Manufacturing Automation
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Lecture – 14
Part Oriented Devices

Welcome back to the Manufacturing Automation course. Let me remind you that overall what we are talking about is the automatic assembly system. And in the automatic assembly system as we said that we can have the in line type or the rotary indexing type. The basic problem that we may have in the automatic assembly is the feeding of the small engineering parts. So, those small engineering parts are fed in very large number and the basic problem is that all these parts have to come in a right orientation

So, keep in mind that there is no human being involved here and the parts are stacked in the bowl and they can be stacked in a very different orientation. And those parts have to come from the bowl, out of the bowl through the delivery chute in the right orientation; so that is what we are now talking. Our job is to feed the parts in the right orientation. Therefore, if the parts are not coming in the desired orientation, we have to either reject the parts or we have to reorient the parts.

In the earlier class we have discussed the part orienting devices and those part orienting devices, as we said, that they can be either active or passive. Active orienting devices are such that they will actually reorient the parts and put the parts in the desired orientation on the track. If it is the passive orienting device, they cannot reorient the parts, but they reject the parts if the parts are not coming in the desired orientation.

So, based on that we have the difference; we have the two groups of the orienting devices in-bowl system or in-bowl tooling or out-of-bowl tooling. So, I am just summarizing what we have discussed in the earlier class. The in-bowl tooling can be passive or active and they are normally kept inside the bowl so, they can either reject or reorient the parts. So, one of them was slot, which was the active orienting device, others like wiper blade, like the slot, like the cutout, V cutout or the scallop, those were the passive orienting devices because they reject the parts. Now, we have seen that the orienting device shape and the type of the orienting device actually should be according to the parts.

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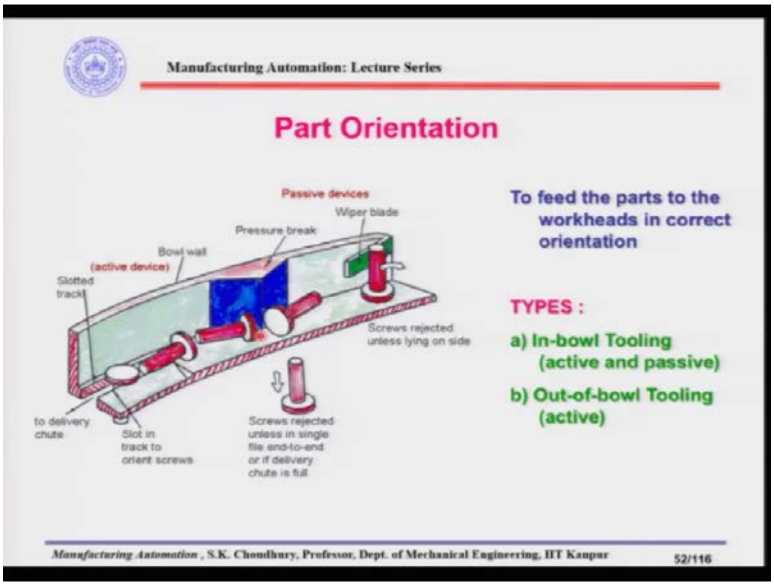

For example, we have discussed parts like as you can see here, the headed parts. So, for the headed parts it is better when the parts can actually be fed hanging on the head, if that orientation is the desired orientation.

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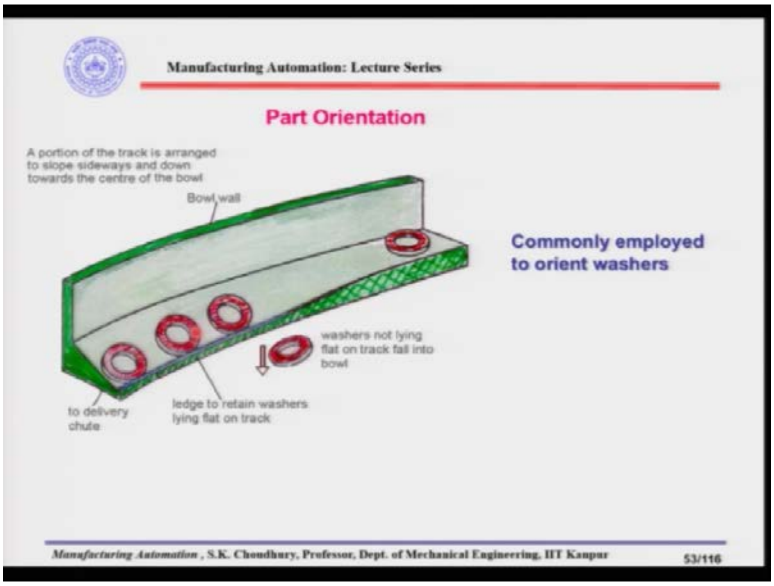

Or as you can see here that for these washers it is only a ledge which is sufficient.

