Automation in Manufacturing
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Week - 02
Lecture – 03
Automated systems and equipment used in manufacturing
part – II

Hello friends, I once again welcome you in the course of Automation in Manufacturing. Now, we will be studying the Automated systems and equipment used in the manufacturing that is the part II. This is the lecture 3 of week 2.

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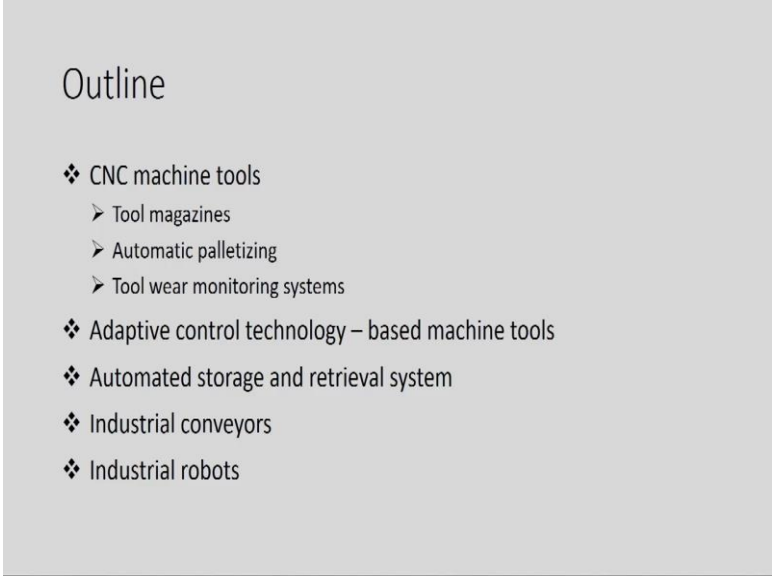

The outline of this lecture is as follows. We will be studying the CNC machine tools, various elements of CNC machine tools such as tool magazines, automated palletizing; tool wear monitoring systems.

Then, we will study a very important concept that is adaptive control technology and how the adaptive control technology is helping to build the modern machine tools. After that, we will learn the concept of automated storage and retrieval system. Then, we will study the industrial conveyors and at the end of the lecture we will study the industrial robots and its application in manufacturing.

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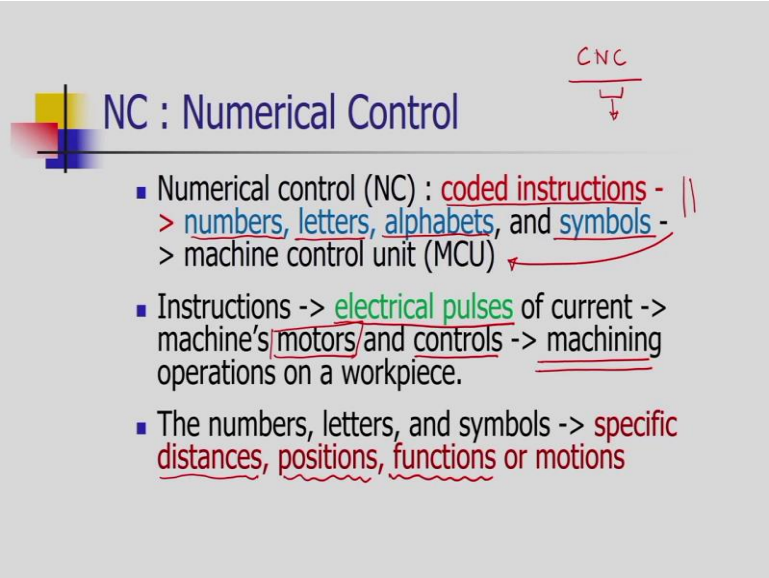

To machine these complex surfaces, we need Computer Numerical Control technology. The CNC technology or the term CNC has 3 letters C and N C. What is the meaning of N C? N C is Numerical Control. In this numerical control, coded instructions are used. These coded instructions have various numbers, letters, alphabets and symbols.

These instructions will be passed to or they will be fed to the machine control unit. Machine control unit is a part of CNC machine tool. Machine control unit reads these instructions, follows them and generates electrical pulses. These electrical pulses are running the motors of the CNC machine tool.

