pattern in the mixing container.

So now, creating flow is a bit easy in the liquid, but what will be the direction of the flow that matters in many times or if your not mixing only 2 liquids, but there is a liquid and solid mixing. So, then also what kind of flow pattern your generating. So, that is important then therefore, the impellers produces the shear forces for inducing the necessary flow pattern in the mixing container. Now, mixing occurs due to the resultant effect of 3 component acting on the liquid, one is the radial component, another is the tangential or circular component and third is the axial or longitudinal component ok.

So, component of what actually, those impeller that is rotating. So, because of that the part the liquid will have a direction in all 3 ways either radial direction or tangential direction or axial. Radial direction in the sense from the towards the barrel side to the inner side or the reverse and tangential that is the particle or the fluid element that is at the end of the impeller that is being thrown in a tangential direction or axial; that means, along the impeller shaft they are moving. So, the vertical mixing will takes place so, all such phenomena in many cases, all 3 may happen or combination of them ok.

So, the type of flow actually depends on the type of impeller that, we are using because not all the impellers we will generate this 3 kind if different motions, they may be variations. So, that depends on the type of impeller that, we are using and also the characteristics of the fluid that is whether it is mixture of 2 different fluid of having different density or these are of some you know dispersion kind of material ok.

So, what kind of material or what is the viscosity of the fluid that is also important, what is the density of the fluid? So, the characteristics of the fluid is important parameter then the size proportion of the tank, baffle and impellers. Now, when will see the geometry of this kind of liquid mixing tank or barrel, we will see that there are some specific geometries are there. We use some time baffles around then periphery inner size of the periphery and this is used sometime to you know the to restrict the vortex or create them, because of vortex will generate the proper mixing. So, because of that the baffles are used and the impeller or the length of the impeller shaft ok.

So, many parameters are there that will help or that will define, what kind of flow will be generated in the liquid mixing case, whether it will be longitudinal or will be the radial flow or tangential flow like that, another thing is the size proportion. So, if suppose your impeller blade is not sufficient and they are only rotating you know central part and the other part of the barrel the liquids are not you know initiated flow in them so, they will be untouched ok.

So, the zone then the mixing will happen in the central zone only in the bottom portion of the imperial, but not will be uniform mixing. So, the size proportion of the tank dia and imperial dia also the imperial blades dimension the baffle everything is important, the height of the tank ok. So, all such parameters are important and based on that, we can

define that what kind of flow regime is there, what kind of flow velocity is there and how far it is effecting at the mixing process in a particular liquid mixing.

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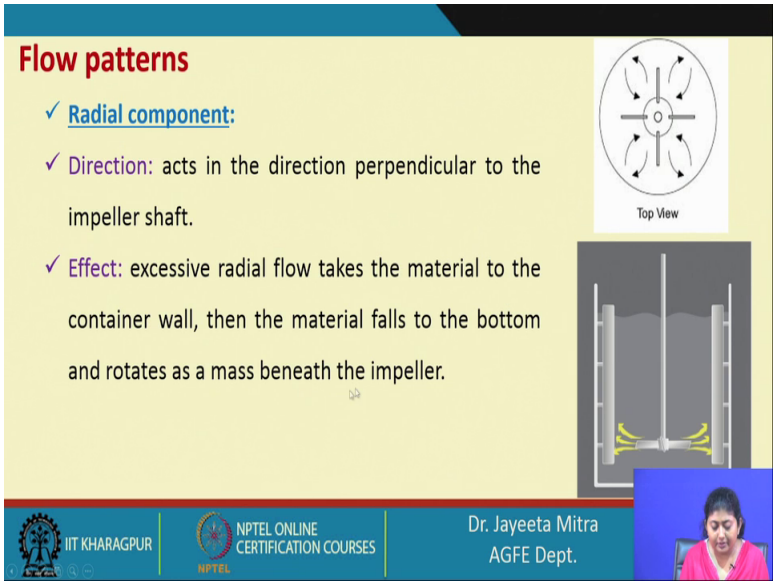


So, we will see for the radial component. Now here, we have the diagram were the top view and the side view is given. So, the outside white frame is signifying the barrel of the tank in which the baffles are attached, you can see a particular thickness of barrel is there and centrally one shaft is mounted and the impeller is attached to it at the end, which is rotating at a particular speed angular speed and it has 4 imperial blades that we can see 4 blades are there and because, this these 4 blades are there and there are baffles. So, it will create the small flow or vortex there and this small flow, if we look into from the top view that the direction of the liquid mixing is in the radial direction from the centre to the periphery and again periphery to the centre.

