**Manufacturing Automation**
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**Lecture – 17**

Welcome back to the Manufacturing Automation series of lectures. Now, in our last session we discussed some of the important points about the feed track and it was told that feed tracks should not be unnecessarily long to make use of the space optimally. Second, very important point that we discussed is that the feed track, apart from passing the parts or transmitting the parts from the bowl feeder to the assembly machine, should also act as a buffer stock.

If anything happens or any stoppage happens in the bowl feeder so that the parts can still be available in the feed track, so that the machine does not starve. And, the third point that we said is that the feed track should not be unnecessarily expensive.

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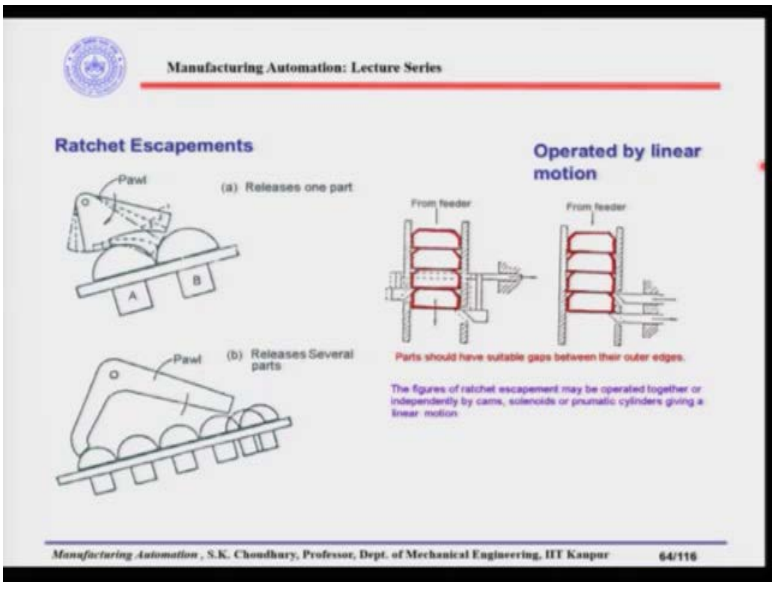


After that we have discussed some escapements. These are the devices we said that when the parts have to be fed to the assembly machine one by one.

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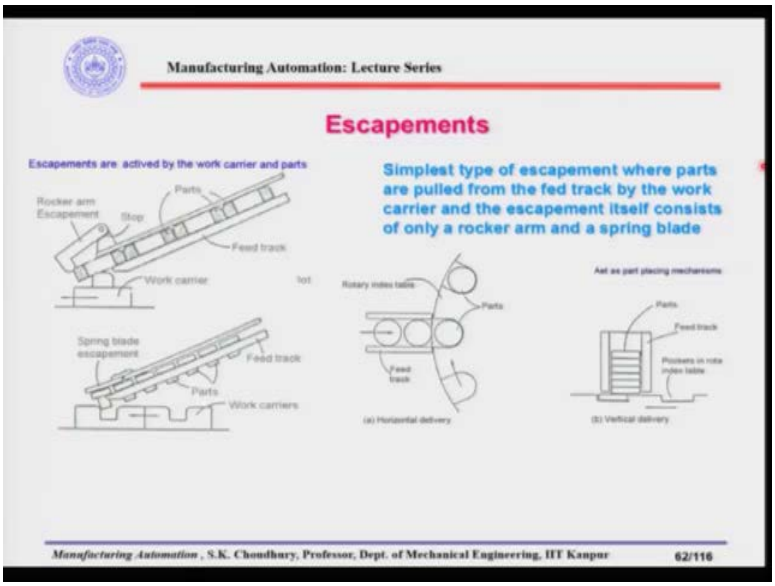


So, there are certain natural devices we have seen for example, I will show it once again. So, you can see that these are the natural devices. I am just summarizing them. These devices are activating the escapement. Escapements are being activated by the parts and the work carrier, but in the actual escapement the idea is that the escapement will activate the parts and the work carrier so that one by one the parts could be fed to the assembly machine.

