Manufacturing Automation
Prof. Sounak Kumar Choudhury
Department of Mechanical Engineering
Indian Institute of Technology, Kanpur

Lecture – 02

Welcome back to the Manufacturing Automation course. So far we have discussed what is Manufacturing Automation; how it can be defined. A truly automated system should actually have the ability to make a decision, carry out the decision and to check whether the decision that they have taken is being performed properly or not. We have also seen what is the benefit; there is a lot of benefits of for the automation.

Then, we have discussed why we need the automation, reasons for automation and so on. So, next let us discuss some of the automation strategies which should be taken up so that the productivity - production rate can be enhanced in the manufacturing processes.

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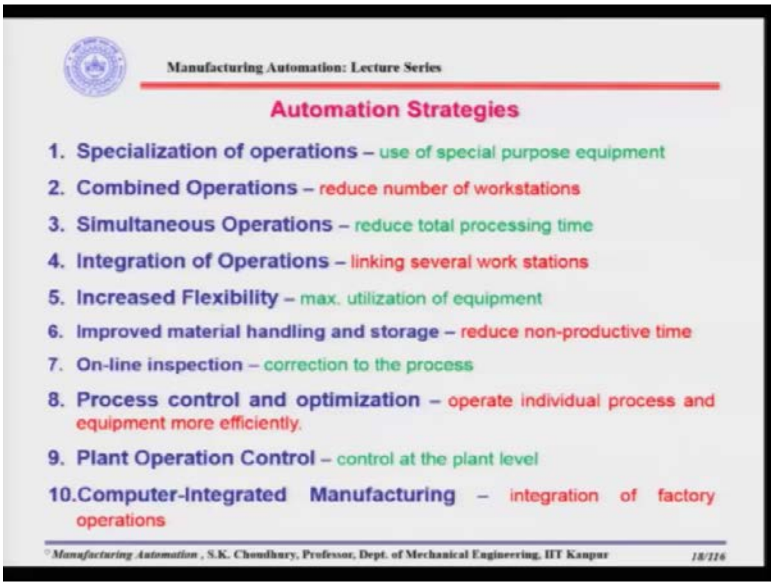

So, first point is the specialization of operation, that is the use of special purpose equipment which will be able to perform one job precisely, and that machine will be specially used for that particular operation. Therefore, we are calling that machine as a specialized machine, for specialization of operation.

Second point is the combined operations. Combined operations do mean that this will reduce the number of workstations. Complex parts may need a large number of processing or a large number of assembly operations, if the assembly is very complicated. In case we can do the processing - different processing in one machine, in that case we can use minimum number of machines and that will reduce the number of workstations. That is the strategy which we are calling as a combined operation. That means, few operations will be combined in one workstation or in one machine which will reduce the number of machines then.

Next point is the simultaneous operations and the simultaneous operations mean that operations which are combined in a machine can be done simultaneously. Let me give you an example of combined operation. Suppose, we need to turn a part, after that we need to chamfer it, after that we need to cut it in pieces. So, in one machine, we can do that in a sequence - first you are turning; then, another tool is coming for chamfering; then, another tool is coming for parting the work piece - parting tool.

Now, the third point which is the simultaneous operation is that in one machine, we are simultaneously doing these 3 operations; that means, we are reducing drastically the total processing time. Whereas, in case of combined operations since we are doing many operations together in one machine, we are actually reducing the number of workstations. In the third point, we are simultaneously doing that so that the total processing time is reduced. So, the productive capacity or the production rate will be increased. Because production rate, as we know, is one upon the time, less time is more production rate.

Fourth point is the integration of operations; that means several machines which are linked together so that the parts could be routed from one machine to another machine. Next point is the increased flexibility; increased flexibility is that the equipment that we are using can be maximally used, maximally utilized. Meaning that one machine can be used for producing different types of parts.

As you understand that we are giving the example of numerically controlled machines. Let us say if you take a turning machine, we call it a turning because only the turning operation can be performed. We cannot do the milling process for example. Whereas, if you take an NC machine, for example, or the CNC machines, we can use many such operations together in one machine. So, we are using the flexibility; that means, we are increasing the machine utilization.

