

Fundamentals of Food Process Engineering
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Lecture – 47
Mixing and Agitation (Contd.)

Hello everyone. Welcome to the NPTEL online certification course on Fundamentals of Food Process Engineering, we are continuing with the topic of Mixing and Agitation.

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Content

- ✓ Introduction
- ✓ Mechanism of Solid mixing
- ✓ Mixing index and mixing
- ✓ Mixers for dry powders
- ✓ Mixers for cohesive solids
- ✓ liquid mixing: flow patterns, Types of agitator
- ✓ Power requirement for liquid mixing

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In the last class, we have discussed about what is a importance of mixing and agitation, what are the different purpose and what are the cases where we use this.


We are started with the solid mixing first and then we have discussed mixing index and mixing process. Now today, we will start from the mixers for dry powders and then we will move on to the other topics that is mixer for cohesive solid liquid mixing and power requirement for liquid mixing.


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Powder mixers


- ✓ **Tumbling mixer:**
- ✓ Types: horizontal drum, double-cone, V-cone, Y-cone, and cube.
- ✓ Operated in batch mode being partially filled with solids
- ✓ Tumbling mixers are run at a fraction of the critical speed required for centrifugation with a practical maximum speed of about 100 rpm.
- ✓ Such mixers may have baffles fitted to the inner walls which help to lift solids or alternatively may be fitted with ploughs to assist convection.




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So, first we will see the powder mixers. So, as we know that the characteristics, the bulk flow characteristics of the liquid and the solid are very different that is why the mixer used for solid material and for the liquid mixer is totally different. And the liquid mixing part some extent we might have seen in your fluid mechanics class as well.

So, here we will see for the mixer for the solid, one such mixer for the powder is tumbling mixers. There may be horizontal drum, double cone type, V-cone type, Y-cone type and also like cube type. These are operated in batch mode being partially filled with the solid.

So, as we need to mix it thoroughly, we need to give some free space to revolve it completely and to have all those mechanism as mentioned that the convective diffusive or shear mixing. So, therefore, we cannot fill it completely for mixing; for a certain degree of fill is desirable. So, these are operated in batch mode all such horizontal drum or tumbling mixer, because as the name suggest we need to perform those tumbling operation here. Tumbling mixers are run at a fraction of the critical speed required for centrifugation with a practical maximum speed of about hundred rpm ok.

So, we will see that the speed is not very high very low or rmp run this and such mixers may have baffles ok. Baffles fitted to the inner wall which helps to lift the solids or alternatively may be fitted with the ploughs to assist the convection.

So, the barrels are like if you have this is a tank or this is kind of a mixer that you are using. So, in the wall there are baffles ok. So, this will help in lifting of the solid that that is there in the chamber some portion of the filling will be there.

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Powder mixers

- a. *Horizontal cylinder* :
- b. *Double cone blender*: The double cone blender consists of two cone-shaped sections, typically with 45° slopes.
- c. *V-cone blender* : V-cone blender consists of two large diameter pipe sections cut at a 45° and welded together to form a V.
- d. *Y-cone blender*: In the same way, the Y-cone blender has a third section that extends the volume of the blender in a bisecting direction with respect to the other pipe sections.

