Advanced Manufacturing Processes
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Module - 1
Introduction
Lecture - 1
Manufacturing and Manufacturing Systems

Dear students, welcome to this course on Advanced Manufacturing processes. This course is designed for undergraduate students of Mechanical Engineering, production engineering and manufacturing engineering. I am Dr Apurbba Kumar Sharma assistant professor in the Department of Mechanical and Industrial Engineering at IIT, Roorkee. In this course I shall present information on various advanced manufacturing techniques apart from introducing the course. I do believe you will get benefitted while going through the presentations. Let us start our presentations with the concepts of manufacturing and manufacturing systems to a brief look at the historical prospective.

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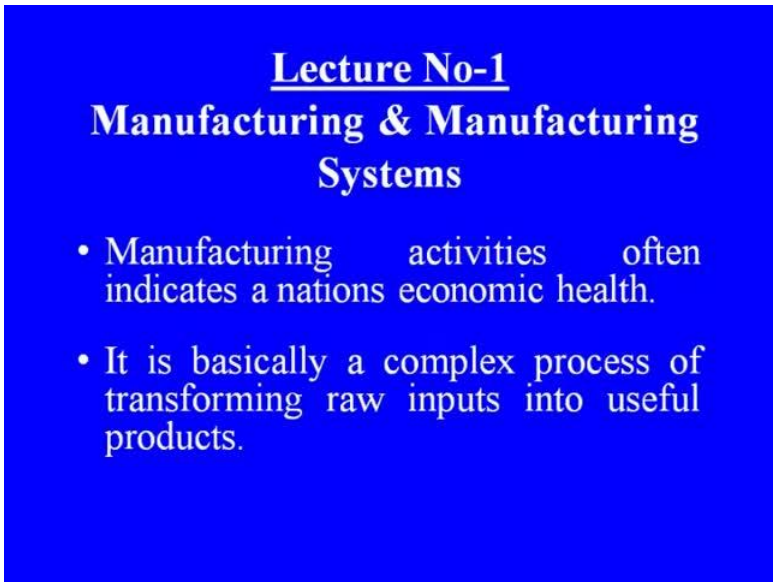

Manufacturing activities often indicate a nation's economic health. It is basically, a complex process of transforming raw inputs into useful products.

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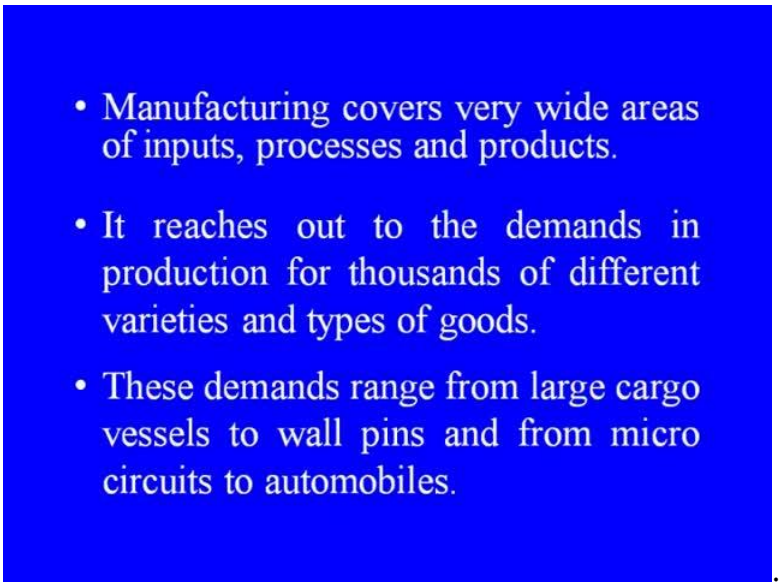

Manufacturing covers very wide areas of inputs, processes and products. It reaches out to the demands in production for thousands of different varieties and types of goods. These demands range from large cargo vessels to wall pins and from micro circuits to automobiles.

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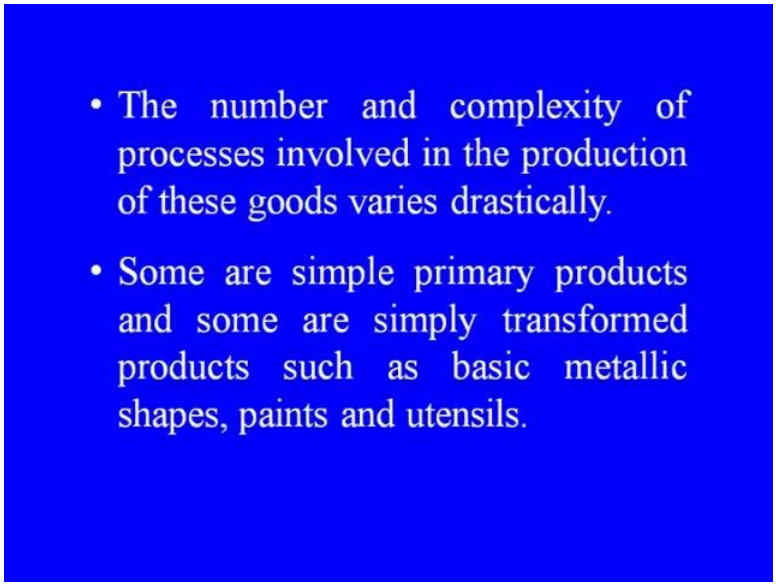

The number and complexity of processes involved in this production of these goods varies drastically. Some are simple primary products and some are simply transformed products such as, basic metallic shapes, paints and utensils.

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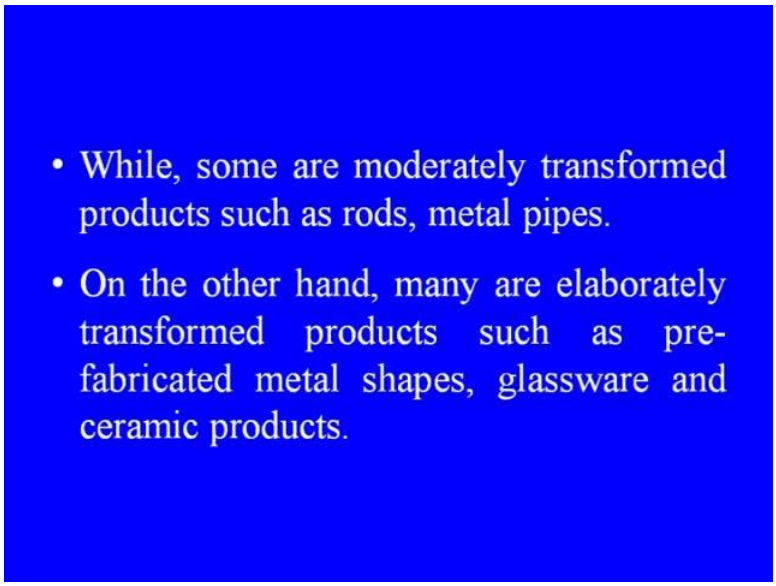

While, some are moderately transformed products such as rods, metal pipes etcetera. On the other hand many are elaborately transformed products, such as pre-fabricated metal shapes, glassware and ceramic products. Manufacturing covers a very wide range of situations, right from Robo controlled highly mechanized lines of production to some simple day to day single operation activities.