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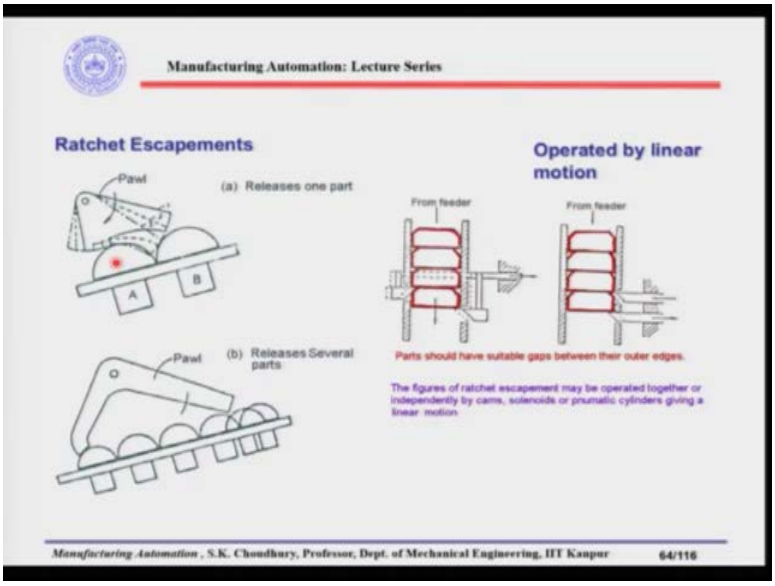

We have shown some of the examples of the escapement. For example, here it is a ratchet escapement, it is for releasing one part at a time or more than one part by using a pawl which is pivoted here and which goes to and fro. So, this is the arrow which shows the direction of movement of the pawl.

Now, here is another example that have been shown that using these kind of pawls or these kind of mechanisms, one can pull or push to and fro and the parts will be taken from the feeder, delivered to the assembly machine one by one.

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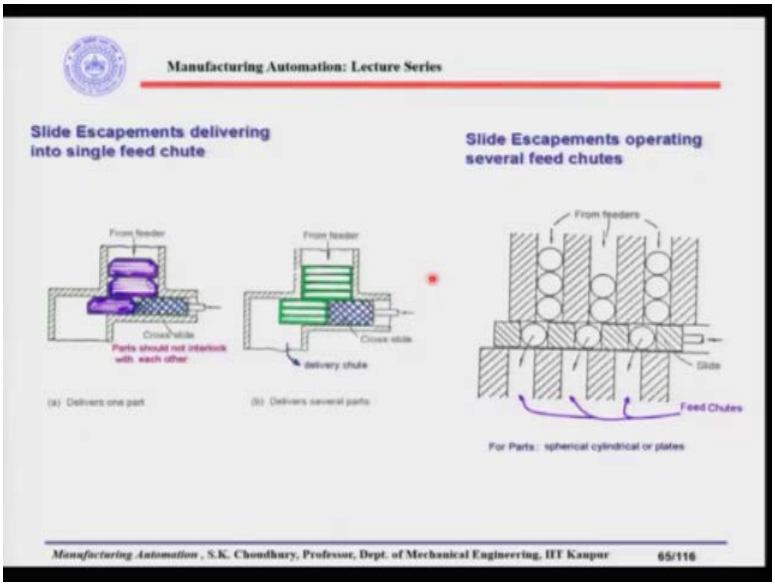


Well, let us see the other examples. In this case, slide escapements delivering into single feed chute. Here these are the parts coming from the feeder either it can be horizontal feeder or it can be a vertical feed delivery. And, the part when it is coming at the end of the feeder, there is a cross slide here and this slide can reciprocate. While the slide is going to this side, it will take one part from the feed track and deliver to the machine. So, this is going to the assembly machine.

So, while it is delivering one part to the assembly machine the other parts in the feeder will be held back. So, they will not be able to fall. And, then again when the cross slide is going to the right side then the all parts will be falling up to this and the size of this cross slide is made according to the parts so that only one part can be selected and the one part can go into the machine.

So, for more than one part, depending on the thickness or the size of the part, it can be made in this way. For example, in this case three parts at a time will be fed to the delivery chute. So, in that case the height of the cross slide or the width of the cross slide is made accordingly either to be fed one part or more than one part.