Motors are the basic drives of the CNC machine tool. The accurate passage of electrical pulses are done by the machine control unit. Moreover, the machine control unit is getting the feedback from various sensors and based on that sensor feedback it may take the decision to adjust or change or to vary the number of pulses that are to be generated and given to the motors. This is called the control. The operation of the drives and control of the drives will be done by the machine control unit.

As the motors are running, we are getting the required operation. In CNC milling machine operation the machining would be carried out. What exactly these coded instructions are carrying the information? These instructions are having the information related to the distances. These coded instructions have the distances, information related to the position, information related to the activation of various functions to carry out

various auxiliary operations such as coolant on coolant off, safety door on safety door off, changing of the tool.

All these functions will be carried out and these instructions are provided in the coded form. All the symbols, letters and numbers together are written in a standardized way, which is called the G and M code; the preparation and the miscellaneous code. We will be studying about this in the later classes when we will study the CNC technology in detail.

Numerical control was started in early 50s in USA. The instructions were written in the form of magnetic strips and punch cards. To write a simple program, very long length punch cards were used. In order to change or edit the program, we have to discard the entire punch card. This is a very cumbersome and lengthy process to develop and write a program on the punch card.

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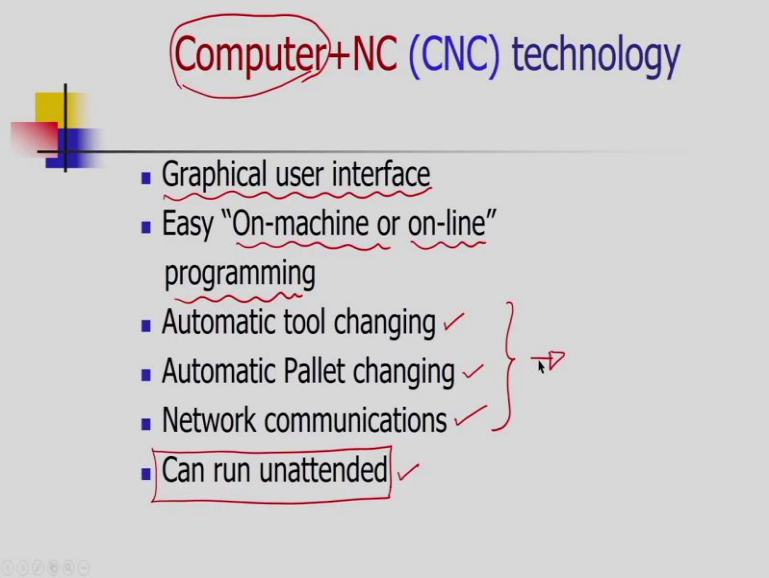

With the use of computers, this problem of editing has now been solved. The computers are helping us to have graphical user interface and now we can write the program in an offline mode. We can write the program on computers, change the program easily on computer console screen and can easily edit the program.

Machine and online programming has now become possible with the computers. In addition to the online editing of the program and online simulation of the program, we

can now incorporate automatic tool change operations, automatic pilot changing operation. The machine can communicate with other machines and the central computer through network communications. Thus, the communications may be done in a wired mode or the wireless mode. This is a very interesting feature of the CNC machine tools, the machines can now run unattended. We will be looking at various tool changing, pallet changing aspects of the CNC machine tools in the coming slides.

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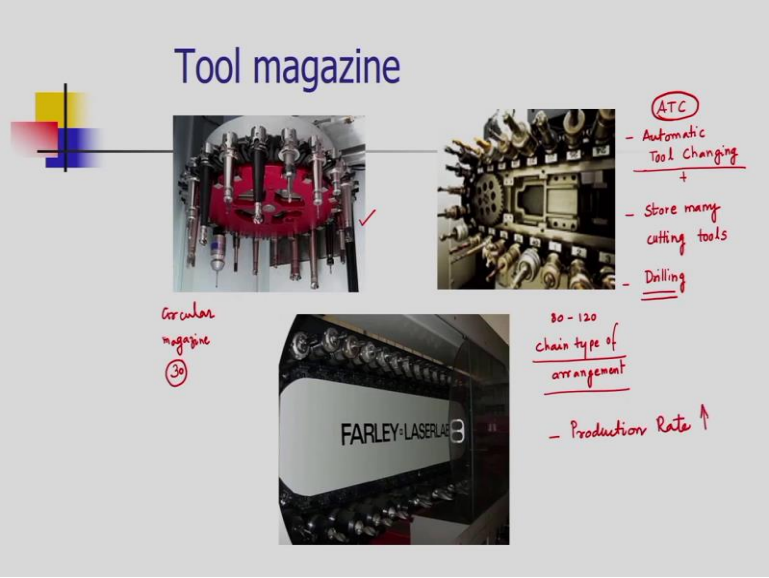