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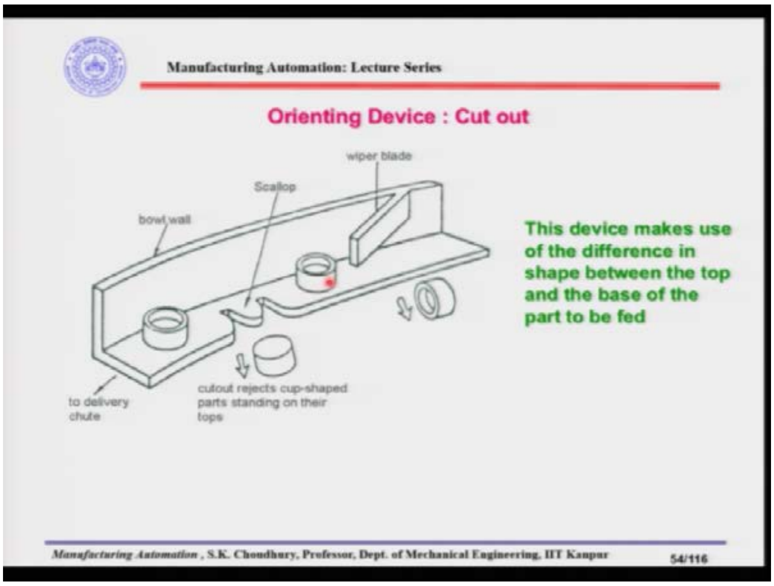

We have seen the parts with the heavier side and the open side. We saw that the scallop is very suitable for such parts to go through when it is coming with the closed side or the heavier side down.

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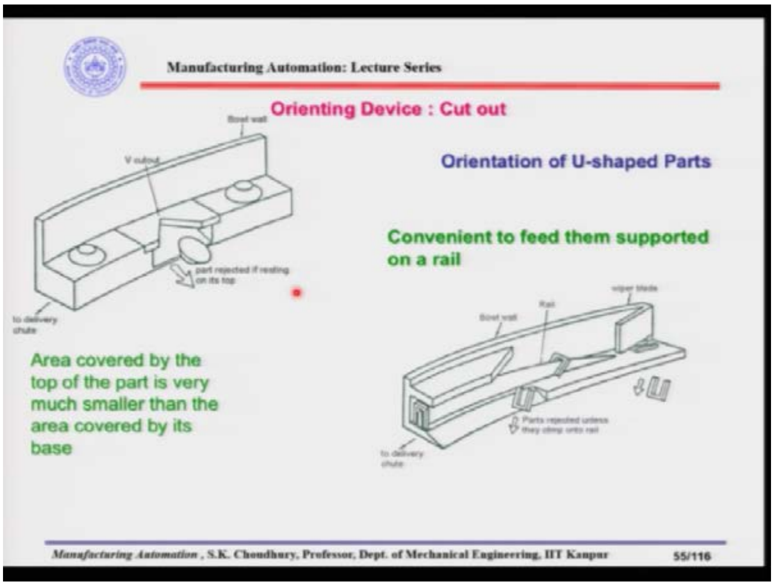

Or we have seen parts where we have the difference in the diameter at the top and at the bottom. So, for them again that V cutout is convenient for the parts with the smaller diameter up or for example, we have the U shaped parts that we have discussed. So, for them, if they can ride on the rail, that is very convenient; so a rail can be designed for example, on which they can ride.

