Advanced Manufacturing Processes
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Module - 1
Introduction
Lecture - 2
Manufacturing Trends and Challenges

Welcome to this second lecture on advanced manufacturing processes. In this session, we will discuss the concepts of advanced manufacturing, hybrid manufacturing and their examples.

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The trends in manufacturing and the newer manufacturing philosophies adopted by the manufacturers to remain competitive in the market have also been presented.

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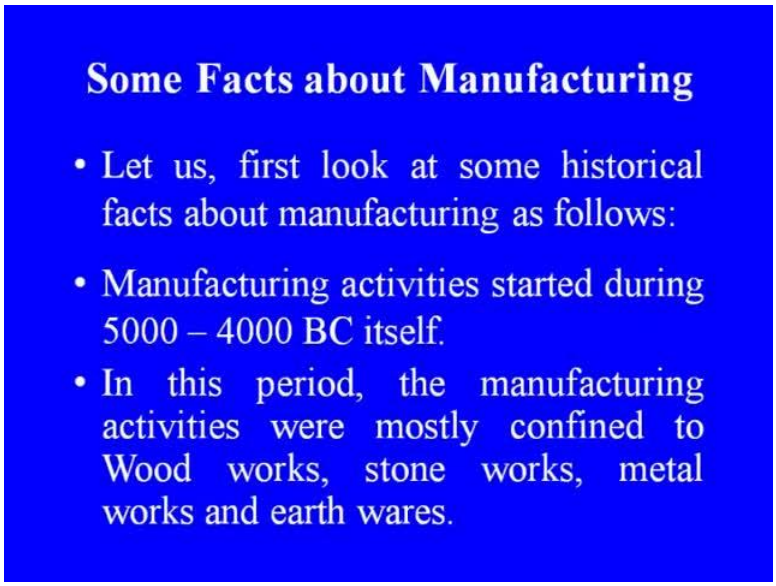

Let us first look at some historical facts about manufacturing as follows. Manufacturing activities started during 5000 to 4000 BC itself. In this period the manufacturing activities were mostly confined to wood works, stone works, metal works and earth wares.

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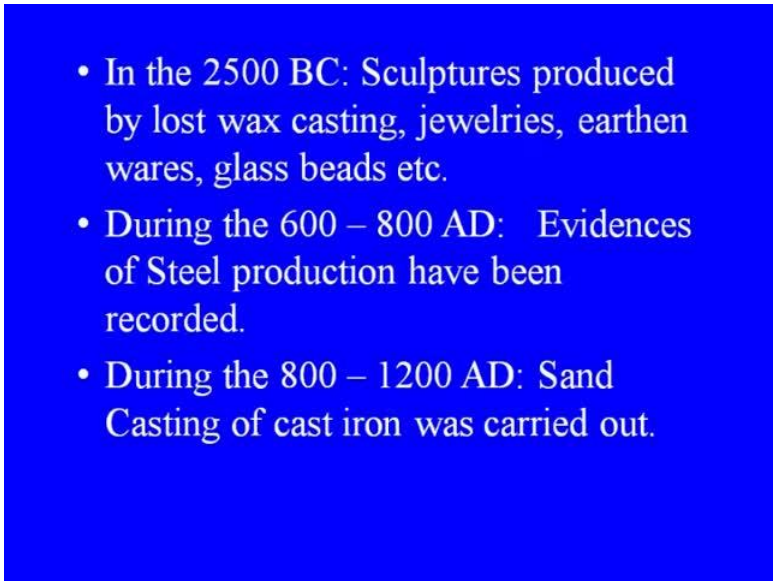

In the 2500 BC sculptures produced by lost wax casting, jewelries, earthen wares, glass beads etcetera where recorded. During the 600 to 800 AD evidences of steel production have been recorded. During the 800 to 1200 AD sand casting of cast iron was carried

out. However, if we look at the developments in manufacturing in ancient India, evidences of manufacturing are available, since the year 3000 BC.

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The earliest castings of that age include the 11 centimeter high bronze dancing girl found at Mohen jo daro.

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In the year 2000 BC iron pillars, arrows hooks, nails, bowls and daggers were found in Delhi, Ropar, Nashik and other places. Large scale state owned means and processes of

metal extraction and alloying had been mentioned in Kautilya's Arthashastra dating back in the year 500 BC. In 500 AD itself, cast crucible steel was first produced in India.

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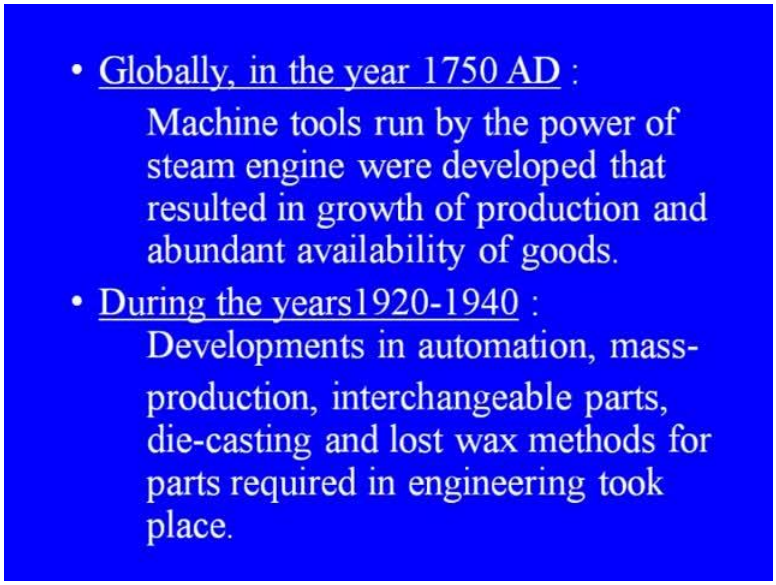

Probably in the year 1750 AD machine tools run by the power of steam engine were developed, that resulted in growth of production and abundant availability of goods. During the years 1920 to 1940 developments in automation, mass production, interchangeable parts, die casting and lost wax methods, for parts required in the engineering took place.

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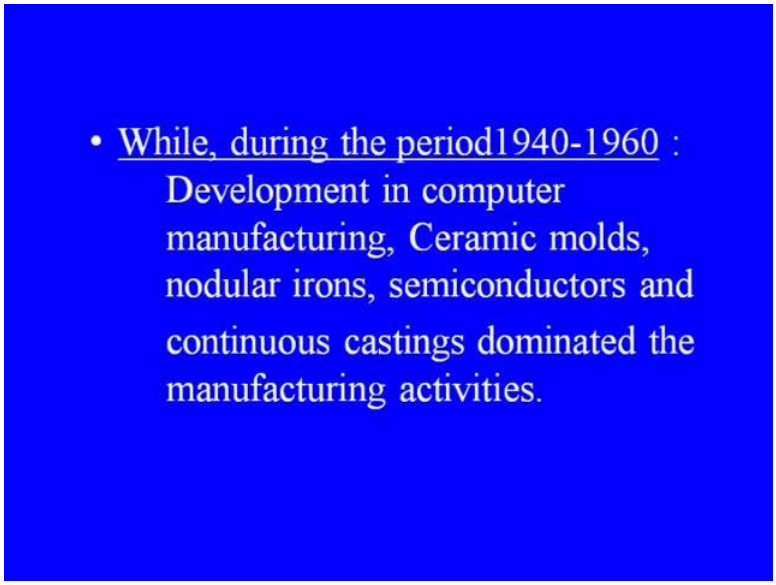

While during the period of 1940 to 1960 developments in computer manufacturing ceramic molds, nodular irons, semi conductors and continuous castings dominated the manufacturing activities. During the period 1960 to 1990, in general the following developments took place.