I In a typical conventional machine tool; very limited number of cutting tools can be mounted, which have to be changed manually. This is a time consuming task. In CNC machine tool operations, we use Automatic Tool Changing facility or ATCs. In addition to that we should hold multiple number of cutting tool.

If we take the example of a CNC drilling machine, the operation is very special that the machine tool should manufacture variety of types of; the machine tool should carry out variety of the drilling operations from small to larger size of holes that are to be drilled. For this purpose we may need to have large number of drill bits. We may also need to have the large number of the semi-finishing tools, which are called reamers and finishing tools in a drilling operation.

For this purpose various types of arrangements are available in CNC machine tool industry. The umbrella type storage device is a circular magazine and these circular

magazines can hold up to 30 number of the tools. But, if wewant to store say from 80 to 120 number of tools, then we use chain type of arrangement.

These ATC facilities have the storage devices as well as mechanisms which are required to remove the tool from the spindle of the machine, which is called unloading of the tool and then loading of the tool to the machine. The removed tool will be taken to the magazine, which and stored at an empty slot.

The designated or the desired tool will be taken from the magazine and that will sit at the spindle of the machine tool. This is the automatic tool changing operation. This saves lot of time and enhances the production. Production rate enhancement is the ultimate aim to provide the tool magazines.

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The next type of arrangement that is required in CNC machine tool is the pallets. Pallets are used to stack, store, protect and transport the work part.We need to stack the work parts, stack the finished products, store the work parts and the stored work parts will be fed to the machine whenever and wherever it is required. On the pallet, various work parts are mounted and the machine will carry out the processing operation like machining or drilling or welding.

This processing will be carried out on the work part or it may be the washing operation as well. Once the operations are done, then the pallets will be removed manually or by using robots. During the processing time, the other operator can ready the next pallet.

Thus, the pallet number 2 will become ready. The work parts are ready which are to be fed to the machine tool for the next set of operations. This again saves the production timeand reduces the lead time in the manufacturing. Designing of the pallet or changing of the pallet, then changing of the pallet transport system or pallet changing system, all varies from machine tool to machine tool.

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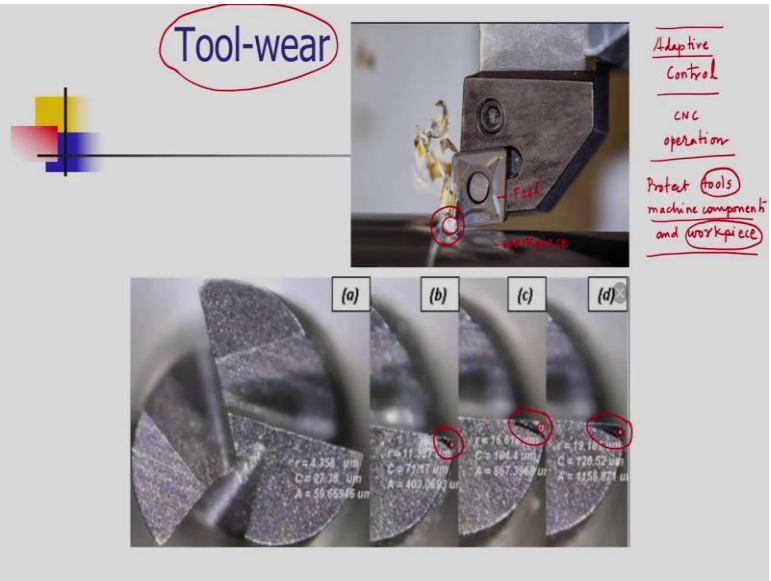

Some of the advanced concepts are coming in the CNC machine tools. These are adaptive controland its usage in the CNC operation. What is the meaning of the adaptive control? In adaptive control, the tool, machine, work piece are protected from the damages caused by the malfunctioning of the machine.

we have to protect tools, machine components and work piece from malfunctioning or unexpected changes in the machine behavior. Machine may behave in an unexpected way due to the failure of the tool.