So, the flow pattern will be following the radial direction. So, these are the radial component, if the radial component of flow, we will exist that will be shown by this kind of a pattern in a liquid mixing case. So, this acts in the direction perpendicular to the imperial shaft ok. So, these are acting perpendicular to the impeller shaft and it is effect will be excessive radial flow takes the material to the container wall then the material falls to the bottom and rotates as a mass beneath to the imperial ok. So, if it is excessive if the excessive radial flow takes place then the condition will be like, this that the material falls to the bottom and rotates as a mass beneath the impeller.

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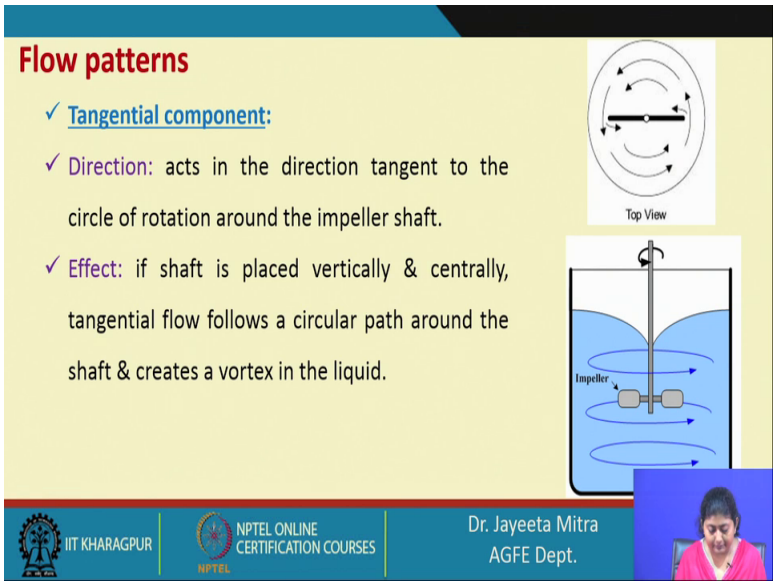


Now, tangential component if we see so, for the tangential component, you can see the flow pattern will be like this, here is the tank and there is an impeller, which is at quiet high from the bottom of the tank. And there are this impeller, which is rotating this is circulating the liquid in a tangential direction. So, if you see the top view, there are the motion of the liquid particle is in a tangential fashion.

So, if it happens then how it is going to effect the fluid mixing or flow pattern. So, this acts in the direction tangent to the or tangential to the circle of rotation around the impeller shaft. And if the shaft is placed vertically and centrally tangential flow follows a circular path around the shaft and creates a vortex in the liquid ok.

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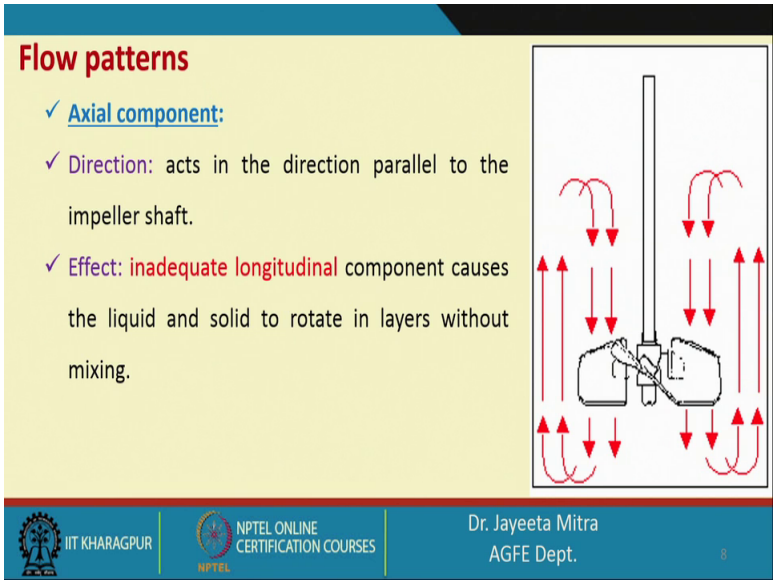


So, creation of the vortex will be beneficial because, then the mixing will be good. Now, actual component, when we see. So, in this figure the blades are this is kind of a curved blade we used and this curved blade will insensate and actual or longitudinal flow ok.

