Manufacturing Automation
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Lecture – 03

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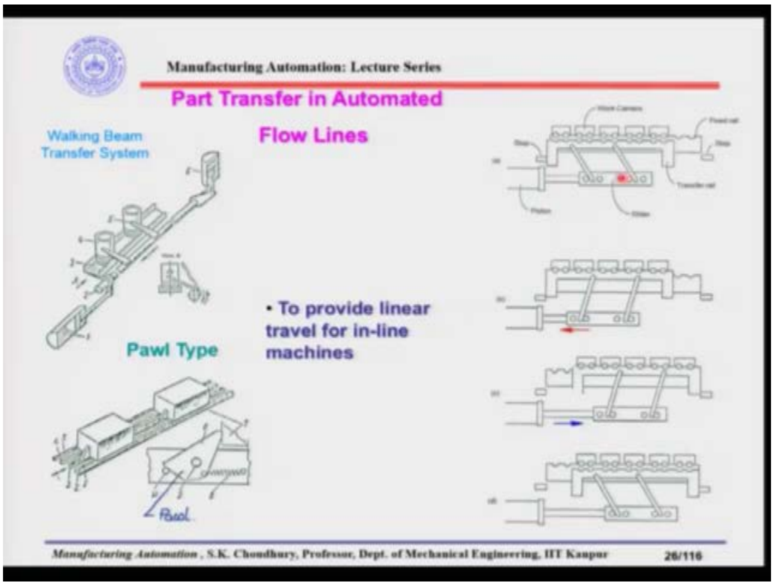

Welcome back. Now, let me remind you that we were discussing the part transfer in automated flow lines. You can see from the diagram here. This is for the linear travel from one work place to another work place for any part or for any sub assembly if it is an assembly flow line. So, this system is called the walking beam system; that means, as if it is walking.

Let me tell you that this is a fixed rail, on the fixed rail we have the work carrier, and this is the transfer rail, which is actually doing semi-circular motion because of the links attached to it; and those links are fixed on the slider of this piston and the cylinder. So, when inside the cylinder the piston goes to and fro, because of the links, this transfer rail will actually make a semi-circular movement that is what we said.

Look here for example, this is the fixed rail where we have the work carrier; and this transfer rail will make semi-circular movement while it is transferring the work carrier from one place to another place and then it is coming back and again it is ready to lift the next one. So, this is how it works. That is why it is called the walking beam system.

Here a similar system is shown. Look at the diagram here. Here we have the cylinder and the piston, and cylinder system here is one and here is one. So, here it is arranged in such a way that it moves to and fro in the horizontal plane and here the piston moves in the vertical plane. Both of them are connected to the same shaft, and on that shaft rigidly fixed are these two arms.

So, when this piston will activate, i.e., this cylinder will activate, then these arms will move the parts towards the right side. And when it is moved towards the right side this cylinder stops, this cylinder starts acting and when this cylinder acts because of these arrangements it will actually release the parts.

Release the parts and then the parts will be transferred from one place to another place; you understand that it will go like this, the part will go from one place to another place, then they will be released and the arms will be coming back and then again it will be repeat the same, I mean to say these arms and then the parts as a result will go from one place to another place like in the case of the walking beam system, but the principle is different.

Here, the another one is the pawl type. In this pawl type what happens is that these are the parts which are to be transmitted from one place to another place. Here is a rod and this rod has the pawls here, these pawls are spring loaded; that means, if we press here it will be actually dipped inside and when it is in this position, if we push the rod forward, the parts will move to the next position.

Then if you pull the rod back, pawls will go under the parts and so they will be dipped and then under the part it will go back to the initial position and then, it will be lifted back for the next parts to be transmitted. That means, these are the same mechanisms used for linear transmission of the sub assembly or the parts from one position to another position. But here you can see that the principle of such mechanisms is different.