If we take the example of the CNC milling operation, there is a huge amount of friction that is occurring between the tool and the work piece. A lot of heat is generated at their

contact point and their interface due to which there is wearing and tearing of the tool as well.

The tool edge gets blunt which further increases the friction and reduces the sharpness of the tool. We may not get even proper surface finish. At certain point, the tool may fail, and the edges may break down. The broken edges will harm the machine tool. Therefore, the tool condition needs to be continuously monitored..

As we get the in situ information or in process information about the health of the tool, we can in a better way control the process. If the tool is getting worn out, the machine tool should give the alarm or the signal to the operator or automatically it should take the decision to change the tool; or it may even adjust the process parameters like speed or feed need to be reduced or adjusted by the machine tool.

This concept is called as the adaptive control in which the machine control unit has the capability to get the information from various sensors which are mounted on the machine tool for the monitoring purpose. Based upon the sensory input, the machine control unit will take the decisions to change the process parameters or to change the tool.

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Tool wear is a critical factor, which affects the productivity of a machining operation. Thus, it is very essential to take care of the automatic tool changing to have an automated machining system, which is the feature of unmanned factories. The unmanned factories

required uninterrupted machining operations, which are helpful to achieve the desired production goals and to get better customer satisfaction. We have already seen that this unexpected failure are damaging to the machine tool and the work pieces.

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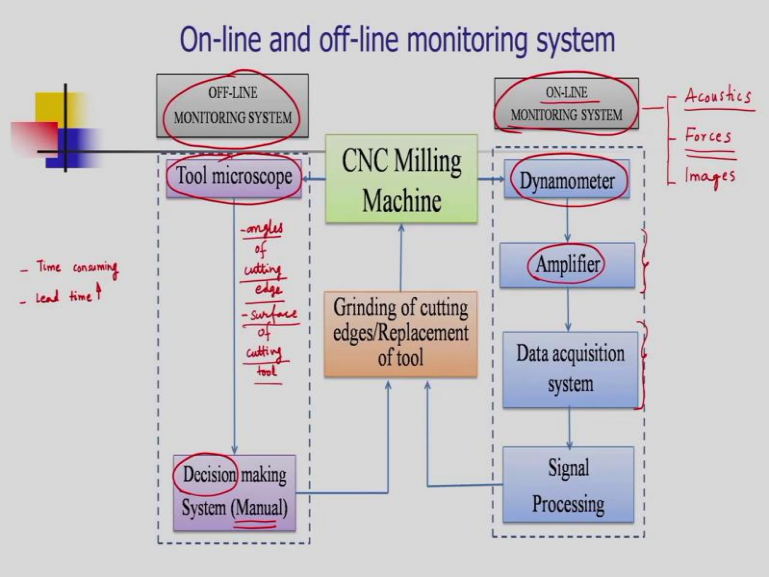

What are the ways or what are the methods to monitor the cutting tool failures or to monitor the cutting tool health? Basically there are two methods; first is the offline monitoring system. In offline monitoring system, the cutting tools are taken out from the spindle and then these cutting tools are observed under the tool microscope.

Special purpose microscopes are available. These microscopes are used to measure various angles of the cutting tool. Based upon the angles of the cutting edge and the surface of the cutting tool, the operator takes the decision, whether the tool is to be replaced or the cutting edges are to be re-sharpen. Thus, this is the manual mode of the tool monitoring system.

This system is time consuming and naturally it is enhancing the lead time. But, the advantage of offline monitoring system is that the human operator can closely monitor the cutting edges and by his or her experience or knowledge he can take the appropriate decision. However, as far as the adaptive control systems are concerned, nowadays people are going for the online monitoring system, that is the second mode. There are various methodologies being used in the online monitoring system.

Various options are available in this system. We can go for acoustics or the measurement of forces or based upon the images. Acoustics is nothing but, the sounds are recorded during the cutting operation. If the sound of the cutting operation is normal, it is standard and the cutting edges are intact and fine.

