Manufacturing Automation
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Lecture – 16

Welcome back to the discussion sessions of Manufacturing Automation course; let me remind you that in our last sessions we have discussed different types of part orienting devices. And, we said that for small engineering parts particularly, this is very crucial that all the parts have to be transferred to the automatic assembly machine with right orientation. So, different kind of devices are used so that the parts which are coming with wrong orientation can be reoriented.

So, we discussed that there are active devices and passive orienting devices, and they may be also classified as the in-bowl type and the out-of- bowl type. Now, in-bowl tooling are those orienting devices which are normally used inside the vibratory bowl feeder or any other feeders. And, out-of-bowl systems or out-of-bowl toolings, as we called those, are normally used in the feed track and that is outside the vibratory bowl feeder. So, those parts which cannot be reoriented are reoriented by rejecting, let us say.

So, they cannot be used outside the bowl or as out-of-bowl tooling because out-of-bowltooling cannot reject the parts to the bottom of the bowl. Whereas, those orienting devices which are used inside the bowl can be either passive or active; active orienting devices reorient the parts. Whereas, the passive orienting devices, since they are inside the bowl, so, they can actually reject the parts if the parts are coming in wrong orientation. And, those parts will go back to the bowl of the feeder and they will again get re-circulated. However, it is not very desired that the parts are rejected because in that case as we discussed that not only the bowl, but the parts also get worn out.

This discussion was followed by the feed tracks and we said that the feed tracks are used to connect the bowl feeder with the assembly machine. Because, the bowl feeders cannot be placed very close to the assembly machines, therefore, there should be a track for the parts to go to the assembly machine. In the feed tracks, we said that there are vertical delivery feed tracks and there are horizontal delivery feed tracks.

Now, in case of the vertical delivery feed tracks we have the parts coming down the feed track from the bowl feeder by means of gravity. And, that is why we said that the time T_p taken for parts to go down the part track, depends on the gravity. Now, in the case of horizontal delivery feed track we have actually analysed and we found out that this finally, the $\frac{A_n}{g_n}$, which is the normal track acceleration depends on few factors like the ratio of the length and the radius of the curved portion; if you remember the dynamic coefficient of friction, and so on. So, this discussion we had in our last sessions. Then we said that the problem becomes that when the feed track is filled up, then the parts actually can get jammed at the exit of the bowl feeder or inside the track or even at the entry of the assembly machine.

Now, the reason behind this is that, normally we keep the conveying velocity of the bowl feeder little more than the parts required in the assembly machine. In the sense that from the outlet of the bowl feeder, the parts coming out will be little more than the parts that can be taken by the assembly machine. And, this is simply because we ensure that the assembly machines do not starve; whenever they need a part they can get it. Now, in that case if the feed track becomes filled up, then the parts cannot actually go to the assembly machine and they cannot be stacked inside the feed track and then they can clog the exit of the bowl feeder.

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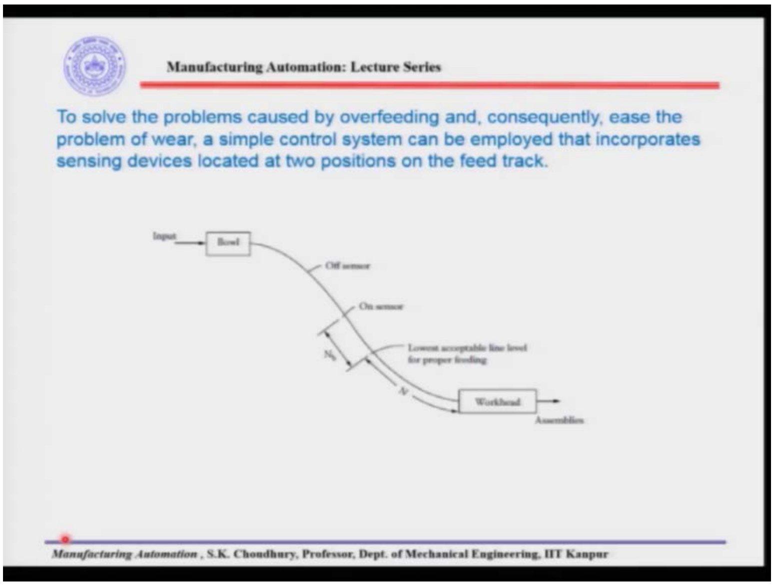

So, then we discussed that we have to ensure that this does not happen. We have to solve the problem caused by over feeding and consequently, ease the problem of wear, a simple control system can be employed that incorporates sensing devices located at two positions on the feed track.