Next point is the improved material handling and storage that will reduce the non-productive time. Meaning that in the normal production, where we do not have the material handling and storage system properly, in that case the crane or a human being carries parts from one machine to another machine - one workstation to another workstation, and they are being stored somewhere for which we have to find out where it is being stored. Whereas, in the case of automation there is a concept of Computer Aided Process Planning: CAPP, for example.

There, within the computer program we can find out where exactly that part is located. So, the automatic guided vehicle will be given that signal and it will go exactly to that particular position and take out the part, it will not take much time and as you understand that if the assembly process or the manufacturing process for complicated parts is performed, in that case the number of parts and the number of processes will be huge, very large number.

So, if you have to find out each part where it is located without any process planning, it will take a lot of time. So, overall the improved material handling storage will increase the production capacity, i.e, the production rate. Next point is the on-line inspection. On-line inspection is the correction of processes. I told earlier also that, for example, an adaptive control system can be used. During the process it can be in-built in the machine so that during the process errors occurring will be identified and rectified by the adaptive control system inside the machine itself.

So, this is the online inspection. In the flow line for example, where we have different machines linked together, in between there could be an inspection machine, which will inspect each part being produced and give the signal that this is the error which is occurring that has to be rectified. Next point is the process control and optimization. That is to operate the individual process and the equipment more efficiently.

Here again the process control will constitute a set of be sensors that will identify the process performance and it will dictate the process how to perform it in an optimum condition. This is the process control and optimization. Now, we are further extending the process control and optimization to the plant level and this is the plant operation control. The plant operation control is for the plant level overall.

So that means, this concept of process control is extended to the plant level, to the factory level and finally, the computer integrated manufacturing, which is the integration of the factory operations with the manufacturing processes, with the design, with the advertisement, with all the activities and the other business activities in the plant. They are all integrated using the computer network system.

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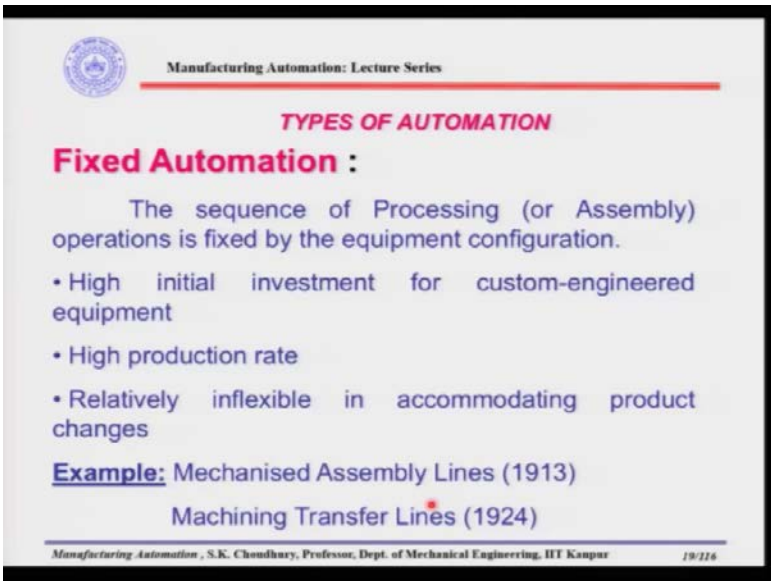

Next let us see: what are the types of automation that we have. Normally we have three types of automations: fixed automation, programmable automation and flexible automation. Fixed automation is normally used in the mass production. Here, the sequence of processing or assembly operations is fixed by the equipment configuration. What does it mean? Let us take an example of a standalone turning lathe which is for a specialized operation.

It means that the lathe machine is designed for making a particular part. So, depending on the part configuration, depending on the part size, we have to make relative movement - relative motion between the tool and the work piece. For that suppose there are cam shafts with the configuration of the cams according to the configuration of the part so that the particular part can be manufactured.

Now, if we have to make another part, of another configuration, then that machine cannot be used because that machine has a particular cam shaft for producing a particular part. Therefore, what we see here is machine that is relatively inflexible. Fixed automation - the machines which are used in the fixed automation or overall the fixed automation has relatively less flexibility in accommodating product changes.

