**Automation in Manufacturing**
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**Module – 01**
**Lecture – 01**
**Basic concepts**

The manufacturing industry is contributing a major share in the GDP of our country. Therefore, it is essential for us to apply automated systems which are improving the productivity of manufacturing industry. In view of this a course on automation in manufacturing has been designed. The primary focus of this course is on the design and development of automated systems which are required in the manufacturing industry.

Initially, the course is introducing various automated systems which are used in the manufacturing industry and then we will be studying the building blocks of a typical automated system. The course is also presenting a study on the principle of operation and constructional details of sensors, transducers, actuators, drives, and various mechanisms which are used in a typical automated system.

Moreover, a detailed analysis and presentation of hydraulic and pneumatic systems which are used in automated systems are discussed. It also covers up micro-processing technology, programming and CNC technology.

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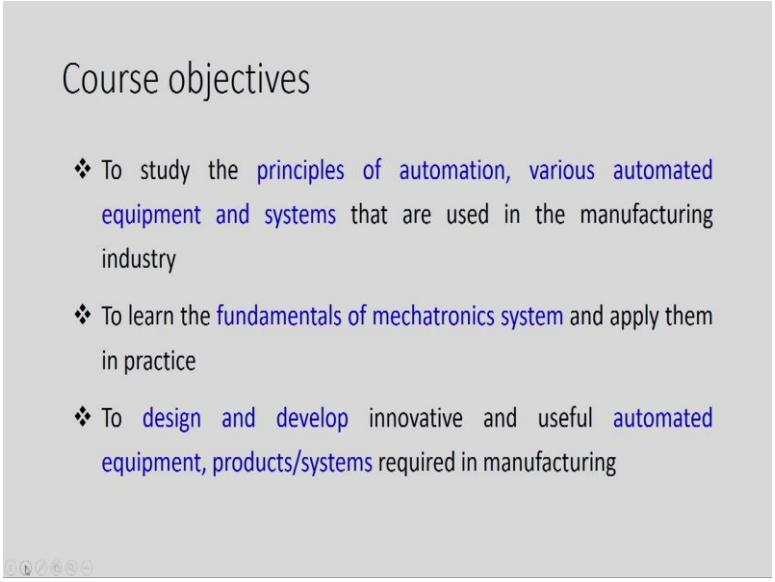

The primary objective of this course is to study the principle of automation and various equipment and systems that are used in the industry. In addition to that, we will be studying the fundamentals of mechatronic system and we will learn how to apply them in practice to develop automated systems.

By applying the principle of mechatronics it is envisaged that we will develop innovative and useful automated equipment, products and systems which are required in the manufacturing and in the society.

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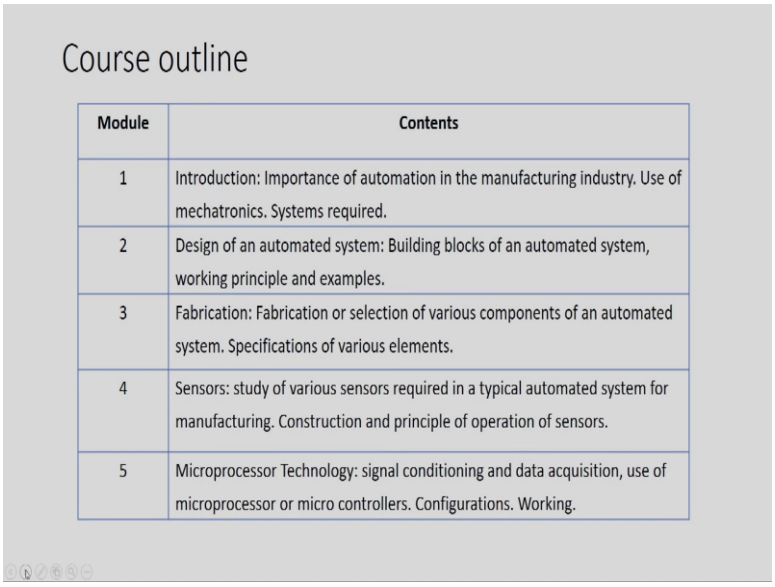


The course has 12 modules. In the module 1, we will be studying the importance of automation in the manufacturing industry, we will study the meaning of mechatronics. In the module 2, we will study the building blocks of a typical automated system which is based on a mechatronics based system the working principle and we will look at some of the examples related to automated systems.

In module 3, the fabrication details or selection of various components of a automated systems will be discussed, how to specify various sensor elements or the constructional elements will be studied. In the next module that is module 4, we will be studying various sensors which are used in an automated system, their construction and principle of operation will be discussed.

In module 5, we will be studying the microprocessor technology that is used in the automated system. Various details related to signal conditioning, data acquisition will be studied.

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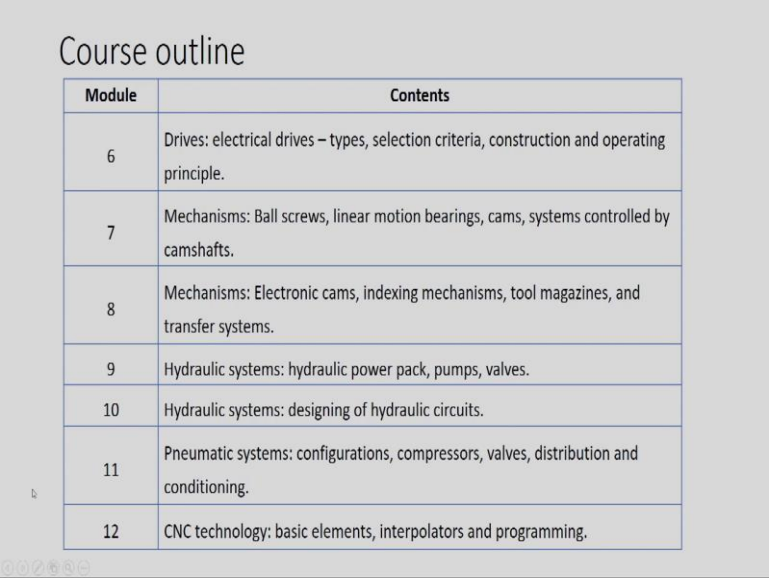


In module 6, the drives which are used in a typical automated system will be studied. Initially we will be studying the electrical drives their selection criteria and construction will be studied at a primary level. However, the detailed analysis of electrical drives is out of scope of this course. In the next module, the ball screws, linear motion bearings, cams and systems basically the mechanical systems will be studied.