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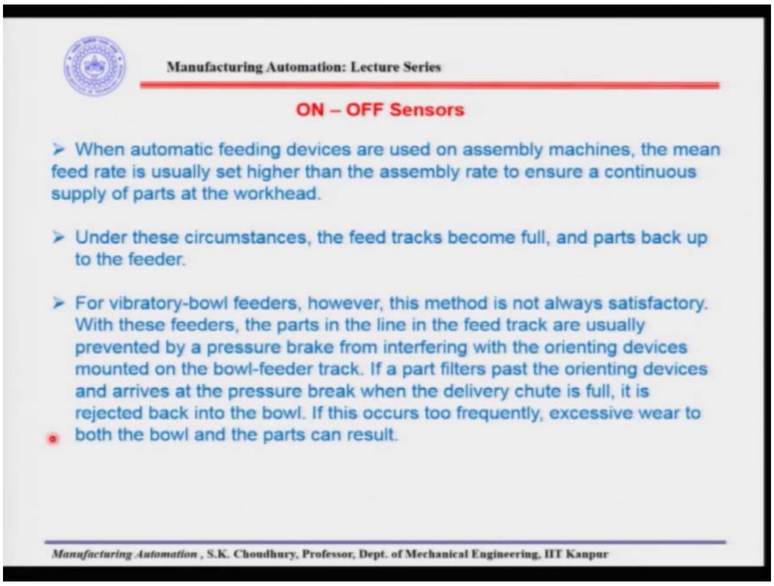

So, what we said earlier actually is that when the automatic feeding devices are used on assembly machines, the mean feed rate is usually set higher than the assembly rate, as I said. This is to ensure a continuous supply of parts at the work head. Under these circumstances the feed tracks become full and parts fall back to the feeder. For vibratory bowl feeders however, this method is not always satisfactory. With these feeders the parts in the line in the feed track are usually prevented by a pressure break. If you remember we have discussed the pressure break which limits the path and it narrows down the path,

So that the parts cannot negotiate this path of the orienting devices mounted on the bowl feeder track. If a part filters past the orienting devices and arrives at the pressure break when the delivery chute is full, it is rejected back into the bowl. If this occurs too frequently, as I discussed, excessive wear to both the bowl and the parts can result. So, to prevent this there is a method that has been adopted in the industry to solve the problem caused by overfeeding and consequently ease the problem of wear, a simple control system can be employed that incorporates sensing devices located at two positions on the feed track.

Let us look into this diagram. Here is a line diagram showing that this is a bowl feeder through which the parts are coming to the feed track, this is the feed track. And, this feed track brings the parts to the work head for assembly, let us say these are the assembly work heads. Now so that the parts are sufficient in the feed track and the feed track does not get filled up quickly or it cannot be kept vacant, there are two sensors: one is in this position, this is called the ‘ON’ sensor and another sensor is kept, it is ‘OFF’ sensor. Meaning that when from the bowl feeder the parts will be coming to the work head, suppose the work head is still working and then the next part has to wait to go to the work head.

And, these parts can be stacked up to this position. As soon as the part level goes beyond this, there is an ‘off’ sensor and it will put off the feed track; that means, from the bowl feeder the parts will not be able to come to the feed track. And, then from here when the sensor keeps the feed track off, then the parts will go as the work head will keep taking the parts for assembly and as soon as the part level goes beyond this point, again this ‘on’ sensor will again start the feed track, so that the parts could again fill up the feed tracks. So, this ‘on’ sensor and the ‘off’ sensor actually maintain the problem of excessive wear of the bowl and the feeder, because in this case the parts do not have to be rejected by the pressure break as we have discussed earlier.

