Manufacturing Automation
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Lecture – 12
Bladed Wheel and Tumbling Barrel Hopper Feeder

Welcome back. So, we will continue discussing what we started in the last class. I will quickly remind you that we have discussed quite a few of hopper feeders in the last classes.

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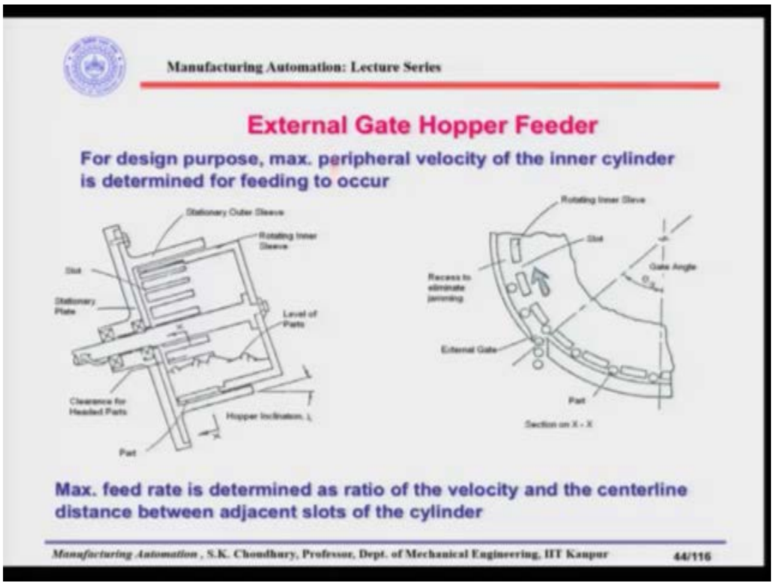

One of them is the external gate hopper feeder as you can see here. So, once again, here we have a stationary outer sleeve and the rotating inner sleeve, sleeve has the slots and the mass of the parts are at the base of this rotating inner sleeve. So, when the rotating inner sleeve is rotating, from the mass of the parts the parts will be nested in the slots and when the slots will be aligned to the external gate, external gate is located on the stationary outer sleeve, the parts will be falling down.

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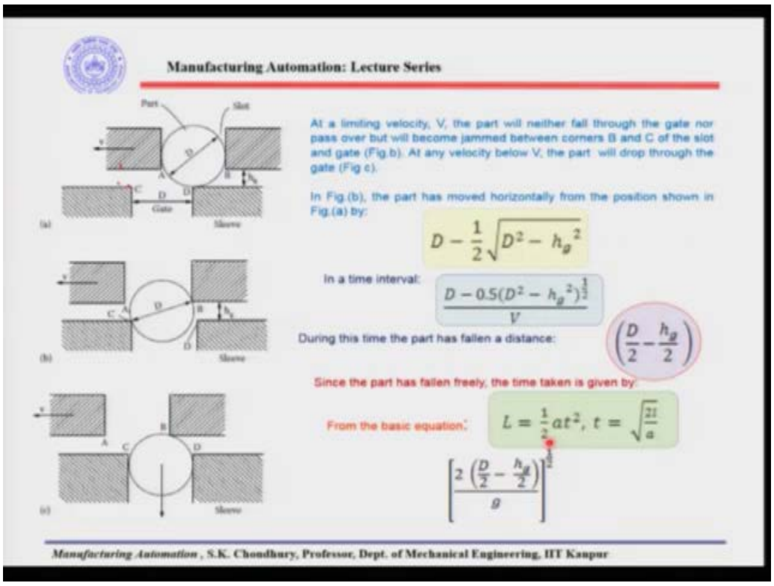

So, here in this analysis what we said is that at a critical velocity, the part may not fall and part will actually clog or jam between the edge B and C. Now, if the velocity is below the velocity of the critical velocity then parts will actually fall through the gate and the gate diameter is equal to the diameter of the part. Now, if the velocity is more than the critical velocity, again then the part by inertia will pass through and it will not fall through the gate. So, only at a velocity lower than the critical velocity the parts will fall, that is what we said.

Now, here to get the maximum feed rate, to summarize that, maximum feed rate we could get by the velocity divided by the adjacent slot length. Therefore, to get the velocity, principle that we have adopted is that, the part while moving towards the gate is actually covering a certain horizontal distance and at the same time it is falling vertically.