So, these are the these are also called the popular blade or curved blade are there. So, these acts in the direction parallel to the impeller shaft. So, this is the shaft and in the parallel direction, the flow of the liquid will be there so, it in what the liquid in the in the longitudinal direction. So, if the inadequate longitudinal component takes place that will cause the liquid and solid to rotate in layers without mixing. So, that if this axial component of the mixing should be proper particularly when, it is a case of the solid and liquid mixture.

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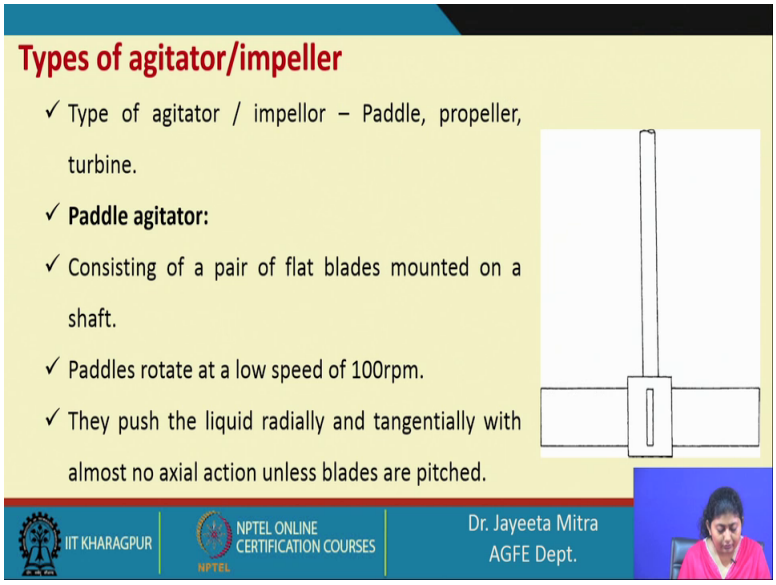


Now, types of different agitator and impeller. So, they may be different kind of impeller or agitator and that will be useful for particular kind of liquid or liquid solid or different kind of mixtures. For example, paddle mixtures are there, propeller mixtures are there, turbine mixtures are there. Now, paddle agitated is looks like this, paddle central shaft is there and the paddles are there and these are having the you know there is no curved portion is there then, these are simple and straight blade kind of agitators, this consist of a pair of flat blade mounted on a shaft.

This paddles, rotate at a low speed of 100 rpm ok. So, a pair of flats flat blade are there that is called the paddle and these rotates at a low speed, that is 100 rpm. They push the liquid radially and tangentially with almost no axial action, they push the liquid radially. So, if it rotate so, you can visualize that it will throw the liquid in a tangential direction that is 1 and some may be in the radial direction. So, no axial direction will be there unless the blades are pitched blade.

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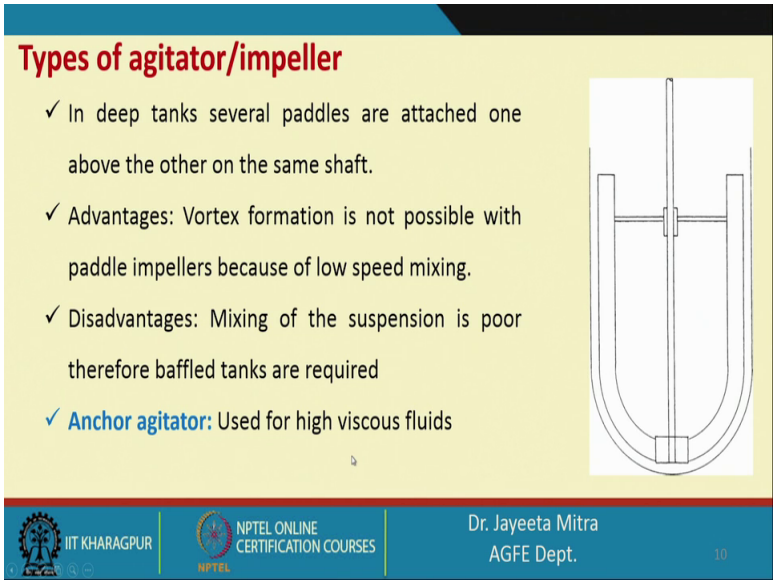