Here the initial investment for the custom engineered equipment is high. I gave you an example of a lathe machine where a particular part is being fabricated. That machine is called the custom engineered equipment because that equipment is made according to the customer's part, customer's order. So, if another customer is giving another order of different configuration part, that part cannot be produced by the earlier machine which is why we are calling it as a custom engineered machine or equipment.

So, the first criterion for this fixed automation is the high initial investment for the custom engineered equipment. Next point that should be highlighted for the fixed automation is the very high production rate because that machine is a specialized machine which can be operated only for producing that particular part or those particular parts and that machine is doing it with a very high precision, very high efficiency.

Therefore, the production rate becomes very high, but as I said that here, these machines are relatively inflexible. Let us take example of mechanized assembly lines which were invented in way back in 1913 or the machining transfer lines which were invented in 1924. So, these are the examples of the fixed automation, which is basically used in mass production.

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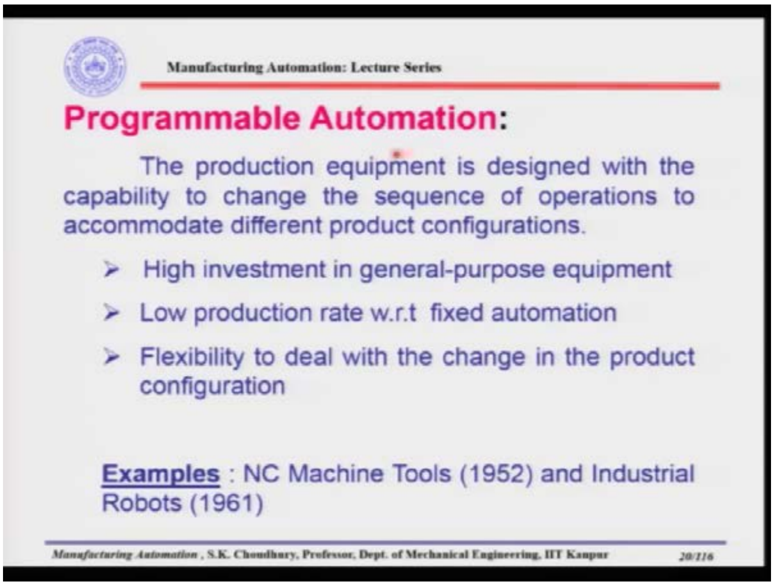

Next is the programmable automation and you must have heard about programmable automation in terms of numerically controlled machines, computer numerical controlled machines – CNC, NC machines. Here, the production equipment is designed with the capability to change the sequence of operations to accommodate different product configurations. So, the basic difference between the programmable automation and the fixed automation is that we are trying to increase the flexibility. Why it is required?

Because our demand has changed. For example, today you are wearing a particular shirt, tomorrow you would not like to wear that because in the market you see different other design of shirts, although your shirt is not old. So, different making, different shirts need different kind of skill or different kind of machines sometimes. So, a machine should have the flexibility so that different configuration of parts can be manufactured.

This is one of the aspects of the programmable automation, where flexibility is increased over all. So, the criteria for the programmable automation is the high investment in general purpose equipment. You see the difference here, which is that earlier it was the custom engineered equipment for the fixed automation, where these machines were capable of making a particular part - parts of particular shape, size, finish accuracy.

Here, what we are using in the programmable automation is the general purpose equipment. Because this equipment will be able to manufacture parts of different configuration and therefore, the investment will be higher. Second point is the low production rate with respect to fixed automation. Low production rate because when you are changing the configuration from one batch of products to another batch of products; it needs some change in the machine.

For example, in case of numerically controlled machines, you need to change the program; you need to change the pallet fixture, for example. So, that will actually take time. Therefore, the production rate will be lower and the third very important point is that flexibility to deal with the change in the product configuration. In one NC machine, you can actually produce a shaft, for example, or you can cut the gears. There are machines which are also capable of making the drilling and so on.

So, in those machines the flexibility is very high and they are being utilized quite properly. As I said these are the NC machine tools, the concept of which was introduced way back in 1952 in the Massachusetts Institute of Technology and the industrial robots way back in 1961 and the NC machine tool around 1952.