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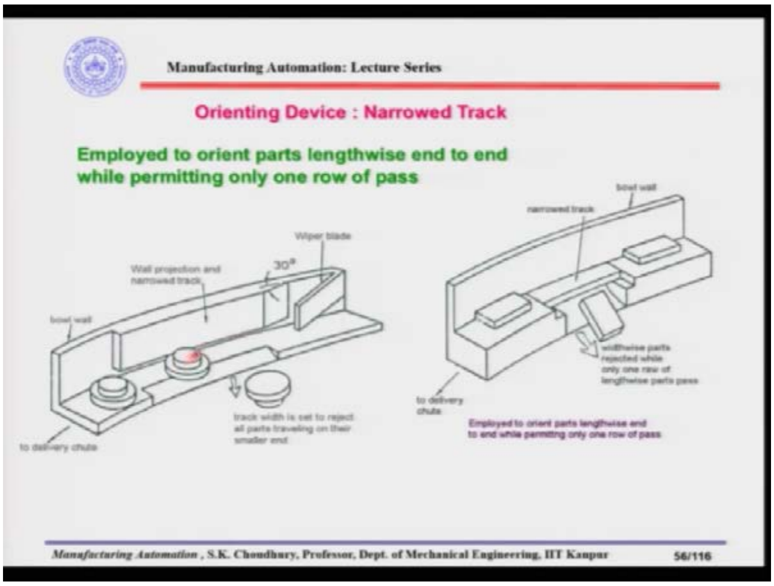

Or we can have for example, the parts like this that we have not discussed. So, this is another arrangement of the orienting devices. So, this is the narrow track and the track is being narrowed by a wall projection.

So, as you understand from this device, from this arrangement of the orienting devices that because of the narrow track, the parts coming with this orientation and the parts have two different diameters. So, the parts coming with this orientation will be rejected because this diameter is not able to negotiate through the space under the narrowed wall and the track.

Whereas, the parts coming in this orientation, this width will go inside, inside the space between the wall projection and the track and it will go through. So, let us say that this is the desired orientation for us; so all parts which are coming through the wiper blade which are not in this orientation or not in this orientation, will be rejected by the wiper blade. And these parts when they are coming after the wiper blade, parts with this orientation will be rejected because of the wall projection.

So, here there are two orienting devices wiper blade as we have discussed earlier and this is the wall projection or the narrowed that that makes the track narrower. So, both of them are the passive devices because they are actually rejecting the parts. Look at this arrangement of the orienting devices; suppose we have the orienting device for a rectangular part like this. Here is a narrow track and that narrow track has been done by a different orienting device.

Now, this kind of orienting devices, that is narrow track or V cutout or scallop, they can be as a block for example, they can be inserted here. So, as you can see from here that this is the arrangement which is made; here through this you can actually put the block like this so that the track can be narrowed or you can put V cutout for example, or a scallop for example.

So, in this case, for these rectangular parts, if the rectangular part is coming in this direction, it will go through, but in this narrowed track, it will be unstable and they will be rejected. So, the narrowed track is a passive device and all the parts which are in this direction, in this orientation, they are the desired orientation for us. So, these kind of parts will go through because this is the width of the part which will be able to negotiate this narrow track and they are all going through; so employed to orient parts lengthwise end to end while permitting only one row of pass.

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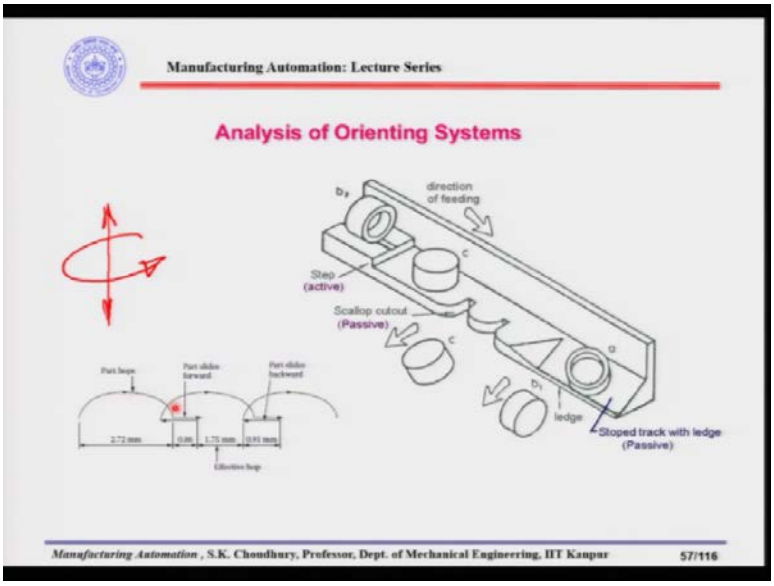

Now, while analyzing the orienting system, suppose we have a part like this where the weight at this side is more or this side is heavier because the part is such that we have a central hole; we have a blind hole and therefore, this hole is closed here; so, this side is heavier than this side.