So, since these two times are the same, if you can find out the horizontal distance and the vertical distance it is falling, they could be equalized and from that we found out what is the velocity. So, once again let me explain it to you because this may not be very clear like, to find out that from this position while moving to this position from A to B, how much horizontal distance that the part has covered, this will be equal to $\frac{D}{2}$.

So, as we are discussing in the case of external gate hopper feeder, now here what we have to find out is the critical velocity and we know the distance traveled.

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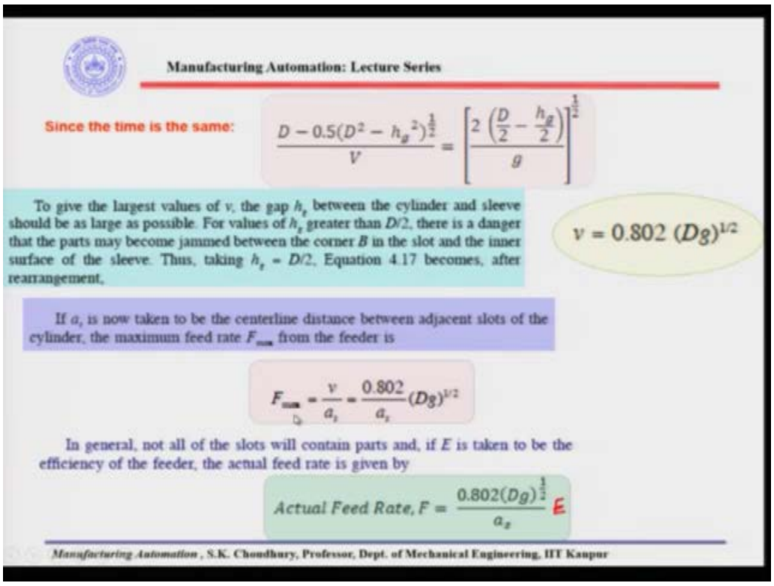

So, the critical velocity can be found out from the distance travelled; that means, the distance while moving from this position to this position, the part is moving horizontally to a certain distance and at the same time the part is falling vertically; that means, moving down.

So, part is moving horizontally because of the velocity that the outer inner rotary disk is having and this distance moved horizontally can be given as $\frac{D}{2}$. And $\frac{D}{2}$, we can actually figure out from $D - \frac{D}{2}$ will be $D - \frac{1}{2}\sqrt{D^2 - h_g^{\,2}}$, this is the $\frac{D}{2}$.

Now, since this distance is moved because of the velocity, this critical velocity, if we divide this distance by the velocity, we can find out the time interval during which the part has moved horizontally. Now, while doing so while moving horizontally, the part also has fallen down so; that means, it has moved vertically and that vertical movement can be given by $\frac{D}{2} - \frac{h_g}{2}$. So, half of that it has gone and half of the $\frac{D}{2}$ it has fallen down, you can see from the diagram, let us say if it is falling down up to this, it has gone up to the $\frac{D}{2}$ and also the half of this distance.

So, this is the distance that it has fallen down and since it has fallen by the gravity, so, if you divide by gravity, you can find out what is the time during which the part is moving vertically. Now, this time during which the part is moving horizontally as well as vertically they are the same. Therefore, we can equalize both the times and solving this we can find out what is the value of velocity. Once we found out the amount of velocity that we can divide by the distance between the adjacent slots and we can find out what is the maximum feed rate.

So, as I said we discussed that maximum feed rate we cannot get. So, it has to be multiplied by the efficiency. So, if we multiply by the efficiency, E then we can get the actual or average feed rate. So, this is the principle how we can get the actual feed rate so that it could be matched with the feed rate that the assembly machine requires.

