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

Hello friends, I welcome you all to the Automation in Manufacturing course. So, this is lecture 2 of week 2 and we will be studying the various Automated systems and equipment used in the manufacturing.

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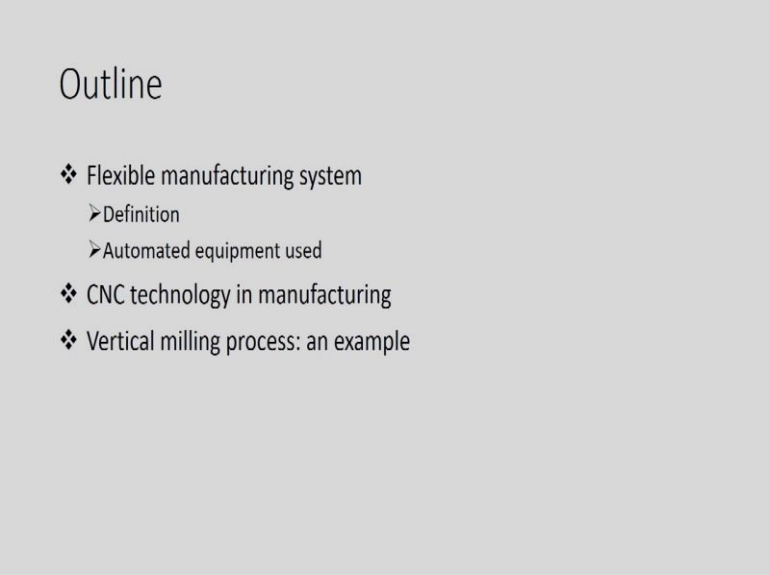

The outline of the lecture is as follows; at the start of the lecture the meaning of flexible manufacturing system, various equipment which are used in flexible manufacturing system will be studied.

The CNC technology in little more details will be discussed; we will understand the concept of CNC technology and its usefulness in the manufacturing by taking an example of vertical milling operation, which is widely used in the tool rooms in mechanical industry.

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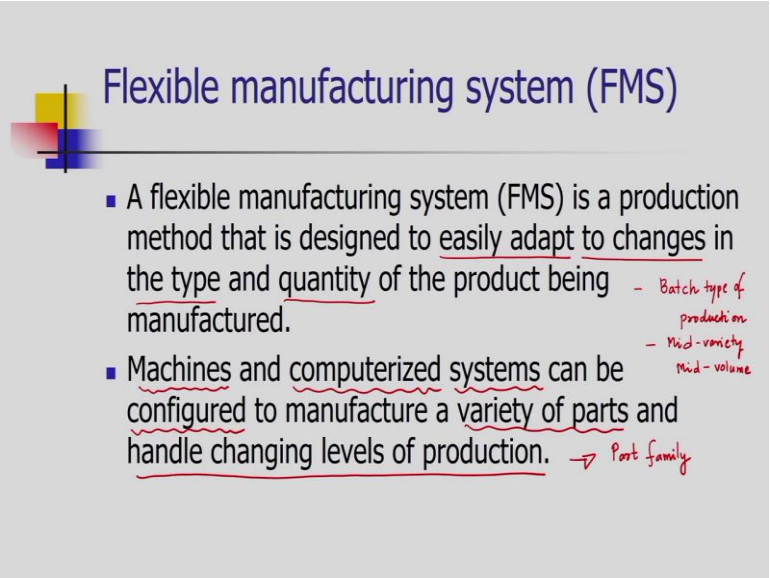

Beginning with the definition of a flexible manufacturing system, there are three types of productions being used in the industry; low production, medium production, and high volume production. In medium production, there is a variety of components need to be manufactured and the volume of the production is in medium range.

To cater the needs of such mid volume production, the flexible manufacturing systems are widely used in the industry. The flexible manufacturing system is a production method that is designed to easily adapt to the changes in the type and quantity of the product being manufactured. As mentioned, this is the best suited manufacturing methodology for mid variety, mid volume production, such that that it can easily adapt the changes in the type and the quantity, in the variety and in the quantity of the product that to be manufactured.

It is best suited for batch production, which is having mid variety and medium volume. In general, a flexible manufacturing system has many equipment which are arranged in logical order, that will be seen in the next slides.

The equipment or the machines and the computerized systems which are part of the FMS are configured, they are arranged in a logical fashion so that a variety of parts can be manufactured to handle the changing levels of the production, to check to handle the changing levels of production, to handle various part families. Part family is nothing, but

a group of products which are having either geometric similarity or manufacturing similarity.