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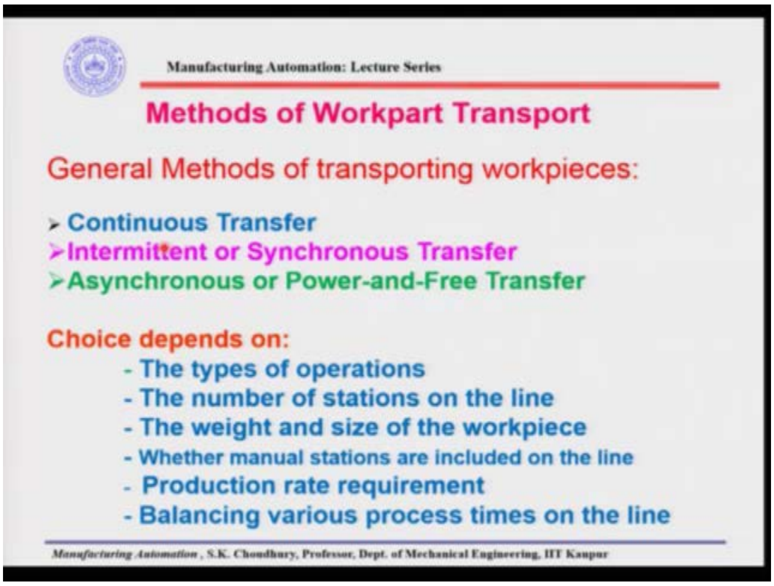

Let us see the methods of work part transport. The general methods of transporting work pieces are the continuous transfer, intermittent or synchronous transfer and the asynchronous or power and free transfer. Let me explain what are those things. Continuous transfer is where the parts are being transmitted continuously, they are not stopping.

So, from one position to another position it is continuously moving, meaning that, suppose an assembly process is going on and the sub assembly is moving continuously. If there is a manual station then the person can actually go along with that, doing the job and then releases and then the person can come back and the part will be moving or the sub assembly will be moving forward.

That means, when we have the continuous transfer, we cannot afford to have the big machines which are rigid machines. Because the machines cannot come back and machines cannot move along the conveyer. It can only have either small machines where the heads are not very big so that the heads can move along with the conveyer and come back without having much of the inertia or a human being who will be going along the conveyer or the material handling device, doing the job. For example, applying some torque to tighten some bolts or spray painting, for example, and then he will come back. He will come back to attend the next part or the next sub assembly.

That means, the continuous transfer can be used for smaller parts for, for the smaller machines. For example, in case of the toffee wrapping process. So, the head will move wrap it and then come back for the next toffee to work on. Next process or next method for transporting work piece is the intermittent or synchronous transfer.

Here the material handling device works in the following way: it will transmit the part from one position to another position, then it will stop for sometimes. And that ‘sometimes’ means that the time required for processing or the time required for the assembly. So, that is called the intermittent or the synchronous transfer.

In that case the machine does not have to move along with the material handling device, whether material is being transmitted in the flow line. Therefore, the heavy machinery can be used for machining, for example or metal working process, for example. Next is the asynchronous or power and free transfer

If you see, in both of these cases, that is, where the continuous transfer is used or intermittent or synchronous transfer is used, machines which are subsequently arranged they are all linked together. So, if a machine is stopping or for some reason if it is faulted, some fault came in, then the adjoining machines will be affected. Or, suppose in one machine the processing time is more than the adjacent machine. In that case the adjacent machine where the processing time is less has to stop for sometimes because, the previous machine takes longer time for processing.

Because of these problems the asynchronous or power and fee free transfer came into picture. Here what happens is that the belt or the transfer line is moving continuously. The machine picks up a part, machining or making the assembly as long as it takes and then when the process is over it will put it back to the conveyer where it is moving further. That means, the subsequent or adjacent machines are no more linked together, they are not affected. If one of these machines will be stopping, adjacent machine will not be stopping.

So, that is the basic advantage of the asynchronous or power and free transfer and that is why it is called the power and free; that means, it will machine or assemble as long as it takes and does not depend on whether the processing time of the adjacent machine is more or less. That is the biggest advantage. Now, which one you will be choosing, that means, whether it is continuous transfer intermittent or synchronous or asynchronous that depends on the type of operations which are being performed.