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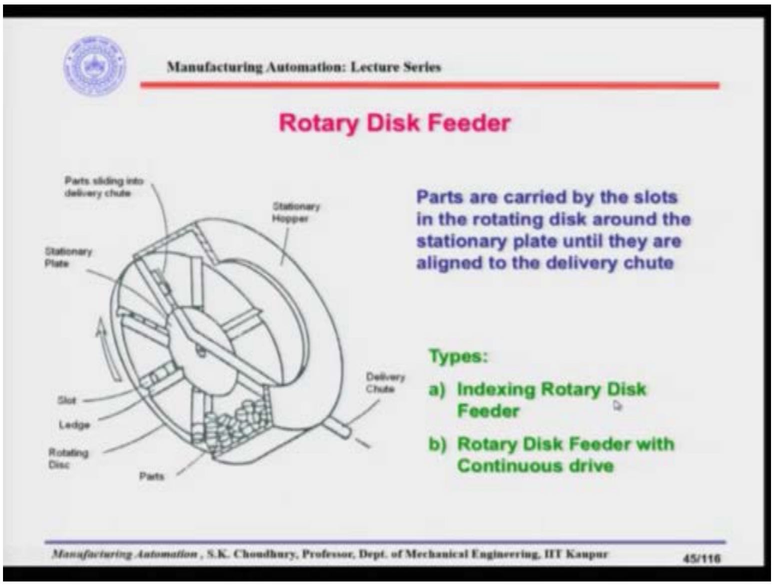

After that we have discussed the Rotary Disk Feeder. In here we have the bowl and the base of the bowl rotating and at the base of the bowl we have the slots and those slots are protected by the ledges here and by a stationary disk, so that when the parts will be nested in the slots, the parts will not be falling down in this direction or in this direction.

There are two types of rotary disk feeders; one is the indexing type; indexing type is when it will go from one position to another position, it will stop for some time, dwell for some time, so that the parts could be moving down the track, down the slot and there is another design which is called the rotary disk feeder with continuous drive. In that case, it will be continuously driven and the part will be different, part will be a disk type and once only one part will be taken and that part will be falling down when the ledge will be aligned to the delivery chute. So, there will be no stop over or dwelling time.

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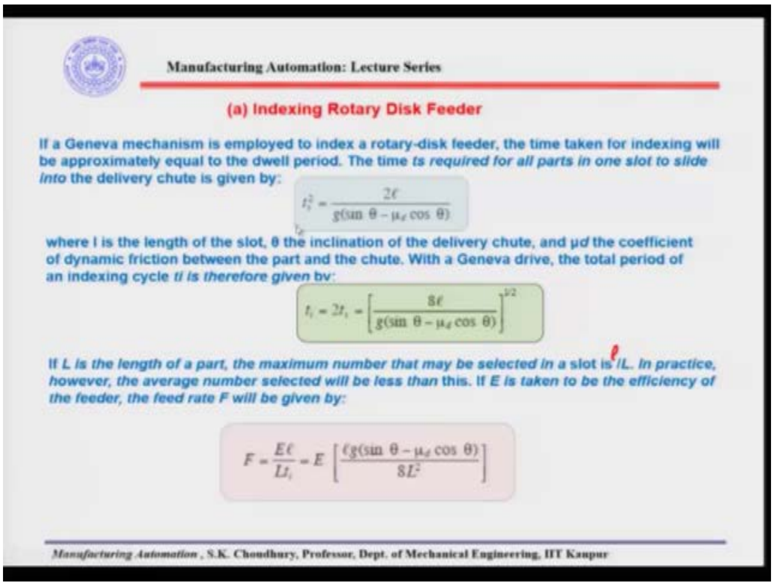

Here, we can find out the maximum feed rate or the mean feed rate by finding out how much time it is taken, if a Geneva mechanism is involved, we consider that the index time and the dwell time is the same. So, this can be found out from the $\frac{2l}{g(\sin\theta - \mu_d\cos\theta)}$, which is $t_s^{\,2}$ if you remember, we have done that earlier.

So, this is coming from, as I said, $l = \frac{1}{2}at^2$. So, here also it is the same way and we can find out the t_s, this is the time required for either indexing or dwelling and we are assuming that this is the same. So, two of these t_s, that is the dwelling time plus the indexing time, will give you the complete time and this is equal to $t_i = 2t_s = \sqrt{\frac{8l}{g(\sin\theta - \mu_d\cos\theta)}}$.

Now, this is the maximum feed rate that we can get and that multiplied by the efficiency will give you the mean feed rate of the feeder. So, this we have discussed.