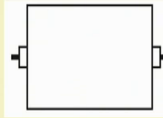


Fig. a

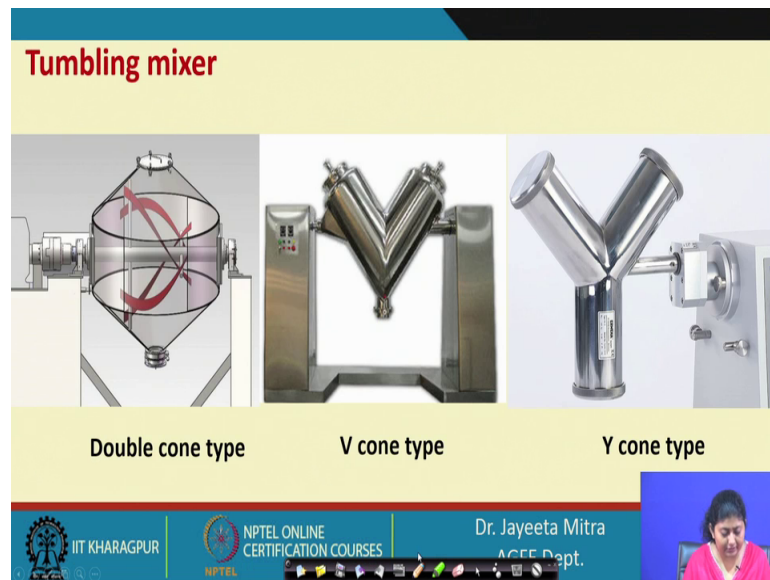
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So, the lifting will be you know initiated or that will be easier if you use the baffles there ok. So, these are the tumbling mixer. Then we will see horizontal cylinder kind of mixers will be there. Double cone blender, the double cone blender consists of 2 cone shaped sections typically with an angle of 45 degree slopes. So, here first one is the horizontal cylinder, we can see that there is a horizontal horizontally oriented a barrel is there and it is rotating based on that central shaft and thereby it is initiating the mixing.

So most of the; I mean there is likely to cause diffusive mixing, where the particle is constantly diffuse into the inter particle coarse ok, then double cone blender and V-cone blender. The double cone blender consists of 2 cone shaped sections typically with 45 degree slopes, we have the diagram will show you. And then, V-coned blender, this consists of 2 large diameter pipe sections cut at 45 degree and welded together to form a V.

Y-cone blender in the same way, the - cone blender has the third section. So, with that V-cone is another section that extend the volume of the blender in a bisecting direction with respect to the other pipe sections. So, we will see the geometry here.

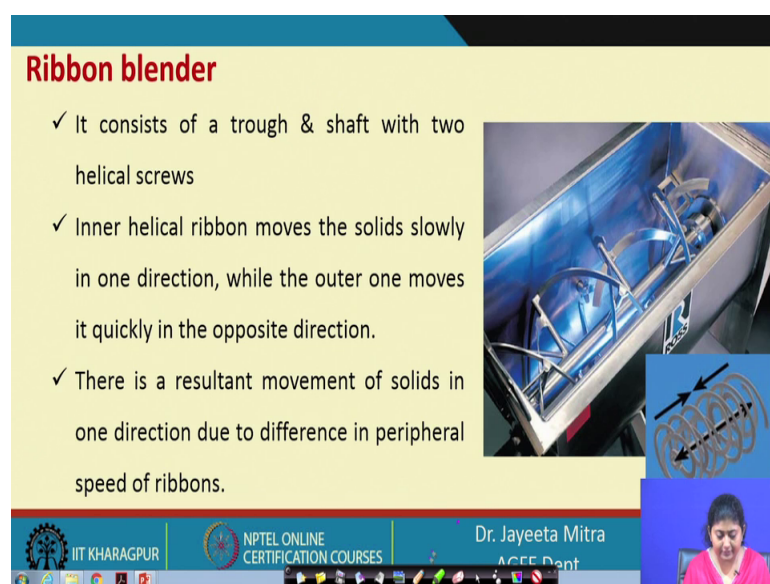
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Double cone type is this one and there is a spiral blades are also there, which will help you to initiate proper mixing and there is V-cone type. So, V-cone type is this one and these are also can be revolved freely. There is a Y-cone type mixer, this there is a 3 1 extra cylinder added to V-cone and this will also have give some extra volume and a better mixing.

So, these are the tumbling mixers different kind of tumbling mixer used for solid mixing.