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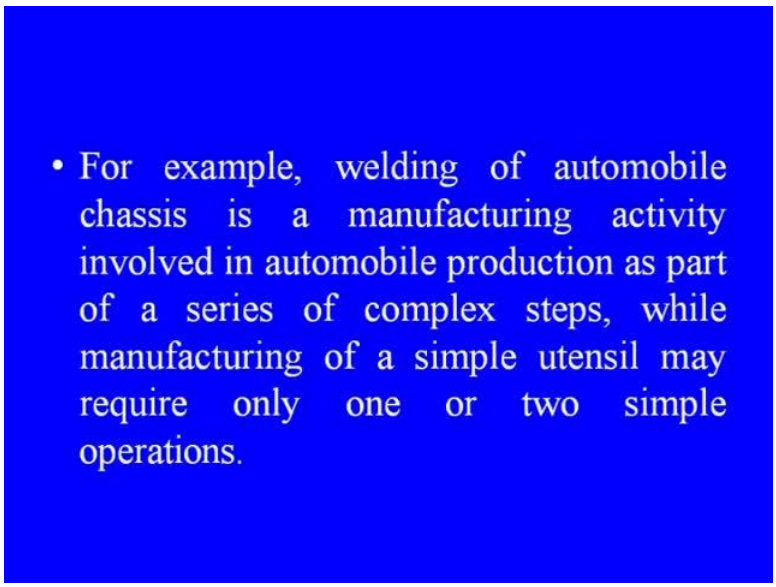

For example, welding of automobile chassis is a manufacturing activity involved, in automobile production as part of a series of complex steps, while manufacturing of a simple utensil may require only one or two simple operations.

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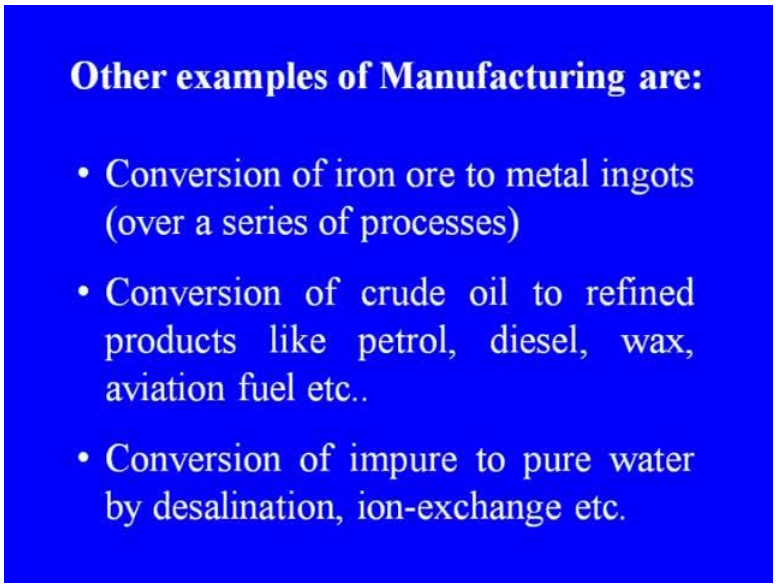

Other examples of manufacturing are conversion of iron ore to metal ingots, over a series of processes. Conversion of crude oil to refined products like petrol, diesel, wax, aviation fuel, etcetera. Conversion of impure to pure water by desalination, ion exchange etcetera. Changing of size and shape of metal to a desired one by forming, casting or machining. Creating useful products by compacting powders, using powder metallurgy techniques. Polishing and coating articles to better products by finishing processes.

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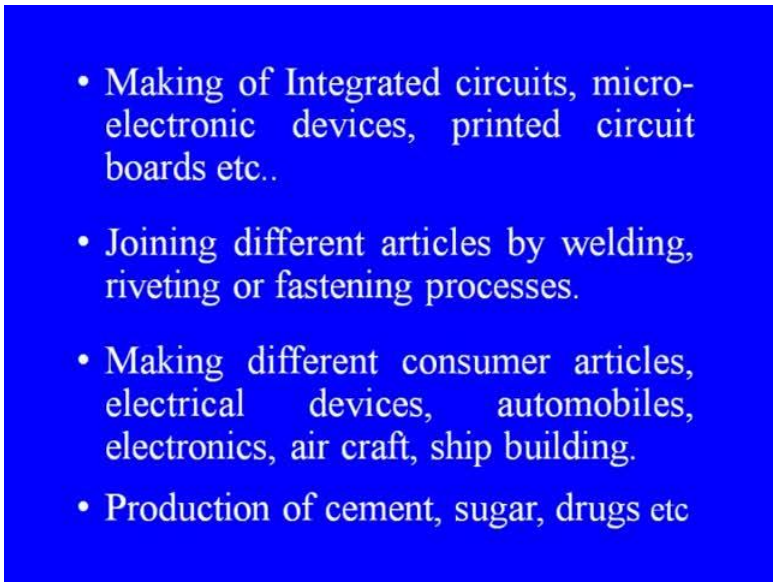

Making of integrated circuits, microelectronic devices, printed circuit boards etcetera. Joining of different articles by welding, riveting or fastening processes. Making different consumer articles, electrical devices, automobiles, electronics air craft, ship building etcetera. Production of cement, sugar, drugs etcetera. The least is never ending as new processes and techniques shall continuous be innovated. In most of the cases the conversion of raw materials to finished products requires number of steps, which calls for dividing manufacturing into various processes and sub processes.

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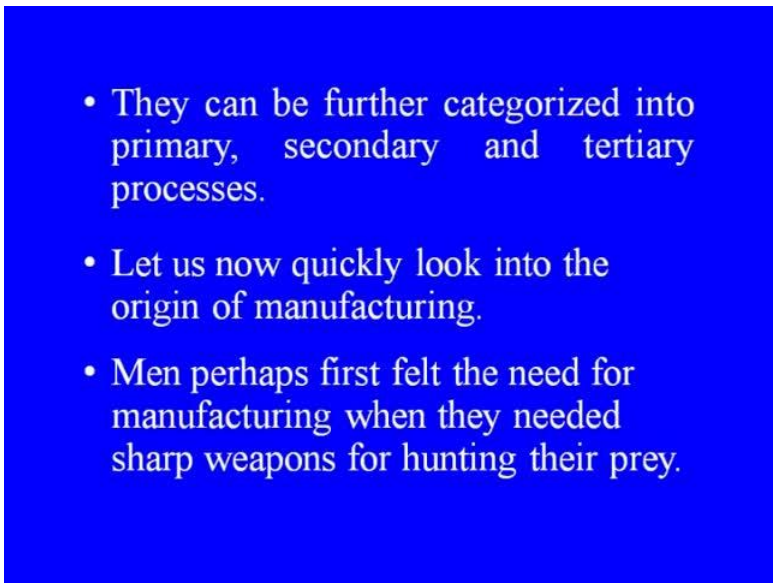

They can be further categorized into primary, secondary and tertiary processes. Let us now, quickly look into the origin of manufacturing. Men perhaps first felt the need for manufacturing, when they needed sharp weapons for hunting their pray.

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Accordingly, attempts were made to make weapons and a tools which perhaps can be thought of as the beginning of manufacturing.

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Slowly it got developed, when they try to give finer shapes to these and they succeeded in manufacturing improved tools.

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However, the manufacturing need kept increasing.

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Making of potteries were attempted, thus with time the art of making things or products.

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That is the technology of manufacturing started getting advanced to cater to the needs of the people. That is users with the increasing complexity of the products and increasing requirements for the volumes of different products.

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Manufacturing techniques are also getting advanced day by day and today most of the products are manufactured using advanced technologies, which tend to get older every five years. Then what are the challenges faced by the manufacturers.

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Manufacturing industry now encompasses dimension scale of more than, 15 orders in magnitude.

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The design and manufacturing of huge machineries, ships and spacecrafts on one side, while nanotechnology on the other side of the dimension scale highlight, the new challenges ahead for engineers and technologists.

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With the technology advancement newer materials energy, sources decision making and new techniques in management are being developed. New challenges such as, environmental and other issues put stringent requirements on technology. Global competition, the trust and quality and demand for higher productivity are some of the challenges before the present industrial and manufacturing units.