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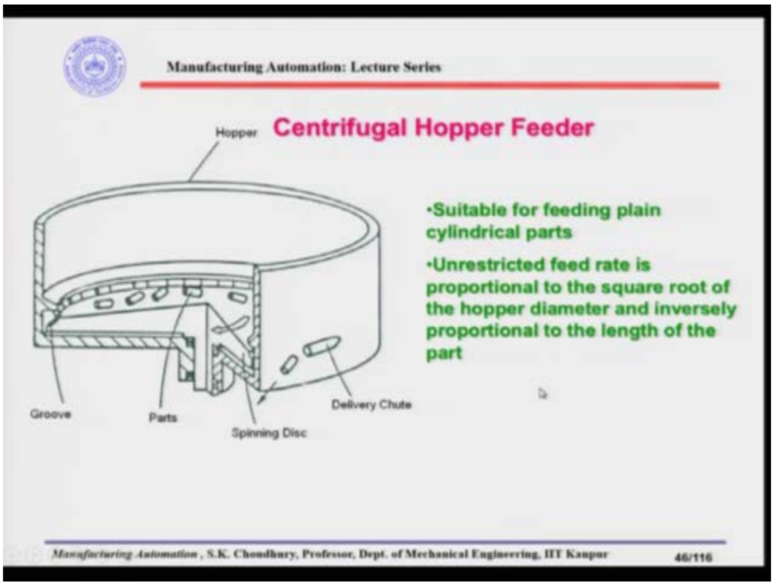

Next we discussed the centrifugal hopper feeder, where we have the base which is rotating and during the rotation the parts are being imparted a centrifugal force. Because of the centrifugal force, the parts are nested in the slots which are located at the outer periphery of the inner disk and when these slots will be aligned to the delivery chute, the parts will be coming out one by one.

This is suitable for feeding the plane cylindrical parts, as shown here and the unrestricted feed rate is proportional to the square root of the hopper diameter and inversely proportional to the length of the part that we have seen actually in other feeders earlier also.

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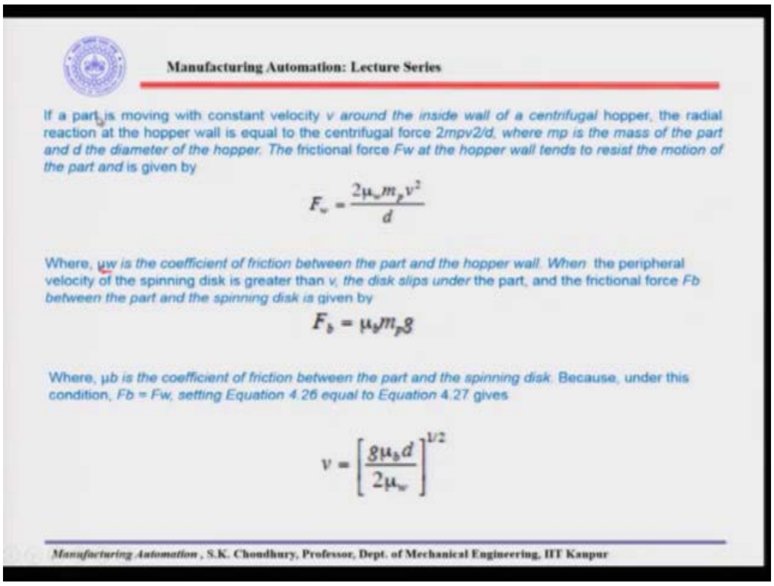

So, if a part is moving with a constant velocity V around the inside wall of a centrifugal hopper, the radial reaction of the hopper wall is equal to the fictional force with the wall. Frictional force with the base, that we have said, occurs if the base is rotating at a higher speed than the velocity of the part, the parts will slips and over the spinning disk. And then the frictional force on the base will be equal to $F_b = \mu_b m_p g$, $m_p g$ is the mass of the part which is acting vertically, that multiplied by the coefficient of friction between the part and the base and that will give you the frictional force on the base.

Now, F_b and F_w are the same, we said because the material of the part is the same as the material of the spinning disk and the wall assuming to be same and therefore, $F_b = F_w$. From here we can find out that the velocity V at which the parts are moving that will be equal to this factor, as shown in the slide. So, you can see that this is proportional to the $\sqrt{d}$ which is hopper diameter.