Slide escapements operating several feed chutes. Look at this. From the feeders the parts are coming in this way and there is a slide where it has the grooves for the parts to be nested and these grooves are made according to the size of the parts, so that only one part can go to that groove. So, as you can understand, this is also self explanatory that as the slide is going to the right side, it will subsequently take up the parts from the feeders in the grooves and when the slide is going to the left this part will be coming one to this and another to this feed chute and the third to this feed chute.

So, as you can understand that depending on the requirement, it can be that number of parts can be fed taken from the feeder and this line diagram is quite self explanatory. So, this is for spherical cylindrical or plates, this kind of escapements can be used for. So, again let me remind you why this is called the escapement; because when from the feeders all the parts are coming together they cannot go directly to the machine, because machine cannot take all of them together.

So, this is the kind of a mechanism which is used called s an escapement to feed the parts from the feeder one by one. One point here you can actually note down that these parts when they are coming from the feeder and with the help of these pawls when the parts are being fed one by one, there should be some gap between the parts so that the pawls could actually penetrate, otherwise they cannot segregate one part from the other.

So, there are certain kind of chamfers made so that the pawl can go into that that groove or the space and they can segregate one part from the others.

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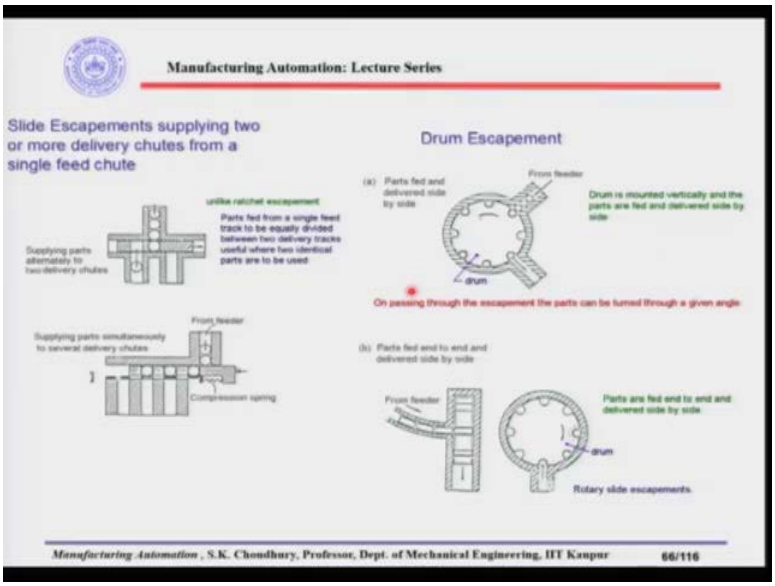


The next escapements we can see from here, this is an example which is the slide escapement supplying two or more delivery chute from a single feed chute. Look at this example here; what we are saying is that there are three parts from the feeders. These three parts are coming in this example and delivered to three feed chutes. In this example what we are doing is one we are taking from one feed track and it is being delivered to once to this feed chute and another to this delivery chute.

So, how it works it is also quite self explanatory. This slider has two grooves; one in here, while it is coming from this side. While it is going to the left for example, the parts will be collected in groove 1 and groove 2 and then when it is going to the other side, the parts from here will be fed to this chute and another part will be fed to another chute.

So, that means, from one feeder subsequently you can put in one delivery chute once and in the second delivery chute next. So, parts fed from a single feed track to be equally divided between two delivery tracks; useful where two identical parts are to be used. So, parts are being supplied alternatively to the delivery chutes. Once one part is going and the similar part is coming to the other delivery chute during the movement of the slider.

Here for example, more than 2 can also be supplied here. It is another design supplying parts simultaneously to several delivery chutes and diagram is again self explanatory that from the feeder the parts will be collected to these grooves during the movement of this slider in one way and while it is moving to the other way, these parts will be delivered to

the delivery chutes. There is a compression spring given here which helps the arm to move to and fro.