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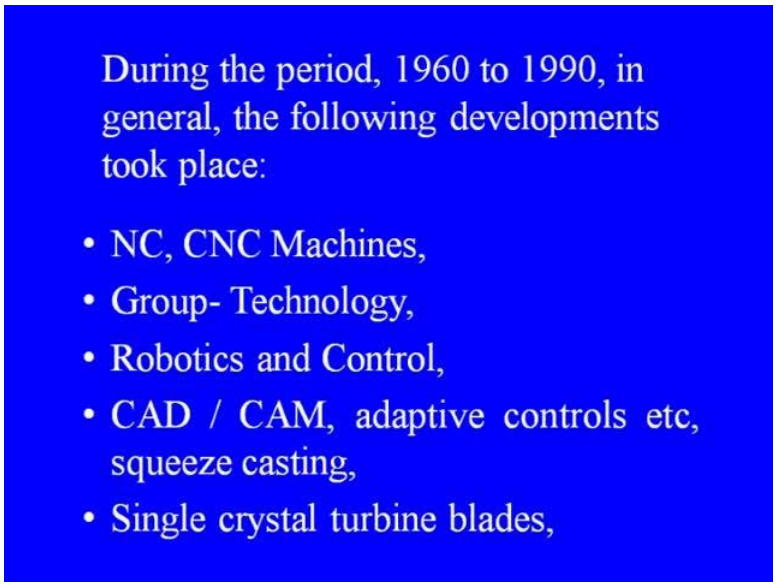

Numerical control, computer numerical control machines, group technology, robotics and control, computer aided design and computer aided manufacturing, adaptive controls etcetera squeeze casting single crystal turbine blades.

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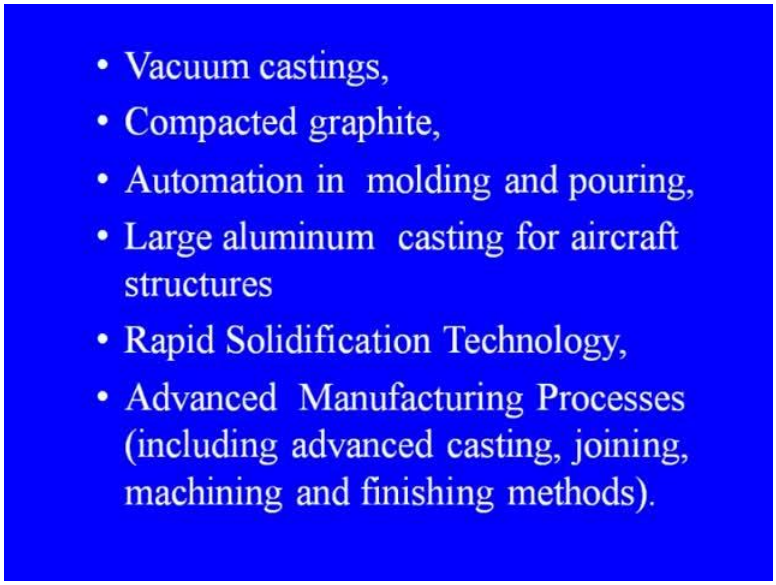

Vacuum castings, compacted graphite, automation in molding and pouring, large aluminum casting for aircraft structures, rapid solidification technology. Advanced manufacturing processes, which includes advanced casting, joining, machining and finishing methods. And in the recent years, particularly since the year 1990 till date, the following developments are noteworthy.

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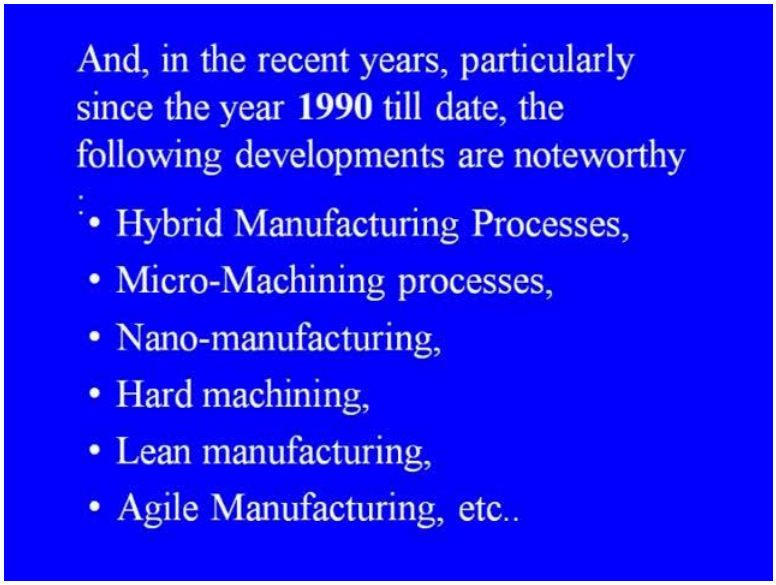

Hybrid manufacturing processes, micro manufacturing processes, nano manufacturing, hard machining, lean manufacturing, agile manufacturing etcetera. Moving into the domain of advanced manufacturing, let us look at a formal definition of advanced manufacturing.

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It is defined as the utilization of enabling technologies, incorporating design and business process innovation, to deliver high value added processes and products in ways that are novel and competitive. The need for advanced manufacturing can be attributed to the following.

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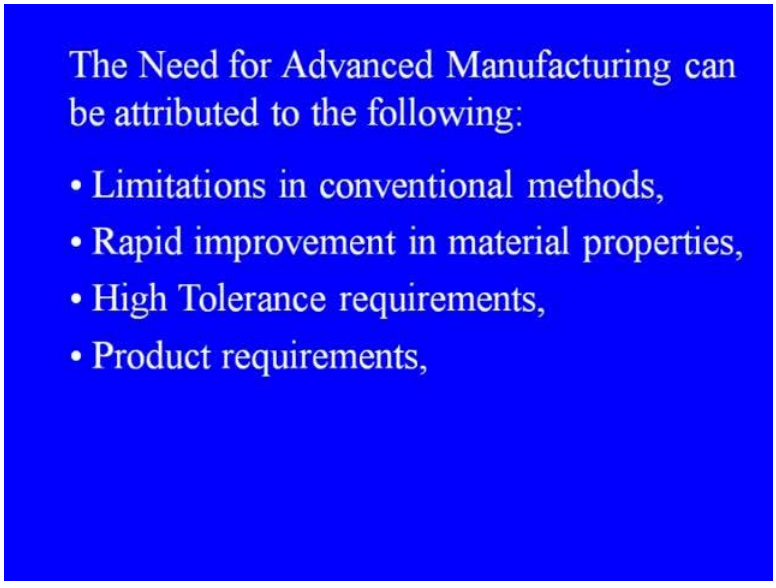

Limitations in conventional methods, rapid improvements in material properties, high tolerance requirements, product requirements.

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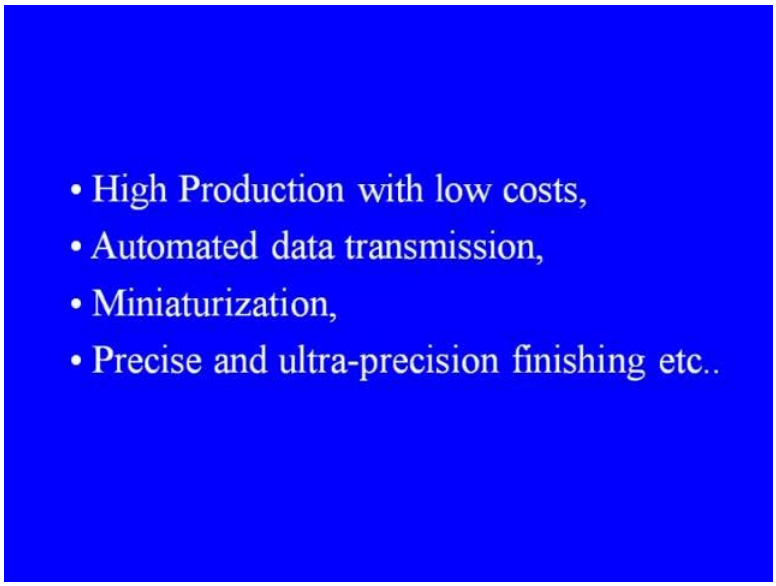

High production with low costs, automated data transmission, miniaturization, precise and ultra precession finishing etcetera.