If unusual sound is occurring, then we can say that there is some problem. It may be either with the tool or with the work piece. Accordingly, the operator will take the decision or the machine control unit itself will take the decision. The second way is by monitoring the cutting forces. When the tool edge is not proper or blunt; then the required cutting forces are more.

If we can monitor the cutting forces by using equipment such as dynamometers then by getting the data from the dynamometer we can easily take the decision to either change the cutting tool or to grind cutting edges. Thus, the signals from dynamometers need to be conditioned. Amplifiers are required for this purpose. A sophisticated data acquisition system needs to be designed which shall help to take the required decision.

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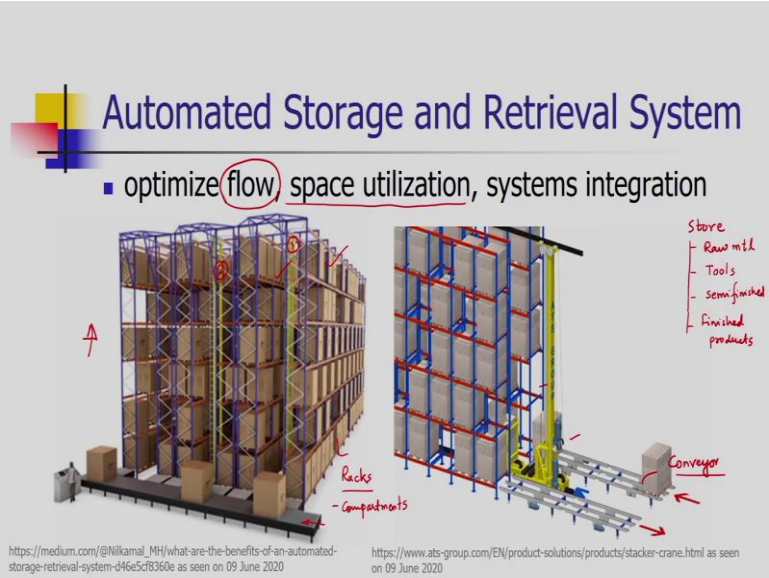

Now, as far as automation in manufacturing is concerned, the next type of equipment which is very common and important is the automated storage and retrieval system, which consist of a rack and a stacker crane.

And, that rack and stacker crane are being handled automatically by the central computer unit. Thus, this system is basically used to store the raw material, tools, semi-finished products and finished product. When the quantity or volume of raw materials, tools, semi-finished and finished product is very high then, manual handling of all these material or commodities is very difficult. For this purpose we are taking help of the stacker crane and a storage device.

A typical automated storage and retrieval systems is shown. Here we can see these are all the racks. The racks has many compartments, the compartments are coded; numbers are given to the compartments. Then, there is a stacker crane. There is a conveyor and that conveyor is taking the commodities to the stacker crane feeding unit. In the next figure, wecan see there is a conveyor over which the commodities are moving. The stacker crane is taking the commodities and then it will store the commodities in the programmed compartment or programmed section of the rack.

Thus, automated storage and retrieval systems are helping us for the efficient space utilization. They provide us with the optimized flow of the commodities inside the system. The vertical space inside the factory can be utilized by using the automated storage and retrieval system. .

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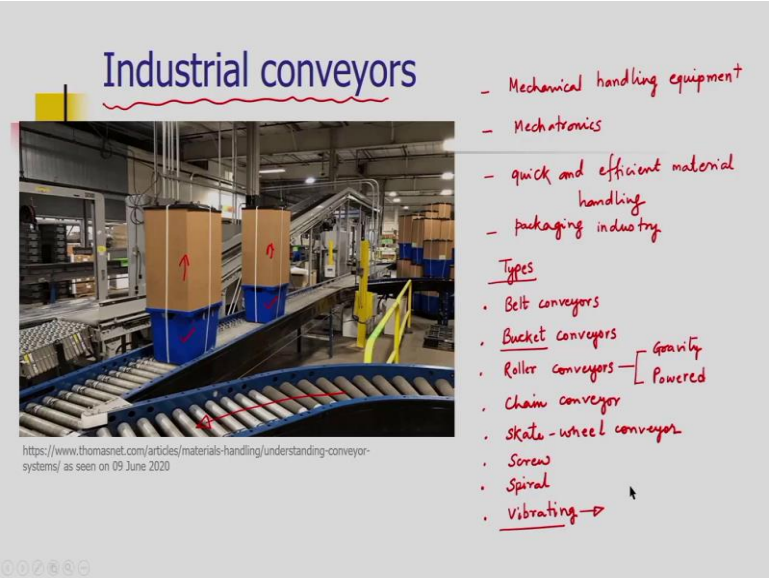