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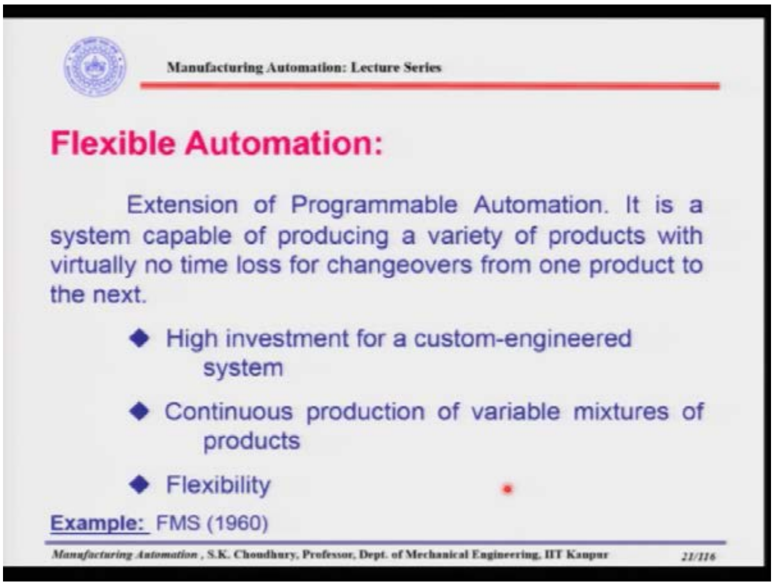

Next is the flexible automation; flexible automation is actually one step ahead of the programmable automation. In case of programmable automation we are changing the program and we are changing the fixtures from one part to another part - part of one configuration to part of another configuration that takes time.

In case of flexible automation that time is reduced to minimum since that change in the program is being done offline. When one part is being produced, the program for another part is being ready. It is prepared offline and then it is transmitted electronically. The fixtures are also made on the pallet fixtures and as soon as the manufacturing of one part is over, the pallet fixture comes in and the changeover in the fixture does not take much time.

So, here the high investment is for a custom engineered system. Therefore, the entire system will also be custom engineered, in the batch wise and the continuous production of variable mixtures of products possible and the flexibility is very high. It is even higher than the programmable automation that we have discussed. Example of the flexible automation is the flexible manufacturing system which was introduced way back in 1960.

In the flexible manufacturing system, there are few NC machines linked together with the manipulators, with the robots and there is a system control; control system consisting of the computer which will control the NC machines - send the signal to the NC machines, program to the NC machine and program to the robot for placing the parts. This will be acting as a part placing mechanism.

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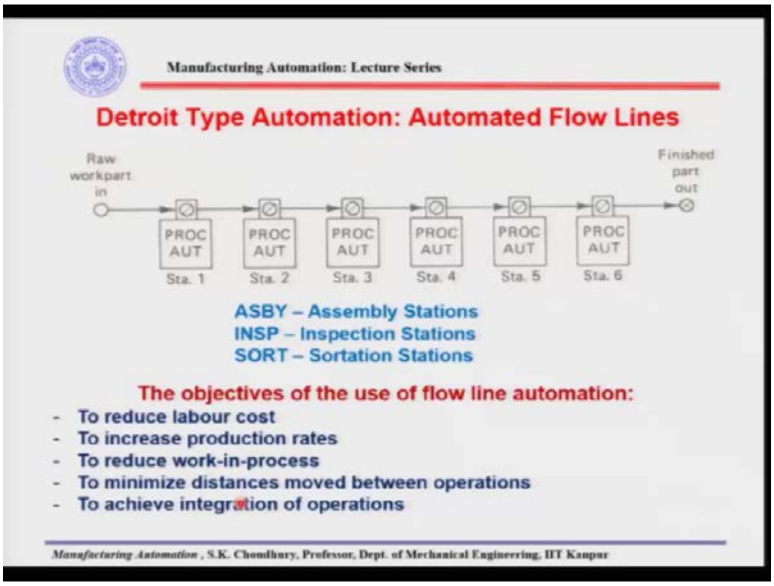

Next let us discuss so called Detroit type automation, that is, the automated flow lines. Here, we will be discussing different aspects of the automated flow lines, as you can see here in the diagram. Now, the traditional symbol of the automation is the mechanised flow line. This is the first example of the automated production to come and the origin of the mechanised production lines or flow lines can be traced in the works of the Henry Ford, Chrysler in the city of USA, Detroit.