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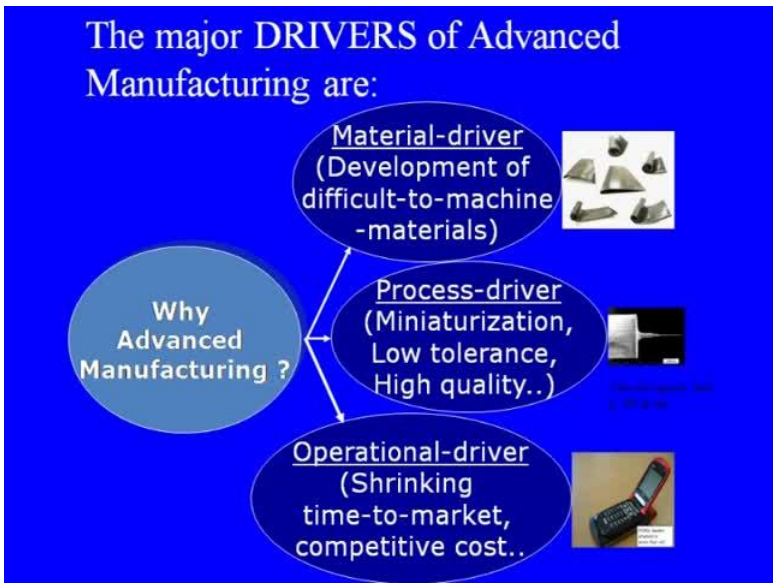

The major drivers of advanced manufacturing are material driver, process driver and operational driver, while material driver is significant due to the developments in difficult to machine materials. The process driver is basically due to the stringent product requirements like tight tolerance miniaturization high quality etcetera. On the other hand

the operational driver is attributed to the shrinking time to market requirements to offer products at competitive cost etcetera.

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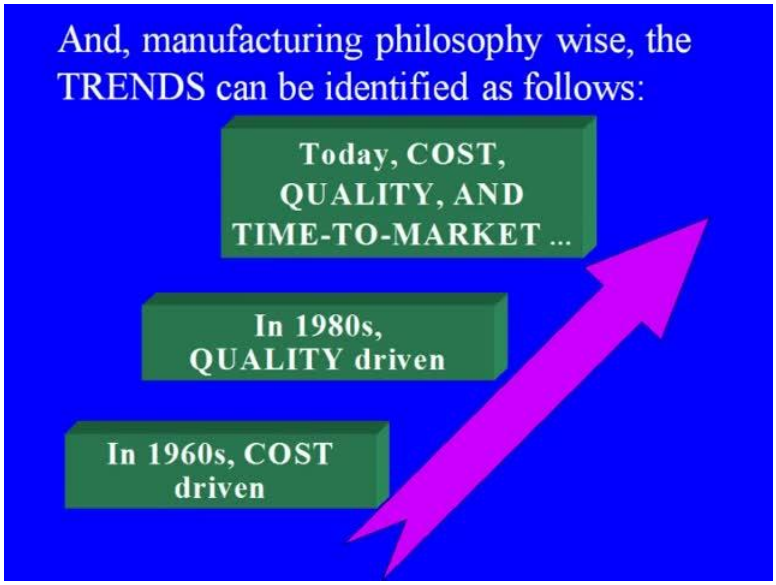

Manufacturing philosophy wise the trends can be identified as follows, in the 1960's it was basically cost driven. Then towards 1980, it became quality driven. However, if we see today, cost quality and time to market are the basic drivers in manufacturing. Let us now identify some major advantages of advanced manufacturing processes.

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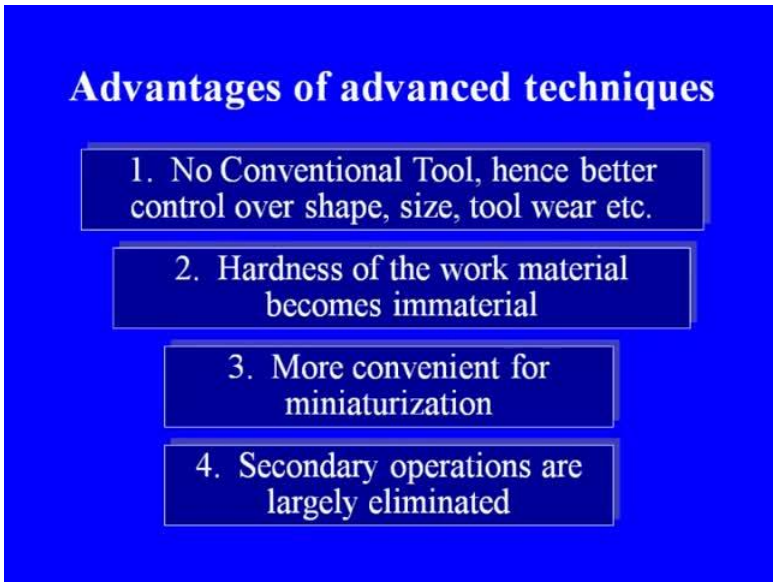

Number one, no conventional tool hence better control over shape, size, tool wear etcetera. Number two, hardness of the work material becomes immaterial. Number three, more convenient for miniaturization. Number four, secondary operations are largely eliminated. Let us see a generic classification of advanced manufacturing techniques. Advanced manufacturing techniques can be broadly classified into three categories, Mechanical, thermoelectric, electrochemical and chemical.

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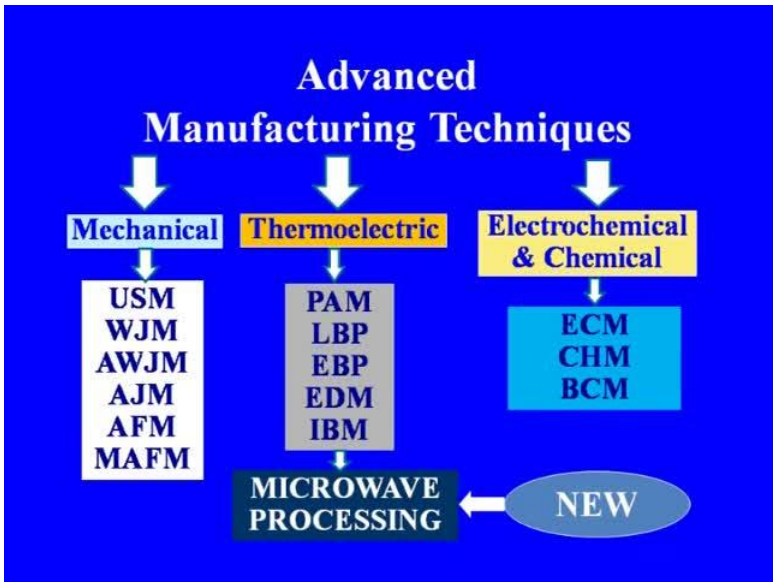

Mechanical processes include some of the techniques like ultrasonic machining, water jet machining, abrasive water jet machining, abrasive jet machining, abrasive flow machining, magnetic abrasive flow machining etcetera. On the other hand, thermo electric methods include plasma earth machining, laser beam processing, electron beam processing, electric discharge machining, ion beam machining etcetera. In this category one new processes are emerging, this is microwave processing in the recent years.