The next type of automated equipment that is used in industrial automation is industrial conveyor. These are mechanical handling equipment and with the help of mechatronics

we are automating their operations. We need to convey variety of commodities; the raw material, semi-finished goods products, finished goods products, tools, the auxiliary equipment or material required in the manufacturing.

A typical conveying system that is a ruler based conveying system is shown. On the conveyor we can see the baskets and the goods are mounted over the baskets..

As the baskets are moving over the roller conveyor, the goods are being taken to their respective destinations. The automated or industrial conveyors help in quick and efficient material handling. They are also widely used in packaging industry.

Various types of conveyors are used in the industry. First type is belt, where the commodities are being conveyed by using belt conveyors. Then bucket conveyors, buckets are used; basically, bucket conveyors are used in coal or in food industries. Then roller conveyors; roller conveyors are suitable when the commodities are packed in boxes, and are having a flat bottom.

Thus, they can roll over the conveyor. Roller conveyors are either gravity operated or they are powered. Electric power is used to drive them. The next type is chain conveyor, then skate wheeled conveyor, screw conveyor, spiral conveyor, vibratory conveyors. Vibrating or vibratory conveyors are used for sorting operation. We are conveying and simultaneously sorting the commodities.

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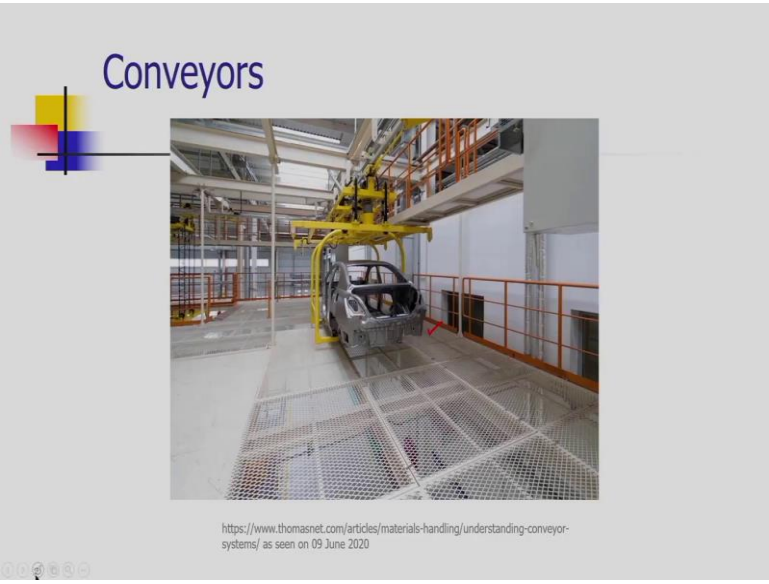

A overhead conveyor is shown and this overhead conveyor is used to convey the car body. The car body is mounted on a carrier which moves by a mono rail mounted on the shop floor. In this way we can save the floor space and have the easy movement of the heavy bodies which are hanging inside the shop floor. Thus, the floor space can be utilized for other operations.