So, when such parts are being fed, so before we design the orienting device or orienting system, we have to find out what are the different orientations the parts can have. So, normally a soft aluminum floor is arranged and those parts are randomly thrown to that soft aluminum floor and seen that after being thrown at from a certain distance of course, and after being thrown how those parts are resting on the soft aluminum floor. For example, suppose our desired orientation is this, that is the heavier side down.

So, the parts which are coming they can have four orientations as I discussed earlier. One orientation is let us say ‘a’, where the heavier side is down. Another orientation is where the heavier side is up or the heavier side can be to the left or the heavier side could be to the right. So, these are the four basic orientations that this kind of a part can come here. Suppose if we use a step and we design the step in such a way that most of the parts coming in the orientation ‘a’ will not be affected; as you can understand that when they are coming here with this orientation, since this side is heavier, so, they we will simply fall and remain in this orientation after falling from the step because the step height is designed in such a way.

Now, many of the parts which are coming either in the orientation ‘b2’ or in the orientation ‘b1’, some of them will actually be reoriented in the orientation of ‘a’. For example, suppose we have the ‘b1’, so most of the ‘b1’ after falling from the step, can actually fall like this and it can remain in this orientation. If it is coming with this kind of this orientation ‘b2’ for example, then ‘b2’ can be toppled and may become in orientation ‘c’ or it may fall in such a way that it will be in the orientation ‘a’ because this side is heavier.

Now after the step there is a cutout here, scallop cutout; through the cutout, the parts with the orientation ‘c’ will not be able to go. Because this inside diameter would not be able to negotiate this space and they will fall. But the parts which are coming with the heavier side down for example, they will be able to negotiate because the bottom is closed, there is no hole, it is a blind hole as I said.

So, those parts will be able to negotiate and they will go through and that is the desired orientation here. And then it will come here and this is a sloped track with ledge; this ledge is protecting the parts from falling down and all the parts with this orientation will be going through.

Now, suppose this is the sector of a vibratory bowl feeder and let us see how this scallop can be made. Because you cannot make that scallop randomly and it has to be made depending on the shape of the parts and since we do not want this internal diameter to negotiate so, we have to find out what is the shape and what is the size of this internal diameter and what is the type of the movement that the parts are making on the track of the vibratory bowl feeder.

Here is a diagram, which is showing how the parts are moving along the track of the vibratory bowl feeder; let us see here. The part starts moving from this point; so as we said that if the dimensionless normal track acceleration, if you remember $\frac{A_n}{g_n} > 1$, we have shown that theoretically. Then, the parts will hop, it will leave the track and because of the torsional force it can go ahead. So, parts will jump, hop and it will go like this; so after going, after falling to the track of the vibratory bowl feeder, it will go ahead a little bit, i.e., parts will be sliding forward.

And then after sliding forward, it will go backward. This is because of the type of the motion or the type of the vibration that is imparted on the parts located at the track. Once again, I have shown that earlier that there are two types of vibration: one is this vibration, another is this vibration. So, due to the combination of these two vibrations, linear and tortional, the parts will go hop like this it will go ahead because there is a torque here and then it will come back.

And then again it will start hopping and it will go forward like this; again it will behave the same way - part slides forward and then backward and then again jumps, and so on. Now, let us see, this hop from this point to this point is let us say 2.72 mm for certain value of the frequency, amplitude of frequency and amplitude of vibration and certain value of the vibration angle. Let us say vibration angle normally used is 20 degree, so for that let us say this hop is 2.72 mm; then after falling on the track it will go ahead by let us say 0.86 mm, then it is going back and going back by 0.91 mm.

So, the effective hop that we are having, although it is 2.72 hop, because of the forward movement and coming back, that is the backward movement, the effective hop that we are having is 1.75 mm. So, knowing this information and knowing the internal diameter of the part, we can actually design this scalloped cutout, which is a passive device so that the parts with the open side down cannot negotiate this scallop and fall because these are the passive devices.

So, they will reject the parts, they will not be able to reorient the parts whereas, the step can be considered as an active device. Because in the steps, many of the parts with different orientations are reoriented to the desired orientation, let us say, heavier side down. So, these steps can be considered as an active device.