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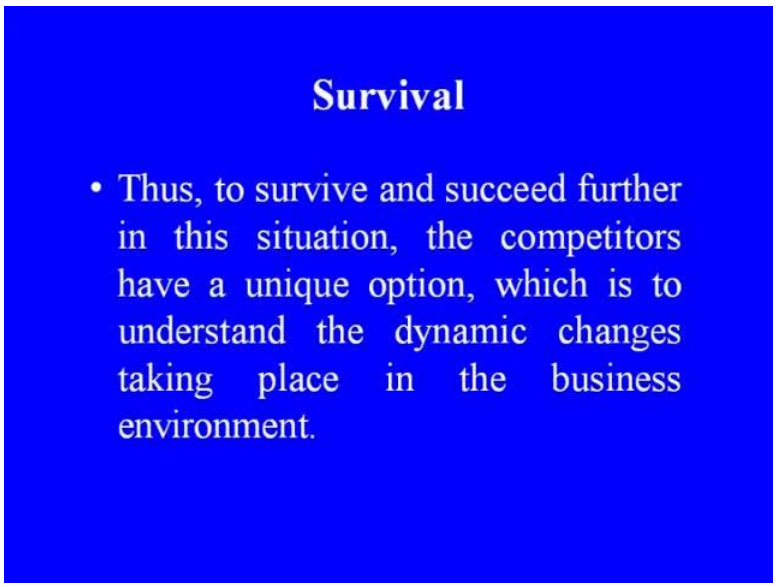

Thus to survive and succeed further in this situation, the competitors have a unique option, which is to understand the dynamic changes taking place in the business

environment. In view of the above a nation should develop and update its infrastructure such that, the new and advance technology gets hand in hand with the ongoing time.

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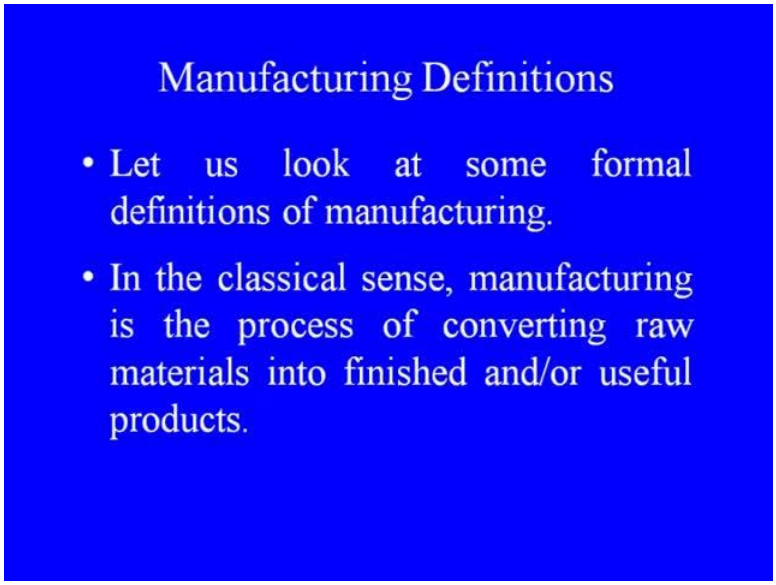

Let us look at some formal definitions of manufacturing. In the classical sense, manufacturing is the process of converting raw materials into finished and/or useful products. It can also be perceived as the making of goods or wares by manual labor and or by the use of machinery on a large scale. Manufacturing is a very broad activity encompassing many functions, right from purchasing to quality control of the final product.

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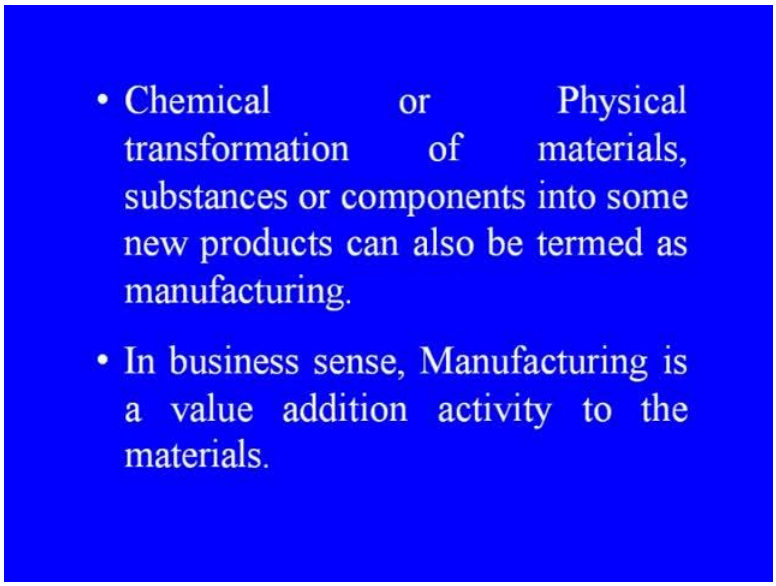

Chemical or physical transformation of materials, substances or components into some new products can also be termed as manufacturing. In business sense, manufacturing is a value addition activity to the materials.

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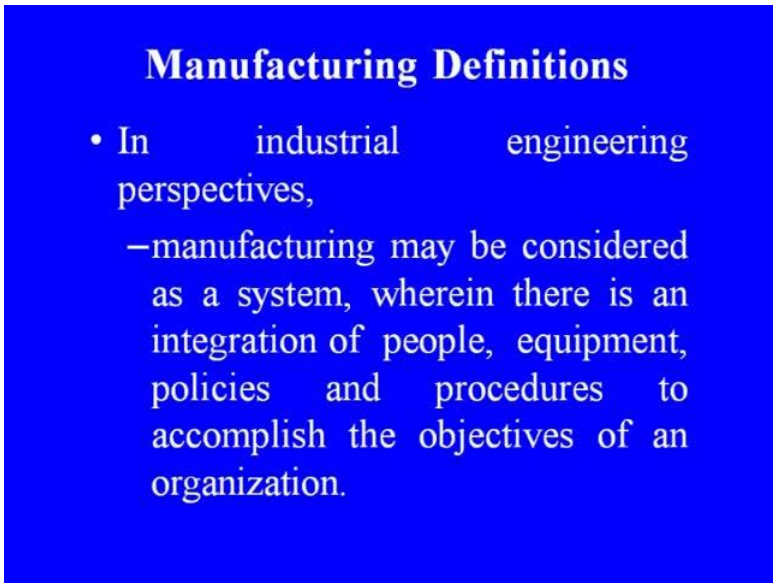

In industrial engineering perspectives, manufacturing may be considered as a system, wherein there is an integration of people, equipment, policies and procedures to accomplish the objectives of an organization. It is applications of different resources such as machineries and people for converting the materials into useful goods.

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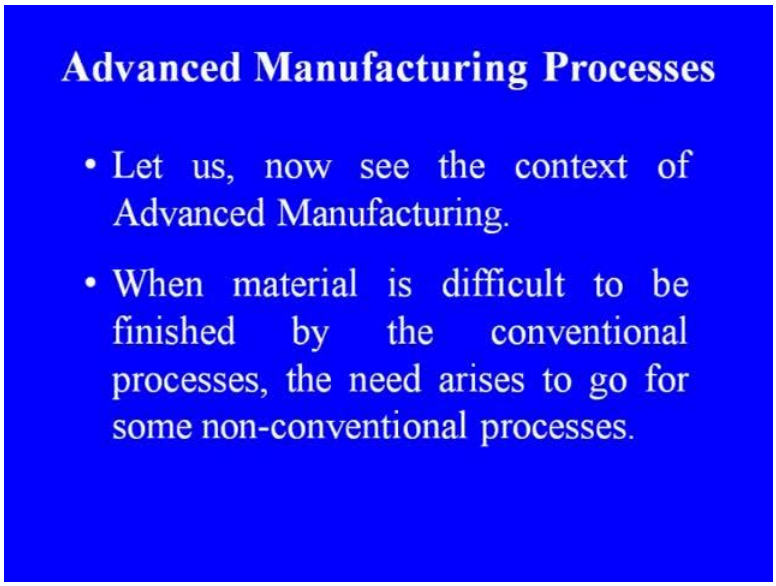

Let us, now see the context of advanced manufacturing. When material is difficult to be finished the conventional processes, the need arises to go for some non conventional processes.