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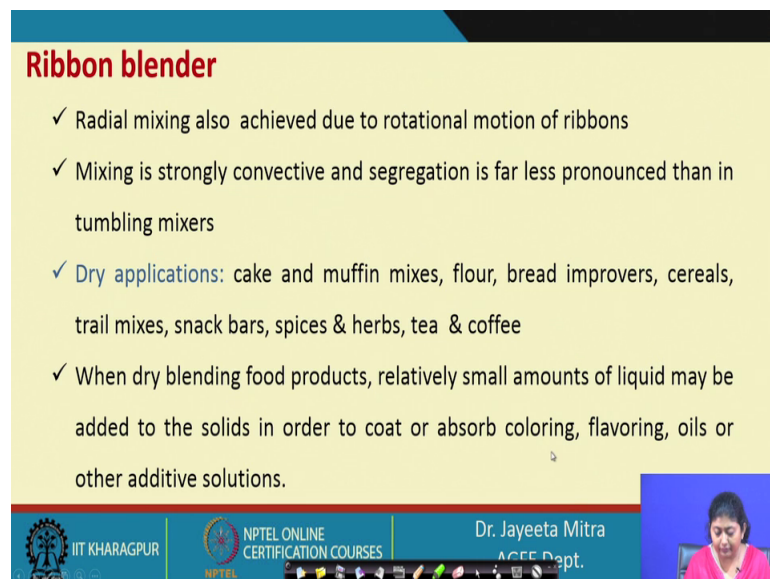
Now the ribbon blender, ribbon blender this initiate the convective mixing if you remember the that was also one mechanism ok. So, it consist of a trough and shaft with 2 helical screws.

There is a trough, there is a trough this one and there is a central shaft is there this one is the shaft with 2 screw, this is one and this is one 2 helical screw is there. So, if you can see in this diagram also it is clearly visible that the two different screw are there, one is rotating in the inner side another is the outer side.

So, inner helical ribbons moves the solids slowly in one direction as the convective motion or convective mixing takes place, while the outer one moves it quickly in the opposite direction ok. So, inner helical ribbon moves the solids slowly towards the forward direction and in one direction where the other moves the quickly in the opposite direction. So, because of this change in the movement the mixing will be done.

There is a resultant movement of the solids in one direction due to the difference in peripheral speed of the ribbons. So, this is how the ribbon blender operates.

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Ribbon blender

- ✓ Radial mixing also achieved due to rotational motion of ribbons
- ✓ Mixing is strongly convective and segregation is far less pronounced than in tumbling mixers
- ✓ **Dry applications:** cake and muffin mixes, flour, bread improvers, cereals, trail mixes, snack bars, spices & herbs, tea & coffee
- ✓ When dry blending food products, relatively small amounts of liquid may be added to the solids in order to coat or absorb coloring, flavoring, oils or other additive solutions.

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Now, radial mixing also achieved due to rotational motion of the ribbons. Radial mixing that is in a radial direction also mixing is been done as associated with the movement of the ribbons. Now, mixing is strongly convective and segregation is far less pronounced than in the tumbling mixers ok.

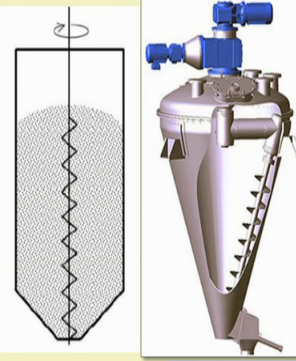
So, here that means, it helps in proper mixing segregation is not there, then dry applications this is used for the cake and muffin mixes, flour, bread improvers, cereals, trail mixes, snack bars, spices and herbs, tea and coffee. So, all these cases these application will be there and when the dry blending food products relatively small amounts of liquid maybe added to the solids in order to coat or absorb colouring, flavouring, oils or other additive solutions ok.

So, these are the application where this the dry mixing will takes place.

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Vertical screw mixer

- ✓ Cylindrical or cone shaped vessel.
- ✓ The screw may be mounted centrally or orbit around the central axis of the vessel near the wall.
- ✓ Materials are lifted from the bottom are then exchanged with materials on the way up.
- ✓ Useful for mixing small quantities of additives into large masses of material.