Now, here is another example of an escapement which is called the drum escapement and in the drum escapements, parts fed and delivered side by side, in the sense that from the feeder it is coming to the escapement, to the drum and the drum is inside which is rotating inside a casing; this outer casing is a stationary casing. So, in the drum we have the grooves here and these grooves can nest the parts which are coming from the feeder.

So, if suppose the drum is rotating in the anti clockwise direction so, while it is aligning with the feeder the parts will be nested to this groove of the drum and while rotating further and as it is being aligned to the exit, the parts will be stripped of the drum and it will come down to the delivery chute. Drum is mounted vertically and the parts are fed and delivered side by side.

So, this is another advantage and also this drum escapement is used for optimally using the space between the bowl feeder and the machine. On passing through the escapement, the parts can be turned through a given angle. This is another advantage of the drum escapement.

Now, here this is another principle. Parts fed end to end and delivered side by side. So, it may so require that parts are coming in  a certain orientation and the assembly machine will accept the part in another orientation . So, here for example, the parts are coming like this, parts are coming end to end and they are delivered side by side and this is again the example of this and this is the rotary side escapements which is the example shown here is similar to this.

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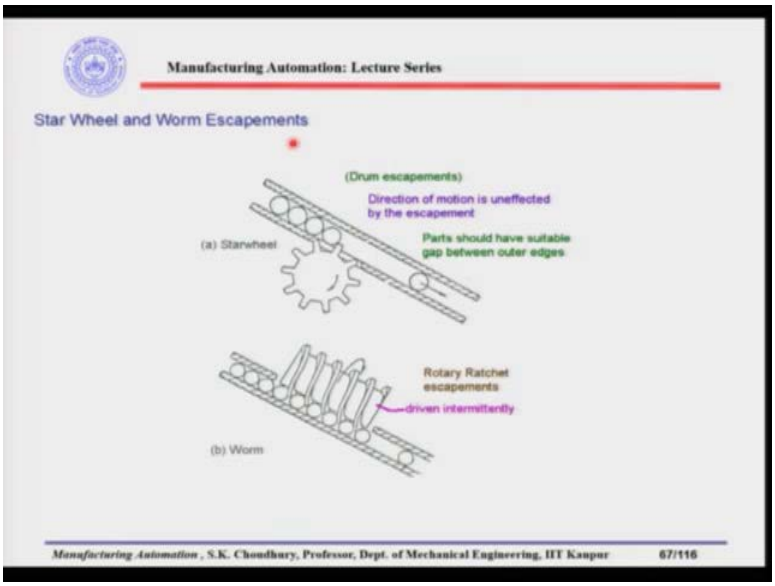


Next is the star wheel and the worm escapements. The diagrams are here. You can see there is a star wheel here and this is the feed track. Now, inside the feed track there is a space here through which the star wheel can rotate and while rotating the distance between the teeth of the star wheel is made in such a way that it will actually grab one part and then deliver while the other parts will be held by the other teeth of the star wheel while it is rotating. It rotates at a very lower speed, the speed which is required for the parts to go to the machine.

Now, direction of motion is unaffected by the escapement, that is one thing. Parts should have suitable gap between the outer edges. Here by virtue of the size of the parts, that means, the shape of the part, that is the round shape you can see that always there will be a space for this star wheel tooth to go in and then segregate the other parts and one part can come to the assembly machine.

Here there is a worm, like in case of worm and worm wheel. So, this worm rotates again inside. I mean some portion of this worm will go inside the feed track. There is an opening here and the teeth which are of the worm when it will rotate they will actually take the parts one by one to the machine because this is rotating in this direction and then parts will be guided by this space here and it will be taken to the assembly machine.

Now, this worm, if it rotates continuously for example, then the speed of the feeding of the parts will be too high. Therefore, this is rotated intermittently as and when the parts are required for the machine. So, depending on the cycle time in the machine, for example, if it is an assembly machine so, how much time it takes for making one assembly of one part, let us say it is 5 second. So, it will stop for 5 second. After 5 sec it will again take another part so that the machine can accept that. That is what we mean by driving this intermittently.