In the 8th module, electronic cams, indexing mechanisms, tool magazines, and transfer systems will be studied. Thereafter we will be having two modules on hydraulic systems, the meaning of power pack, various types of pumps and valves will be learnt. In addition to these we will also be looking at the designing of a typical hydraulic circuit.

In the next module that is module 11, we will be having a discussion on pneumatic system, its configurations, various compressors, valves and distribution and conditioning of the air that will be studied. In the last module, we will be having discussion on the CNC technology, its basic elements and the programming the basics of the programming of CNC machine tools.

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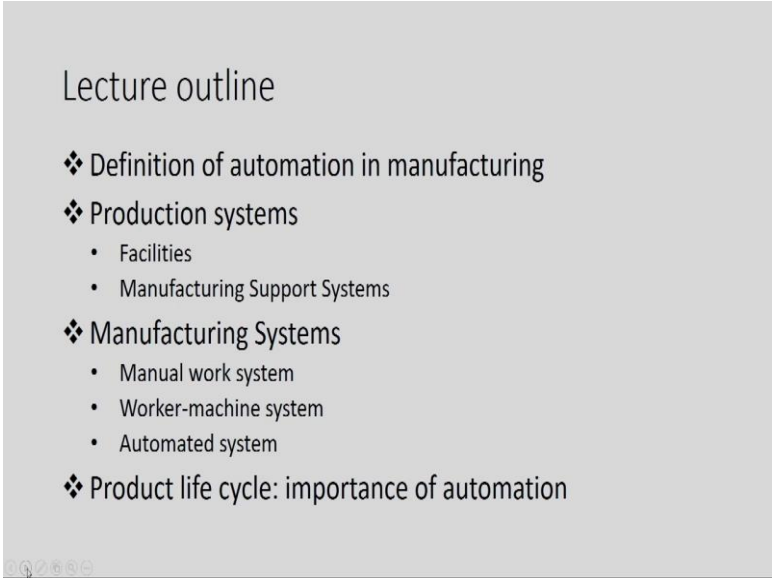


In this lecture 1, we will be studying the Basic concepts related to automation in manufacturing. Initially, we will be studying the definition of automation in manufacturing.

Then, various elements of a typical production system that is facilities and manufacturing support system; what is the meaning of facilities and what are the various manufacturing support systems that are essential for a production system will be studied.

Then, we will look at various manufacturing systems which are used in present day manufacturing system. These are manual work system, worker machine system and third one is automated system. This differentiation will help us to know how the automated systems are essential and important in comparison with manual work system and worker machine system.

Then, we will be studying an important concept that is a product life cycle and the importance of automation in the product lifecycle.

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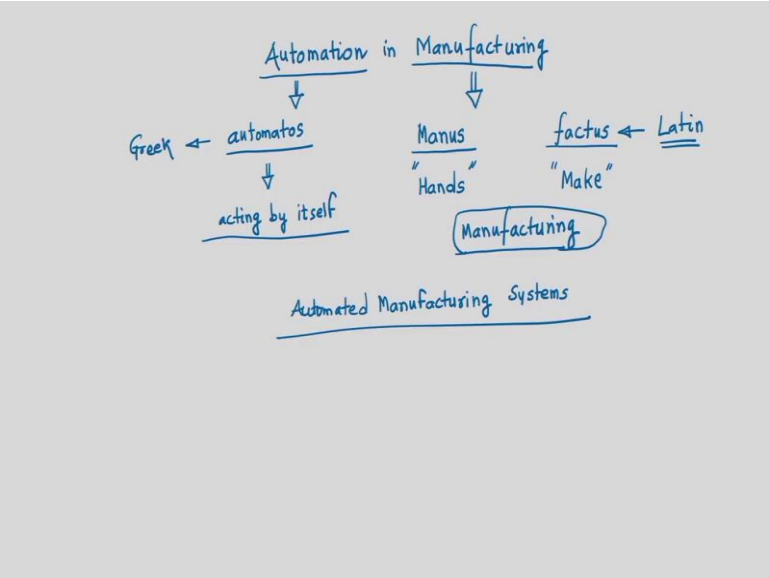


The name of the course is automation in manufacturing. Thus, it is essential for us to understand the meaning of these two words that is automation and manufacturing. The word manufacturing has Latin origin and it has been derived by using two word that is *manus* in Latin and *factus* in Latin.

What is the meaning of manus? *Manus* means by hands in English and *factus* is nothing, but make or do. The *manus* means whatever you do by hands and make certain things. You create, you fabricate, you developed by using hands that is nothing, but manufacturing that was the meaning and it has the origin Latin.

The automation word has the origin from Greek. The basic word is *automatos* and the meaning of the word *automatos* in English is nothing, but acting by itself. So, it is very simple acting by itself. The system which is acting by itself is called an automated system.

When the machines carry out the manufacturing operations, it is called an automated manufacturing system. The objective of this course is to learn the fundamentals and the principles of automation and to develop the automated equipment, which are useful in the manufacturing domain.