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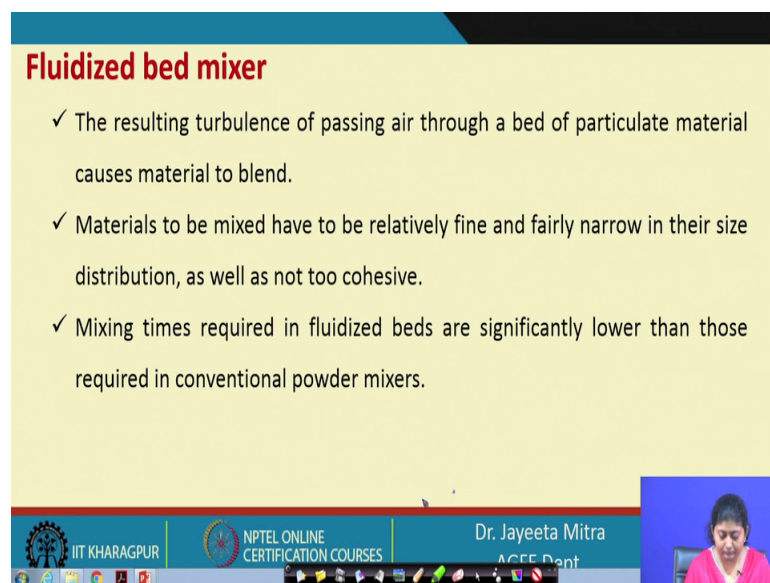
Next is the vertical screw mixer. So, we can said we can see here that that the cylindrical or cone shaped vessel are there ok; other cylindrical vessel or the cone shaped vessel can be there and in that the spiral screw will be there. So, the screw will be either centrally mounted as in the figure 1 or this is set in a this is orbit around in a slanting side of the conical vessel and it is moving with the orbiting around the central axis or moving around the central axis ok.

So, these are called the screw mixers. Vertical screw mixers materials are lifted from the bottom are then exchanged with the material on the way up. So, from the bottom because of the screw motion the material will be lifted to the top. And then again it will be mix with the materials.

This kind of mixers vertical screw mixers are, useful for mixing small quantities of additives into large masses of the material ok. So, when a small fraction of one component has to be added to the larger fraction of the other component then, we need to use this one.

So, that thorough mixing from the bottom to the top layer will be there and this will be even more suitable, if we use the orbit mounted orbit kind of screw can screw mixtures. So, it will initiate the better mixing.

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Fluidized bed mixer

- ✓ The resulting turbulence of passing air through a bed of particulate material causes material to blend.
- ✓ Materials to be mixed have to be relatively fine and fairly narrow in their size distribution, as well as not too cohesive.
- ✓ Mixing times required in fluidized beds are significantly lower than those required in conventional powder mixers.

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Next type of the mixer is called fluidized bed mixer, the resulting turbulence of passing air through a bed of particle material causes material to blend properly ok. Because in fluidization what we do is, there is perforated sheet or cloth or trace there through which we send the high velocity air that the particles, which needs to be needs to be dry or need to be mix properly. That will become in a suspended state and there by the proper mixing will be there.

So, because as there kept at a suspended for fluid is state by application of high velocity air, we call it the fluidized bed mixer. So, materials to be mixed have to be relatively fine and fairly narrow in their size distribution as well as not to cohesive; because if they are fine particles then only the proper fluidization will be easier. And if they are cohesive then also they will not be exposed properly on the on the fluid stream and the proper mixing will not be done.

Mixing times required in fluidized beds are significantly lower than, those required in conventional powder mixers. So, mixing time required in fluidized beds are significantly lower than those required in conventional powder mixers. So, this is because when we use the fluidized bed. So, each and every particle these are in you know fluidized state and from the all phases it is open to mix with the other composition.

But that cannot happen when we use the powder mixer, conventional type, tumbling type like that. So, then what happens that to get an uniform composition time requirement will be more, because every with every instance very small fraction will be you know coming contact with the material and the uniformity to take you know, the whole zone will be a uniform composition. So, that extent mixing will take of a longer time.

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Mixers for cohesive solids

- ✓ Mixing elements cannot generate flow currents
- ✓ High viscosity
- ✓ High power consumption
- ✓ Types:
 - 1) Change-Can mixer
 - 2) Kneaders, Dispersers & Masticators
 - 3) Mixer extruders & Mixing rolls
- ✓ Mixing is by combination of low speed - Shear, Smearing, Folding, Stretching & Compressing.