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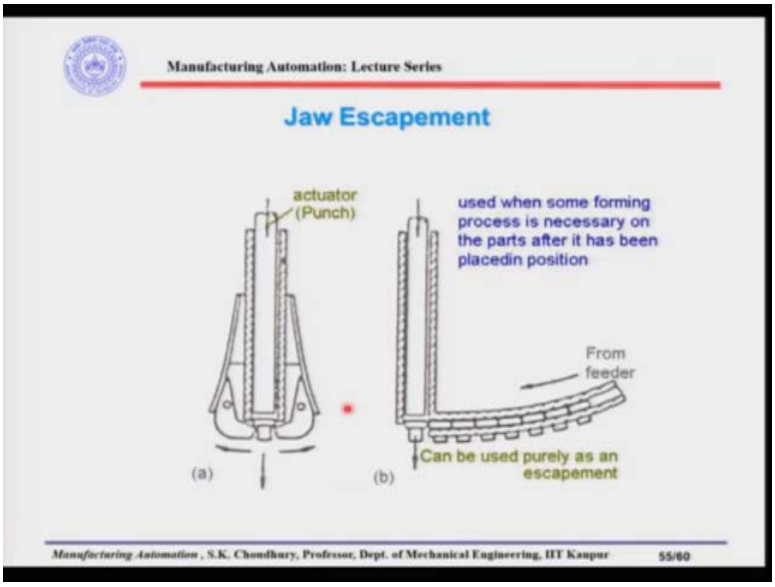


This is one example of the jaw escapement and the jaw escapement works in the following way that we have the actuator which is a punch also and here there are pawls. So, it is when the parts are coming let us say in this figure you can see that from the feeder the parts are coming like this and, the actuator can also be used as an escapement. As well as when it is required to push for example, let us say for push fitting or for riveting for example, used when some forming process is necessary on the parts after it has been placed in the position.

The positioning is done one by one from the feeder by this punch and then it can also work further to push it, to impart some forces, so that either it goes in or it is push fitted or it is riveted for example, if it is required. So, this is called the jaw escapement and it works very well. So, here in this diagram as you can see that this is the escapement and

the actuator releases this part from the escapement and then doing some forming work; that means, imparting some force if it is required. I hope this is clear.

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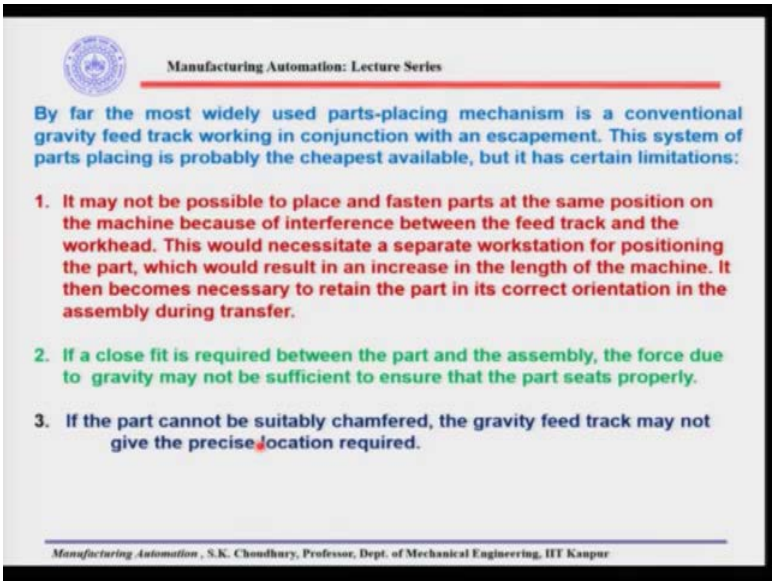


By far the most widely used parts-placing mechanism is a conventional gravity feed track working in conjunction with an escapement. This system of part placing is probably the cheapest available. Example I have shown to you earlier. So, those are the conventional gravity feed tracks in conjunction with an escapement.

Now, it has certain limitations and those limitations are that it may not be possible to place and fasten parts at the same position on the machine because of interference between the feed track and the work head. This would necessitate a separate work station for positioning the part which would result in an increase in the length of the machine or line. It then becomes necessary to retain the part in its correct orientation in the assembly during the transfer.