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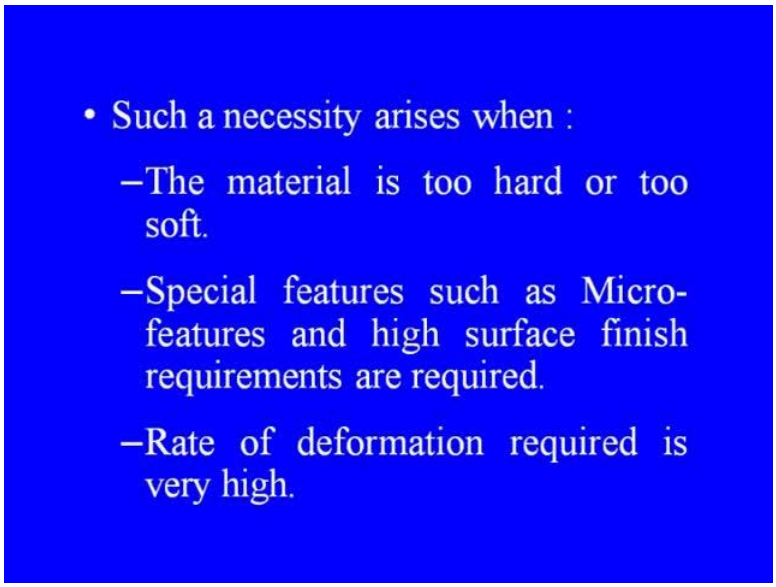

Such a necessity arises when the material is too hard or too soft. Special features such as micro features and high surface finish requirements are required. Rate of deformation required is very high.

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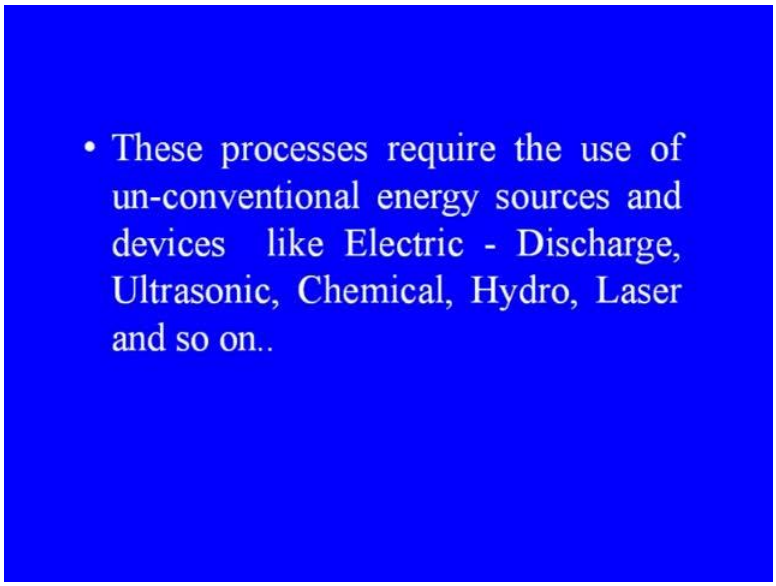

These processes required the use of unconventional energy sources and devices like electric-discharge, ultrasonic, chemical, hydro, laser and so on.

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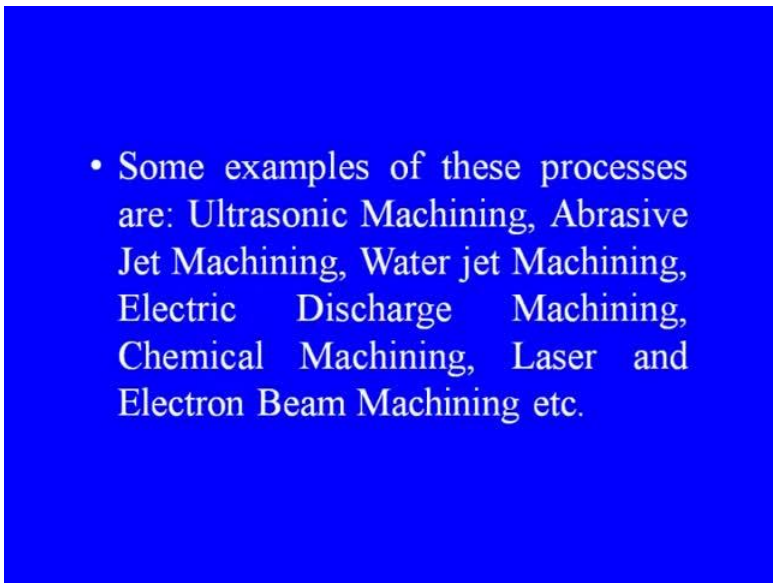

Some examples of these processes are ultrasonic machining, abrasive jet machining, water jet machining, electric discharge machining, chemical machining, laser and electron beam machining etcetera. To understand the concept of manufacturing systems, one need to look beyond converting raw material into finished products. The understanding of manufacturing system as a whole helps in identifying, the process

parameters and functions of the organization, that are important this helps to make decisions about the economical ways of reducing the end products.

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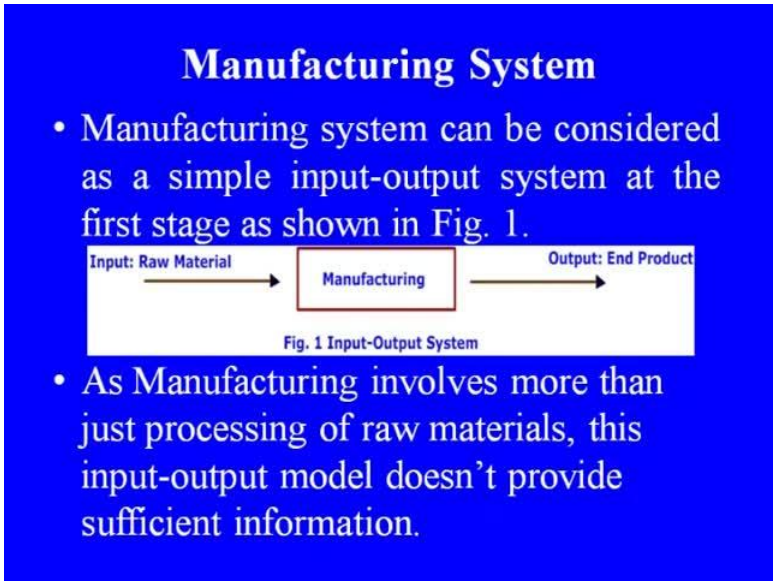

A manufacturing system can be considered as a simple input-output system at the first stage as shown in the figure 1. As manufacturing involves more than just processing of raw materials, this input-output model does not provide sufficient information. Manufacturing as a system involves other inputs like energy, planning, appropriate missionaries and product or customers' requirements apart from raw materials.

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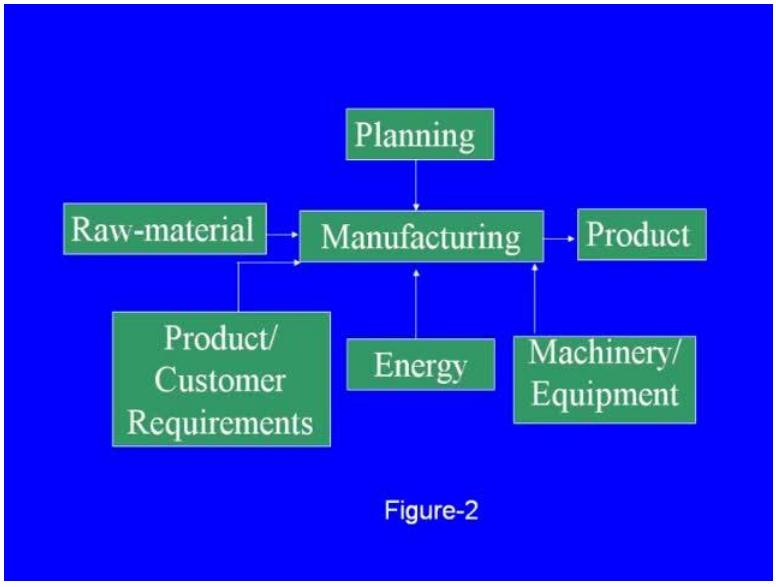

Hence the input-output model can be modified as shown in the Figure-2.