So, here of course, depending on the types of the parts, depending on the assembly work head and depending on the bowl feeder; the position of the ‘on’ sensor and ‘off’ sensor can be decided and accordingly they are placed.

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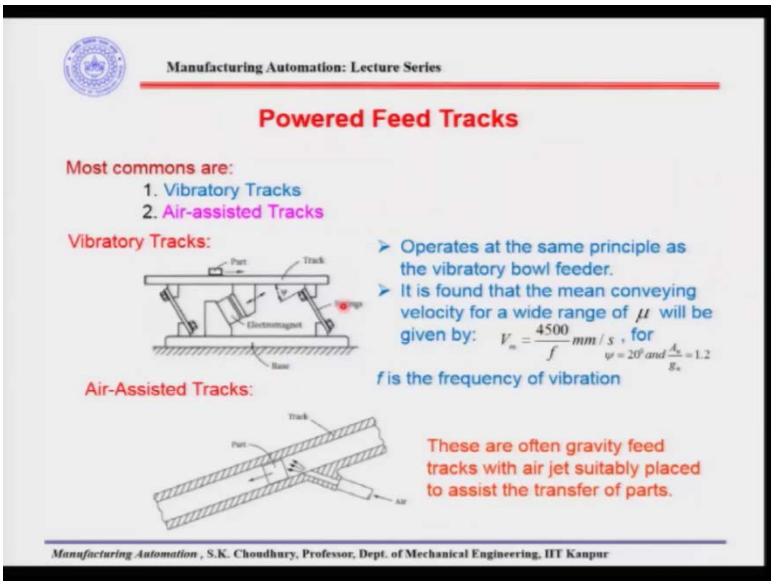

Let us talk about different types of feed tracks. Most commonly used feed tracks are the vibratory tracks and the air assisted tracks. So, the vibratory tracks work in a very similar way as the vibratory bowl feeder. Let us see the line diagram, Here, we have the track, on the track the parts are moving. Now, the track has a base here which is given a vibration from the electromagnet which is mounted at the base of the vibratory track. Now, the track and the base are connected to each other with the springs and those springs are similar to the suspension springs that we have seen in the vibratory bowl feeder.

So, the electromagnet when it imparts the vibration, there will be two types of vibration: one is the vertical linear and one is the torsional vibration. Because of the combination of these two, the parts will be moving on the track and it will be hopped and then move forward as in case of the vibratory bowl feeder. This operates at the same principles as the vibratory bowl feeder. It is found that the mean conveying velocity, that is fV_m for a wide range of coefficient of friction between the part and the and the track which is μ will be given by V_m; particularly it will be 4500 divided by the frequency in millimetre per second.

Well, this has been experimentally derived and experimentally it has been found out that for a vibration angle of 20^0 and the normal track acceleration of 1.2, this is the case. Meaning that if we have for example, f which is the frequency of vibration of 50 for example, so, the V_m the number of parts or the conveying velocity will be $\frac{4500}{50}$. So, you understand this 90 mm/s. Now, if this is the vibratory feed track which is driven by the electromagnet, there is a vibration, there are also air assisted tracks. And, the air assisted tracks line diagram is here, these are often gravity feed tracks.

So, gravity feed tracks we have seen earlier, but in case of gravity feed track although we are using the gravity for feeding the parts, it may so happen that the parts in inside the feed track may be clogged. So, to assist the part to move smoothly, inthe gravity feed track we have the passage for passing the high pressure air. And, because of that high pressure air the parts, if even they are clogged or if the coefficient of friction becomes more while moving through the feed track, this can be eliminated. So, this is a simple diagram, this is called the air assisted track where we have the passage through which the pressurized air is passed from a compressor and it will assist the parts to move along the feed track.