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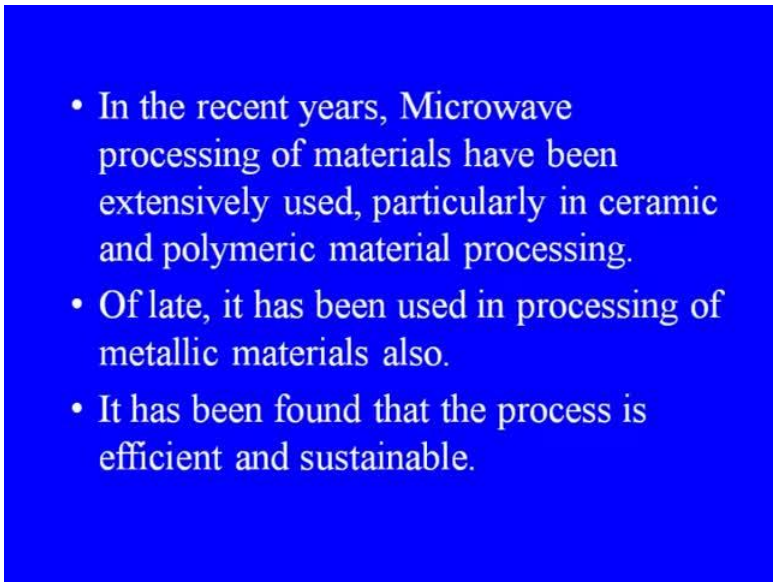

Microwave processing of materials have been extensively used particularly in ceramic and polymeric material processing. Of late, it has been used in processing of metallic materials also. It has been found that the process is efficient and sustainable. Hybridization of manufacturing processes has been the new trend in advanced manufacturing.

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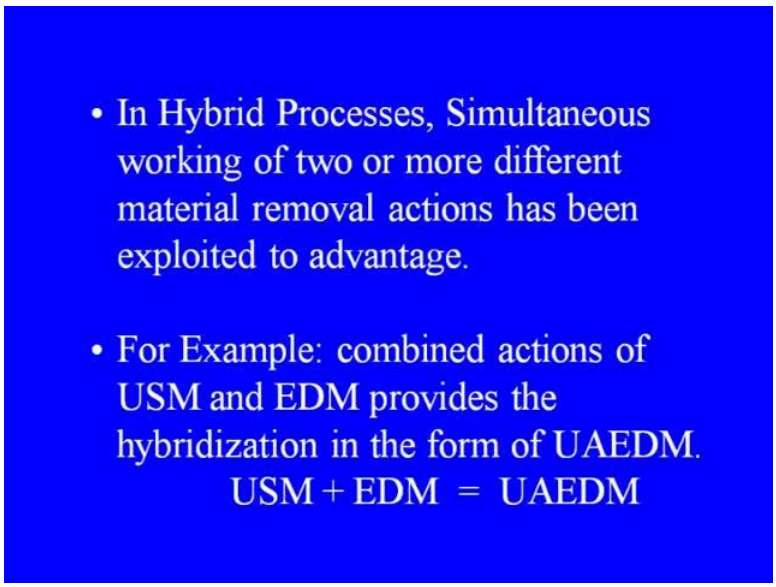

In hybrid processes simultaneous working of two or more different material removal actions have been exploited to advantage. For example, combined actions of ultrasonic

machining and electric discharge machining provides the hybridization in the form of UAEDM, that is ultrasonic assisted electric discharge machining, in which USM and ETM, both the processes will be working at a time, to keep the advantage in the form of ultrasonic assisted electric discharge machining.

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Some examples of hybridization of manufacturing processes are abrasive electrochemical grinding known as AECG, abrasive electrochemical honing known as AECH, electrochemical arc machining ECAM.

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Magnetic abrasive machining - MAF. Magnetic abrasive flow machining - MAAFM. Magneto rheological abrasive flow machining- MRAFF. Electrochemical discharge machining – ECDM. Abrasive electrical discharge grinding - AEDG.

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Centrifugal force assisted abrasive flow finishing CFAFM, spiral flow assisted abrasive flow machining SFAFM, ultrasonic assisted abrasive flow machining USAAFM, ultrasonic machining with electrochemical assistance USMEC.

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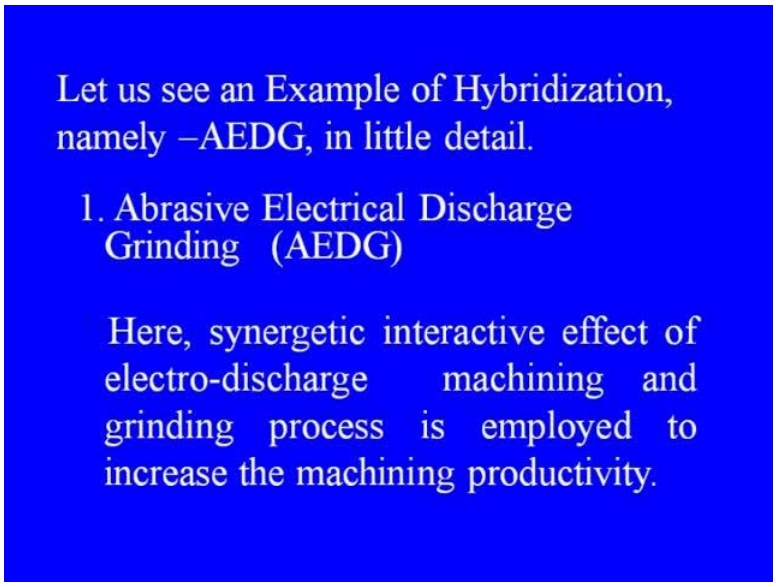

Let us see an example of hybridization namely AEDG in little detail. Here in this process, synergetic interactive effect of electro discharge machining and grinding process is employed to increase the machining productivity the schematic of the AEDG process is shown in this figure.

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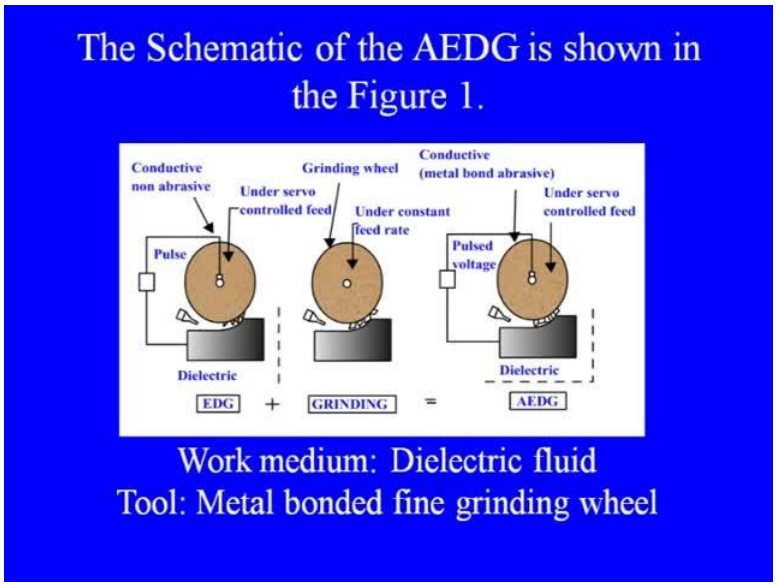

In this, this is the conventional grinding wheel with abrasives, which is will be responsible for abrasive actions and connecting this will under work base, through an electrical field, which will work as electric discharge machining. Here work medium is dielectric fluid and the tool is metal bonded fine grinding wheel. In this hybrid process, the passive and heat effected layer produced due to electric discharge action is removed simultaneously by the mechanical grinding, which is combined in the system. Thus the synergy of the both the systems could be exploited for effective machining of the material similarly.