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The present day trends also look beyond the delivery of the product to the customer that is after-sale services offered by the organization. The basic models as shown earlier at figure 1 and figure 2 can then be further expanded to incorporate further functions, involved in an organization. The holistic approach incorporating all the above aspects is shown in figure 3.

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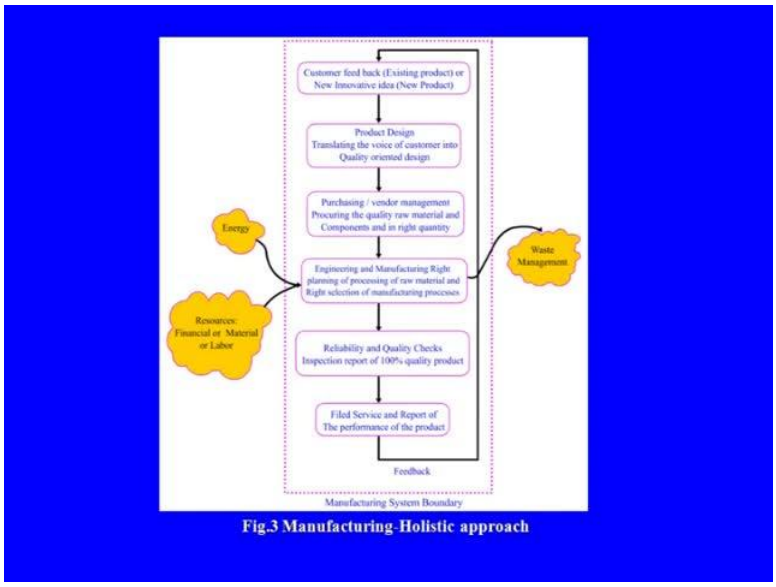

Fig.3 Manufacturing-Holistic approach

In this model, all the activities right from it a conceptualizing and innovative idea for a new product or getting customer feedback for an existing product, till the manufactured product is made available to the customers or considered.

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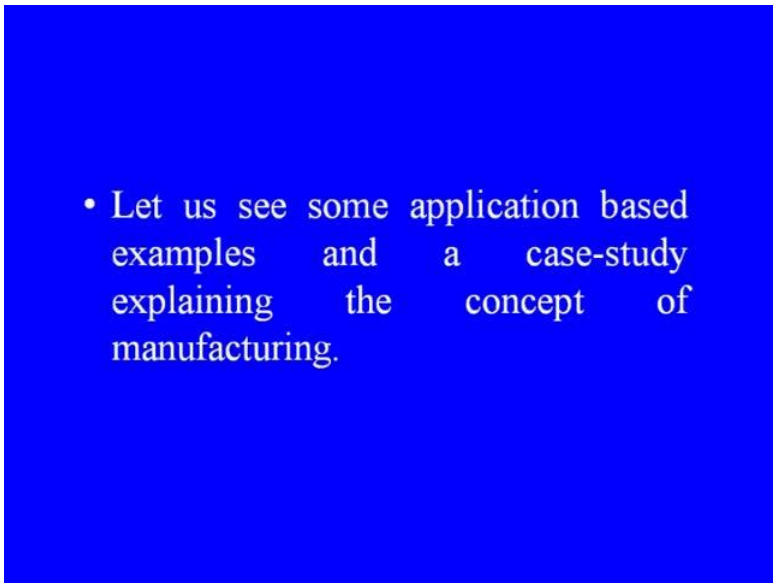

Moving on let us see some application based examples and a case study explaining the concept of manufacturing.

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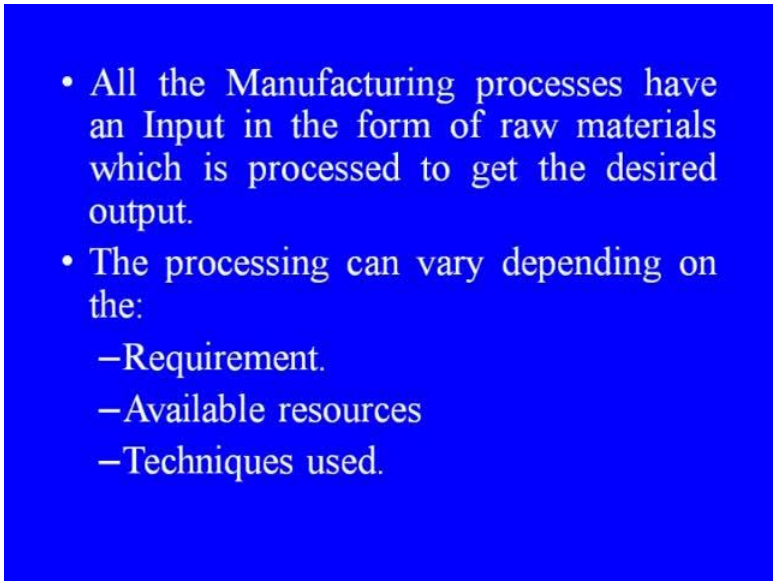

All the manufacturing processes have an input in the form of raw materials, which is processed to get the desired output. This already I have explained, the processing can

vary depending on the requirement available resources and techniques used. So, this can be explained like this.

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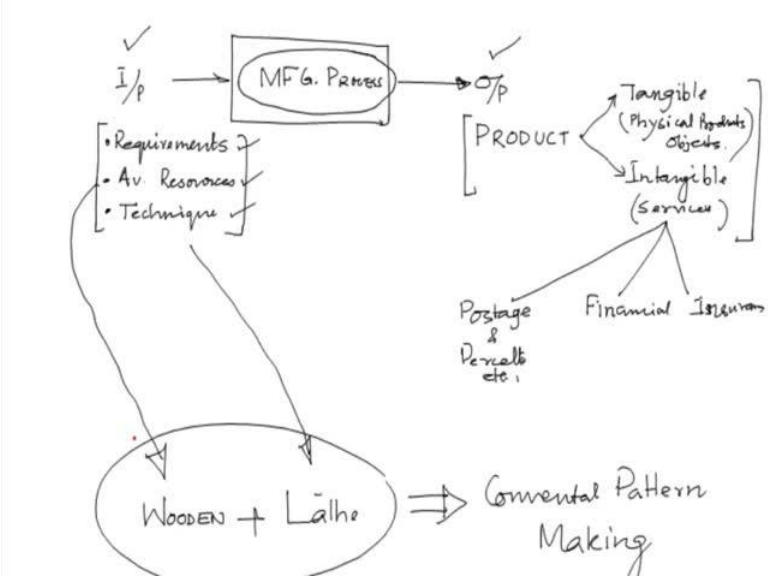

So, manufacturing basic manufacturing process is nothing but so if this is this we consider as a manufacturing process and this is the input and this is the output. This input, input can vary depending on the requirement, then depending on the available resources, then depending on the technique, then output may be a product, but not necessarily be a tangible product. Product can be a tangible product or it can be intangible as also. So, here in tangible we will consider that these are physical products, some physical objects we can say, whereas this intangible may contain or tangible products are generally, services like we obtain in the financial services then in insurances.

Then say postage and parcel and so on etcetera that is it. So, these are intangible services, but these are also, some forms of products. Now, the main issue is how we define or design this manufacturing process, this is a very basic configuration so to say that consist of input as well as output, but this is not as simple as this. As I have already indicated, this input or the process may vary depending on the requirements, depending on the available resources, depending on the technique. Say for example, one pattern is to be manufactured for casting, then if I have the raw material as wood, as a raw material.