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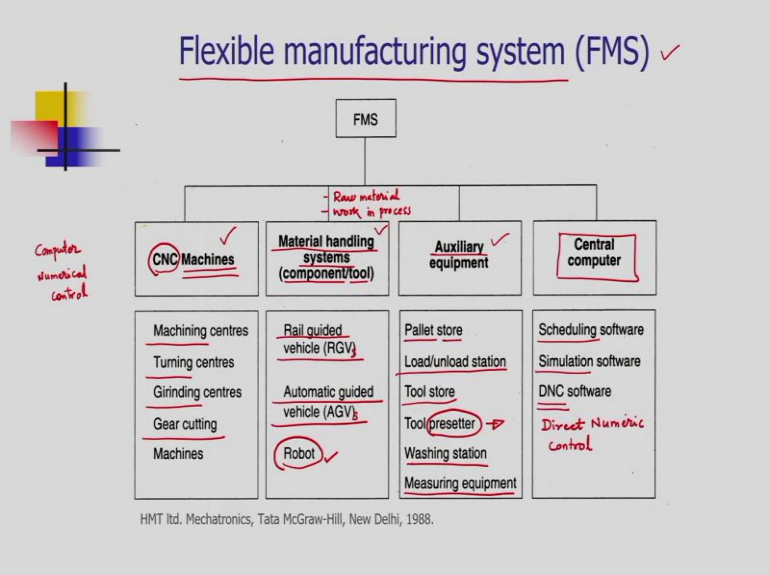

Let us move ahead and look at what are various elements or what are various types of equipment which are the part of the FMS system. The first group of equipment or the first group of machines is the CNC machine. CNC is nothing but Computer Numerical Control machines.

This CNC technology is applied to various operations such as machining operation, turning operation, grinding operations, gear cutting operations and variety of other machine tools which are computer numerical controlled. So, these are called as the CNC machines. CNC machines can be called as the backbone of the flexible manufacturing systems.

Next group of equipment which are widely used, which are important in FMS are material handling systems. Material handling does the material handling of the component or the tools or even convey the raw materials. The tools maybe the dies and moulds and also, the maintenance material.

All these are come in the material handling system. To carry out automatic material handling, various types of equipment are used. These are rail guided vehicles, automatic guided vehicle, and robots. RGVs, AGVs, and industrial robots are used to handle the

material. Material handling also include the feeding of the component to the machine and then removal of the component from the machine or in other words, loading and unloading of the machine also come comes into the material handling systems.

Basically robots are used for feeding the work parts to the machines, loading the work parts to the machines, and unloading the work parts from the machines. Third group of FMS equipment is the auxiliary equipment. Auxiliary equipment include pallet stores load and unloading stations, tool storage or tool stores, presetting of the tools, presetting involves taking care of the cutting tools.

Tool presetting takes a considerable time in manufacturing operation. If this operation can be done offline, a lot of lead time in the manufacturing can be saved. That is why, dedicated tool presetting stations are designed in FMS, where the tools are being set and get ready, such that, they can directly be utilized for actual manufacturing operation.

In washing stations, the work parts which are processed have to be cleaned. We need to have a washing stations and then measuring equipment. To check the size shape, to check the surface quality of the process part, a dedicated station is needed, where all the measuring equipment are arranged and the work parts will be examined. There they will be inspected whether the quality of the product is as per the desired specifications are not.

The last and the most important component of the FMS is its brain, that is the central computer. So, central computer is controlling the operations of the CNC machines, material handling systems, and auxiliary equipment. The computer has various software installed. These are simulation software and DNC software.

DNC is direct numeric control. In this philosophy, a single computer is controlling the operations of a variety of machine tools and as such, they are called as direct numerical control.

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Now, let us see how a typical flexible manufacturing system works. For that purpose, on the figure, a typical arrangement is shown, where the various elements of the flexible manufacturing systems are shown. These are CNC machines. Here in the figure, a CNC milling center, a turning center can be observed.

This is also CNC operated; CNC turning center, CNC milling center, then the stores. But these stores or the storage system is automated. The components are stored in an automatic mode and it has the automatic retrieval as well.

The system is widely known in the industry as ASRS, i.e. automated storage and retrieval system. The conveying arrangement can also be seen. In these FMS automated guided vehicles are used.

The entire operations or the coordination among all this equipment will be done by a computer that is the central computer. The shown configuration is a typical one used for the education purpose only. In industry little more complicated or little more different configurations are used and the configurations vary from the industry to the industry.