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Hybridization in the form of electrochemical grinding ECG process can be obtained. In which conventional grinding will be combined with electrochemical machining, to obtain the electrochemical grinding process. The process is used for machining metallic components, combining these two processes improved productivity and tool life to a great extent.

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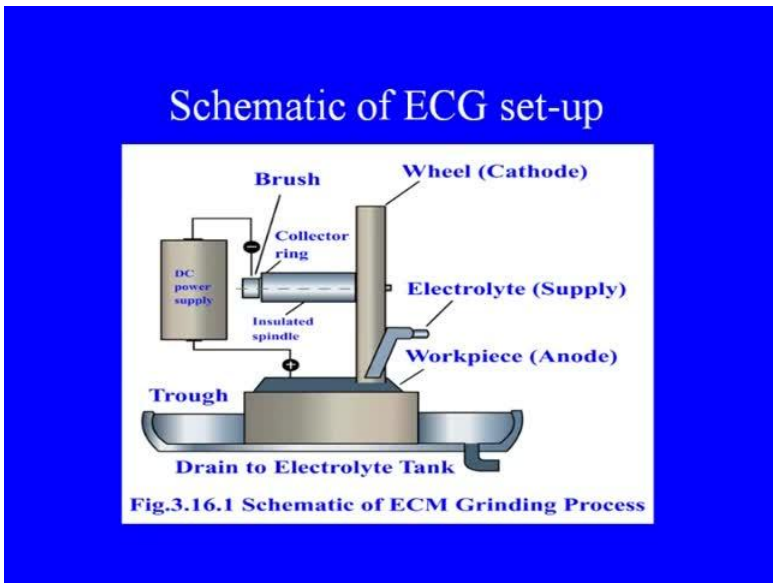

The schematic of ECG setup is shown in this figure. Let us have a quick look at the manufacturing challenges. Now, with the emerging economies and with the social and

political transitions taking place, new ways of doing business are changing the world dramatically.

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It is visualized through these trends that manufacturing environment of the future would be extremely competitive and significantly different from what it is today. Then how to become successful in order to remain successful? In such an environment the manufacturers need to be updated with latest trends and process distinct dynamic capabilities. The main challenge for future entrepreneurs is the attainment of such capabilities some of which are as discussed below. (Refer Slide Time: 20:28)

For this one needs to build the following capabilities. Ability to innovate ideas and develop a creative environment for such innovations. Developing effective and efficient training or education programs for the workforce as more skilled workforce is required. Use and implementation of information technology in various areas of manufacturing industries, and their sub functions.

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Sustainability of small and medium scale enterprises to provide support to large manufacturing units. Focusing on clean and green manufacturing technologies for fulfilling the environmental and societal concerns. Responsibility for production process that is, goes hand in hand with responsibility for the final disposal of products, that is recycling aligned with environmental policies. In this process advanced manufacturing can contribute significantly.

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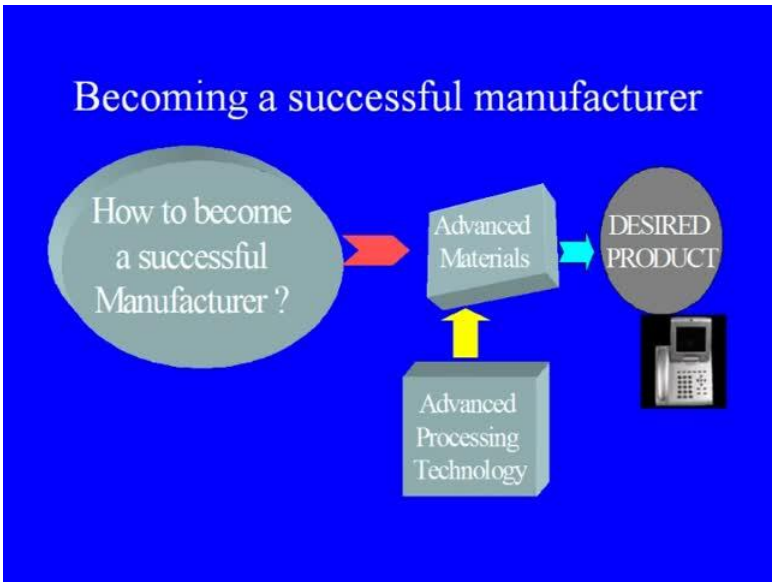

To become a successful manufacturer, what next? Then with the development of newer materials, newer processes and improvised technology special skills are required. For handling them, the customer requirements have increased in manifolds and the demand is for customization along with the basic.

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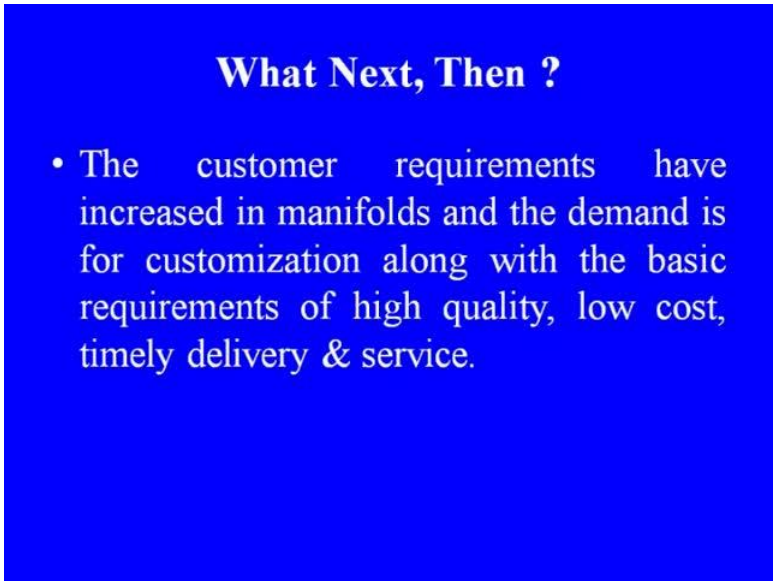

Requirements of high quality, low cost timely delivery and service and there are many scopes for further improvements. There is a vital necessity and tremendous scope for improvement in terms of development of a sustainable research base.

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Concurrent flow of technology and manufacturing for fulfilling new demands, up gradation of existing technology, and managing the change. How to fill up the gap then? Advanced manufacturing technology is one area, which promises to fulfill the gap between present and the future requirements development of new and hybrid processes, cleaner and competitive processes can help develop the economy of the country.

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As we have already indicated due to the enormous population growth, there is an increasing necessity of providing and developing or processing the resources. As in

earlier manufacturing caters to almost every segment in day to day life activities, and applications.

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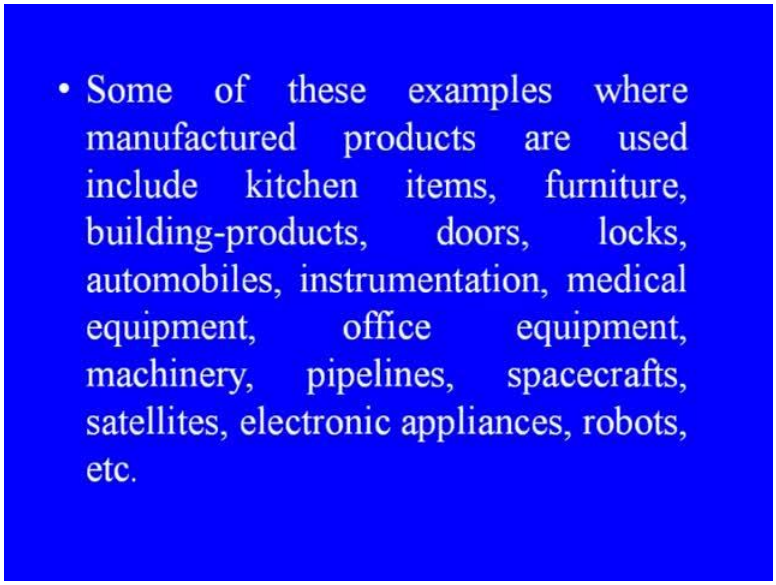

Some of these examples where manufactured products are used include kitchen items, furnitures, building products, doors, locks, automobiles, instrumentation, medical equipment, office equipment, machineries, pipelines, spacecraft, satellites, electronic appliances, robots and so on.