The slide also features a small video inset of Dr. Jayeeta Mitra, ACEE, Dent, and logos for IIT Kharagpur and NPTEL Online Certification Courses.

Next, we will see the mixture for cohesive solids. Now the property of the cohesive solids is again different from the property of the free flowing solid material for that, we have use the tumbling mixer or fluidized mixer, but we cannot use those for the cohesive solids.

But mixing elements cannot generate the flow current. Mixing elements cannot generate the flow current, because if we use any this kind of a mixture that is use for that is use for the solid particles. So, even in the solid also they generate some kind of flow; but this cohesive solid because, they have very high viscosity and cohesive in nature, so therefore, they cannot generate flow currents. High power consumption this is one

significant thing that this needed for the cohesive solid and the types will be change can mixer, kneaders, dispersers and masticators mixer extruders and mixing rolls. Mixing is by combination of low speed shear, smearing, folding, stretching and compressing.


So, here we can see that there are clock many individual applications that combiningly combinedly use in the mixing of cohesive solids. Those are the low speed, shear, smearing, folding, stretching and compressing.

So, those might have seen the dough making process in the or you have seen the Farinograph analysis, there we use this kind of a shear mechanism to need the dough properly. So, there is a kneader blade and a very particular shape of the kneader blade is used. So, that it can give a proper shearing action to the material and eventually make it often uniform composition even, if the moisture contain is very high.


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Change can mixer

- ✓ Principle: Change can mixers work by the relative motion of the blades and the can
- ✓ Types: pony mixer & beater mixer
- ✓ In the pony mixer, the rotating agitator carries several vertical blades positioned near the vessel wall.
- ✓ The can is driven by a turntable in a direction opposite to that of the agitator.



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So, first you see the change can mixer. The principal is change can mixer work by the relative motion of the blades and the can. So, the type is pony mixer and beater mixer, in the pony mixer the rotating agitator carries several vertical blades positioned near the vessel wall. The can is driven by a turntable in a direction opposite to that of the agitator.

So, we have seen that there are lot of the lot of blades are there that is mounted on the on the top section ok. So, the rotating agitator carries several blades these are these are

rotating and the blades are also rotating with that rotator and their positioned near the vessel wall.

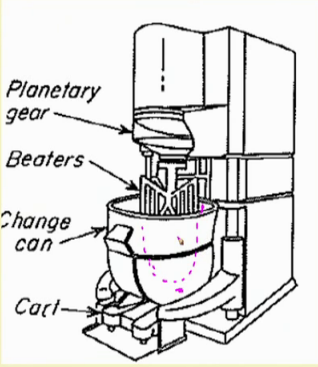
The can is driven by a turntable in a direction opposite to that of the agitator ok. So, they are rotating in a opposite direction. So, that this opposite direction. There will be very less space between the blades and the periphery or the barrel inner side.

So, in between that small gap, the door will be shear and because of this shearing action the mixing will takes place.

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Change can mixer

- ✓ Beater mixer
- ✓ Can or vessel is stationary
- ✓ Agitator has a planetary motion
- ✓ Beaters are shaped to pass with close clearance over the side & bottom of mixing vessel



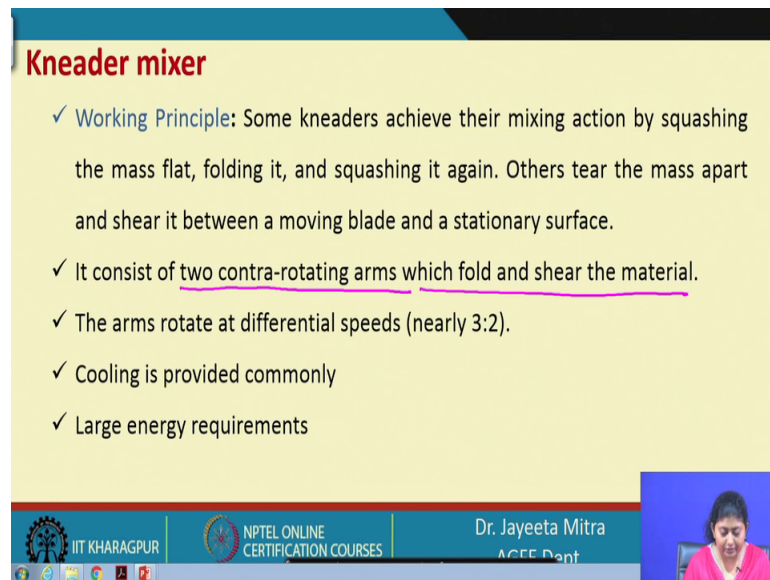
The diagram illustrates a change can mixer. It features a central vertical shaft with a planetary gear at the top. Below the gear are several beaters that rotate around the central shaft. The beaters are positioned inside a change can, which is mounted on a cart. The cart is shown with a dashed line indicating its rotation. The entire assembly is supported by a base.