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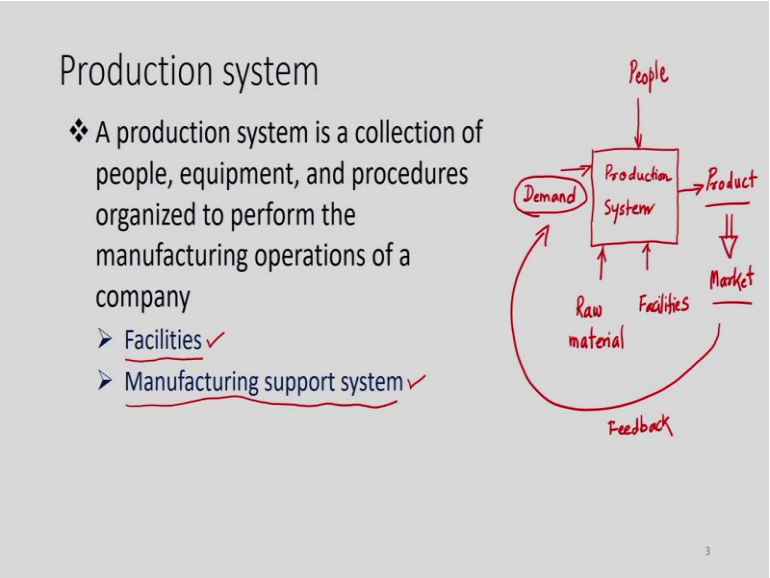


Production system is the first thing that we will be considering here. If you take example of any enterprise, any factory or a plant layout, every organization or enterprise has an objective and that objective is to produce something, to sell that product in the market and to earn the profit and survive. Then, you excel in the market, become the leader in the market, but what are the various elements of a production system that we need to first see.

The production system is a collection of the people which is the most critical element, equipment and the procedures which are required to perform the manufacturing operations. If we try to draw a simple diagram of a production system, we can consider the production system is a block which has the input that is the demand – demand from the market, demand from the customer.

These production systems are taking in the raw material and processing the raw material and that raw material is processed by using the equipment or the facilities. Needless to say, we requir the people to control the operations of a production system and ultimately we will be getting the product. The product will go into the market, the customer will use this product and they will give feedback to the enterprise or the company. And, based on that feedback again we can change the input to the production system that is a demand. The demand may be in terms of the number of quantities that are to be produced or the demand may be the quality of the product or the demand may be in the various features,

which are required in the product. Well, if we look at the production system we can see that there are basically two elements which are constituting the production system.

The first element is *facilities* and the second element is the *manufacturing support system*. We will see what is the meaning of facilities and what are the various elements of the facilities and we will also see what is the meaning of manufacturing support system and what are the various blocks of manufacturing support system.

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The facilities primarily comprise of the factory itself. Second is the production facilities which comprise the machineries or the equipment. These are converting the raw material or semi-finished products or goods into the finished products or goods.

For this purpose machineries are being used; simple examples of a production facility are a lathe machine / central lathe or a milling machine or a drilling machine or a welding machine for fabrication of furniture, a moulding machine to manufacture the plastic components, etc. When the products are being manufactured in the house or on the shop floor we need to move the raw material from one shop to another shop, from one place to another place, we need to move or convey the semi-finished products. We need to convey the finished products for inspection and dispatch.

Thus, we need to convey the tools required to manufacture the components. There are various materials which are to be conveyed on the shop floor. To handle them we need equipment, we need machinery. This is the third element in the facilities.

The next element in the facility is inspection. Once the raw material comes inside the shop floor or once the raw material comes into the factory, we must first ensure the quality of the raw material because the final product quality is dependent upon the quality of the raw material. For inspection of the raw material, inspection of the cutting tools, whether they are intact, inspection of variety of other maintenance or auxiliary equipment, we need the equipment for this purpose. .

And, most importantly we need to also inspect the products which are in process. This is called the quality assurance. During the process of development itself we are inspecting whether the product are as per the designers specification. And, at the end we are checking the quality of the product in terms of its specified size, shape, colour, surface quality.

For this purpose various equipment are needed like coordinate measuring machine, Perthometer for the surface roughness measurement, etc. There are many non-contact equipment also like camera based or image-based process equipment in the industry nowadays. All these equipment come into the inspection equipment element of the facility.

The next element is very common and very important nowadays is the computer systems. Nowadays computers are the integral part of our day to day life and that is the same case in the industry as well. It is now by default that we are using the computer technology or the electronics or mechatronics-based technology to carry out the activities at the shop floor in a manufacturing operation. Thus, computer systems are the most critical parts nowadays in the facilities.

Computer systems are used to program the equipment or machineries, monitor their performance and also used to collect and analyse the data, and produce the reports as well.

The next point of the facility is the layout. Layout is not a physical term, it is the general term, but the way equipment is laid out on the shop floor which is called the plant layout.

So, how these layouts are developed? The layouts are developed by applying certain logic.

We cannot randomly prepare the layout on the shop floor. We have to have a certain logical grouping say all the similar kind of machines are grouped together or we can group the different types of machine tools based upon their utilization that we call the sales.

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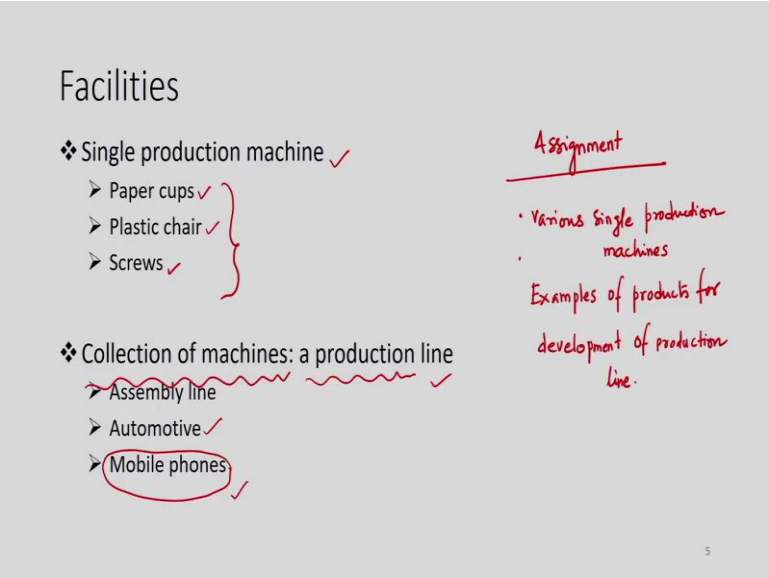


So, all these things are coming inside the facilities. The basic element of the facility as far as a manufacturing unit or a production system is concerned is the production machinery.