So, these points have to be kept in mind because these are the important things that whether you are going to have the kind of part placing mechanism you should have, what kind of escapement you should have and so on. If a close fit is required between the part and the assembly, the force due to gravity may not be sufficient to ensure that the part seats properly.

This example exactly means that suppose you are putting the part in the place and it is not enough that with the gravity it will go into the position. So, there you may need some kind of force from outside to impart on the part so that it can actually be placed here. Otherwise also what may happen is that the part may be misplaced in the position. It may be wrongly positioned. So, that is another thing which can make a faulty assembly for example.

If a part cannot be suitably chamfered the gravity feed track may not give the precise location required. So, if they are chamfered, that is fine it can be, but not all parts could be chamfered and in that case the gravity feed track alone cannot actually work. So, there have to be some kind of a part placing mechanism apart from the escapement. Escapement that we have discussed - their job is to put the part one by one to the machine. Here what we are talking about is that some of the gravity feed tracks along with the escapement that may not be enough for the parts to put in a right position. So, for that we need normally a part placing mechanism.

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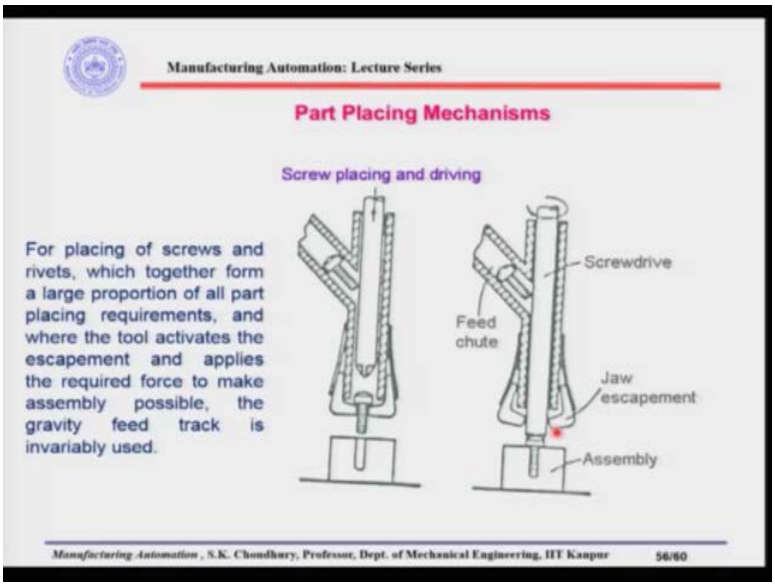


Let us see what are the part placing mechanisms. Normally, they are the manipulators, they are the robot hands and so on. However, look here this is the diagram which is showing the screw placing and driving. Here in this diagram what is shown is that from the feed track the parts are coming in here. So, this is the jaw or this is the screw drive for example, this can go up and down.

So, while going up to this position it can allow one part to come in, the space can be such that one part goes in and then after that the screwdriver, it can be a screwdriver as well, so, this can go in and it can apply some torque so that the screw can actually go inside the threaded hole.

So, both of them, both these two working conditions are shown here. For example, here the part is placed and there are jaws here so that the jaws could be acted as an escapement and after that the screwdriver comes in and it rotates to impart the torque to this. So, for placing of screws and rivets which together form a large proportion of all part placing requirements, and where the tool activates the escapement and applies the required force to make assembly possible, the gravity feed track is invariability used. So, in all these cases the gravity feed track is used.

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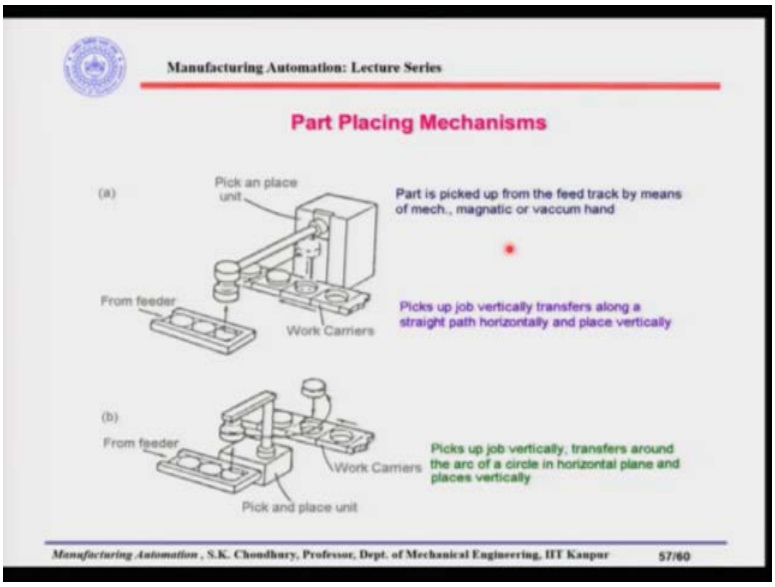