Say for example, some wooden pieces are there, wooden pieces are there. I have one lathe machine at my disposal, then probably I will go for a conventional method of conventional pattern making procedure pattern making, but however this I am taking considering the technique that is lathe machine, I have available. Now, I have with me then available resources that is with me wood and my requirement is that is I need a pattern, a pattern.

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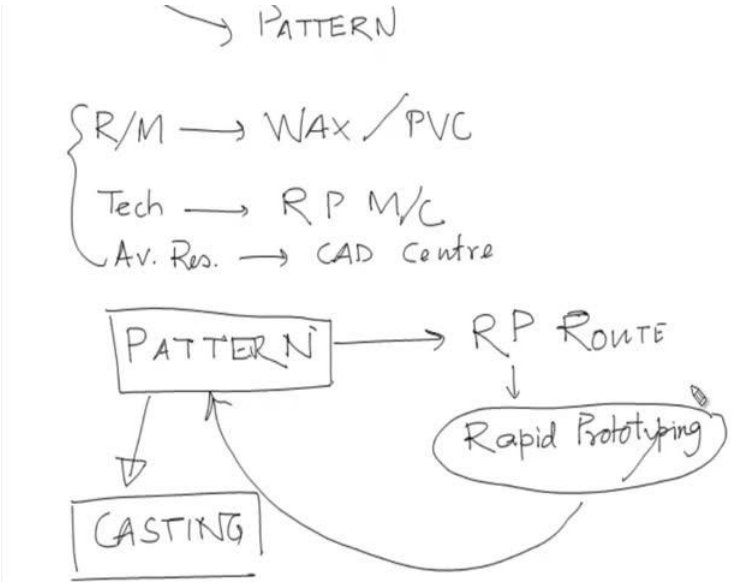

However, in the same situation if the things are say. For example, as raw material I have raw material is say wax or some other say P V C material, then I have the technique available, say technique available is say rapid prototyping technique or the machine I am having is the rapid prototyping machine. Then probably with these requirements and techniques available probably I will go for the same pattern making, pattern and of course, I have say available in available resources.

Resources I have a CAD centre with me or a CAD terminal with me, then probably same pattern making. I will follow the rapid prototyping route, this will come in later in details about this rapid prototyping. In fact, we will try to discuss this rapid prototyping method in a complete module with spreading over two, three sessions this is known as rapid prototyping. Now, so this is also one method or process that is manufacturing process and output of this is nothing but a pattern, which will be used for this pattern will be used for same casting process.

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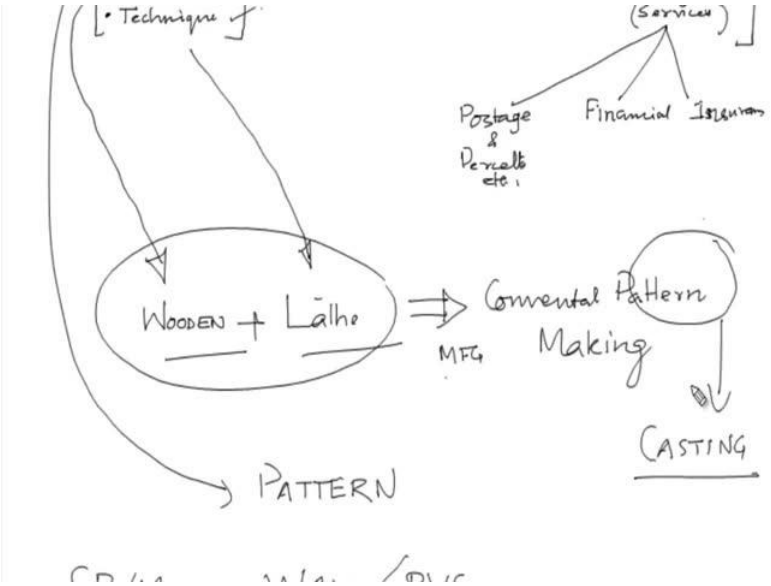

And on the other hand if I have wood, if I have a lathe machine then probably same pattern, I can produce to be used for again same casting process, but I am following a different route for manufacturing or different manufacturing process. Thus, this explains how different requirements, different available resources, different available techniques can influence the process of manufacturing the same product.

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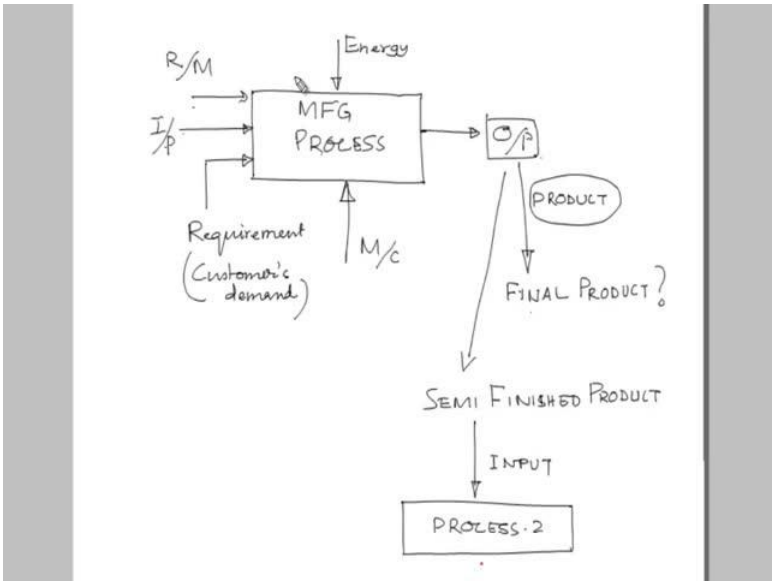

Also here the manufacturing we can just now, I have explained that this is nothing but manufacturing process. So, this is a kind of black box in which certain inputs will be

there and depending on the output to be produced. So, here other things also will be will matter like what are the different requirements. This requirements will be mostly this is customer, as per the customers demand or customers requirement we can say, what he wants. Then energy which will be used for conversion of the raw material or the inputs to the corresponding output. Then the input in the resources in the form of say raw materials etcetera, say raw materials etcetera.

Then the machines, machines whatever the machines available there or the resources we can say, but now the question is whatever being the raw material converted into output will it be the final output or not or final product or not is it a final product or does it represent the final product answer is not necessarily. The thing is the fact is this product whatever we are getting as output. So, this is in a just few minutes back also.

I have spoken about so this is no doubt this is a product may be tangible product, may be intangible product does not matter but at this stage, I should also make it clear that this product not necessarily be a final product. This could be a as well a semi finished product, semi finished product which will go through. Again this semi finished product will come as or will enter as input to some other process in between some other process.

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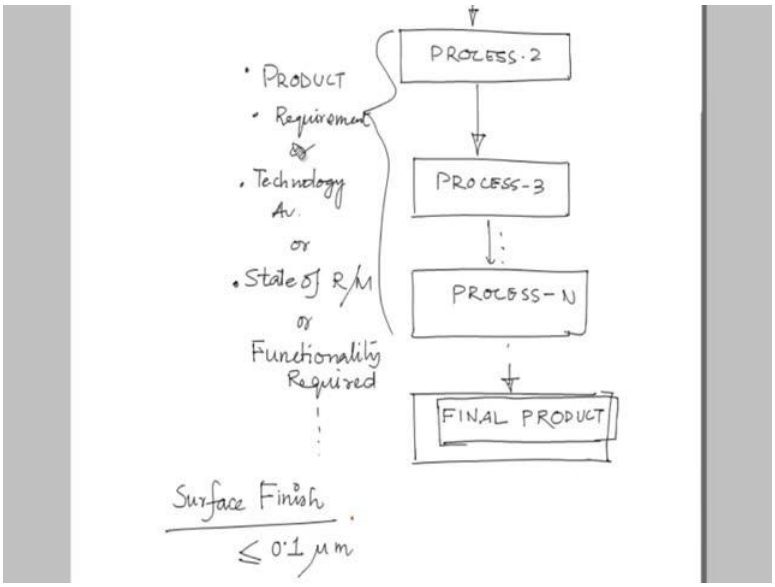

Say another process say process say 2 then may be again this will be met to flow through process 3. Then so process like that it can go through process N and finally, we may get the final product. Now, who will determine how many intermediate processes are there

so this will depend on the product requirement, product requirement or the technology available or depending on the state of raw material this R R, R oblique M.