Automobile industries of Ford, Chrysler are located in Detroit city, that is why this kind of technique used in the automation is called the Detroit type automation. Now, here is an example of an automated flow lines, you can see. Automated flow line will have the combination of different machines and they are linked together by the material handling device. This is the material handling device.

So, the material handling device is bringing the raw material from one machine or one work place to another work place and these are the machines which are stationery. These machines can be either production machine, processing machine, or it can be assembly stations for which it is given ASBY in short that is assembly or it can be inspection stations or it can be sortation stations and so on.

So, basically they are linked together. That means, the parts are routed from one work place or one work station to another work station with the help of the material handling device and the finished work part will be coming out of this. So, the entire system is called the automated flow line and the use of the automated flow line - the optimum use of the automated flow line was shown by Ford in his manufacturing and the assembly of automobiles in the city of Detroit. Finally, the result was the 10 second per car assembly that became a history.

Now, the objective of the use of the flow line automation, there are few. First of all, to reduce the labour cost. Here, it is very important to mention that the labour cost, particularly the loading and unloading, are the very important factors which are being reduced or which are being eliminated overall. Second point is to increase the production rate. Of course, machines are linked together, the routing is less; routing means, shifting of the part or the assembly from one machine to another machine. The time taken is less. Therefore, the production rate will be increased.

Third point is to reduce the work-in process; that means, the work routing is so optimum that the duration of time the work piece is located in the process will be less. Duration of time will be less. Here, this will also minimize the distances moved between the operations. Let me explain it to you, for example, if a part needs a turning, then milling, then drilling and so on.

So, suppose if we put the turning machines together, drilling machines together, milling machines together; in that case first the turning will be done, then the milling, then the drilling and so on and the part does not have to come back after turning to milling and then, again for turning and so on. So, overall it is minimizing the distance, moved between the operations. This is also to achieve the integration of operations. So, all similar processes are integrated together. This is one of the advantages of the automated flow lines.

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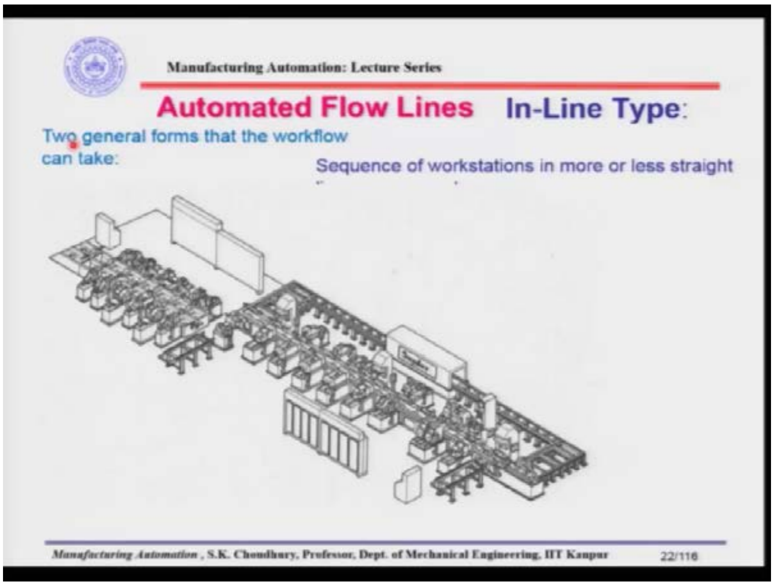

Now, basically there are two general forms that the work flow can take place. As you can see in the diagram, the first is the in-line type. In in-line type all the machines are located in a line, in a straight line - more or less straight line. There are few rotations at 90 degree.

But overall, all the machines are located, all machines are arranged more or less in a straight line. Here in this example, this is the differential of an automobile which is being machined. So, these machines are here and after machining up to that point, the parts are turned at a 90 degree angle and then again, they are machined.

So, all the machines here are in a line and in between we can have the inspection machines, we can have the heat treatment process and then, the final work piece will be taken from somewhere here. So, this is the in-line type or we can have the rotary type.