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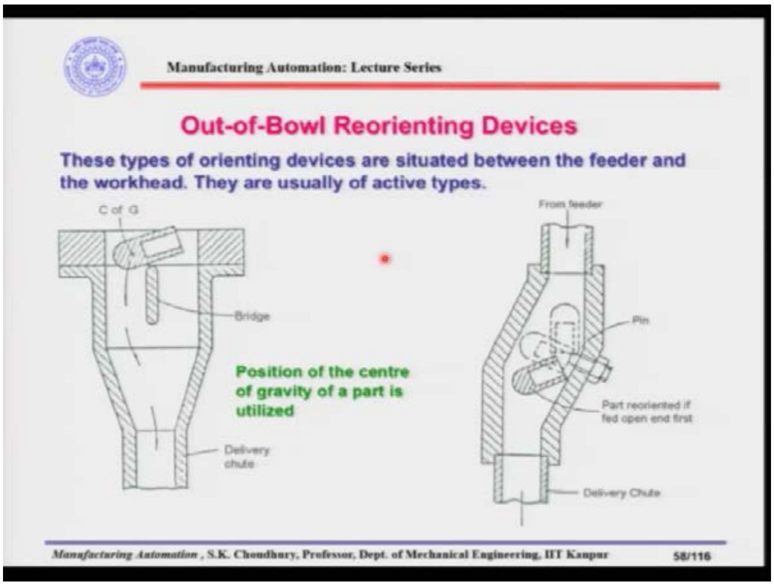

Now, let us discuss the out-of-bowl reorienting devices and I will remind you that out-of-bowl reorienting devices are always used outside the vibratory bowl feeder. And they are normally active orienting devices because had it been passive orienting devices, the parts will be rejected, but the parts cannot go to the bowl back because these parts have already come out of the bowl.

And now they are going to the assembly system, to the assembly machine. So, let us say this is a feed track or the delivery chute. So, parts come out of the bowl feeder and now we desire that the parts are delivered with the heavier side down. Parts are such that the center of gravity will be here alright.

And if the parts are coming either with this orientation or with this orientation, they will hit the bridge here, which is located in the delivery chute. After hitting the bridge, since the center of gravity here is the below and the heavier side will be down, so the part will be reoriented with the heavier side down and it will always come out of the delivery chute with this orientation, with the heavier side down.

Meaning that if the part is coming with the heavier side up, for example, it will hit here and it will be reoriented because the heavier side is here and the center of gravity is at this point. Or for example, from the feeder the parts are coming in different orientations; the same parts let us say with the heavier side up or with the heavier side down.

So, when it is coming with the heavier side up and we want the parts to come out of this delivery chute with the heavier side down, in that case we can put a pin here and when the part is coming from the feeder it will hit the pin like it was in the bridge case. So, they will be reoriented; either they are coming with the heavier side up or with the heavier side down, they will, after hitting the pin, come with the heavier side down only, which is the desired orientation. So, this is another example of the active orienting device which are used normally as I said and now as out of bowl tooling.

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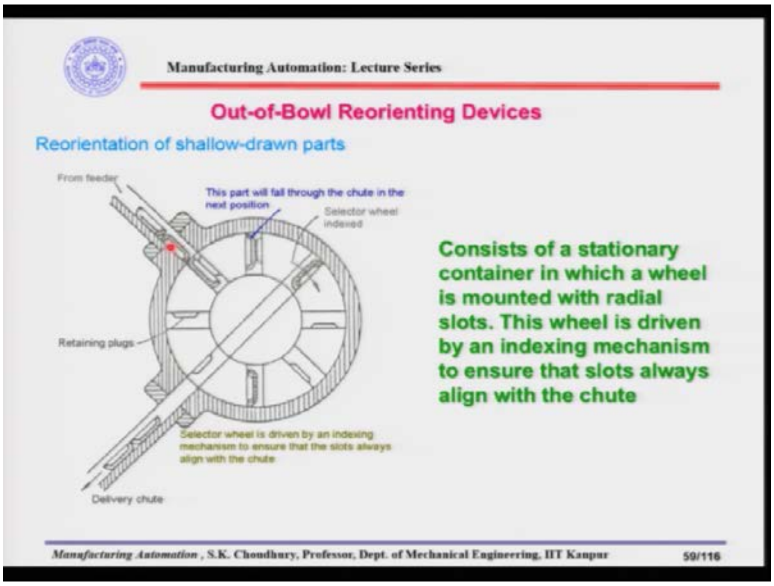

Here is an interesting out of bowl reorienting device and these devices are used for cup shaped parts like this; here is a kind of a cup shape.