Hence, we can say the facility may have a single production machine. The simple example of single production machines is manufacturing of paper cups. Now, single machine is there with a small-scale industry or a small enterprise and the task would be to just manufacture the paper cups.

A medium scale industry is having few moulding machines, which are just manufacturing the plastic chair. A single unit will take the raw material inside, will produce the product and that product can directly be inspected and given for the dispatch. This is called the single production machine. The third example for the single production machine is the screw manufacturing.

When we are having multiple production machines, which are grouped together and carrying out the production operation, that is called as the production line. A simple example of a production line is assembly of an automotive assembly of a two-wheeler or assembly of a four-wheeler automotive. You might have seen such videos on YouTube as well.

There is a long conveyor over which the chassis of a four-wheeler is there and the robots or the human beings are assembling various parts, various sub-assemblies on the chassis and a car will be produced at the end of the conveyor.

The chassis is starting at the start of the assembly line and then at these various levels of conveying of the chassis we are adding the part to the chassis. This is called a production line. The production line is having a collection of machines.

So, what are the various examples? Automotive and a very common example is mobile phones. We can see nowadays a variety of mobile phones are coming into the market. The mobile phones are also very good example of “production line” type of manufacturing.

At the initial class itself I would like to just give an assignment. Just look around and try to find out what are the various single production machines available. You may search through the Google or the search engines and try to find out what are the single production machines available, those are manufacturing a product with only one machine tool? Also find out some examples of a production line?

It is suggested to the learners to apply these concepts, learn from the things around us; visit some of the automation companies nearby.

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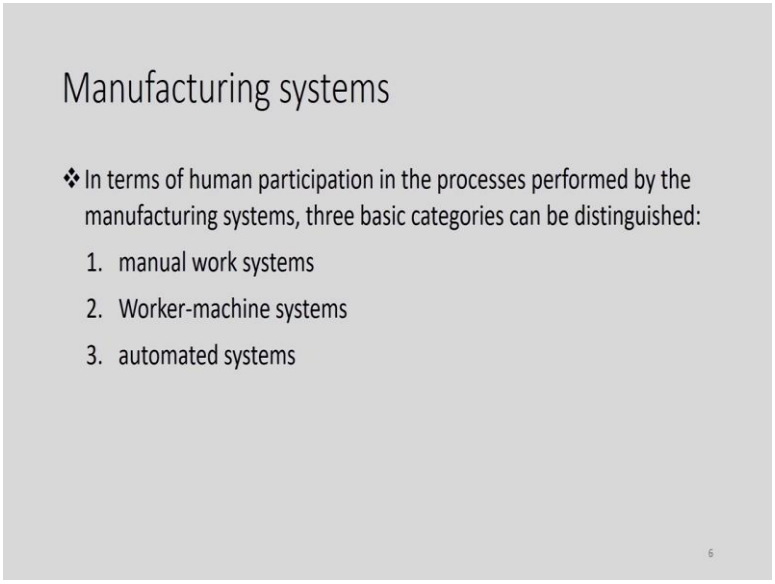


Now, next point of discussion is manufacturing systems. Now, as we have seen the definition of a production system there is a set of equipment raw material and we are processing that raw material by using the set of equipment.

So, who is doing all the things? Needless to say, the human beings, operators are carrying out these production operations. Of course, there is a human participation in the entire operation. The extent of human participation will decide the type of production system. There are basically three categories of manufacturing systems. The first category is the manual work system, the second one is worker machine system and the third is the automated system.

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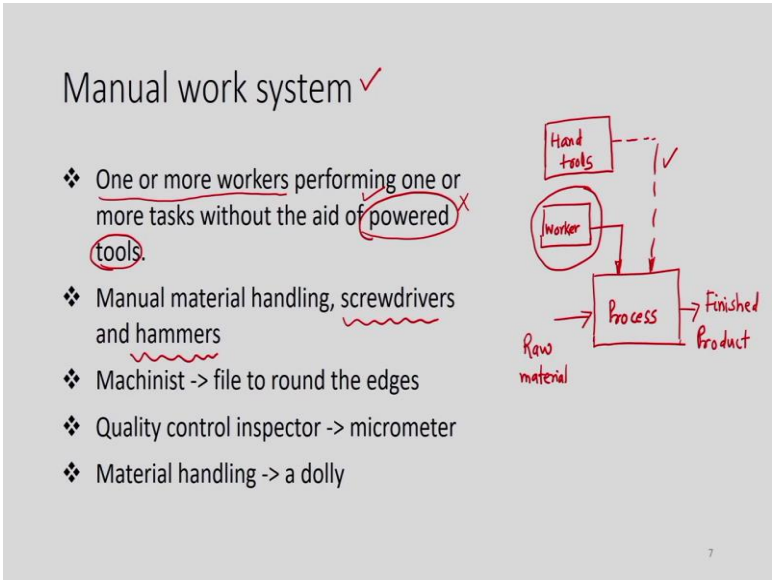


Now, let us see what is the meaning or what is the meaning of manual work system. Manual work system has one or more workers and these one or more workers are carrying out the manufacturing operation with the tools, but the tools are not powered. The simple example is a carpenter.

The carpenter is using a jack plane, chisels and hammers. He is not using any power tools like the drilling machine and by using these jack planes, chisels and hammers, the carpenter is manufacturing a stool or a furniture; this is called as the manual work system.