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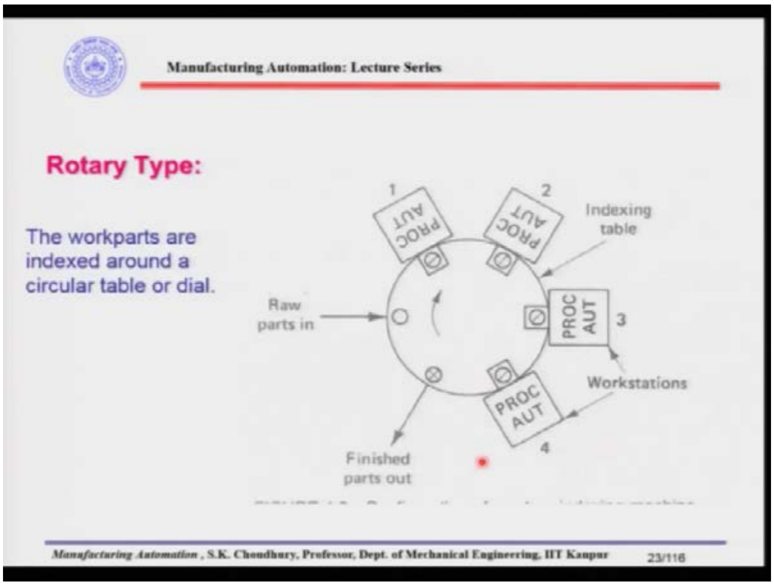

In case of rotary type, we have the stationery machines around a disk or this is called the table or a dial. These machines are also called the dial indexing machines - dial indexing rotary machines. For example, here the raw part raw material will be provided and then, it is being rotated to this work station and the part is being processed. After processing this, it will go to the next stop or to the next work station and so on. The finished work piece will be coming out from here.

Now, here you mind one thing that this dial or the table is an indexing table; that means, it will rotate and it will stop for sometimes - stop for sometimes till the part is being processed or the assembly is completed. So, from here it will rotate up to this point and stop and then again when the process is over in this station it will go from here to here and so on.

So, it is called the dial indexing machine. This is the indexing and when it is stopping, this is called the dwelling. The time period, during which it stops, it is called the dwell time and the time period it is going from one place to another place is called the indexing time. This concept you must have heard in the Geneva mechanism, for example.

In such kind of dial indexing machines, in many cases, the Geneva mechanism is used for rotating or indexing and then dwelling and then again indexing and dwelling and so on. What kind of choice you will be making, whether you will be choosing the in-line type or the rotary type depends on whether your parts are smaller. For example, rotary types are basically used for smaller parts, or for small assembly.

Small assembly means that assembly consists of, let us say, fewer parts of 10-15 or if the machines are smaller. Normally in the rotary type not very expensive machines are used. One very important point in the rotary type is that here we do not use the buffer stock or the buffer storage.

The concept of the buffer storage we will be discussing later in details. Let us come back to the in-line type. For example, in the in-line type what happens is that if a machine stops, if this machine stops, then, next machine will not be getting the parts for assembly or processing and therefore, in between these two machines, we should have some buffer. So, if one machine stops, next to that machine can still take the part from the buffer and use it.

So, the stopping of a machine will not affect the working of the next machine. That is the concept of the buffer stock. In case of rotary type, the buffer stock is normally not used because these are the smaller machines and we expect these machines to have fewer break down whereas, in case of in-line type, there has to be a buffer stock. Because in the in-line type we use larger number of machines and in rotary type, the number of machines will be less. Therefore, the buffer stock is not used in case of the rotary type whereas, it is used in the in-line type.

These are the criteria, which you should keep in mind for selecting whether you will be going for the rotary type or for the in-line type.

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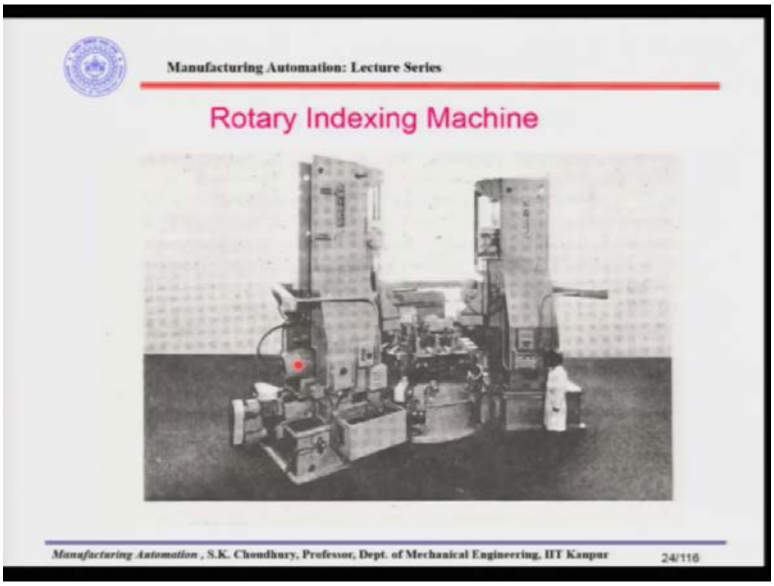