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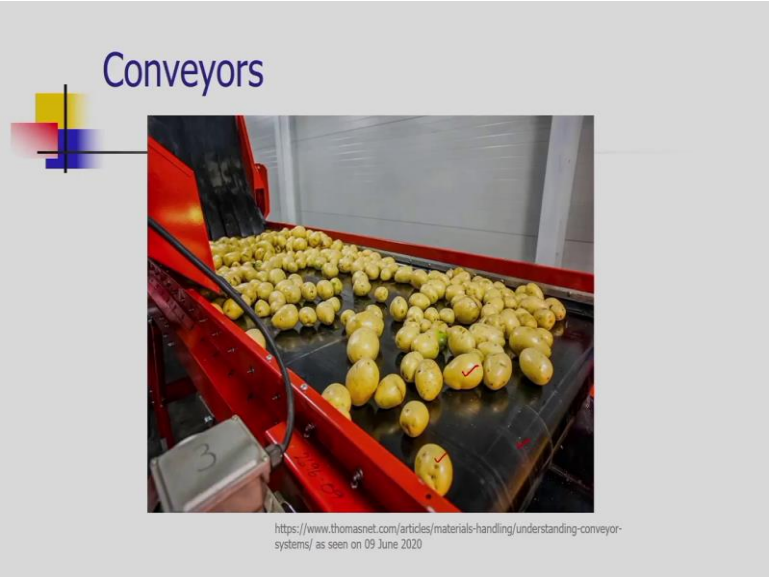

The next type is the belt type of conveyor with sufficient frictional coefficient to carry or to convey the food products. The belts should be of food grade quality which should not contaminate the food products. Potatoes which are to be moved on the belt conveyor are shown, which may be utilized for its processing further.

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In this case screws are used. Stainless steel screws are used. Stainless steel is a good quality food processing material and here we can see the grapes which are to be conveyed and further crushed to produce the wine. The grapes that are to be moved are shown in a stainless steel screw conveyor.

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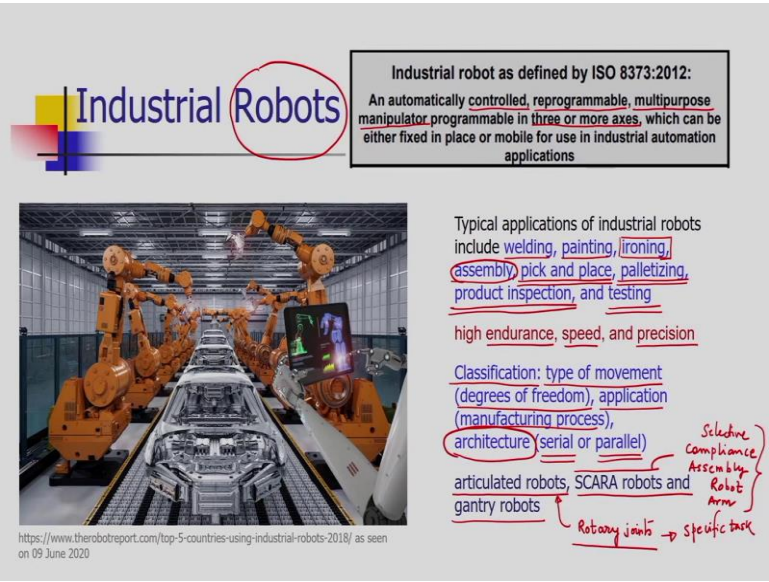

A very important automation equipment is the industrial robot. A industrial robot as far as ISO 8373:2012, is defined as an automatically controlled, reprogrammable, multipurpose manipulator. It is a mechanical equipment controlled by electronics. It is a

mechatronics based equipment, which is reprogrammable, for a variety of operation. It is multipurpose andthere are many applications of robots.

We will see some of the applications relevant to manufacturing. It is easy to controland can be controlled using sensors and a feedback system. These kind of robots have multiple axes, generally 3 or more axes, and they are very useful and widely used equipment in the industry.

Various applications of industrial robots are in welding, welding of the structures mainly in automobile industry, painting of the products, ironing,which is a very useful application in textile industry, assembly which is a very useful application in all manufacturing processes.

Pick and placeis a material handling operation, which is used to feed the products inside the manufacturing facility. Palletizing to prepare the pallets and those pallets may be used for the storage purpose to create unit loads on the pallets. Inspection is done in Coordinate Measuring Machines (CMM)..

Variety of testing can be done on the wear parts using the industrial robots. Why the robots are widely used? Why they are popular? They do have high endurance. So, what is the meaning of endurance? The robots can carry out difficult task without giving away. They carry out many repetitive tasks with speed and high precision.

This is why industrial robots are very important nowadays in the manufacturing industry. Various types of robots are used in the industry and they can be classified based upon the type of moment, i.e. degrees of freedom or the application that is the manufacturing processes. It may be for the welding, for the palletizing or for assembly or any other manufacturing process operation.