We may have one or more workers inside that. Theoretically we will try to draw a block diagram for that. There is a process, there is a human being that is a worker and a set of hand tools. The major contribution to carry out the process is the conversion of raw material into the finished product.

The entire operation is dependent upon the skill power of the worker. The hand tools are assisting to convert the raw material into the finished product, but the entire operation or the power is applied by the worker.

Therefore, in this way the process of manufacturing will be carried out in the manual work system which is a very basic work system which we are still using in our day to day life. These are some of the examples like a machinist is using a file and the file is

used to round up the edges to make the edges blunt. A quality control inspector is using micrometer gauge to measure the dimensions of products. Thus, this is also manual work system.

Third one as far as the material handling is concerned there is a dolly and a person is carrying out or conveying material stuff or things on a dolly that we can consider as an example of manual work system.

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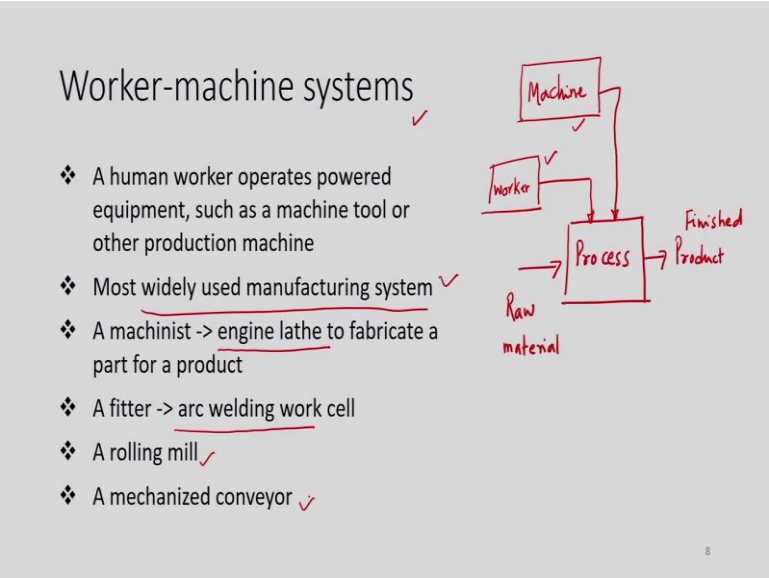


The next type of or category of the manufacturing system is worker machine system. A worker machine system is a human worker or operator using powered equipment such as machine tool or other production machine to carry out the conversion operation. So, we will try to find out a block diagram. We can say that there is a process of conversion of raw material into the finished product, we need the worker and we need the machine as well.

If we see the contribution of conversion in the conversion process the worker and the machine both of them have the significant contribution. The worker is controlling the operation of the machine tool, he is giving feed to the work piece against the tool and the machine is a powered machine tool which is applying the mechanical energy converted from the electrical energy as far as the typical material removal process is concerned and that mechanical energy will be utilized for the conversion operation say the material removal during a material removal process.

Both the worker and the machine have the equal or the significant contribution in the conversion process. Thus, this is called the worker machine system. Naturally we need such kind of system to produce at a higher level, to produce larger quantity and to handle the larger size products or the bigger size products or the raw material.

This system is very widely used in the industry. We are using the powered machine tools some of the examples are there on the screen engine lathe or a lathe machine. Arc welding machine can be considered as a worker machine system as well. Welding is a fusion process or a joining process.

Rolling mill is used to reduce the thickness of the metal sheets. Mechanized conveyor is the powered conveyor in which we are using electrical motors to drive the conveyors and these conveyors are taking the part from one location to the other location inside the factory.

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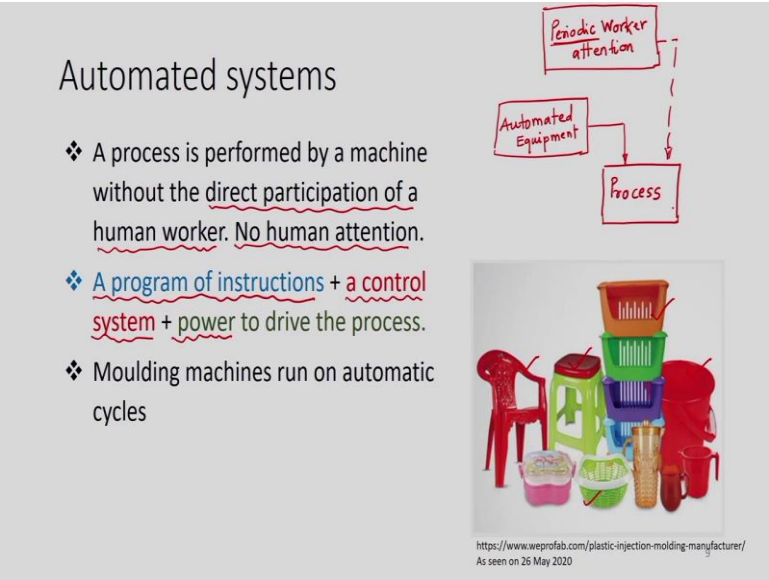


The third manufacturing system is the automated system. In automated system a process is performed by a machine and there is no direct participation of the human being. Thus, at advanced automated system level we can say that there is no human attention even required to carry out the manufacturing operation.

Now, how it is possible to carry out such an automatic control? For this purpose, we need a control system. The control system has a hardware as well as a software; the

software is nothing, but a set of instructions that is called the program. These set of instructions are controlling the operations of a process. Of course, to carry out the operations we need the power to drive the variety of actuators of that equipment.

A simple example of an automated system is the moulding machine which are running on automatic mode and they are used in manufacturing of variety of products which are seen on the screen at the mass scales. If you imagine the manufacturing of a plastic chair or a stool or a bucket or the baskets at a mass scale we are taking the automated machine moulding machine.