Then in next case, we will see that for the deep tank, several paddles are attached one above the other on the same shaft. So, this is another mechanism that in the same shaft, if you use more number of paddles, if for a particular kind of large or very high tank. Then there will be advantages and vortex formation is not possible with paddle impellers, because of the low speed mixing and disadvantage is that the mixing of the suspension is poor therefore, the baffle tanks are required ok.

So, types of agitated or impeller, if you see this is another kind of which is the anchor agitated. This is used for the high viscous fluid, these are anchor agitated. So, the blades are the shape of kind of a anchor and it will since, it surrounds the whole region and it has high power of mixing. So, it is used for the high viscous fluid because, it has a is a kind of a sharing and a blade it will it will help in moving, the viscous liquid, because of trust will be more, because of the length of the of the blades ok.

So, this is one kind of and here we have seen that the vortex formation is not possible that consider as an advantage, because if vortex formation will be there. The chances of the local mixing will be high, but uniform mixing will be not there in the whole chamber therefore, the to therefore, the vortex formation is prohibited by this mechanism.

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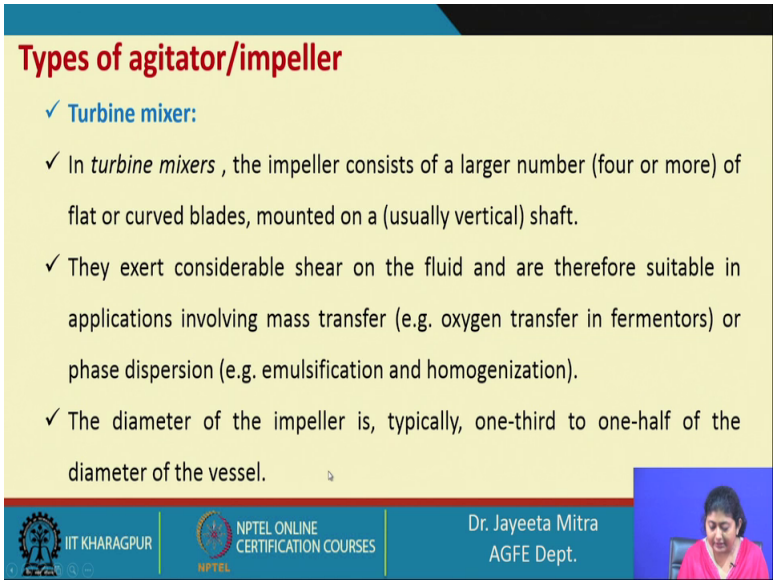


Now, next type of agitated or impeller is that turbine mixture. In turbine mixture the impeller consist of large number that is 4 or more number of flat or curved blades these are mounted on a usually vertical shaft. So they exert considerable shear on the fluid and are therefore, suitable in application involving mass transfer. So, because of this the curved blade and they consider, they exert considerable shear on the fluid and therefore, the suitable for application involving the mass transfer. As for example, oxygen transfer in fermentors or phase dispersion, as for example, emulsification and homogenization.

So, phase dispersion that is emulsification and homogenization. So, in homogenization we also do another application along with this dispersion of the fact. In fact, produce into the other liquid that is the liquid milk, what is does is? It with mixing it reduces the size of the particle as well. So, that is why the difference in the homogenization is such that, it initiate the particle mixing as well as the size reduction. Now, the diameter of the impeller is typically one third to one half of the diameter of the vessel or tank dia. So, with that one third or one half of the diameter, we consider specially, in case of this turbine mixture.