So, what we have in the reorienting device is a selector wheel; this is called the selector wheel system. And here we have a stationary outer casing and inside that there is a selector wheel, which has the grooves here like this. And this selector wheel rotates and indexes, i.e., inside the housing the selector wheel will rotate and dwell for some times; when they are coming or when they are aligning to the exit, let us say this is the exit and through which the parts can come out.

Now, when from the feeder the parts are coming either with this orientation, that is the open side up or with the open side down, they will be coming here and they will fit into this protrusion. If they are coming with the open side up, there is a protrusion here and when it is rotating like this, it will come to this position.

And it will be retained here. It will not go down because as you understand that this has climbed here in the protrusion. With the further rotation when it will come to this exit, the parts will be stripped off from here and the part will exit. Let us assume that this is the right orientation as we desire. The desired orientation out of the delivery chute, the way that this part will be assembled in the assembly machine is with the open side up.

Once again, let us say in this example the part will come like this; then while rotating it will go to this position, but here there is an exit, but it will not fall because the part is held by the protrusion. So, it will go further; this protrusion will not be able to hold it anymore and the part will be stripped off and will exit.

Now, let us take another example. Suppose the part is coming like this with the open side down; when it will come to this it will be in this position; that means, since the open side is down, it will not be held by this protrusion, but it will be located in this way. So, when it will go from here to here, the part will come down because it is not held by the protrusion, the part will be stripped off and it will come here and again when it is coming, the part will be in this orientation with the open side up.

So, that is our desired orientation. Therefore, all the parts whether they are coming to the orienting device with this orientation or with this orientation, always will be getting the parts with the orientation which is desired, which is the open side up.

Now, this consists of a stationary container. As I said that this is the stationary container in which a wheel, this is the wheel, which is the drum selector wheel, this is mounted with radial slots; these are the radial slots. This wheel is driven by an indexing mechanism because when this position will come here, it has to stop for some time for the part to be stripped off and part to slide down the slot and going to the delivery chute.

So, this kind of indexing mechanism may be Geneva wheel for example, Geneva mechanism that we have discussed earlier to ensure that slots always align with the chute. Meaning that slot is either here or here these slots have to be aligned; so these are the two exits - one exit is here and one exit is here from where the parts can actually slide down the slot and to the delivery chute. So, this is also a simple mechanism, but very effective mechanism for particular parts; here you cannot reorient or feed parts of any other kind which are not of the cup shaped.

So, again I will repeat that reorienting devices can be designed depending on the parts and it is very easy to design. Because you know the part configuration and then you can say that out of the existing orienting devices, you can combine them, you can select one of them or you can design a new orienting device for that part to be reoriented to make an active device.

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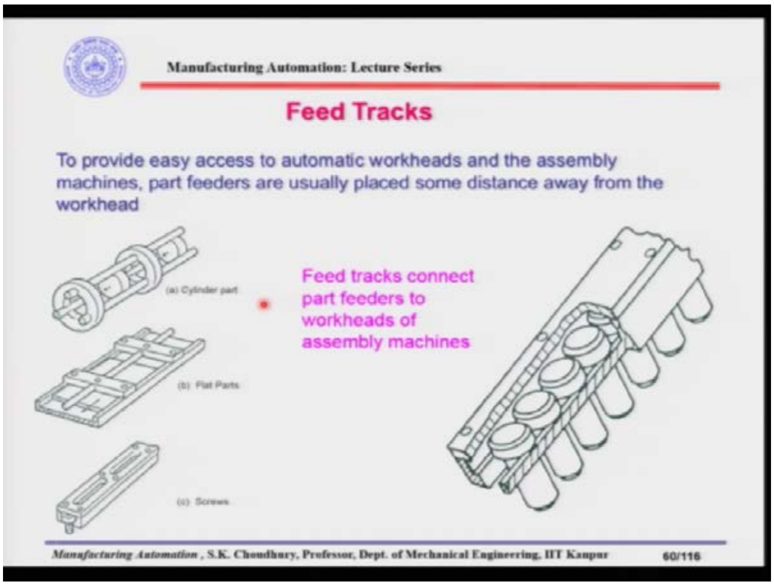

Now, next topic that we will be discussing here is the feed tracks. Let me tell you what are the feed tracks like. We have discussed the bowl feeders; different kind of bowl feeders.