These are some of the examples. This is the rotary indexing machine. You can see the rotary indexing table here and around that we have the machines. Here we have the part. The part will be indexed and it will stop for some time for processing or the assembly and when the processing or assembly process will be completed, the part will be transferred from one place to another place for the subsequent assembly or processing.

This is an example of the rotary indexing machine. Here is the rotary table in the middle and around that we have the machines for performing the operations. So, if we see this diagram, here this is the indexing machine where we have the work places. These are the work places and these are the stationary machines around the rotary indexing table, which is the rotary indexing table indexing and dwelling, i.e, rotating and stopping.

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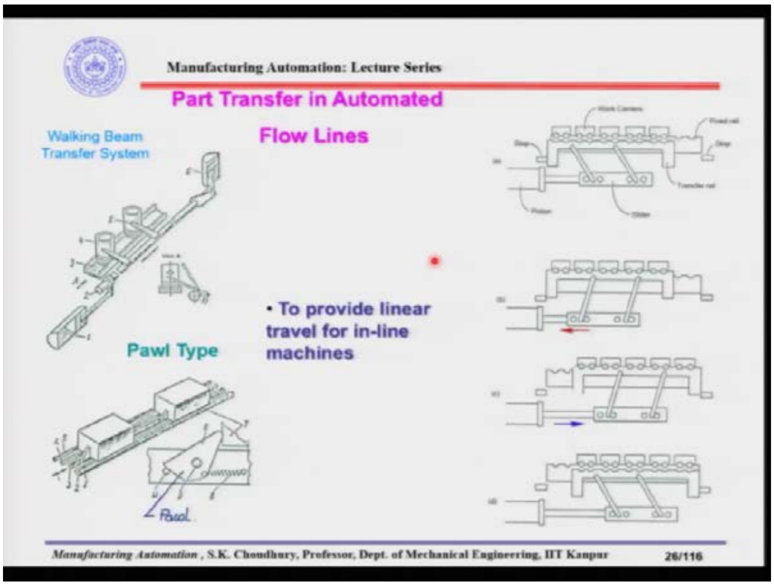

Part transferred in the automated flow lines - how the parts are being transferred from one place to another place. There are various mechanisms. They are distinguished by the type of motions - one is the linear motion, another is the circular motion. For example, if a part has to be transmitted from one place to another place and then, it has to dwell. One example is this one. See here we have the piston and the hydraulic cylinder or a pneumatic cylinder and this is the slider which is connected to the hydraulic or pneumatic cylinder. So, it actually goes to and fro and while doing so, these are the links which are connected to the piston or the slider. So, these links will move in a semi circular way like that.

So, when it is moving towards the right or it is coming towards the left, it will do this kind of a motion. While doing so, there is a fixed rail and there is a transfer rail. On the fixed rail, there will be the work carriers with the work parts and then, the transfer rail which is connected to this links, will lift it - lift the work carriers clear and then, going to the next stop. So, it is like, if I have to show it, for example, this is the fixed rail.

So, on the fixed rail we have the part, and here is the transmitting or the transfer rail moving like this. So, while doing so, it is taking out the carrier from here and while going ahead, it is actually putting the part to the next position. Here we can see that the hydraulic cylinder is working and the piston is moving to and fro.

This is doing the semi-circular movement. While doing so it is actually lifting the transfer rail so that the work carriers are lifted up from the fixed rail and then, transmitted to the next position - from one place to another place. This is used in case when the sub assembly or the product needs to be transmitted from one place to another place. Other examples we will be discussing later.

Thank you very much.