Another part placing mechanism or other part placing mechanisms as I said that these kind of robotic arm or manipulator can be used. So, in this part is picked up from the feed track by means of mechanical, magnetic or vacuum hand. So, this is the manipulator or the robot arm and it has an end effector. It can be a mechanical gripping or it can be a magnetic if the parts are of ferromagnetic material or it can be a vacuum hand.

For example, if the television screens are to be picked up or if a very precise plate should be picked up where you cannot afford to have any kind of gripping so that there is no scratch or computer screens for example. So, from the feeder the parts are coming here

and the robot manipulator will come like this, then the end effector will come to this position, pick it up, go up and then again going to this side and putting it on the work carrier.

So, it picks up from the feeder and it will place on to the work carrier that is the job of the part placing mechanism. It picks up job vertically, transfers along a straight path horizontally and place vertically again. So, this kind of movement can be programed so that all the time it will move like this, come here go up again and come to this position. So, it can actually repeat this position. They are normally programmed so that the parts can be placed one by one from the feeder to the work carrier.

Here is another example using the same, using the robotic hand, but that manipulator is of different configuration, this is the manipulator like in here. So, here this manipulator picks up the part from here and it rotates and place it here. In this case what is happening is that the work carriers and the feeders are side by side and the mechanism is behind the work carrier.

It may so happen that the mechanism is placed in between the work carrier and the feeder, in this case will take up the job from the feeder, this hand will rotate about this axis and place vertically to the work carrier. Picks up job vertically, transfers around the arc of a circle in horizontal plane and places vertically. So, this is the idea and this is the working principle of the part placing mechanisms. These are simple mechanisms, pick and place units and those units can be placed either behind the work carriers or in between the work carrier and the feeder, as I said.

Now, the signal to activate this mechanism may come from the assembly machine itself. Assembly machine when it finishes a work sends a signal to the pick and place unit and then it will be activated to bring the part from the feeder to the work carrier.

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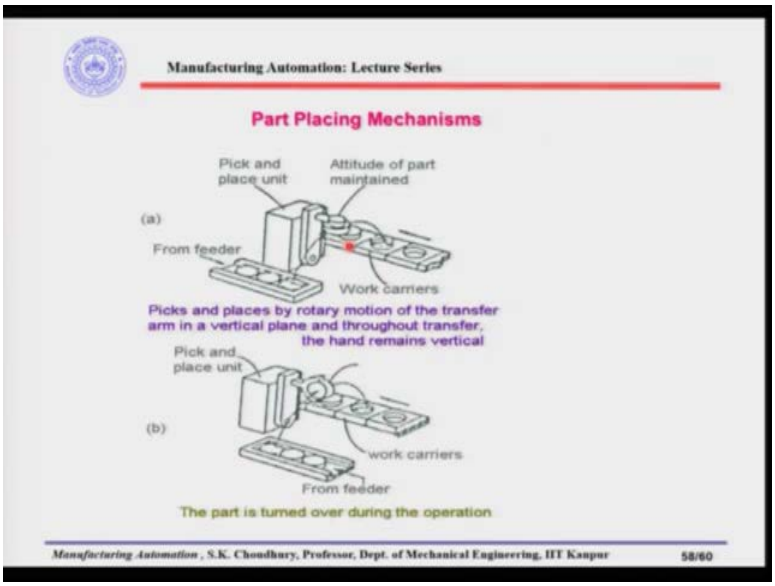


Here are some other examples of the part placing mechanisms, the diagrams as you can see are self explanatory. Here it picks and places by rotary motion of the transfer arm in a vertical plane and throughout transfer the hand remains vertical. See here we have the feeder, the parts are coming from the feed track and this is the pick and place unit. Here we have the manipulator. This is pivoted here; in the sense that this arm can rotate about this pivot, about this point and here is a manipulator. This manipulator can also rotate, at a $90^0$ angle.