They are customized configurations and are designed as per the need of that part family, as per the requirement of the company or as per the investment capability of the company. A video was shown in the lecture which gave a glimpse how exactly the typical flexible manufacturing system works.

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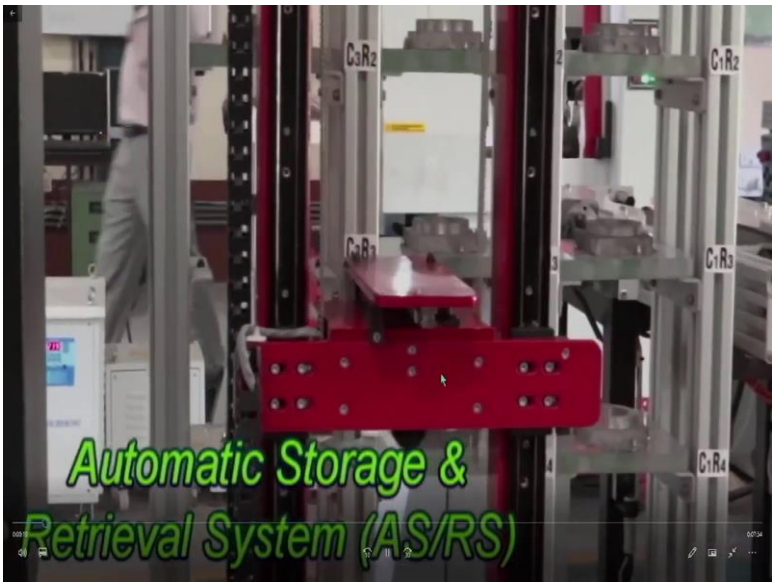

Afterwards we will be shown, one by one what are the various equipment used. In the figure, an automated storage and retrieval system and a crane stacker can be observed. The retrieval system is having a crane stacker.

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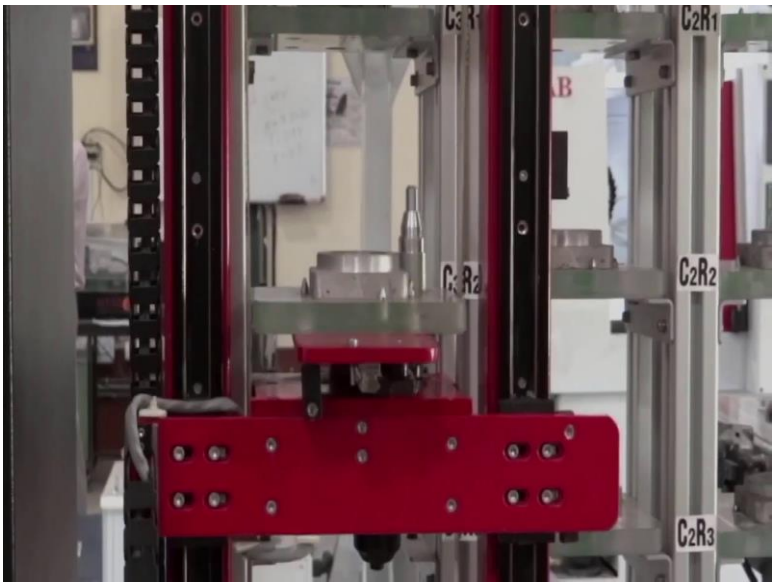

Now, this stacker goes inside, it takes the components that to be machined in the flexible manufacturing system. The components are then taken and these components will be fed to the conveyor, which will take the components and load the automated guided vehicle.

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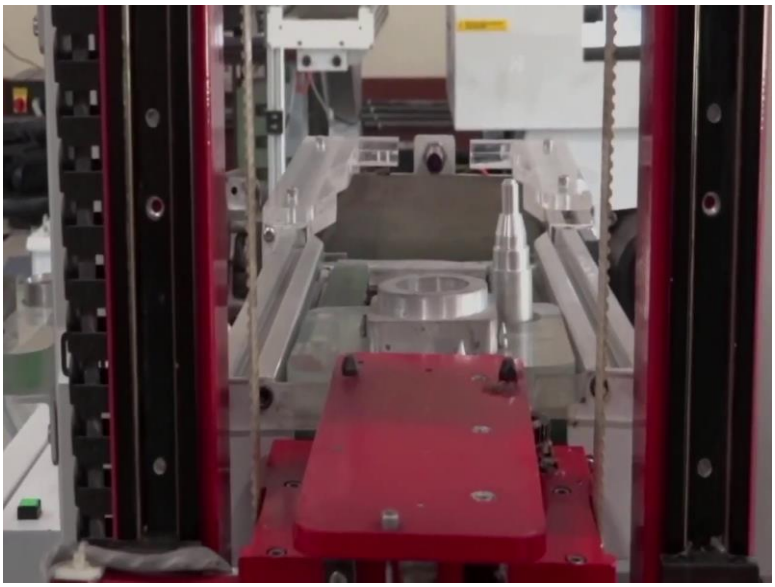

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The figure shows an automated guided vehicle. This automated guided vehicle is moves and reaches to its destination, the components are then taken through the conveyor on automated feeding system.