As I said, if you have a heavy machinery, you cannot use the continuous transfer for example. The number of stations on the line: if there are large number of stations or the small number smaller number of stations, if there are larger number of stations then the probability of the breakdown of the machines will be more that we will discuss at a later stage. And therefore, all this factors you have to consider and then decide accordingly whether you will be using the synchronous or the asynchronous type of transfer.

The weight and size of the work piece: if the work piece is very heavy, then there will be inertia, when it is moving and those things have to be considered in selecting the method of the work part transport. Whether manual stations are included on the line: why it is important? As I said previously, that if a manual station is included, in that case the processing time can be varied, in the sense that a person can process a particular part and it takes little more time or less time for the same process. Therefore, when the manual stations are included, the synchronous type or the intermittent type transfer will be very difficult to use. In that case probably, asynchronous or power and free or continuous transfer can be used. Production rate requirement:

Production rate requirement has to be considered; whether you need the high production rate or low. For the continuous transfer the production rate will be higher because the parts are not stopping or not dwelling in as in case of the intermittent or the synchronous transfer.

Balancing various process times on the line: this is important because suppose two adjacent machines will have the different processing time. In that case if one machine has completed the part in that case the problem will come and then one of the machines will be starving; that means, it will be stopping. So, all those points have to be considered while selecting which method of transporting work piece has to be considered.

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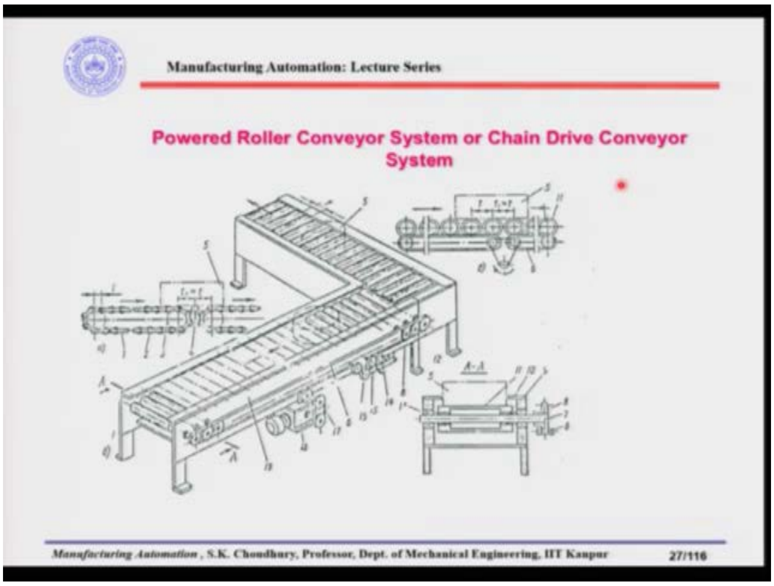

Here are some of the examples of material transfer. It can be with the powered roller conveyer system or chain drive conveyer system; here these are the examples of conveyers.

The part is supplied at a point which is being transmitted to the next position with the help of the rollers in the conveyer and the rollers can also be power driven. There are motors attached to the rollers or the chain or the chain and sprocket system. So, these rollers are being moved and the parts are being transmitted from one place to another place and finally, they are coming out. These are the systems which are shown here as a cut out and this is a chain drive belt drive and so on.