We are putting the raw material, setting the program and we will be getting the required product say the plastic chair at a mass scale. For that purpose, many a times it is required to have the periodic attention of the worker to know whether the operations are as per the required specifications or the operations are working smoothly or not.

In block diagram, we can draw the automated system as a process and this process is having an automated equipment. Thus, an automated equipment may be a processing equipment or assembly equipment or it may be a inspection equipment. and we need to have periodic worker attention.

The word periodic is very important here, periodic means there is no continuous human attention is required. We can have the intermittent attention of the worker to just know whether the automated equipment is working as per our desire as per our requirements.

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Well, till now we have seen the meaning of facilities, the various equipment which are needed to carry out the manufacturing operation.

Now, in addition to the facilities we also need manufacturing support systems to carry out the desired manufacturing operations in the factory or in the enterprise. To utilize the production facilities effectively, the enterprise should design the process and the equipment.

When the product design is finalized based upon the product design, the enterprise will design the processes and the special equipment if required to carry out the manufacturing of the product it will be designed or the equipment can be procured from the market.A readymade equipment may be available say a lathe machine or a drilling machine that can be procured from the market.

Next, planning and controlling of the production orders. Plan means we have to decide. The sequence of operations are to be carried out in a logical way and we have to ensure whether that operations are being carried out as per the decision as per the plan. This is called the control of the operation. Thus, we have to decide the plan and the strategy to control that production plan.

Third, we need to satisfy the product quality requirements. So, we are designing the equipment, we are designing the process, then we are setting up the plan, we are setting

up the strategy to control the plan and this together should ensure that whatever we are deciding whatever the customers are giving us to manufacture whether that standards are achieved or not, whether that standards are obtained during the process or not. To carry out all the things we need people or we can say the human resource or human power. It is not only human resource or human power; we need a set of procedures.

The collective term of people and procedure is nothing, but the manufacturing support system, which is carrying out the operations of designing, the process and equipment, planning and control and they are ensuring whether the facility which is created is capable of satisfying the product quality requirements or not.

These people and procedures may not directly be affecting or they are not directly coming in contact with the product, but they are controlling the entire operations through the factory, through the equipment. So, what are the various elements of this manufacturing support system? Manufacturing support system has work related to the business functions, work related to product design, work related to manufacturing planning and manufacturing control.

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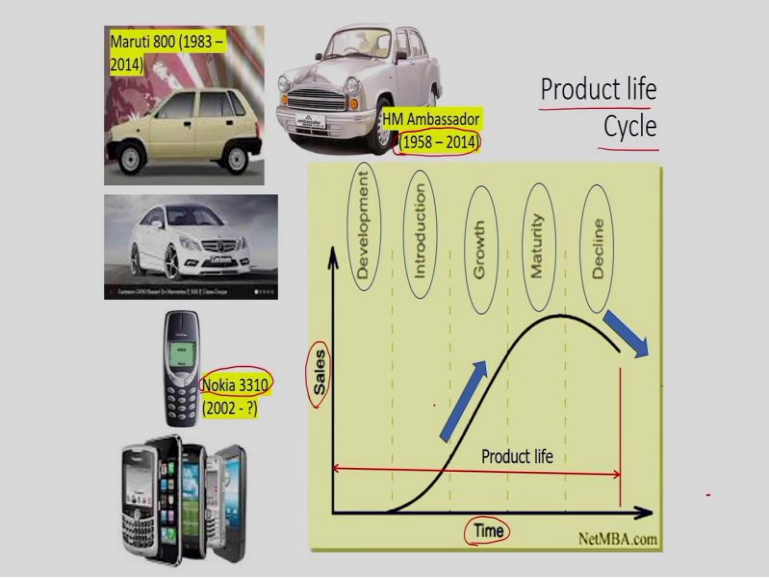


Now, we will see an important concept in automation i.e. the product life cycle. The meaning of product life cycle on your screen you can see a graph. The graph is having the x-axis as the time and the y-axis is the sales, sales of a typical product. When we plot

the sales against time the start of the sales of a product to its decline or stop of the sale of the product it is called as the product life cycle.

If you look at the various stages in the product life you can see there are various stages – development introduction, growth, maturity and decline. The first stage of the product lifecycle is the development. In this stage the product is being developed in an enterprise; designated team will carry out a detailed analysis of the customer requirement, feedback from the customer or the requirements of the customer based on that they carry out detailed design methodology and they come up with the product design.

Naturally there is very less sale or there is zero sale of the product at the start. After the development the product will be launched into the market, it will be introduced, lot of promotion offers will be given to the customers, advertisement will be done in the market and slowly the sale of the product will start.

As we can see in the introduction phase, there is less sale at the start and slowly the sales are growing up. After some time when the product is getting popularized in the market the growth of the sale is increasing.

As the sale is increasing, it will get mature means it will achieve the peak of its sale. The product will be popularized, people will know, the customers will know its usefulness, its features. Lot of people will purchase, lot of offers may also be given by the enterprise and the sales activity is at its peak. During this period the newer product may come into market and that may be better than the developed product of the enterprise.

Moreover, the customers may have change in their taste. They may be interested to have more features, they may be demanding more features because the products which are available in the market may be providing the same. Thus, in this case there is a decline in the sales of the product. The declining will start after achieving the peak of the product sale and after some time the product will not have any customers in the market.

At that particular moment, the enterprise has to look at the feedback given by the customer and they have to come up with a newer product, or an improved version of the product to survive in the market. This total duration from the development of a product to its decline in the market it is the *product life*.

I In earlier days this duration used to be in decades. If we take the example of a Maruti 800 car, it was launched in the year of 1983 and it was in the market up to 2014. For four decades the Maruti 800 was in the market. Therefore, the total product lifecycle was 40 years approximately, four decades.

Another example is the Hindustan Motors Ambassador car. The car was launched in 1958 and it was in the market up to 2014, the product life is again in number of decades.