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The first operation will be carried out on the CNC turning center. The automatic feeding system has taken the component that is to be turned on the CNC turning center.

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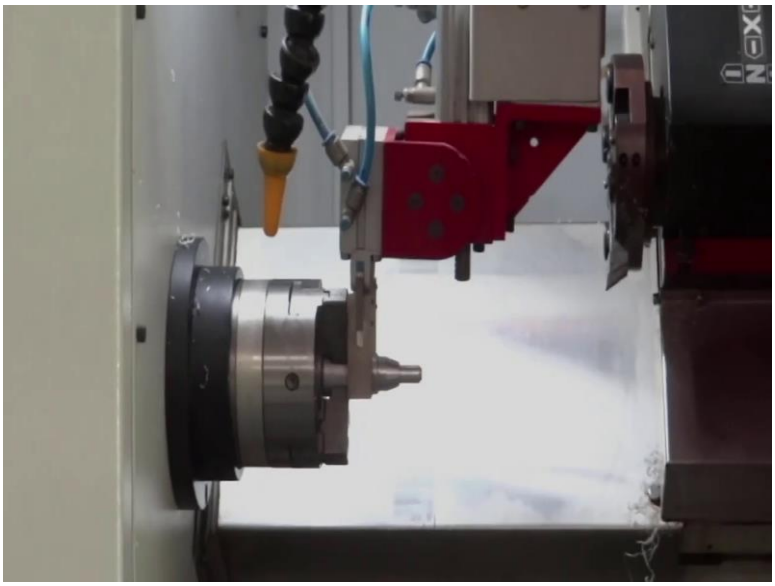

The component has been taken and will be feed to the machine. The machine has a three jaw automatic chuck (chuck is holding the component). It is a pneumatic operated chuck, the feeder will leave the jaw and immediately the chuck will hold the jaw. The component is now held in the chuck.

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The machine door will be automatically closed. The central computer will now give the instruction to the CNC machine tool to carry out the desired manufacturing operation.

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The turning operation means, there is reduction in the size, reduction in the diameter of the axisymmetric parts.

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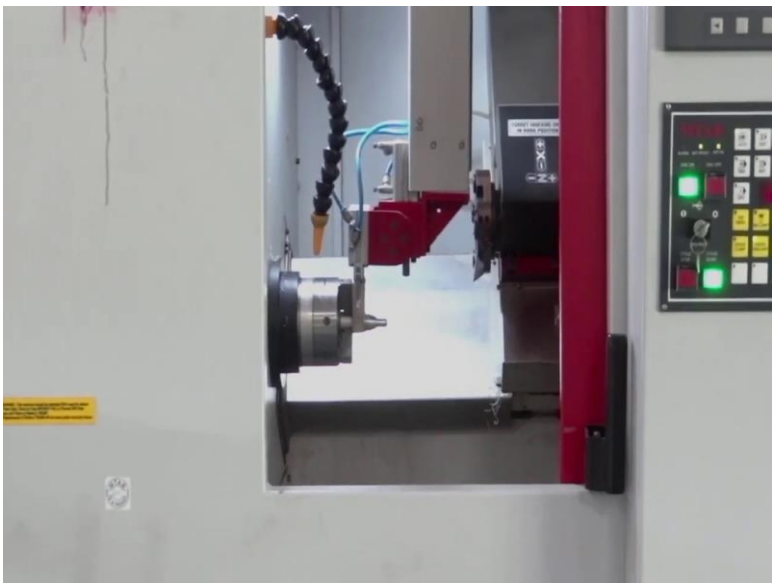

After machining of the work parts or after processing of the work parts, the same feeding mechanism will approach the work part, the chuck will open and immediately the feeder will hold the work part and will safely unload the work part from the CNC turning center.