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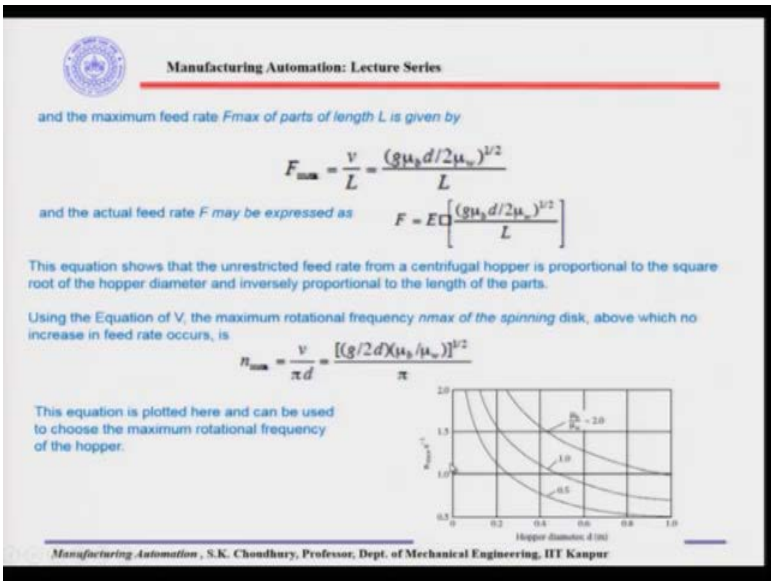

And this divided by the part length will give you the maximum feed rate. Therefore, we said that the maximum feed rate is proportional to the velocity and inversely proportional to the part length.

Now, the actual feed rate is given by multiplying this factor with the efficiency and efficiency into this will give you the actual feed rate because as we said maximum feed rate we do not get. This equation shows that the unrestricted feed rate is proportional to the square root of the diameter of the hopper and inversely proportional to the length of the part.

Now, using the equation of the V, that we have said, now the maximum rotational frequency n_{max} of the spinning disk can be obtained above which no increase in the feed rate occurs. What we are saying here basically that we have the velocity.

So, from the velocity knowing the diameter of the hopper disk, we can find out what is the n_{max}, the maximum rotational frequency above which no increase in the feed rate occurs. So, n_{max} will be $\frac{V}{\pi d}$ because πdn is the velocity. So, the velocity will be known and that divided by the πd will give you the maximum rotational frequency. Now, this equation if you plot here, in the y-axis we have the n_{max} and unit is 1 by second, this is the hopper diameter in meter.

So, depending on the hopper diameter and by varying the ratio of these two coefficients of friction, that is between the part and the base and the part and the wall, this will be the curve that if you are using, if you are increasing the hopper diameter, the $n_{\max}$ is actually decreasing, can be used to choose the maximum rotational frequency from here. So, if you have to have the maximum rotational frequency, then what is the hopper diameter that you have to select for a particular ratio of the μ_b and the μ_w can be found.

So, this is kind of a calibration curve that is made so that the maximum rotational frequency you can select, depending on the hopper diameter.

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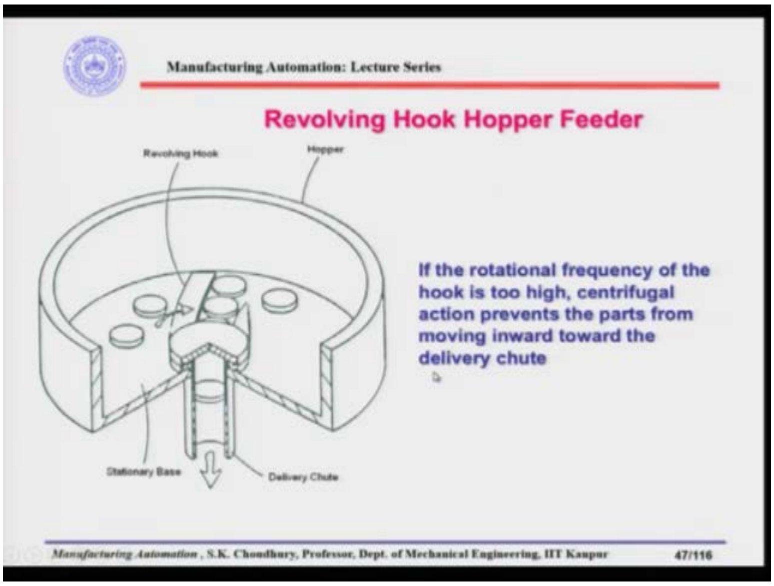

Here there is another hopper feeder this is quite simple and this hopper feeder is called the revolving hook hopper feeder because in this hopper feeder, there is a revolving hook which rotates and the base is stationary. So, the parts are at the base and while rotating, this revolving hook will guide the parts along its edge and at the center there is a hollow cylinder and that hollow cylinder is acting as a delivery chute. So, through that hollow cylinder the parts will be fed to the assembly machine.