Nowadays we are getting very fine luxury automobiles and we are getting the variants or the improved versions of these automobiles every after 6 months. The product life cycle has been reduced from the decades to years or months, as far as automobile is concerned.

If we take example of the mobile phone which is nowadays an integral part of our day to day life let us take example of Nokia 3310. Nokia 3310 was launched in 2002 and still we may get it. The product is still alive, but in comparison with that many smart phones have come up in the market.

Thus, we may have the enormous variety of the smart phones, but interestingly the smart phones variety keep on changing, we are getting newer and newer versions of the smart phones every after 6 months.

This is because the customer demands a new feature product. As the product life cycle is getting reduced, there is enormous pressure on the manufacturing plant to respond to the market.

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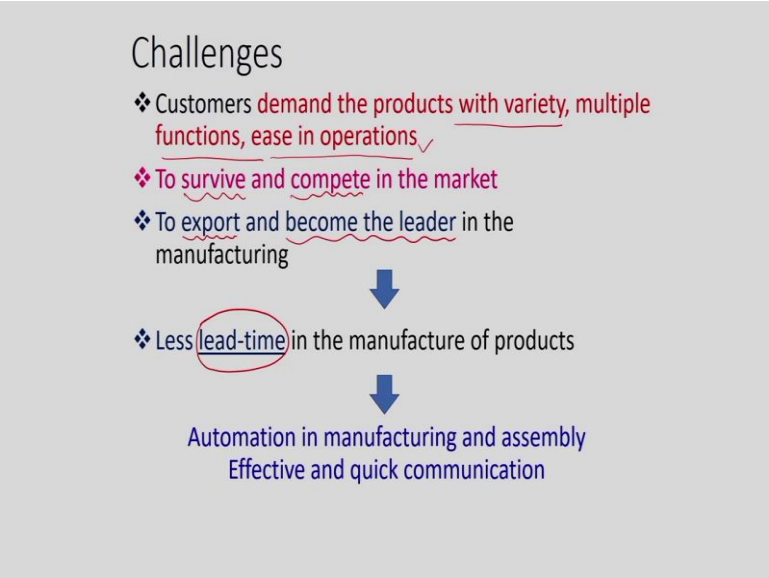


Thus, there are various challenges in front of the manufacturing industry or manufacturing enterprise. Customers demand of the products with variety, multiple functions and ease in operations. They are demanding newer products which are having a wide variety many functions, multiple functions, advanced functions and they should have ease in the operation.

Again, why we need to come up with a new product? Of course, we have to survive in the market. If we do not come up with a new product in the market probably we will lose the sale of the product and we may not be able to compete in the market and naturally the enterprise or the factory may die. Hence, to survive in the market it is one option.

It is not only survival, the next challenge maybe we have to export it to earn more profit, and become the leader in the manufacturing sector, become leader in our own domain. This should be the objective of an entrepreneur and an enterprise to export and to become the leader in the manufacturing.

So, how it is possible? This is possible by reducing the lead time in the manufacturing. You must respond to the market and come up with newer products in a rapid way. To achieve this we have to reduce the lead time, i.e, the product design and manufacturing time at the factory level. For this, we have to go for automation in manufacturing and assembly.

In addition to have the automation in manufacturing and assembly, we should have effective and quick communication. The automation in manufacturing and efficient and quick communication is the *industry 4.0.*It is the part of this manufacturing concept which is now prevailing in the industry.

To reduce the lead time in the manufacturing, we must first understand what is the design and manufacturing process.

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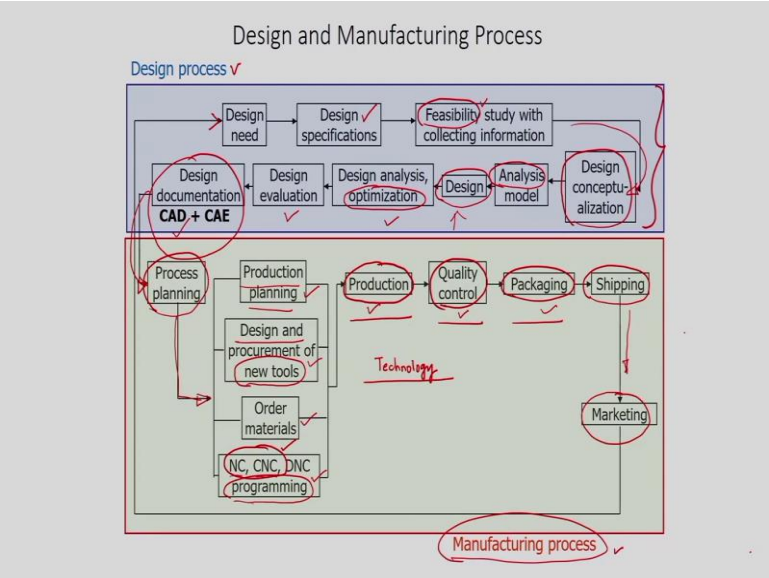


Now, as the design process is concerned, there are various design activities that need to be carried out. In addition to these design activities, there is a set of production activities we need to carry out.

Thus, To develop or manufacture a product, we must know how exactly the process of a product design is getting carried out. The product design starts with inputs from the market.

There is a sales and marketing team, which is in contact with the customers. It receives the feedback from the customers; sorts the data; classify it and provide to the design team. The design team has experienced and knowledgeable persons. It will first convert the classified information coming from the market into design specifications. Afterwards these specifications will be studied in terms of their feasibility. For example, if the customer is asking to reduce the size of the component or they want lighter product. If

we take the example of a smart phone, the customers want a lighter smart phone from that enterprise.

The designer will see whether it is possible to reduce the size of the smart phone or can we reduce the weight of the product, based on that the design conceptualization will be carried out. Design conceptualization means if the weight has to be reduced or if the size of the product is to be reduced in what way it can be possible. The concept will be thought of and will be analyzed thoroughly. The analysis of the concept will be carried out. Based on the analysis the final design will come up.