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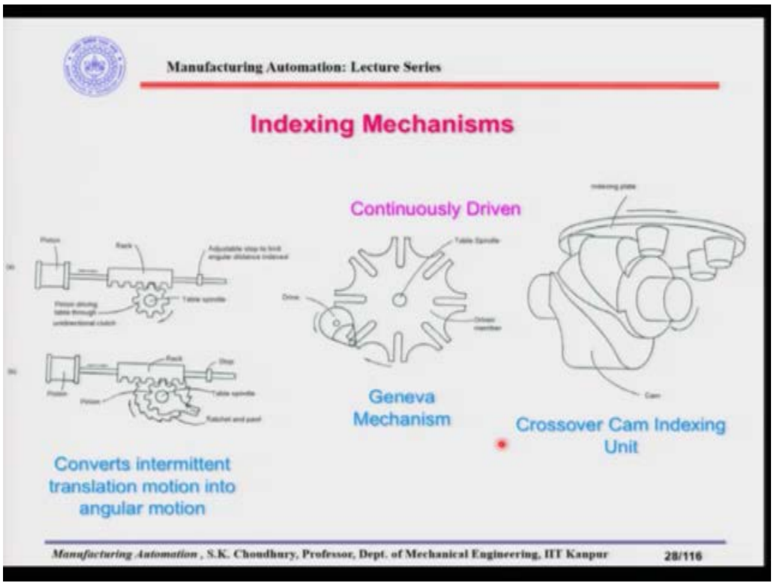

Indexing mechanisms: indexing mechanisms have a tendency of indexing and stopping and particularly for that purpose the indexing mechanisms are used. One of the basic examples of the indexing machines and most popularly used is the Geneva mechanism. Here is an example. Geneva mechanism is continuously driven by a driver and this pin which is being driven by this driver, goes inside the groove and coming back. While doing so, while going and coming back, this Geneva mechanism is not moving. And then it is going through this groove and then again coming to the slot and coming out.

So, what happens is in one rotation or full rotation of the driven member it will index and stop. So, that index and stop because of the pin going to the groove and coming back. In this Geneva mechanism the basic drawback as you can understand is the pin and the pin is the weaker point of the Geneva mechanism because the entire torque which is given by the part or the sub assembly located on the Geneva mechanism, i.e., located on the driven member, is coming on to the pin. Therefore, if the pin breaks, in that case the Geneva mechanism cannot be operated. Another drawback of the Geneva mechanism is of course, the limitation in the number of stop overs.

So, because of that there is another improved version of the Geneva mechanism, which is called the cross over cam indexing unit. Here as you can see this is the cam and here we have the groove, this is the pictorial view and while rotating these are the pins which are entering the groove and it is indexing and dwelling like in the case of the Geneva mechanism.

So, here the drawback of the Geneva mechanism is eliminated because at a time at least two pins will be engaged in the groove of the crossover cam. So, the torque coming on each of these pins will be less and therefore, this pins are no more the weaker point of the mechanism. Therefore, the crossover cam indexing unit will have the higher torque carrying capacity than the Geneva mechanism. However, the number of stop overs limitation is the same in the cross over cam indexing unit as in case of the Geneva mechanism.

Another example is the rack and pinion system. Here as you can see, there is a cylinder, it can be hydraulic or a pneumatic cylinder, which is moving the piston back and forth. And there is a rack here with the pinion. With the linear movement of the rack, the pinion will be rotating and the table with this spindle. Table will be on this pinion and it will be rotating. So, while going to one side, it will rotate and there will be an unidirectional clutch here so that while the rack is coming back the movement of the table is not affected.

On this we have the indexing table; the indexing table will be rotated by this pinion. Meaning that indexing table axis will be the same as on the pinion. Here is another example. This converts intermittent translation motion into the angular motion and this is similar or very close in the design as in case of the mechanism which is shown here.