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So, in that category another is the beater mixer. So, in that beater mixer what happened that, there is a can or vessel which is a stationary one and agitator has a planetary motion. So, there is an agitator this is kind of a beater mixer is there, where there is stationary vat is there or stationary can is there and there is a agitator which has a planetary motion. So, this is called the beater this is called the beater and there is a change can, there is a cart, there is a planetary gear, which helps in rotating this arrangement.

So, the agitator has a planetary motion and beaters are shaped to pass with close clearance over the side of over the side and bottom of the mixing vessel. So, at one side at one peripheral at one peripheral side and also at the bottom, it may have some kind of geometry like this at the bottom and the periphery, it will be utilized for shearing of the do material for proper kneading.

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Kneader mixer

- ✓ **Working Principle:** Some kneaders achieve their mixing action by squashing the mass flat, folding it, and squashing it again. Others tear the mass apart and shear it between a moving blade and a stationary surface.
- ✓ It consist of two contra-rotating arms which fold and shear the material.
- ✓ The arms rotate at differential speeds (nearly 3:2).
- ✓ Cooling is provided commonly
- ✓ Large energy requirements

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(A small video inset in the bottom right corner shows a woman speaking.)

Then kneader mixer working principle is that some kneaders achieve their mixing action by squashing the mass flat folding it and squashing it again ok. So, this is a you know common mechanism, if you see kneading action in home or any you know small scale industries you have visited. So, you know that first the sheeting thing is done or squashing is done and then this is you know rolled this is rolled properly.

And then again squashing or stretching forces will be given ok. So, these are the normal action of the hand by, which we need normally any dough and the same action has been simulated using a particular kind of blade. So, that will do the act of kneading.

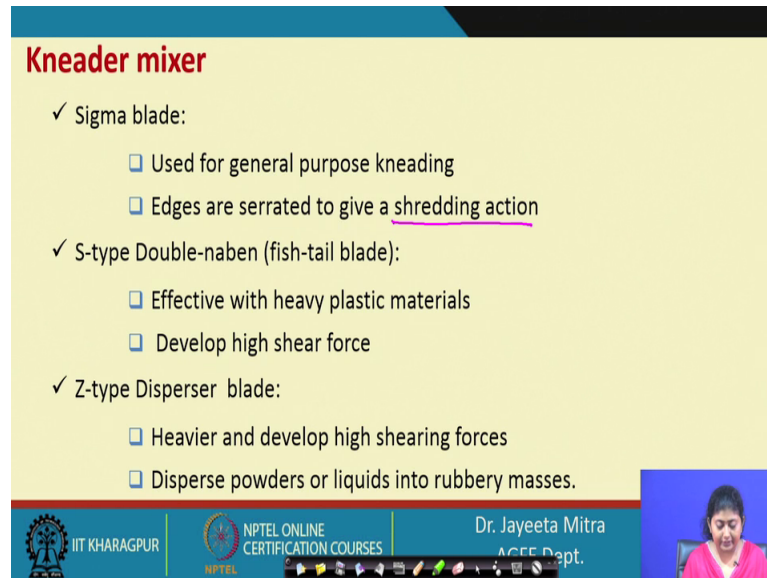
So, others tear the mass apart and shear it between a moving blade and a stationary surface. So, two kinds of kneaders we may get in a normal practice in the industry, one is called the kneader, where the mixing action is by squashing the mass flat folding it and again squashing. And the other method is that shear it between a moving blade and the stationary surface.