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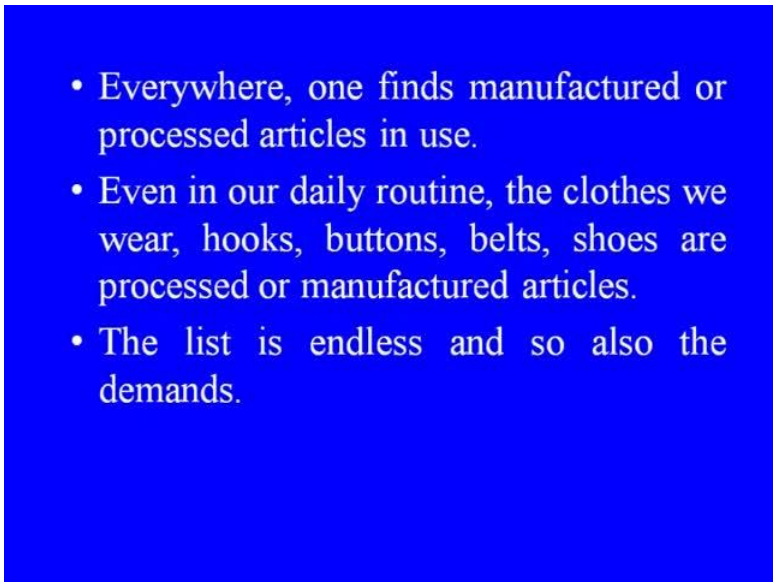

Everywhere one finds manufactured or processed articles in use. Even in our daily routine the clothes we wear, the hooks, buttons, belts, shoes are processed or manufactured articles.

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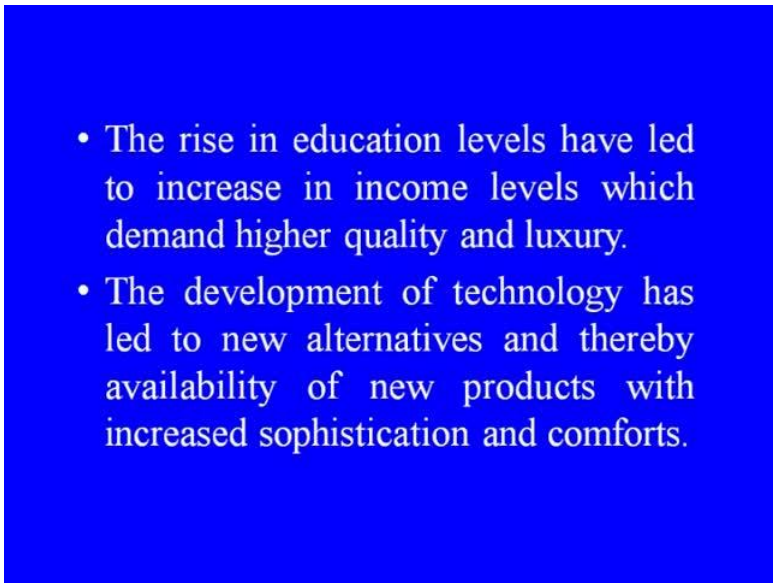

The rise in education levels have led to increase in income levels, which demand higher quality and luxury the development of technology has led to new alternatives and thereby availability of new products with increased sophistication and comforts.

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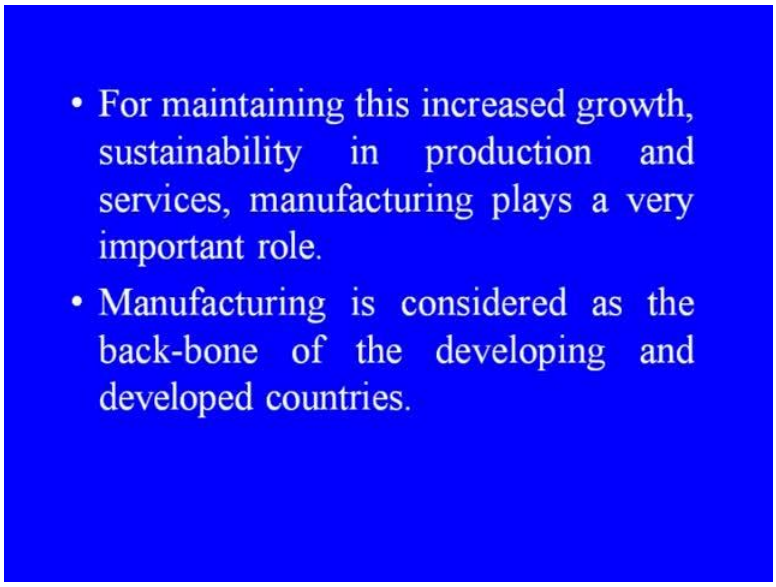

For maintaining this increased growth sustainability in production and services manufacturing plays a very important role. Manufacturing is considered as the back bone of the developing and developed countries. As we have already indicated manufacturing activities indicate a countries wealth at many times.

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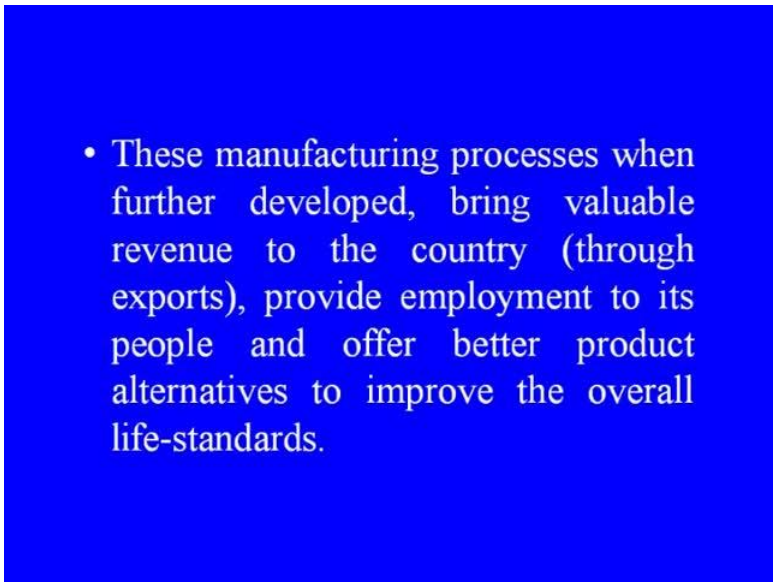

These manufacturing processes when further developed bring valuable revenue to the country, may be through exports. Then provide employment to its people and offer better product alternatives to improve the overall life standards.