So, those bowl feeders are feeding the parts and the bowl feeder cannot be located very close to the assembly machines because parts which are coming out of the bowl feeder, have to go to the assembly machine for an assembly. So, since it cannot be located very closely, there has to be some path through which the parts will go to the machine. Those are called the feed tracks. Here are some of the examples of the feed track, this is to provide easy access to automatic work heads and the assembly machines; part feeders are usually placed some distance away from the work head.

Now, in this example you can see that this is for the cylindrical parts; it is a very convenient and very easy design; this is open here and through this the cylindrical parts are being feed. Here it is for the flat parts. This kind of a flat part is coming and this is the clamp and this side is open; this is the rod which is preventing these parts from coming out. And through this slot the flat parts will be coming from the bowl feeder to the machine.

Or for examples for screws, what we can do is you can have a slot as we have seen in one of the reorienting devices and the parts may actually hang in the slot and come out. This is the example which is shown here. Part tracks connect part feeders to work heads of assembly machine and here is the part track which is for the headed parts like in here.

So, these are the spaces which are kept open normally in the feed tracks so that if anything goes wrong, any clogging happens within the feed track, so you can quickly have the access. So, to have the access they are open or you can have the easy access by opening this lid for example. Here, you can see that there are windows and if these windows do not help, in that case you can quickly remove this casing or cover and you can have the access so that the clogging can be removed.

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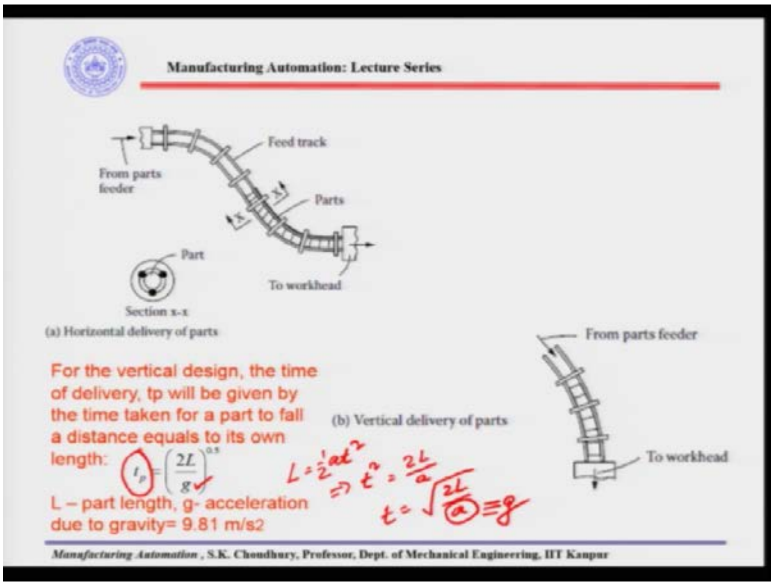

Now, how to design the feed tracks and what kind of feed tracks normally we have let us see. So, feed track design is crucial because you have to first of all find out the actual diameter or the space inside the feed tracks so that the parts are not reoriented inside while moving. Because we have ensured that within the feed track the part is in the right orientation.

So, the part feeder space should be such that the part is not reoriented and also it can have the easy access to the work head since after the bowl feeder it is going to the work head. Easy access means that it can smoothly move through that and does not get clogged.

Part feeders are basically of two types: one is of vertical delivery of parts, where we use the gravity for parts to fall or we can have a horizontal delivery of the parts. Here, this is the schematic diagram or the line diagram of the feed track; the parts are coming from the feeder and going to the work head.

So, in between we have the feed track and through the feed track the parts are going like this. Here, it is the sectional view, this X - X section is here and they are going to the work head. This is open space for the easy access to the parts. And here it is the vertical delivery of parts where the parts are falling down by gravity.

So, for the vertical design, the time of delivery t_p will be given by the time taken for a part to fall its own distance equal to its own length. So, for example, in this case what we are having is the t_p is equal to $\sqrt{\frac{2L}{g}}$. So, this is coming from earlier we have said that $L = \frac{1}{2}at^2$ and therefore, $t^2 = \frac{2L}{a}$ and $t = \sqrt{\frac{2L}{a}}$; this acceleration in our case is the gravity.

So, we are using, L is the part length and g is the acceleration due to gravity. So, according to this equation $2L$ by acceleration root over will be the t_p which is the time taken for a part to fall. And that will be the distance of its own length from the beginning to the end. Rest of the things we will discuss in the next class.

Thank you very much.