I am trying to represent raw material here. In the most of the cases or functionality required and so on. These are some of the major factors that will go on how many stages or how many processing stages, a particular raw material should go through to arrive at or to come to the final product stage like here say for example, if we need a surface finish off, we every one of us we know what is a surface finish.

So, surface finish that defines actually status of a surface smoothness of a surface, say surface finish requirement is in a particular surface for a particular surface. Say this should be less than or equal to 0.1 micro meter. Now, the thing is that in my process 1 through which it came through so probably this may be capable of producing the surface in the range of 1 micron only. That means, the capability of the particular resources or the machine I am using at that stage, can have the capability to produce a surface having surface roughness or surface finish of 1 micron only. Then I cannot gift a same product to the customer saying that, this is my capability of the machine rather I shall have to take that product, which I will call at this stage as a semi finished product.

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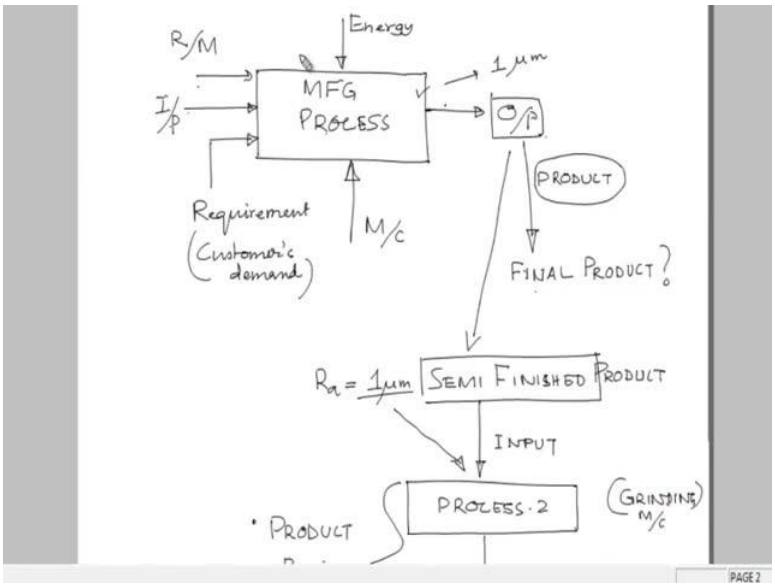

Semi-finished product, which is having 1 micron or 1 micrometer R a. Now, this needs to be processed through another machine. Say in this particular example, this can be a grinding machine. A grinding machine which is obviously capable of giving better

surface finish than say a lathe machine or than a milling machine or may be a shaping machine or planning machine. Now, obviously in this case this is a second processing I am using and if this machine is capable of giving me 0.01 micro meter surface finish.

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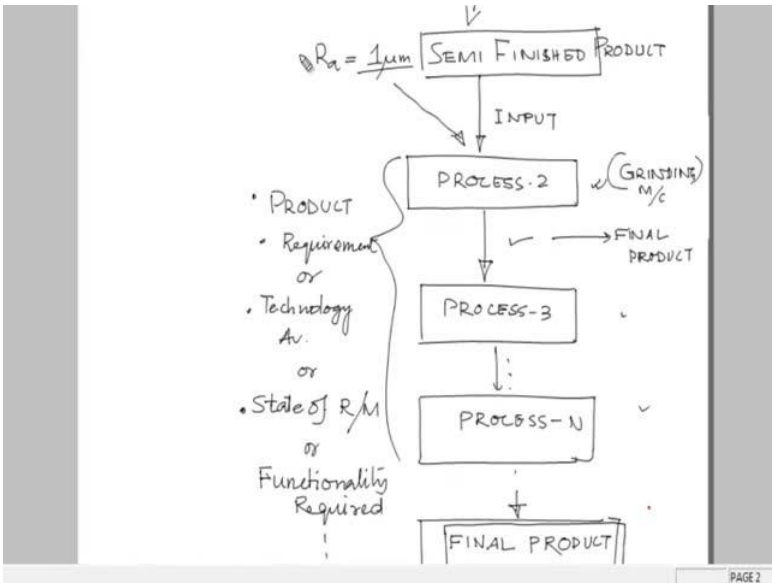

Then probably at this stage itself I am arriving at the final product, if not then probably I have go through the other processes as well. Now, let us for example, let us take another state the same product after having the surface finish of 0.01 micro meter also needs to be hardened by a depth of 1 mm. That means, my product surface should have a hardened surface and that hardened surface, thickness should also be limited to only 1 millimeter. Now, if this additional heat treatment of the surface is required then what need to do? We cannot do the heat treatment in the lathe machine. We cannot do the heat treatment in a milling machine neither in a grinding machine.

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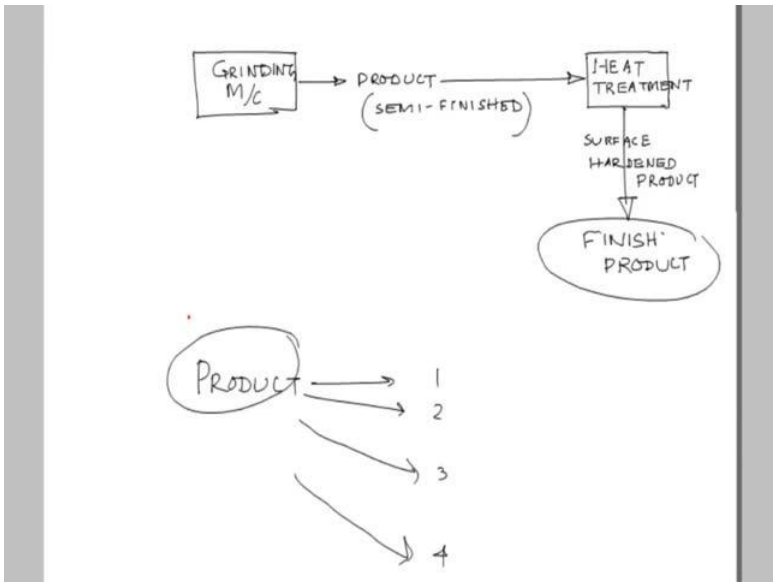

Then this whatever, we are getting the output from the grinding machine, say grinding machine. So, this is the product so this product again we can say so this is a semi finished. Semi finished product only, because it does not meet the criteria of the hardened surface. So, therefore we may need to take this semi finished product to some heat treatment, say heat treatment process in which the surface hardening will be done and that product with surface hardens.

So, this will be a surface hardened product, hardened, surface hardened product and this product we will call as the finish product. Similarly, one particular product may need number of processes, say process 1, process 2. As I have already discussed so number of processes through which it will come. The raw material will come through and finally, we will obtain the product. Let us take an example.