So, here of course, the revolving hook velocity is very important because if the hook rotates at a very high velocity, in that case the parts will not be guided to the delivery chute. Now, there are two more things here; one is this support which actually is supporting the parts and directing to the delivery chute. Second thing is the disk here, this is the stationary one, this stationary disk is actually preventing more than one part to come to the delivery chute if they are stacked over each other.

If the rotational frequency of the hook is too high, once again, the centrifugal action prevents the parts from moving inward towards the delivery chute as I said earlier. Now, there could be another design in the revolving hook hopper feeder where the hook is stationary and the base rotates. So, that is called stationary hook hopper feeder.

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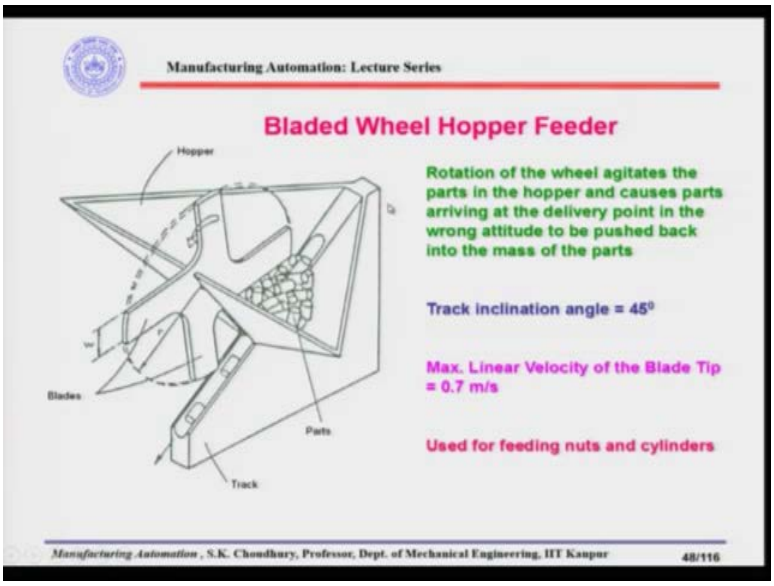

The next hopper feeder is the bladed wheel hopper feeder, this is another design; there are various designs of the hopper feeders. You have to select one of them depending on the type of your production, depending on the type of the part that you are actually feeding.

Over and above of these designs, the idea of giving you these designs is that you can design your own feeder as well depending on the part that you are having, that you have to feed. So, let us see the bladed wheel hopper feeder; bladed wheel hopper feeder is a very strange design in the sense that this bladed wheel actually does not pick up any part or it does not take the part to the delivery chute like we have seen in earlier hopper feeders.

Here there is a hopper as it is shown in this figure and at the base of the hopper there is the mass of parts. There is a track here, the silhouette of the track is the same or the shape of the track is the same as the shape of the parts and when the parts will be on this track, this wheel while rotating, will agitate the parts to be on the track and if there are more than one part stacked, then the rotation of the blade will actually remove the other parts except the one which is nested in the track.

The rotation of the blade is just above the part which is nested in the track and it will only agitate the parts, it will help by agitating the parts to be nested on the track. Here the track inclination angle is about 45 degree with the horizontal and the maximum linear velocity of the blade tip is about 0.7 meter per second. Because as you understand that it is not doing anything rather than agitating the parts and if there is no blade for example, then the parts will not be able to slide down the track one by one.

So, this blade while rotating, is actually helping. This is a simple design, but this is effective and it will help the parts to come one by one. Here, if you read this, rotation of the wheel agitates the parts in the hopper and causes parts arriving at the delivery point in the wrong attitude to be pushed back into the mass of the parts. Because as I said that the silhouette or the shape of the track is the same as the shape of the part.