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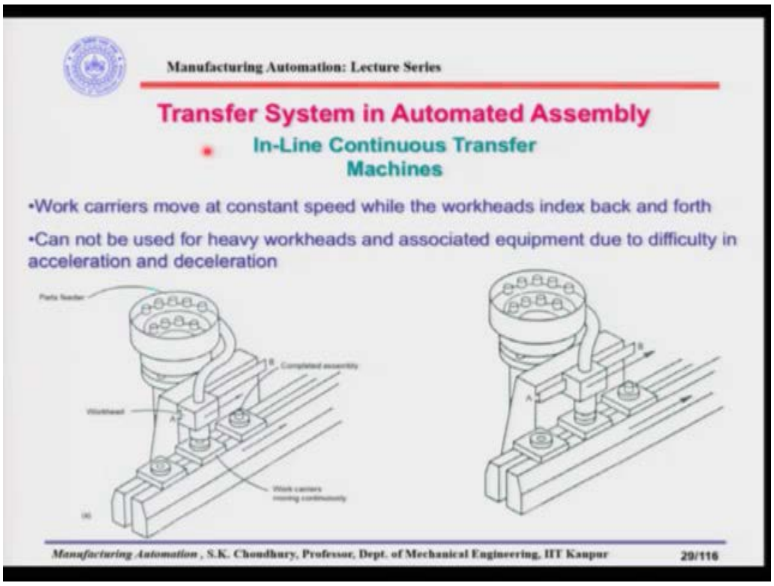

Next is a transfer system in automated assembly. Here it is the in-line continuous transfer mechanism, as I was telling you that in-line continuous transfer mechanisms there you cannot use the bigger head or the bigger work heads because they will have the inertia. Look at this example, here we have the feeder, where we have the small parts which are being fed to the machine which is being processed or assembled.

So, here this is the work head, which is processing the part and to the work head the parts are coming from the feeder. Now this is the material handling device or the conveyer that I was telling you which will actually transmit the part from one position to another position. So, here it is continuously driven, so that the parts are coming from one position to another position and it is not stopping; because, when it is coming to this position the work head will start operating and moving at the same time.

Therefore, it does not matter for this work head whether this stops or not because it can actually move. So, it moves to this position, while moving it is also working on the work piece or the assembly/sub assembly then it is completing and coming back. So, if the machine or the work head is very bulky, if it is machining or if it is the material handling in that case while doing this movement to and fro, because of the inertia there will be positioning error. And therefore, for work heads which are only small - smaller in size can be used for this kind of a transmission.

The same here. It is shown that this work head is moving to and fro and the work carrier will be coming from one position to another position and it is not stopping, it is moving continuously. So, these are the same examples.

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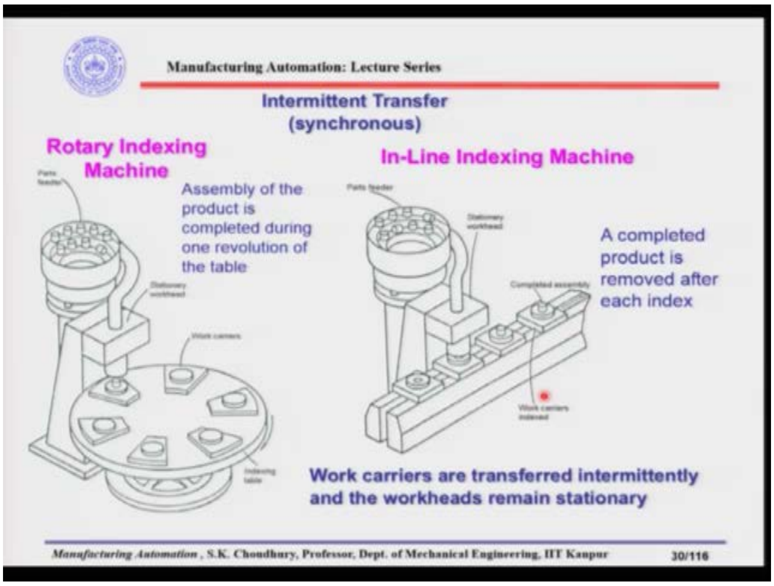

Here is another example. This is a rotary indexing machine and normally the rotary indexing machines are driven, as I said, by Geneva mechanism, so that the parts can be moved from one position to another position. And dwell for some time. Dwell for some time means it will stop for sometimes so that, this work head can actually make the process either it is a processing station or it can be an assembly station.

If it is an assembly station, in that case the sub-assembly will be moving from one position to another position. And say here for example, this the loading, it is going to the next position, being operated upon then to the next position and it is coming out, the complete part will be coming out from here. So, this is called the indexing table, which will be indexing and dwelling and this is driven by the Geneva mechanism.