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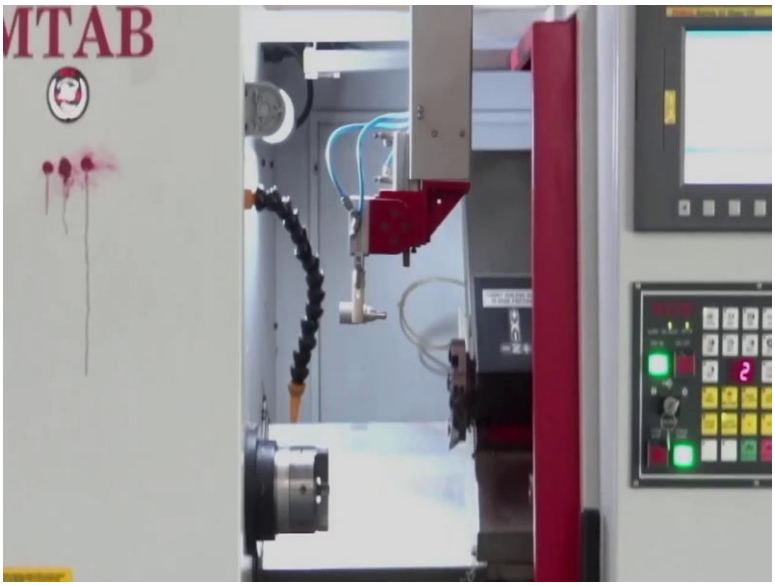

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The feeding mechanism will orient the work part in its original position and then it will be put on the conveyor system. The conveyor system will load the finished or the semi processed work part to the AGV.

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The conveyor then moves and comes to the pallet, it will get loaded on the top portion of the AGV. Now, the next work part will be processed on the CNC milling center. Again, an especially designed feeding mechanism will approach the work part.

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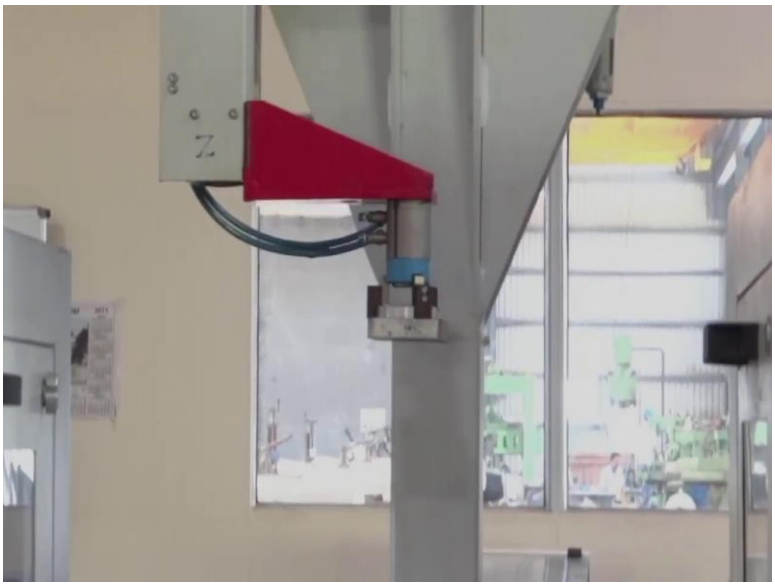

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It holds the work part and that work part is fed to the CNC milling center. The milling center is having a pneumatic operated automatic voice, machine voice, compressed air is used to hold the part. The device is closed and the work part is firmly held.

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Now, the door will close as per the instruction given by the central computer through GNM code.

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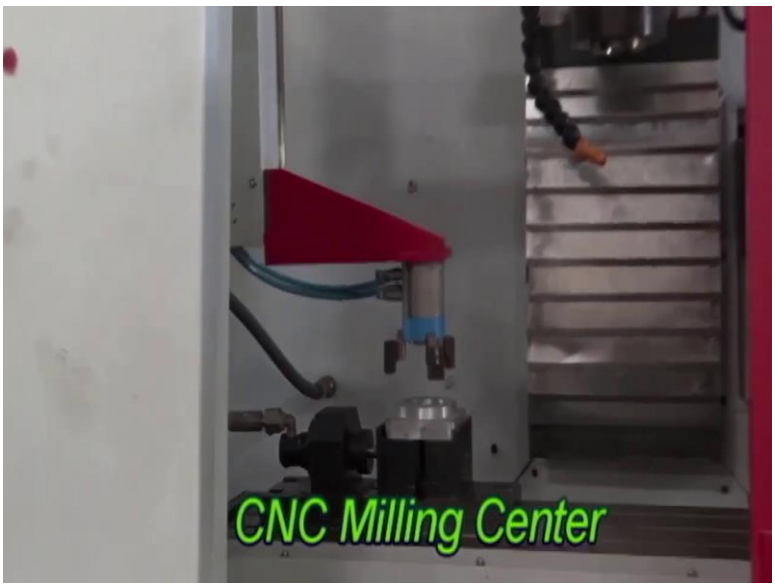

The GMN code will get executed and then the process part or the machine part will be ready for its further operation. The same feeding mechanism is approaching the work part. It takes the work part and that work part will be put on the conveyor for its further transfer to the automated guided vehicle.