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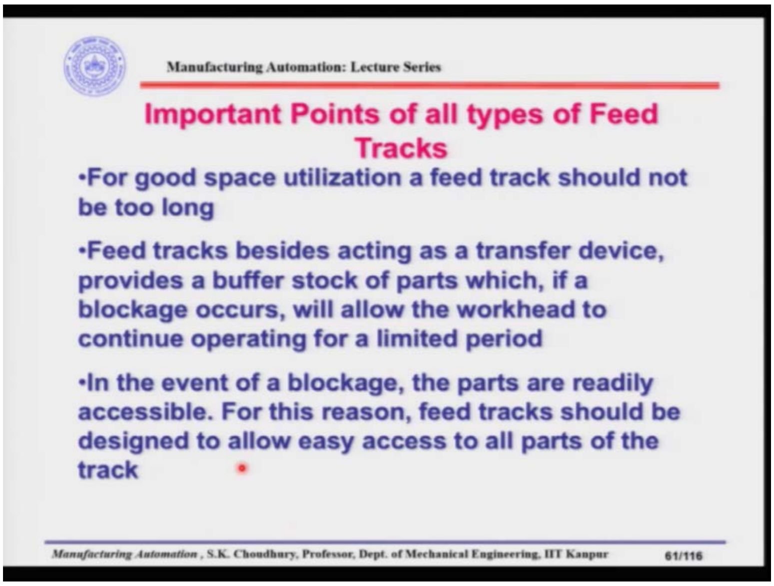

Some important points of all types of feed tracks are the following: for good space utilization a feed track should not be too long. Now, what does it means is that we said these bowl feeders or feeders cannot be kept very close to the assembly machine. So now, if we have a feed track, we are occupying some of the space between the feeder and the assembly machine. So that the space could not be occupied very long therefore, the length of the feed track should be limited. And, it is necessary for the feed track not to be unnecessarily long as well.

Next point is that the feed tracks, besides acting as a transfer device, provides a buffer stock of parts, which if a blockage occurs, will allow the work head to continue operating for a limited period. Now, initially we said that it should not be too long, but it should be sufficiently long so that the parts can be stacked as a buffer stock. Suppose, if something happens to the bowl feeder, bowl feeder stops. So, still the assembly machine can get the parts which are stacked inside the feed track. So, the feed track can work as a buffer stock as well for a certain period, of course. Third point is that in the event of a blockage, the parts are readily accessible. I have shown in the line diagram in the beginning that the parts have to be accessed easily.

So, normally it is either an open or you can easily remove the lid so that you could access the parts. For this reason feed tracks should be designed to allow easy access to all parts of the track, either by keeping it open from a side so that you could easily remove the lid.

Now, our next topic of discussion is the escapements. What are the escapements let us see. From the feed track the parts are coming and there is nothing to regulate that the parts will come one by one. Whereas, in the machine, what the machine needs is the parts to come one by one. So, the escapements are the devices which provide the parts to be fed to the assembly machine one after another or one by one.

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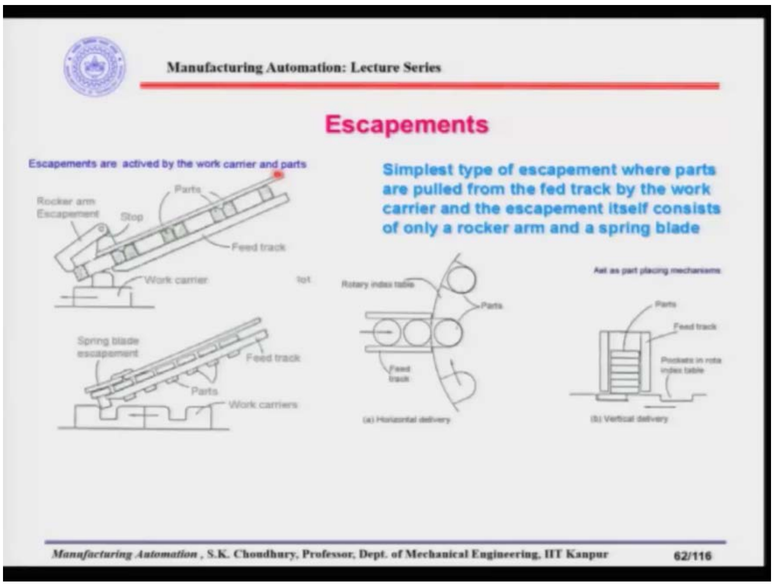

Now, escapements are activated by the work carrier and parts in these two diagrams shown here. See for example, here this is the work carrier; work carrier will take the works or the parts which are coming through the feed track from the bowl feeder. Now, we have a rocker arm escapement or a spring blade escapement, as shown in this diagram; these diagrams are self explanatory. In the sense that rocker arm escapement or the spring blade escapement are assisting the parts to come to the work carrier one by one. .