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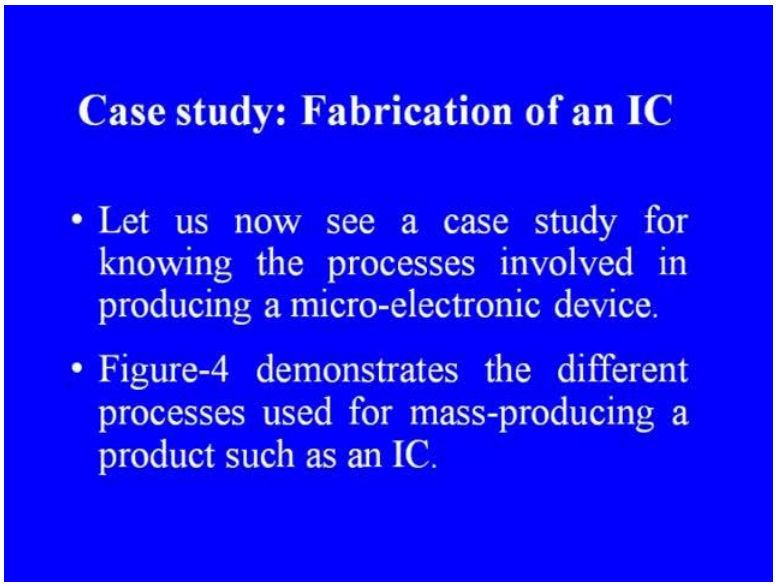

Say this figure, so this describes the manufacturing sequences of an I C, I C we have seen integrated circuits. Now, almost every electronic product is not complete without an I C inside it. So, I C is an essential component so to say for each and every electronic gadget. So, let us see an example as an example this I C manufacturing what could happen, what are the different processes just now we have discussed process 1, 2, 3 may be required depending on the functionality, let us see in brief.

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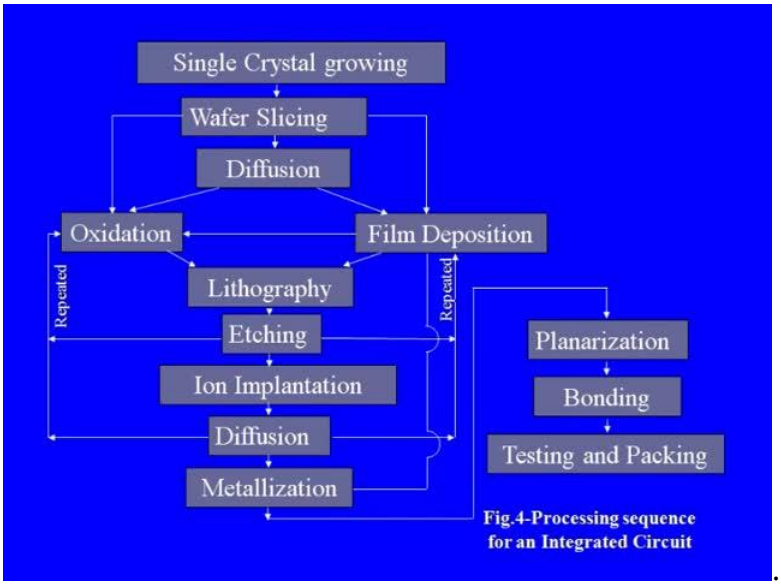

So, the process sequences some generalized process sequences. There may be more number of operations in it or may be some operations can be shortened also or cut down also from these sequences, but this is let us consider, this as a generalized process sequence of manufacturing of an I C. So, first and foremost requirement is we need a single crystal so that is considered as the first thing.

So, this is show in the screen so single crystal let us take an single crystal. This can be considered as a raw material as well, then this would be sliced to proper shape which we call as wafer. So, this slicing itself is a process or a strip in that whole manufacturing process of the I C or when I C this slicing is a part of this process rather, we can say for slicing we may have to go to a different machine and therefore, we can say this is a different process itself. Followed by this is each sliced wafer should be diffused, then oxidized, then film deposition has to be done, then lithography has to be done, etching has to be done, ion implantation has to be done and so on.

As shown in the figure so here so sliced may require diffusion or may not be required. So, depending on so this is the generalized that is why generalized a scheme. So, some in some applications then the diffusion may not be required. So, we may go directly for oxidation or for film deposition. In some cases diffusion is also required as well as oxidation is also required or in some cases diffusion plus film deposition may be required. Therefore, depending on what we were talking about sometimes back depending on the technology, depending on the requirement the processes may vary.

Now, it may require lithography then etching, ion implantation again some diffusion, then metallization, then planarization, then bonding, then testing and packing. So, what we do in this these operations, sometimes 1or 2. In this sequence may be redundant depending on the functionality of the I C. What different functions it will perform while in use depending on that, we may have to have less or more number of components embedded in it and therefore, less or more processes may be required in this process sequence.

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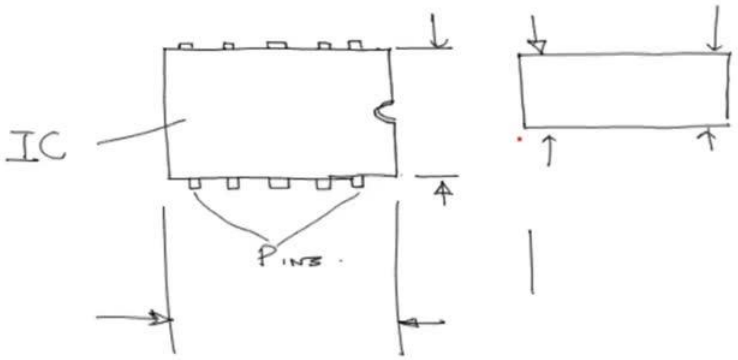

Planarization is can be considered as a common process. In which all I C's are having some shape something like this. So, here that connecting button should be or connecting pin should be there, these are known as pins. So, these are pins and this is the body of the I C, in which number of circuits will be there integrated and this for orientation. Now, in this, this planarization that means the I C should be as for as the dimension is concerned.

So, the thickness wise it should be plain like this means, this thickness and this thickness should be same. Similarly, the dimensionally so this also should be so from here to here from here to here. All these dimensions should be very, very accurate then only it will get fit in some other components, or other circuits in which it will be appropriately used. Therefore, these things have to be taken care of during the manufacturing stage itself.

So, these are also, some requirements, some essential requirements in production of an I C. Similarly, now before this I C is dispatched from the shop or manufacturing shop, it needs to be tested whether the all the circuits are performing well or they are up to the mark or whether there is any discontinuity, or there is any short circuiting kind of things or you can say there are any defects inside it so that has to be taken care of and for that there is one more stage or step record testing.

So, this is also considered to be one of the aspects in the manufacturing itself then of course, it needs to be bonded and packaged and any product to reach to the customer safely, safe and sound need some sound packing. Therefore, this packing is also a very,

very important job and an important aspect. Therefore, this is also being taken care of at this stage itself.

Likewise, likewise we have seen while manufacturing 1 I C there are a number of steps that needs to be followed depending on the requirements, or the functionality of the I C's for other components as well or other products as well. We may have to go through a number of processes before we get the final product, as a product which is usable to the customers.

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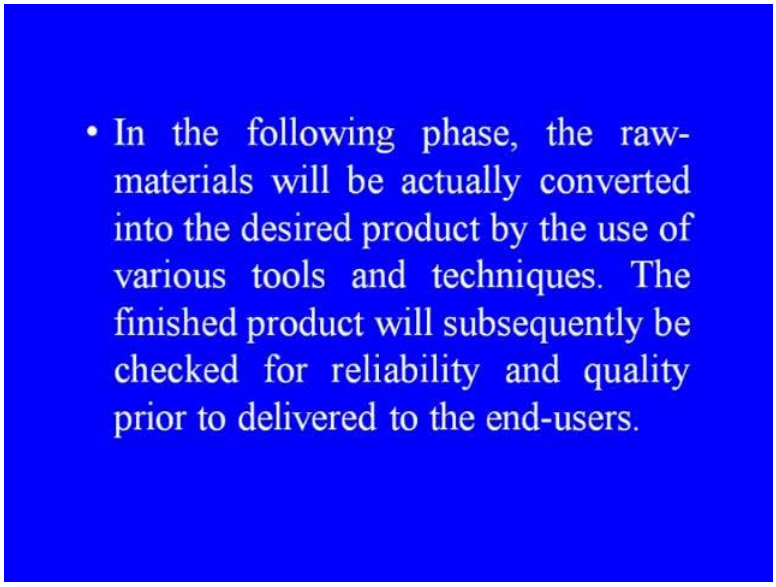

In the following phase, the raw materials will be actually converted into the desired product by the use of various tools and techniques. The finished product will subsequently be checked for reliability and quality prior to delivered to the end users.

Thank you.