Thereafter, a thorough mechanical analysis will be carried out and the final design will be come up. This design will be the shape size of the components which will be further analysed and optimized. the analysis is giving the range of the design parameters, the size can be between a certain range or the thickness or even length and width can be within certain range.

Further the design team will carry out the optimization For the optimization process, they will be using various mechanical tools and mechanical methods, afterwards the design will be evaluated. The performance evaluation may be carried out either virtually or by using the analysis software or the simulation software, or we can develop a prototype of the proposed design which will be analyzed thoroughly.

The performance of the product will be evaluated and when the design is finalized, the design of the product will be documented. For documentation, we are using the CAD softwares. Once the design is ready it will be sent to the process planning group. Process planning is the start of the manufacturing processes. It comprises of experienced engineers in the company. The process planners will plan and then they will send the necessary information to the production department.

The production department has various activities like planning of the actual production. Design and procurement of new tools if needed, otherwise plan the production with the existing equipment. If it is not possible to manufacture the modified design with existing equipment naturally we need to go for newer tools. This will follow the procurement of newer materials, development of numerical control or CNC part programs . After this, the production plan will be sent to the shop floor for the production.

After the production, the product will be tested for its quality, it will be packed and then it will be shipped into the market. As the product has come up and has been launched in the market, the marketing team again will take the feedback from the customers and that feedback will be shared with the design team. This cycle will keep on working in the company on regular basis

Now, as far as the variety of the functions or elements of this design and manufacturing process are concerned, we will be looking at the technical aspects of the production equipment, quality control equipment, packaging equipment and variety of tools like numerical control, computer numerical control, machine tools. To improve the performance in production, in quality control, in packaging by using the advanced technologies. We will be studying the technological aspects in this course.

A lot of managerial or management related information and a lot of industrial engineering related concepts are there which are out of scope of this course. Even the design related activities or the concepts related to the design activities are out of scope of this course.

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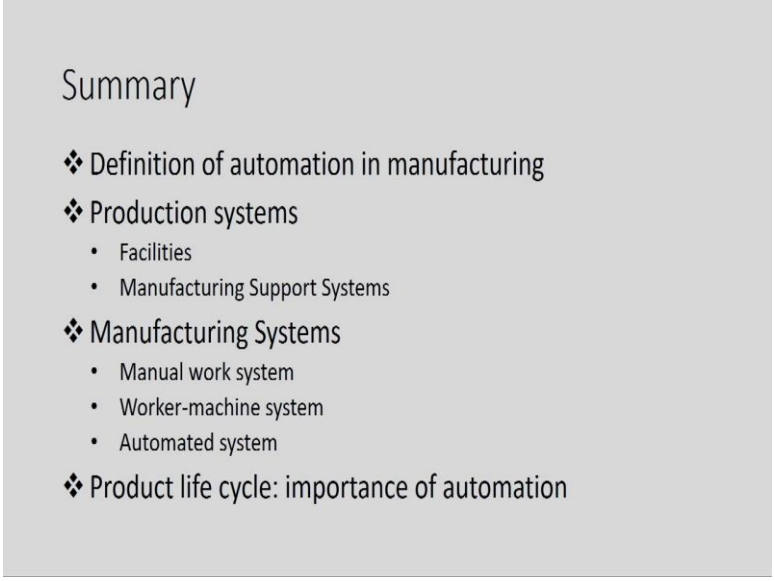


With this we conclude the 1st lecture of week 1. In summary, I would like to say we have studied the definition of automation in manufacturing; we have seen various facilities which are used in a typical production system and we have also seen the meaning of manufacturing support system and its functions.

Then, we have comprehensively studied various manufacturing systems, which are used in the present manufacturing industry. These are manual work system, worker machine system and an automated system.

At the last, we had a comprehensive discussion on the product lifecycle and the importance of automation in the product lifecycle.

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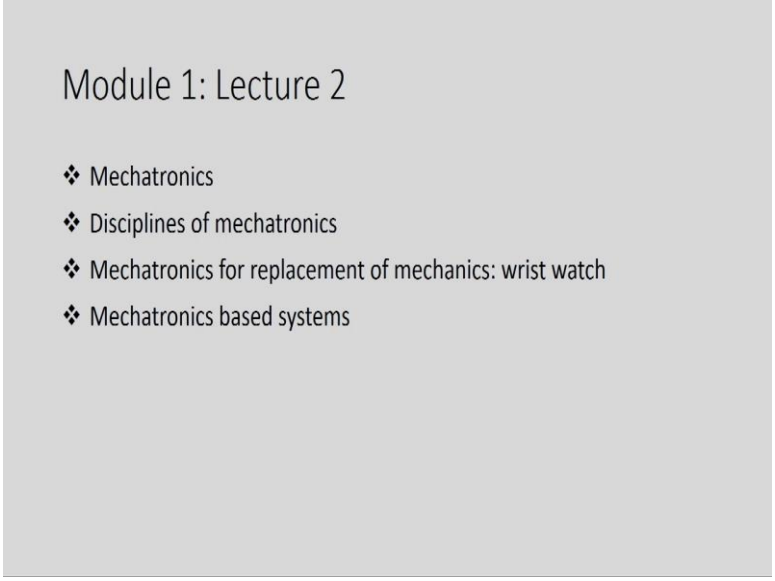


In the next lecture we will be studying the meaning of mechatronics, the definition of mechatronics, the various disciplines associated with the mechatronics – these disciplines are mechanical engineering, electrical engineering, electronics engineering and computer science engineering.

Then, we will be having the meaning of mechatronics in the perspective of replacement of mechanics. For that purpose, we will be having a very simple example of a wristwatch. After that various mechatronics-based systems will be introduced to you.

Thank you.