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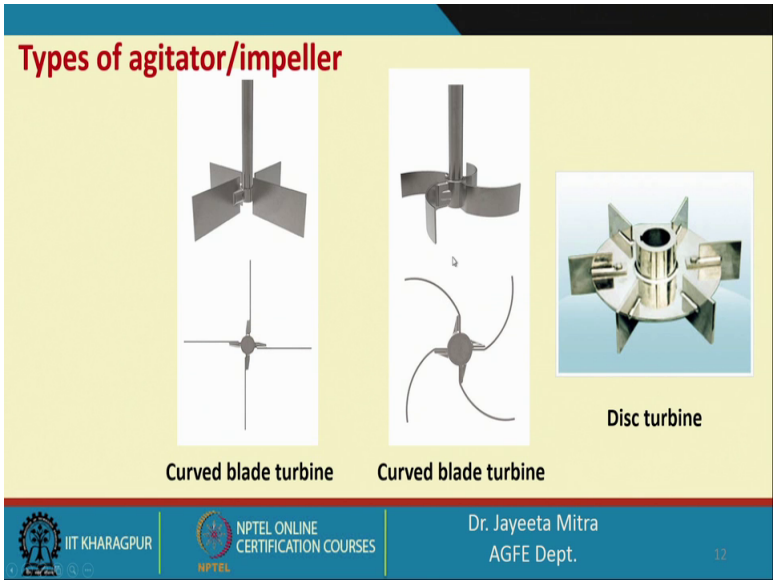


So here, the types of agitated or impeller given. Curved blade turbine, this is also can be of many types. So here, this is the curved blade, this can be of flat as well as little curved section and this is the disc turbine were the flat disc is there, in that the blades are attached. Whereas, in the in curved blade turbine, there is no this portion is there only with the shaft, the curved blades are attached. So, these are the various kind of agitators or impeller.

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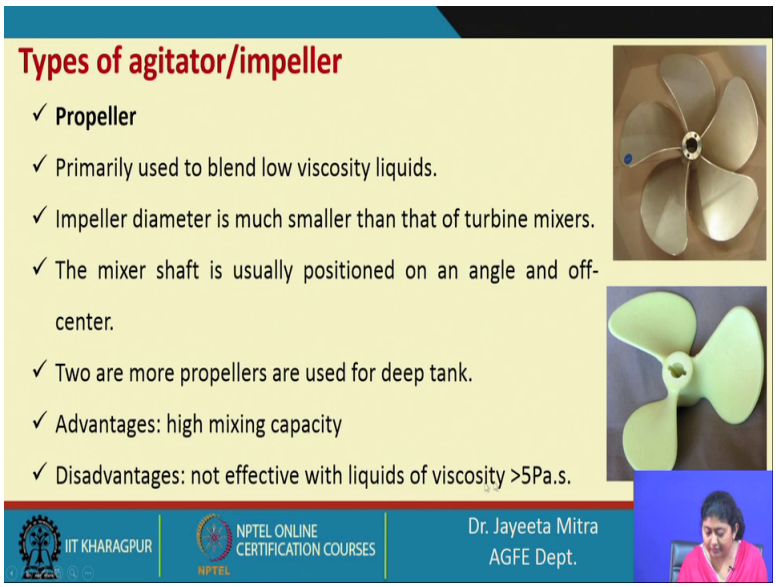


Now, another is the propeller kind of impellers. So here, is the picture how the propeller type agitated looks like ok. So, these are as the picture is shown, it is kind of initiating the axial mixing of the liquid. So, primarily used to blend low viscosity liquids and

impeller diameter is much smaller than that of the turbine mixture and the mixture shaft is usually positioned on an angle and off centre. And the two are in the two are more propellers are used for deep tank, two or more propellers that is in the same shaft more propellers we can use, this is the advantages high mixing capacity and disadvantages not effective with liquid of viscosity higher than 5 Pascal second. So, for the low viscous sample only, this propeller type of impellers are used. So, these are about the different kind of impellers, we will stop here and we will continue in the next class.

Thank you.