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AGV now comes back to the storage system for storing the finished product or the semi finished product back to their destination in the rack.

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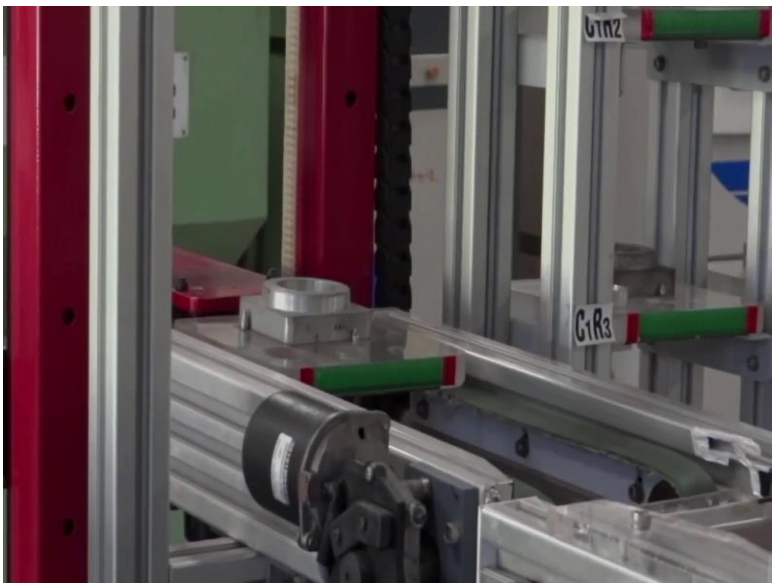

All the racks are coded. Here we can see the racks are C 1 R 3. C 1 means column 1 and R 3 is row 3. Thus, column 1 row 3 is the rack number.

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Stacker crane stacks the work parts at their respective destinations. Let us look at all these parts one by one. The objective of this course is to design all these equipment. To design all these equipment, we must first know their utilizations in the industry and then slowly we will look at their the constructional elements in the coming lecture.

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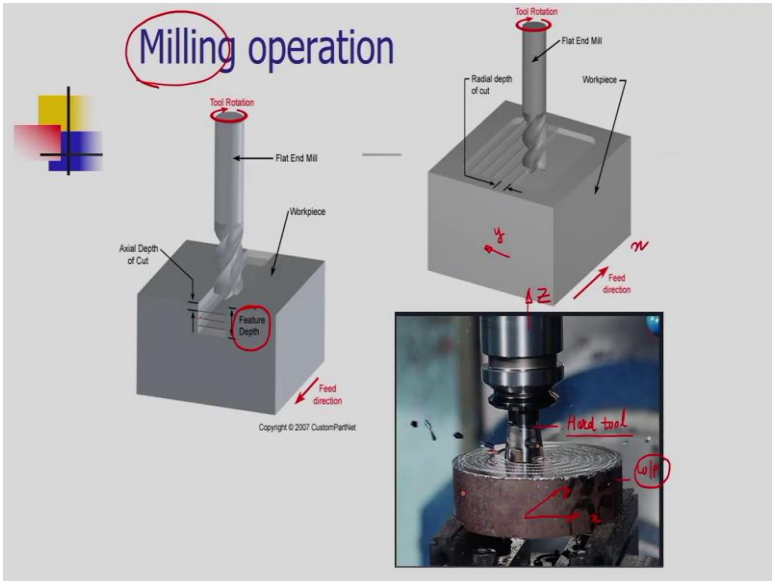

In order to understand the CNC machining center, we have taken here the example of CNC milling operation. Milling operation is a material removal operation, in which a

hard tool is used. The hardness of the tool is much more than the work piece and we are having a relative motion of the hard tool, high strength tool material with the work piece.

When there is a relative motion,there is a sheer plastic deformation of the softer material which is the work piece. In this case we can seethe hard tool is rotating about the z axis and the work part is moving along x and y axis. We can also see schematically that the tool is rotating and when the work piece is fed along the z direction, then we achieve deeper cavities or deeper features.