This is the in-line indexing machine where it is moving continuously. So, this is moving from one place to another place in a straight line and then it is stopping. And here it is called the rotary indexing because it is moving at a circular motion. So, this is the difference, but in both cases parts are going from one place to another place and stopping for sometimes. So, this is the in-line indexing machine and this is the example of the rotary indexing machine.

In case of in-line indexing machine, what kind of mechanism can be used we have discussed it earlier, this is the walking beam system. And the Geneva mechanism can be used or pawl and ratchet mechanism can be used for the rotary indexing machine for example.

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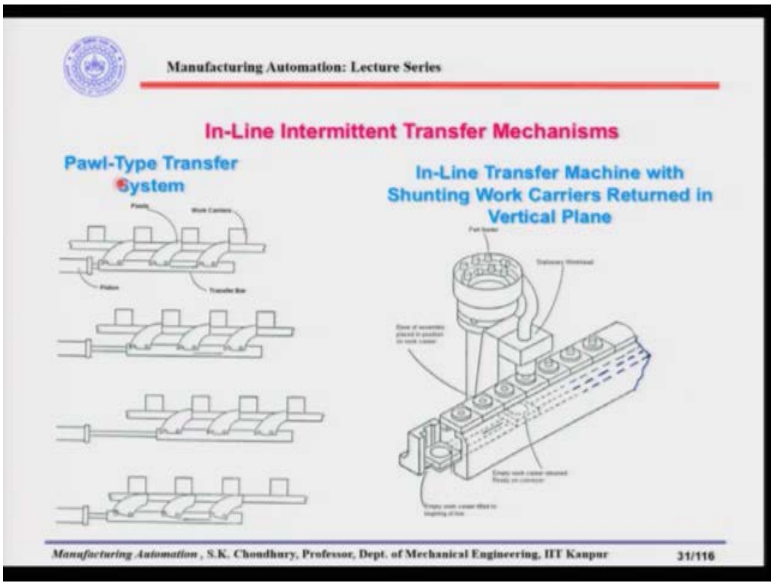

Here is another example of the pawl type transfer mechanism. This is similar to the one which we have discussed earlier and like the walking beam system. So, these are the pawls, these are the pawls which are spring loaded and while this works with the work carriers, when it is coming back, they will actually go under the parts and they will be dipped so that it could come back to the initial position.

These are the four positions which are self explanatory you can see that it is going to the right side and then it is coming back. When it is coming back, they are spring loaded, so they are dipped under the work piece ok and coming back to the initial position then they are going up again and ready to transmit the parts from one position to another position.

Here this is the in-line transfer machine with shunting work carriers returned in the vertical plane. Here what happens is that the parts are moving from the starting position, they are moving and then there is a lifting mechanism.

Empty work carriers are lifted to the beginning of the line and then the line is moving again, taking the work carrier from one place to another place and then they are being placed on the conveyer and it is returning the empty carriers. This kind of mechanism you can see at the airport for example, that the trays, which are coming and you take the tray and they are going along the conveyer then the empty tray is coming to the conveyer again and it is coming back to the initial position. So, this is a similar example here also, but here it is used for processing of parts or processing of the sub-assemblies.

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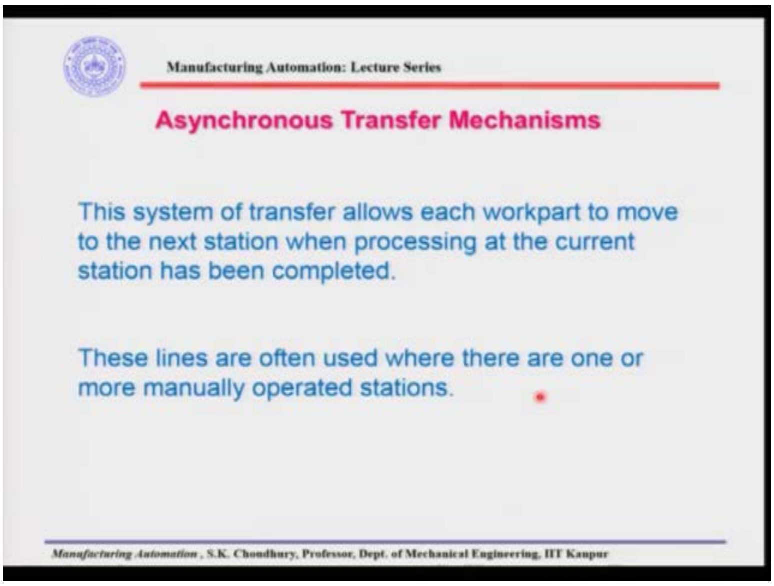