So, part which is not fed accordingly or not in the right attitude they will not be nested properly on the slot and therefore, while this blade will rotate, it will actually take it off the track. Because it will be protruding out, it will not be sitting, not nesting in the track.

So, that is the reason why the wrongly oriented parts or wrong attitude parts will not be coming through the slots of the track. This is used for basically nuts and the cylinders, i.e., for small engineering parts. Now, this is very important because during the assembly, it is only small engineering parts like nuts, bolts, washers, cylinders etc. So, most of the parts are like that and they have to be fed and they have to be fed in the right orientation. So, in that case, these kinds of hopper feeders come very handy and they are cheaper and their maintenance etc. is not very expensive.

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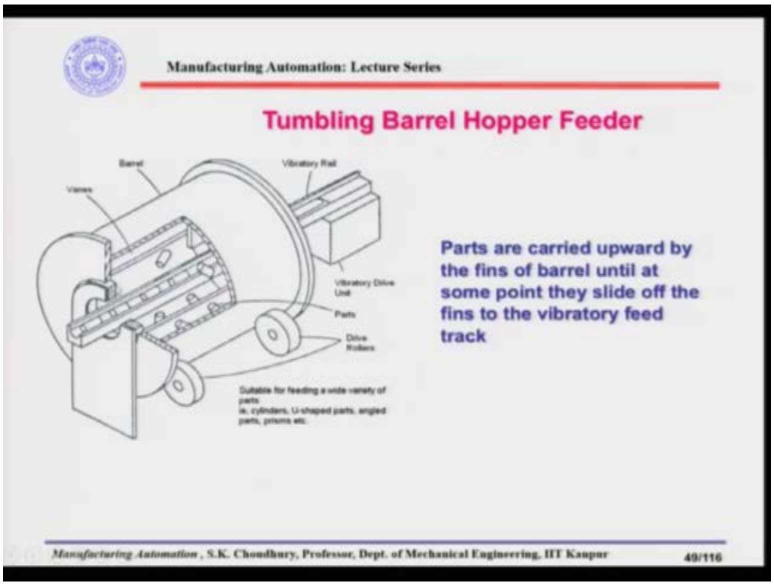

Another design of the hopper feeder is the Tumbling Barrel Hopper Feeder. So called tumbling barrel hopper feeder is a combination of the vibratory bowl feeder and a normal tumbling barrel. So here, there is a barrel that rotates and inside the barrel there are vanes, those vanes while rotating will take the parts from the base of the barrel where the parts are located. And while going up or rotating further, the parts will be falling from the vanes to the track which is going through the center of the barrel and the track is vibratory track, and it works as a vibratory rail based on the principle that we have discussed in the vibratory bowl feeder.

That means, there is a vibratory drive unit here, which vibrates that rail as we have discussed in the vibratory bowl feeder and because of the vibration, the parts are hopped and then moving forward the rail when the parts are falling from the vanes as the barrel is rotating.

So, this is a very simple design suitable for feeding a wide variety of parts, for example, cylinders, U shaped parts, angled parts, prisms etcetera, and depending on the type of the part you can design the vibratory rail, that is the silhouette of the vibratory rail, shape of the vibratory rail, so that also the rightly oriented parts can be actually nested.

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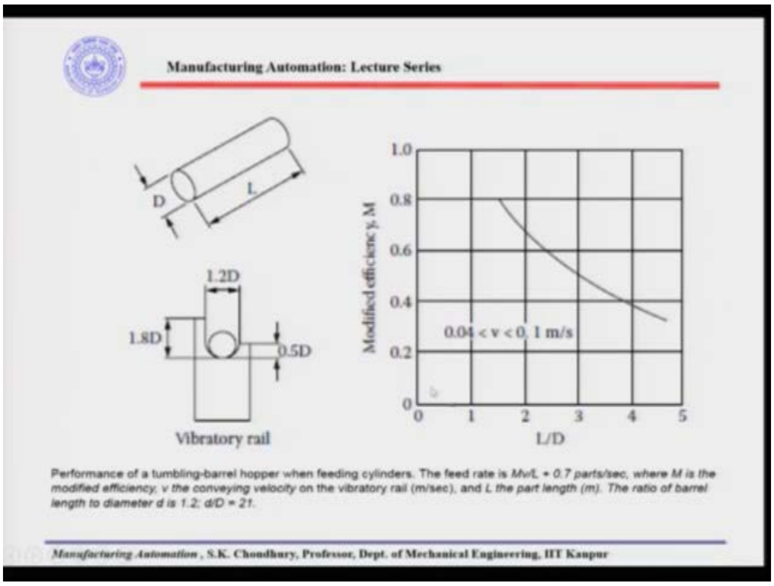

Here is one example of the kind of a part that is fed through the vibratory rail, length and the diameter given. So, vibratory rail when you are actually selecting, if the diameter of the part is this. So, this is 1.2 dia and this is 0.5 diameter. This is the shape of the vibratory rail, that you can design depending on the part that you have with a certain diameter and with a certain length.