The feature depth is controlled by giving the feed along the z direction in multiple number of passes. To have broader features that are be machined we have to give the feed along x and y direction. If the material is given feed along x and y directions, then we can generate the features on the surface which is called surface milling. . When we want to mill pocket by cutting along the z direction, it is called as pocket milling.

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Milling tools may have two flutes or two cutting edges or it may have four flutes or four cutting edges. There are many tools which have a flat end and are called as flat end mill. When the tool end is of ball shape, it is called as ball end mill. Variety of such tools are used to generate various complicated surface using the milling operation.

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However, the conventional milling machine is having a drawback that very high level of surface finish, freeform surfaces cannot be manufactured, and it is very difficult to achieve the accuracy or the resolution in microns. The reason is obvious that there is human intervention and it is difficult for a human being to control the feed that is to be given to the work piece.

A typical conventional milling machine is shown. It has a work table. On this work table, the workpiece is mounted and there is a spindle. On the spindle, the cutting tool is held, on work table there is a clamping vice., The workpiece is clamped or fixed in the clamping vice. . The work movement is manual and this manual work movement is carried out by the control wheels and the handlers.

The spindle is rotated by a DC motor and various speed levels can be obtained by using a gearbox. We set a spindle speed and then we can have the relative motion of the tool with the work part by rotating the handlers. It is very difficult for the human being to have a proper feeding of the workpiece by rotating the wheels in a consistent manner.

For this purpose, the CNC based machine tools are developed by using the various building blocks that we have seen in our previous class. The CNC machine tool is solving or overcoming the limitations of a typical milling machine. How? The work table movement is automatic. Thus, a machine tool is developed with automatic movement of the work table.

For this purpose, we are using the precise lead screw arrangement and these precise lead screws are being driven by the servo motors in conventional milling machine and the tool changing is manual. This takes a lot of time. In CNC machine tools; the tool changing is automatic which is saving lot of lead time. The tool is moving along the z axis automatically. The safety operations are also there; door on and off, then auxiliary operations like coolant on and off.

All these operations are carried out in an automatic mode. The CNC machine tool has a controller or the brain as the microprocessor which is nothing, but the system which is having logic gates, memory elements, battery and some memory storages and these microprocessors are working as per the instructions given by the programmer.

The software is installed in the microprocessor according to the instructions written in the software, the microprocessor carries out various functions. Processor basically generates the pulses that are needed to actuate the drive mechanisms.

In CNC machine tools basically we are using electrical drives, electrical motors to generate the pulses, and the microprocessors are producing the signals to drive these electrical motors. In addition to this the microprocessors generate the signals to make the compressor on and off, to control the directions of various control walls, and also to control the door opening and closing.

all these operations are taken care by in the microprocessor. Thus, in this way we can improve the surface quality, enhance the capability of a typical conventional milling machine to generate very complicated shapes.

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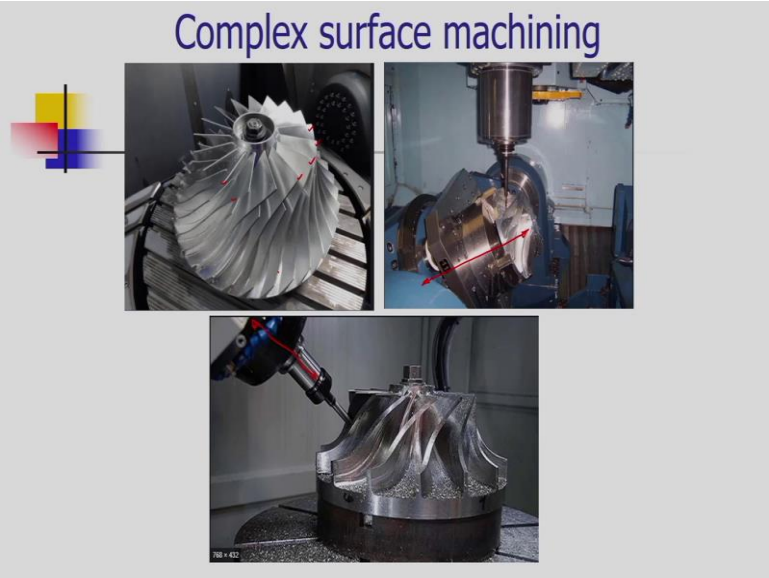

A turbine blade is shown as an example. The shape of the turbine blade is complicated. All the blades are thin, they are intact with its core and are precise as per as their thickness is concerned. Their shape is so complex that it is very difficult or rather impossible by using the conventional machine tool to carry out this operation. Hence, for this purpose, multi axis CNC machine tools like the five axis CNC machine tools are used. .