So, what it does is that this arm will rotate, this manipulator will pick up the part and then again it will go to this position and then place the part vertically. So, here you can understand that it may actually have two movements; one movement will be by this and another movement will be by this. So, there are two degrees of freedom here.

Here is another example of pick and place unit. This is the work feeder and parts are coming from the feeder and to be placed to the work carriers. So, here also like in this design we have the manipulator which can actually rotate about this point, it can swivel around this point and here this arm can also swivel about this axis.

So, if the part is taken from the feeder in one orientation it can turn the part and put the part in another orientation. It is taking like this and putting it in this way. So, this is the idea of this part placing mechanism - the part is turned over during the operation, suppose if it is so required. So, in this case these kind of part placing mechanisms are

used. Here I will come back to this in this case the part can be placed in the same position as it is picked up. Here the part is turned from the position it is coming.

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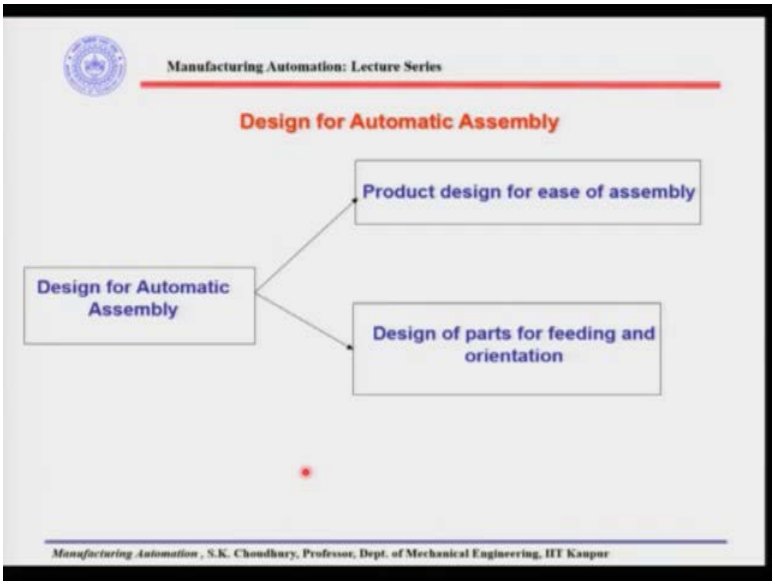


Next we will discuss some of the points in the design for automatic assembly. Now, when we are having automatic assembly it is understood that since the human being is not involved there so, some of the jobs that the human being can do very easily, may be very difficult for the automatic assembly to perform or automatic machines to perform. And therefore, some of the points you should consider in the design of the part while designing them, so that the automatic assembly could be performed in a better way without the intervention of the human being.

I will give you some examples: suppose, you have a part which is of a very complicated shape and there are several of them that have to be assembled. So, in that case what is happening is that we require several machines for performing each of these assembly operations whereas, we can change the design in such a way that some of the parts could be combined together in the design to make one part out of those.

In the sense; that suppose using developed metal forming processes or metal casting techniques to join some of the parts and make it as one part, so that as if we have two parts joined together in the design. In that case two assembly processes could be avoided and there would be only one assembly process.

So, for design for automatic assembly two aspects will be required – one is the product design for ease of assembly; as I said, in product design for ease of assembly, chamfer is one component which we have discussed earlier that actually facilitates the parts to get assembled.

And, there are many other aspects that will see in the subsequent discussion that the product design should be for ease of assembly. Another aspect is that design of parts for feeding and orientation. It is not only that we are assembling the part, but we are also feeding the part. So, in the design we should consider some of the aspects so that the feeding could be done in the proper way as well as the part could be assembled in a proper way. These things in details we will discuss in the next session.

Thank you very much.