Now, performance of a tumbling barrel hopper when feeding cylinders is given graphically here. This is for the velocity between 0.04 and 0.1 meter per second and this is the modified efficiency here and this is the ratio of the L by D, L is the length of the part and D is the diameter of the part. So, this kind of curves are normally given as a reference curve so that you can find out or select the efficiency for example, here it is the efficiency which is given.

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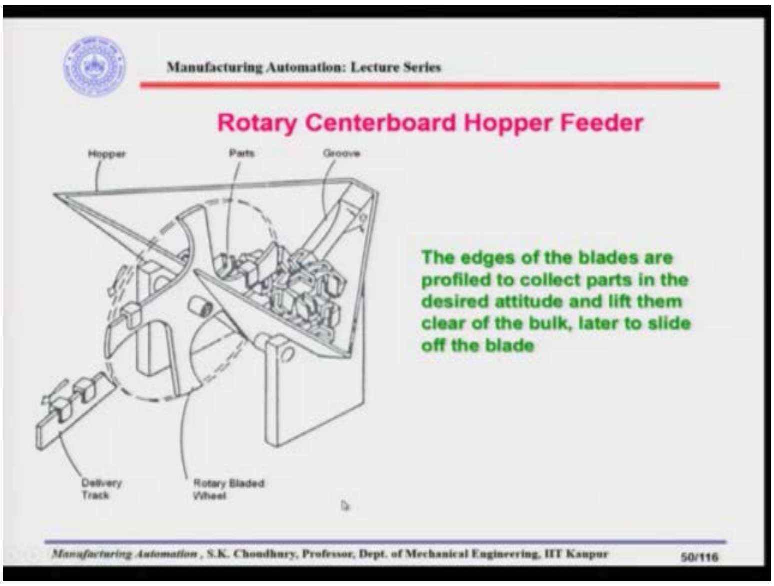

Here is another centerboard hopper feeder. Tthis is called the rotary centerboard hopper feeder and here the principle is different than the one that we have discussed. See they are very similar to the look as the bladed wheel hopper feeder where the blade is not selecting the parts, its agitating the parts; whereas, in this case, what happens, the same kind of a bowl hopper and at the base of the hopper we have the parts.

Now, these kinds of hopper feeders are particularly suitable for the U shaped parts like here; like it is shown here. The rotary bladed wheel which you can see here, rotates in this direction and while rotating through the mass of the parts, it will pick up some parts, because the parts are of the U type and they will be picked up by the blades. Let us say in this position where one part has been picked up and if it is rotating in this direction, that means, part will be coming from here to here and while it is here, the part will be sliding down the blade and when it is aligned to this delivery track, the part will be coming through the delivery track.

So, this is also a very simple design and as you can see that not all the time the number of parts will be the same. So, when you are finding out the average feed rate, you have to multiply it by the efficiency. Efficiency you can find out experimentally by rotating few times and find out how many parts on an average it is coming per rotation.

So, once again, the wheel is not agitating, the rotation of the wheel is not agitating the parts, but actually it is picking up the parts from the mass of the parts. And because of the profile of this blade, the parts which are being picked up on that while rotating, will be falling from here and if it is aligned to this delivery track, the parts will be coming down.

So, here if the edges of the blades are profiled to collect parts in the desired attitude, another very big advantage of such kind of feeders is that parts will always be delivered in this orientation. It will never be in another orientation. So, there is no reorienting device and if this is the desired orientation which should be coming to the assembly in this way.

So, then this is the very big advantage of the hopper feeder because it will be coming at a particular desired orientation and always it will be available in that orientation only. Some of the issues, next feeders and characteristics we will discuss in the next class.

Thank you.