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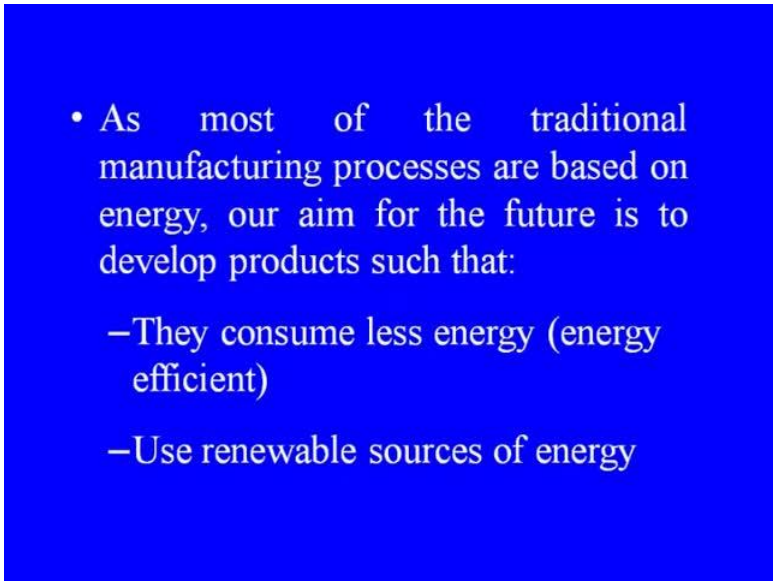

As most of the traditional manufacturing processes are based on energy our aim for the future is to develop products such that, they consume less energy, that means their energy efficient. They use renewable sources of energy, then the time for processing is minimum. That is one way we can say that is again energy efficient. Time for processing is minimum means, we are spending less energy in producing in some way. Also time is a very, very valuable resource. Therefore, less use of time means, we are using less resources and therefore, it is cheaper.

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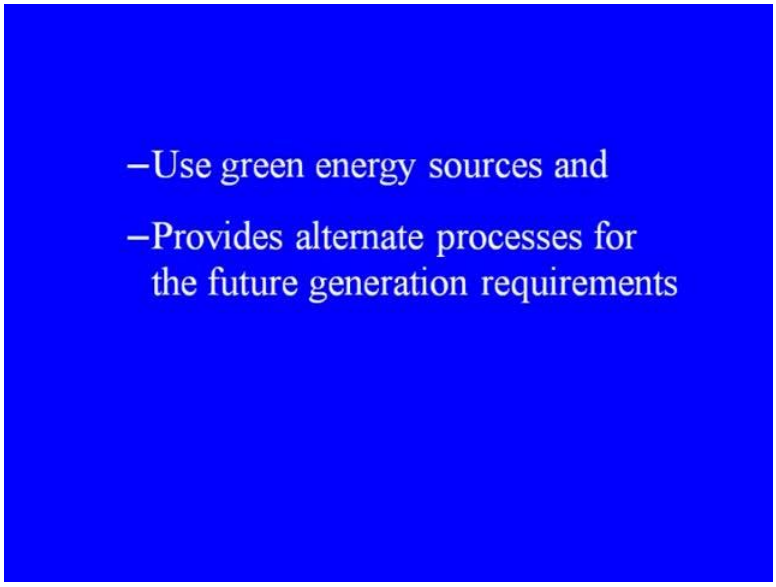

Then use of green energy sources, then provides alternate processes for the future generation requirements. So, these are some of the primary considerations for better manufacturing in future. In most of the cases the conventional manufacturing, produces lot of green house gases or some detrimental products to the environment, which is not a good sign for the future of the mankind. Therefore, the emphasis or the trust is on to have manufacturing processes; that is green in nature that is one step towards sustainability.

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Then another important aspect, which is becoming very, very important and worldwide the researchers are giving emphasis is hybrid manufacturing. Hybrid manufacturing processes promise, most of these things that whatever we have spoken about. Researches are in-progress to make them more suitable at the production stage. Most of these processes are in research stage itself and they need to be fine tuned to make them better or more suitable to bring it to the actual production stage. Once developed they will help in giving valuable substitutes for the future. Then let me slightly discuss about, what this hybrid manufacturing is or hybrid processes are?

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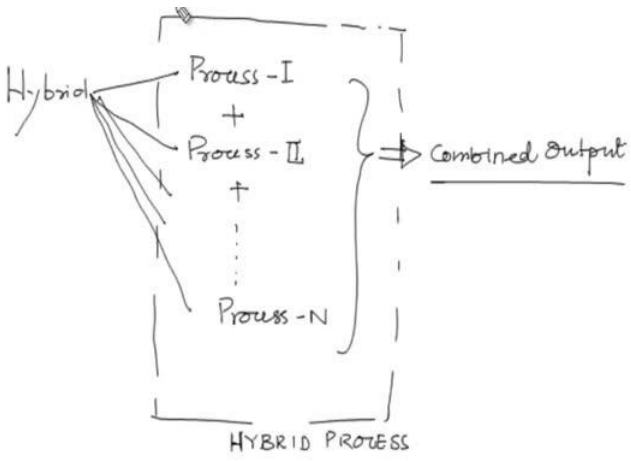

Material Removal Rate (MRR).

Hybrid is basically, we consider that it is say for example, say process one. Then plus process two or plus so there may be number of processes in between. So, process say n, so combined output of these processes that means say combined output we can say, we can say it is the hybrid manufacturing or a hybrid process. So, this put together, if this gives all these processes put together, gives us the combine output that I, then I can say this is a hybrid process. However, so here some aspects are to be taken care of say for example, let us let us consider material removal rate. Material removal rate, this we consider in short, we write as MRR in production technology or manufacturing terminology.

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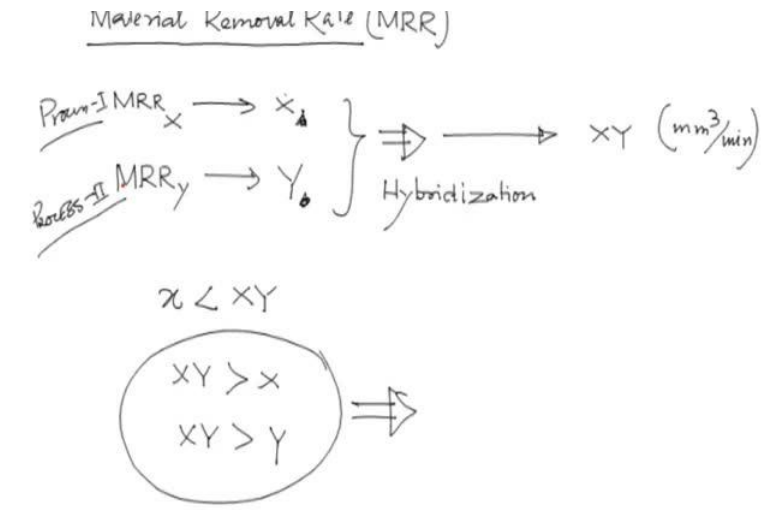

Now, in many processes particularly non conventional processes or advanced manufacturing processes like USM EDM ECM etcetera, this material removal rate is generally very low. Say for example, material removal rate or MRR MRR for process X is given by X A then MRR MRR of process Y is given by Y, say Y. Now, the their combined effect say as part of or, as as an effect of hybridization, after hybridization if we combine these two processes to give a single output, then their combined say MRR is say X Y. This can be in-conventional whatever mm cubed per minute or whatever conventional units.

Now, ideally by definition, this should be mathematically expressed like this. X should be less than X Y or otherwise in other words we can say, X Y should be greater than X,

X Y should be greater than Y, that means what we are gaining with this? The combined effect of hybridization gives us higher material removal rate than that could be obtainable from the individual processes. Say this is from the process one, process one and this is from the process process two. Now, we can see the effect or the positive outcome of hybridization.

As a result of combining these two processes in this simple case, we are considering that two processes are being combined to give the hybridization. Therefore, we are getting a higher MRR than it could have been individually obtained. That is how in effect we are getting time compression; that means same amount of material we are removing. Now, at lesser time and thereby the productivity of that process is increasing more number of units have to be will will be produced, now which is economically backer.