So, it consist of 2 contra rotating arms which fold and shear the material and the arm rotate at differential speeds nearly 3 is to 2 ok. So, the speciality is 2 contra rotating arms is there, which fold and shear the material, cooling is provided commonly.

So, we can use a jacketed kind of system, where if the excess heat will generate. So, that can be cool immediately and large energy requirement. So, for kneading operations the

energy requirement is bit high, because these are highly cohesive material. And to make it in a movable or foldable condition are to stretch it properly to squash it properly lot of energy requirement is needed.

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Kneader mixer

- ✓ Sigma blade:
 - Used for general purpose kneading
 - Edges are serrated to give a shredding action
- ✓ S-type Double-naben (fish-tail blade):
 - Effective with heavy plastic materials
 - Develop high shear force
- ✓ Z-type Disperser blade:
 - Heavier and develop high shearing forces
 - Disperse powders or liquids into rubbery masses.

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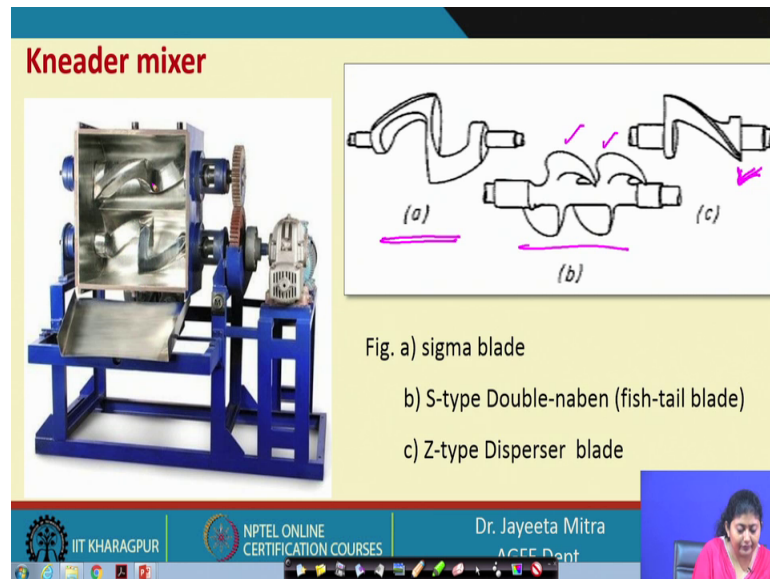
Now, coming to the different kind of the blades of the kneader mixer, we have seen that one kind of blade is sigma blade. This is use for general purpose kneading and edges are serrated to give a shredding action.

So, with sharing here we are providing shredding action also; that means shredding means we tear them in many parts ok. So, these are the sigma blades then S-type double-naben, fish tail blade these are effective with heavy plastic materials and develop high shear force these, S-type blade the other type is Z-type disperser blade.

So, what it does the heavier and develop high shearing forces Z-type disperser blade these are heavier blades and develop high shearing forces. So, the cases were high shear forces require. So, the cases were high shearing forces were required very cohesive kind of example we can use this, disperse powders or liquids into rubbery masses.

So, that is another application of this Z-type of dispersion it disperse powders or liquid into rubbery masses.

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So, these are called the kneader mixer as I said the sigma blade, sigma blade is the first figure this is the sigma blade and the second one, which is the S type double-naben, fish tail blade this is this one, this is look like this is look like an S.

So, this kind of double-naben blade are, there and the other which is used for very viscous material. So, this is the Z-type blade ok. So, we have seen that in a dough kneading in Farinograph other this sigma blade are Z-type blade, these are use normally and here is also one kneader mixer the picture is given.

But this two blades are attached and there is a trough, where these are rotating and in between there is also one deviation or demonstration is given. So, that one blade is moving in one trough, and other blade is moving at another trough, and they are rotating in a deferential speed and making the mixing properly ok.

So, here we will stop and we will continue in the next class.

Thank you.