These pictures will give us the idea how exactly the CNC machine tools are operating. In this picture we can see the workpiece is oriented in such a way that it is easy for us to carry out the actual machining operation.

We are adding more number of control, more number of movement of the axis, we are adding more degrees of freedom to machine these kind of work parts. It is not only the x y and z that that are being used, in addition to this, we are giving one more axis to the workpiece movement.

In the third picture, we can see the tool is inclined. The tool is inclined to carry out the machine part. The work part is fixed, which is not moving, but more degrees of freedom are provided to the tool axis. Various configurations can be found in the industry. Many industries are coming up with a variety of novel configurations to machine such complex surfaces.

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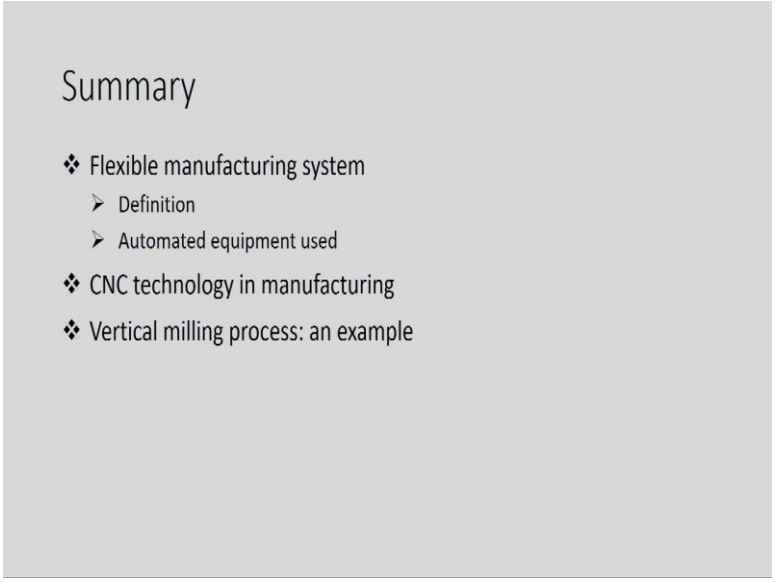

Let us summarize the lecture. In this lecture, we have seen the concept of flexible manufacturing system, we have seen its definition and various automated equipment which are used in this system. We have seen in details about the CNC technology the NC CNC technology used in the manufacturing domain. We have seen example of a vertical milling process at the end of the lecture.

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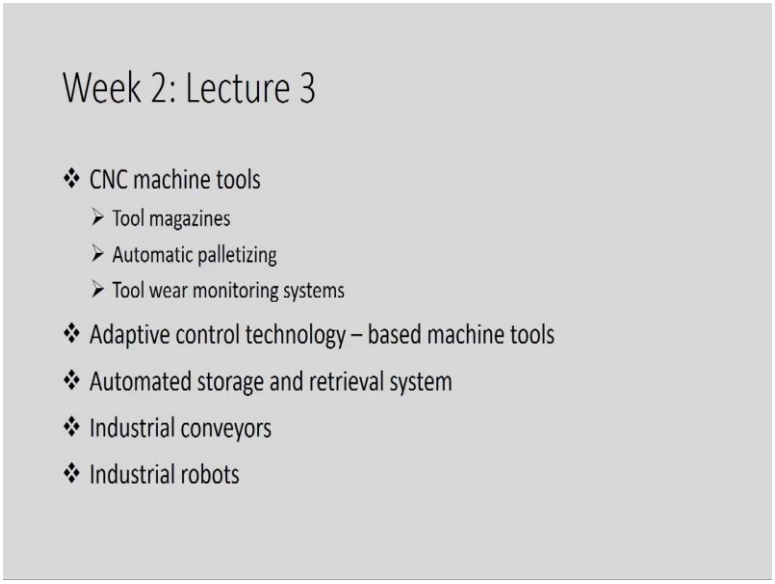

In the next lecture i.e. lecture 3 of week 2, we will be studying the CNC machine tools in little more details. Various elements of CNC machine tool such as the tool magazines,

pallets, and palletizing, tool wear monitoring systems will be discussed. We will be also looking at the adaptive control technology based machine tool concept, then ASRs which is a very useful utilitywill be studied, then we will also look at the industrial conveyors and the use of industrial robots.