The robots can be classified based on their architecture; it can be a serial robot or a parallel robot. Many robots are used in the industries and these three are the prominent robots, which are being used in the industry- articulated robots, SCARA robots and the gantry robots.

What is the meaning of the articulated robot? These robots have rotary joints and they can do specific task which is programmed by the programmer. SCARA is also a very

useful configuration and the meaning of SCARA is Selective Compliance Assembly Robot Arm; The gantry robots are the overhanging robots, which are used to carry out variety of task.

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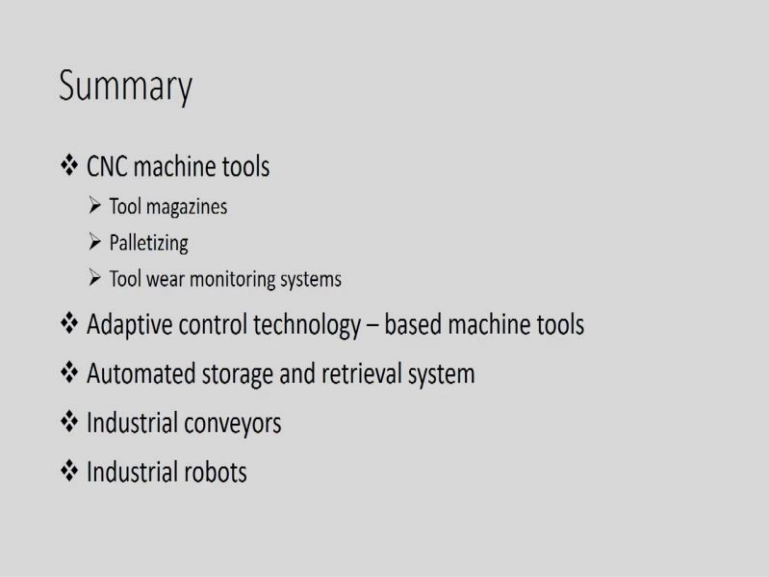

Let us summarize. The lecture 3 of week 2, in this lecture we have seen CNC machine tools. We have seen various elements such as tool magazines, pallets, tool wear monitoring systems. We have also studied the adaptive control technology concept and how to build a machine tool based on this technology.

Then, we studied the automated storage and retrieval system and its usefulness in the advanced manufacturing system. After that, we have seen various industrial conveyors, which are employed in the manufacturing domain. And, at last we have seen the industrial robots and their applications in the manufacturing.

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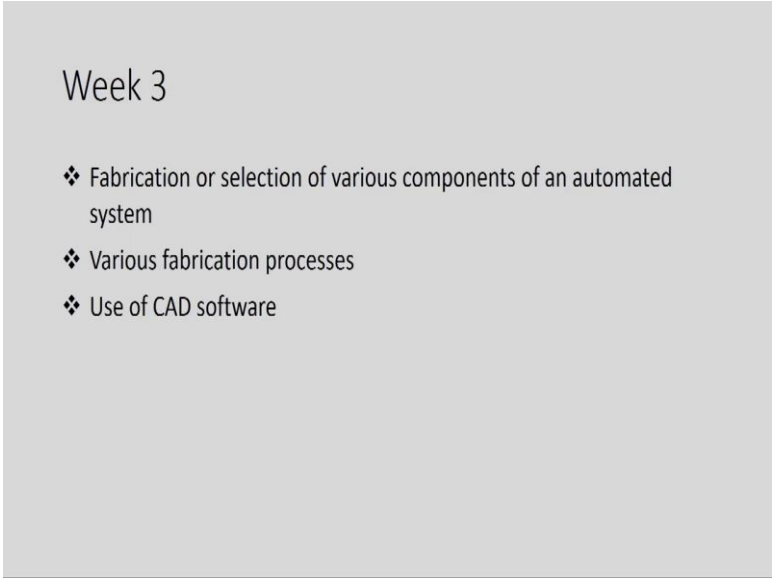

In week 3, we will be studying the fabrication and selection of various components which are required to develop an automated system. To manufacture or to fabricate an automated system we need various processes.

We will have a preliminary discussion on fabrication processes which are commonly used to develop automated systems. We will also study the use of CAD software for the design and development of automated manufacturing equipment.