So, when one part is coming here, the rocker arm escapement will stop the other parts from falling here down the feed track. Similarly, spring blade escapement will resist the other parts to come to the work carrier when one part is taken. Now, here in both these cases what is happening is that escapements are activated by the work carriers and the parts let us see here. Here these are the two line diagrams, these line diagrams are given for the feed track here and this is the rotary indexing table. And, feed track is connected directly to the rotary indexing table, simplest type of escapement where parts are pulled from the feed track by the work carrier.

So, these are the feed tracks and the parts will be pulled by the work carriers which are located here on the indexing table. Let us say for example, in this case this is the vertical delivery one. So, this is the work carrier and the parts are here stacked in the feed track. So, as the work carrier is moving along the line, the work carrier will actually pull the parts one by one. So, these are the natural kind of escapements. Now, these are the simplest type of escapements and in both the cases what is happening is that escapements are being activated by the parts and the work carrier.

But, actual escapements are those which will activate the parts to come to the work carrier, not the other way round. Not that the escapements are activated, but the escapements will activate the parts to come to the work carrier whenever it is required.

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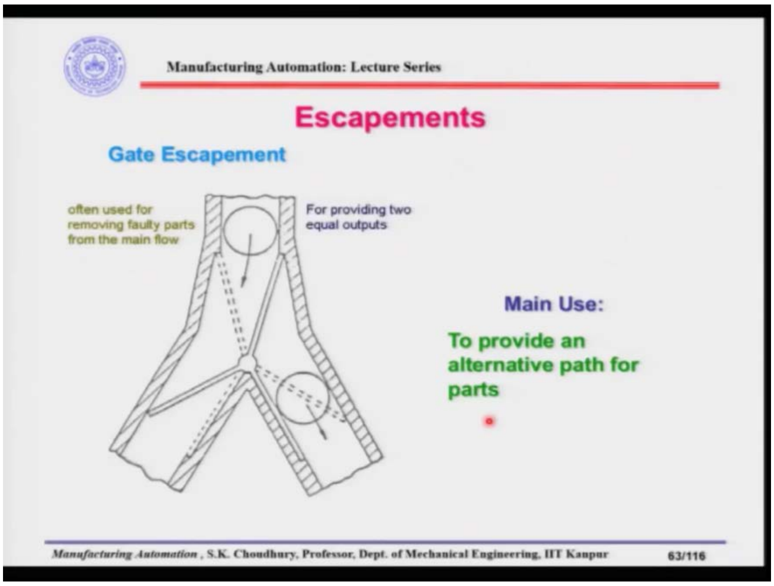

Let us see some of those examples, this is called the gate escapement. Gate escapement is often used for removing the faulty parts from the main flow. Now, let us say that here there is a passage through which the parts will be coming and here is a device. When the part is coming in this way, it will go since this passage is opened so, this is bifurcated as you can see and this is pivoted here. So, when the part will be coming through this rigid star which is fixed here. This will be moving from this position to this position as it is shown here in the dotted lines; that means, the other passage will be opened now.

Then when the part will go through the other passage, the star here, the leg here will actually move to the other position. So, it will keep on moving like that as the parts are coming in one passage or to the other passage. Now, the main use of this is to provide an alternative path for parts. In the sense that let us say at the output of this and this passage that these are going to two different assembly machines and two parts are needed, may be similar parts. So, one will be fed from here, other parts will come after that followed by this. Now, here this design can also be used by controlling this with a device or with a sensor.