Now, the asynchronous transfer mechanism. As I discussed earlier, this has eliminated the disadvantage of the earlier mechanisms where the adjacent machines are affected if the machine breakage happens or if the processing time of the adjacent machines is different.

So, in case of asynchronous machine, this system of transfer allows each work part to move to the next station, when processing at the current station has been completed. Therefore, the machines are individual, I mean they are not linked together in the sense that they are not dependent on whether the processing time is more or less in the adjacent machines.

These lines are often used where there are one or more manually operated stations. I discussed it earlier that when there are manually operated stations for example, if there is a station where men/human being is sorting or human being is inspecting the parts - small parts. These are the operations which are very difficult to automate. And if even you try to automate some of these manually operated processes it will be very expensive and it will be not economically feasible.

So, in a flow line sometimes economically it is feasible to have the manual stations. Whenever we have the manual stations, in that case we cannot actually control the processing time because, the manpower is involved there, human being is involved there. Therefore, in that case these kind of asynchronous transfer mechanisms will be very helpful. Because they actually, the adjacent machines, are not dependent on each other whether the processing time is more or less.

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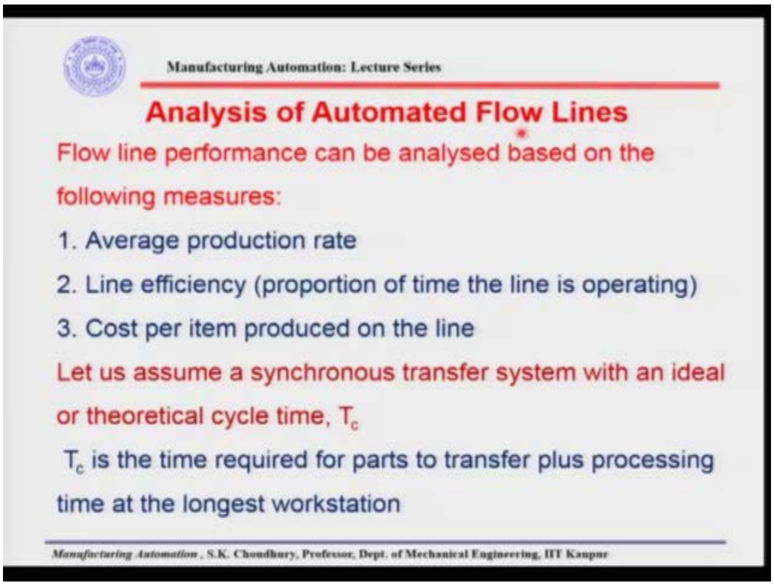

Now, we will come to the analysis of the automated flow lines. I will give you the basics or the outlines and the next time we will discuss the analysis of automated flow lines in details. What is that analysis and what do you need it for?

First of all, we have to design the automated flow line; what kind of automated flow line, how it will work depends on the kind of work we have taken up on that flow line. Automated flow lines are actually analysed based on the three measures; that is, the average production rate, line efficiency; line efficiency is that the proportion of time the line is up the line is operating and the cost per item produced on the line.

These are the three basic points or the measures based on which the automated flow lines will be analysed. Next time I will discuss each of them, that is, average production rate, line efficiency and the cost per item produced on the line in details.

Thank you very much.