For example, suppose we want the faulty parts to take out. So, whenever there is a faulty part in that case the sensor will sense the signal that there is a faulty part and suppose we want the faulty part to come to a particular side, so, sensor and the device will place this star in such a position so that this passage is kept open for the faulty parts to go. And, all the correct parts will come to the other side by moving after the faulty parts have gone through this passage, this star will come back and block this passage; block this passage and it will come to this passage. So, it has different uses.

First of all, once again the two parts can be fed to the two different assembly machines or the faulty parts from the main flow can be taken out.

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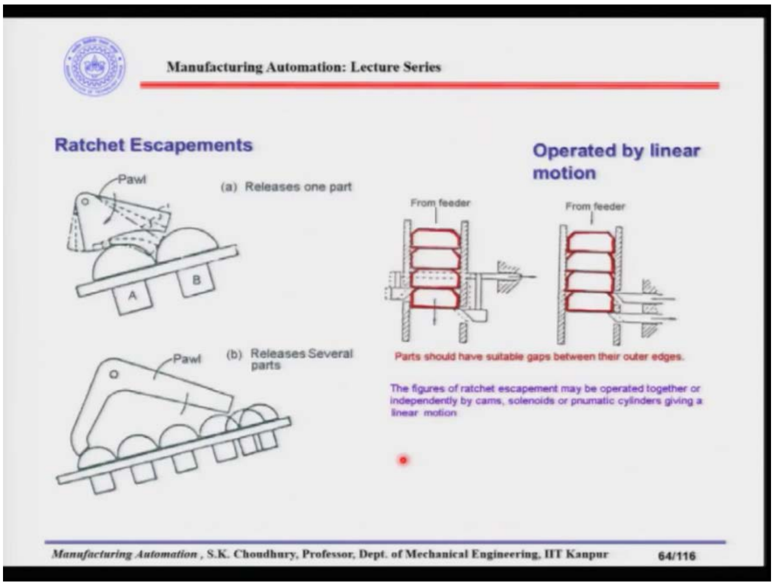

Let us see the other types of escapements that we have; here there is a design which is called the pawl escapement or ratchet escapement. Here there is a pawl here which is pivoted here and which can actually oscillate like this according to the arrow which is shown here. It can go like this or it can go back to the initial position. And, here from the feed track the headed parts are coming through the feed track. And, they are hanging in the slot as we have shown earlier how it can be done.

Now, because of this pawl, the parts can be fed one by one as you can see. This is quite clear from the diagram itself, that when it goes like this it will prevent the other parts to come through the feed track, but the part which is here will go to the assembly machine. Then when it will go to the other position, it will take another part and so, it will be one by one. As the pawl is swinging or it is reciprocating from one position to another position then one by one the parts will be coming. However, we can have the arrangement with the same kind of pawl, but the pawl design could be different, here is the pivot.

So, around this point, the pawl can reciprocate to and fro. And, here the pawl distance from one leg to another leg is such that at a time three or four parts can be transmitted to the work head. So, if it is required that more than one part is required for the assembly, in that case such kind of pawl or ratchet escapement can be used. So, , here it is one by one, here it is more than one and depending on the number of parts you can have the distance accordingly designed. Look at this design for example, this is operated by linear motion, these are the parts which are coming from the feeder and going to the assembly machine.

Now, here there is a lever and that lever as you can see is pulled to the right then this lever will go in and this lever will go to the left side. In that case what happens is that when this is released and this is going like this, in that case one part will be released from here and other parts will be held by this pawl or by this mechanism. So, what we mean is that you have to actually pull the handle to and fro so that parts exit from the feeder one by one. Now, this is one handle which can also be used like this, the same principle that the two jaws will be moving to and fro.

So, when this jaw is moving in, these parts in the feeder are held and one part is released. And, when this is coming in and this is going out in that case all the parts will be stacked on this and then this will again go in to hold this part and this part will be released. So, the figures of ratchet escapement may be operated together or independently by cams, solenoids or pneumatic cylinders giving a linear motion either to this two or one of them. So, I hope this is clear because the diagrams are self explanatory and the rest of the things we will discuss in the next session.

Thank you very much.