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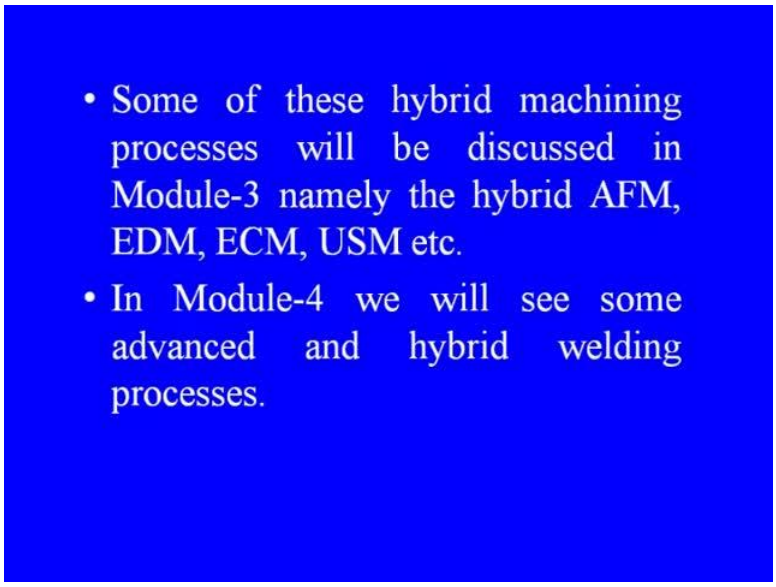

Some of these hybrid machining processes will be discussed in module 3, namely the hybrid AFM process, abrasive flow machining process. Then hybrid EDM process electric discharge machining process, then electrochemical machining process and ultrasonic machining process USM. Some hybridization, that means addition of some other processes include these basic processes, one of these basic processes have been developed. People are working in these areas and they have given much better result than their individual counterparts.

Not in all cases, only the material removal rate matters, but in some other cases, as the case may be. May be surface is more important for certain components or the products, then we will be aiming for getting better surface finish. Say for example, in case of ECM. Generally we get very good surface finish through ECM, but very poor surface finish with EDM. Therefore, can we combine these two EDM and ECM to have better surface finish as well as improved material removal as well.

So, that means it need not be only restricted to material removal or not restricted to improvement in surface finish, but it could be a combined effect as well or can be either or it can be in some other aspects as well. Like for example, in ECM sometimes we feel because of the enhanced gas bubbles, the pessivation thus takes place. Those rate of material removal comes down. There in such cases, if by some mechanical action we can remove or scratch away, the bubbles, gas bubbles formed due to this process, then the electrochemical reactions will continue in the same rate and the material removal will not come down as it would have happened had it been only ECM.

That is how it led to ECGM, that means electrochemical grinding machining. In which electrochemical process is also there, then grinding, mechanical grinding process is also there, both combined together it is giving raise to the hybrid process that is ECGM. So, it is the case with ECDM. We have basic EDM process, we have basic electrochemical effect and both combined together giving the hybridized process, that is called ECDM. In a module 4 we will some more advanced and hybrid welding processes as well. as we know there are a number of basic welding processes are available. However, if we use like in case of machining, some hybridization combination of different processes, probably you can get better result that we will see in the module 4.

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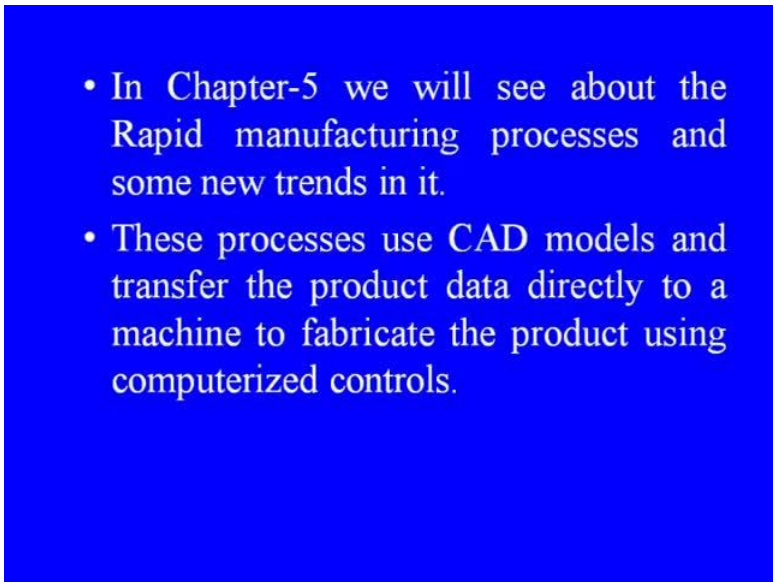

Similarly, in this module 5, we will see few rapid manufacturing processes, which represent a class of modern manufacturing techniques. So, that helps us to produce a product right from the CAD terminal itself, so that we will discuss in details. These processes use CAD models and transfer the product data directly to a machine, to fabricate the product using computerized control. Some of the important and widely used processes under this category that we will discuss in details.

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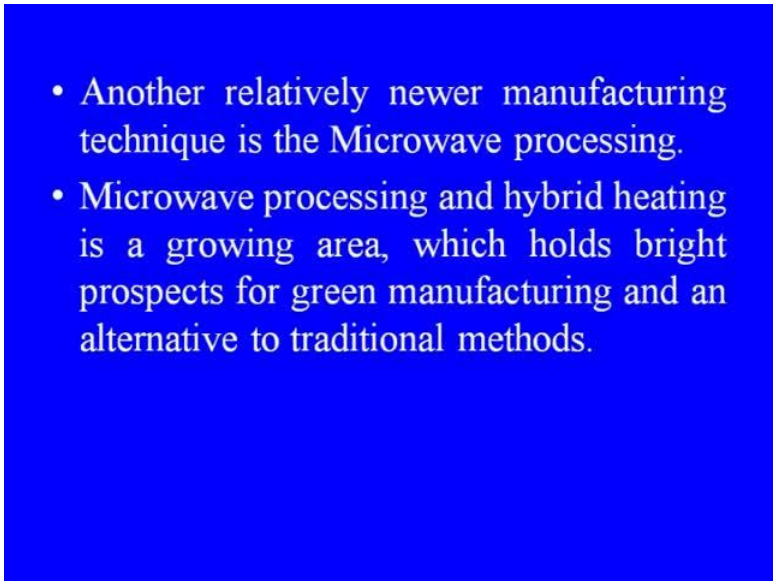

Then another relatively newer manufacturing technique is microwave processing. Microwave processing and hybrid hitting is a growing area, which holds bright prospects for green manufacturing and it could pose as a, as an alternative to the traditional methods in near future. The advantage with microwave processing is, we can selectively process a material among a number obtained. That means microwaves do not affect all the materials in the similar fashion, once they are exposed to microwaves.

They they get effected by microwaves or we can process only those products or the objects materials which, absorb microwaves in that particular condition. By condition what I mean is the temperature, prevailing temperature it can be room temperature, it can be below room temperature or it can be elevated temperature. Say for example, 500 degree celsius or 1000 degree celsius. A single material will behave in a different fashion at a room temperature at 500 degree celsius or at may be 1000 degree celsius, with respect to microwaves or when exposed to microwaves.

Similarly, if the material contains moisture, then it is process ability will be again different. So, this is another condition and so on and another important or significant aspect of microwave processing is it can be called as a green process. It does not create any unnecessary or unfriendly gases toxicity in the environment and so on. It is generally safe easy to operate and therefore, it can be a very useful technique another advantage having.

Using microwave is, it causes very rapid hitting inside a material. If the material is microwave absorbing thereby it can save huge amount of time for processing a material. Therefore, this kind of techniques for material processing may be welcome within few years in a manufacturing sector.

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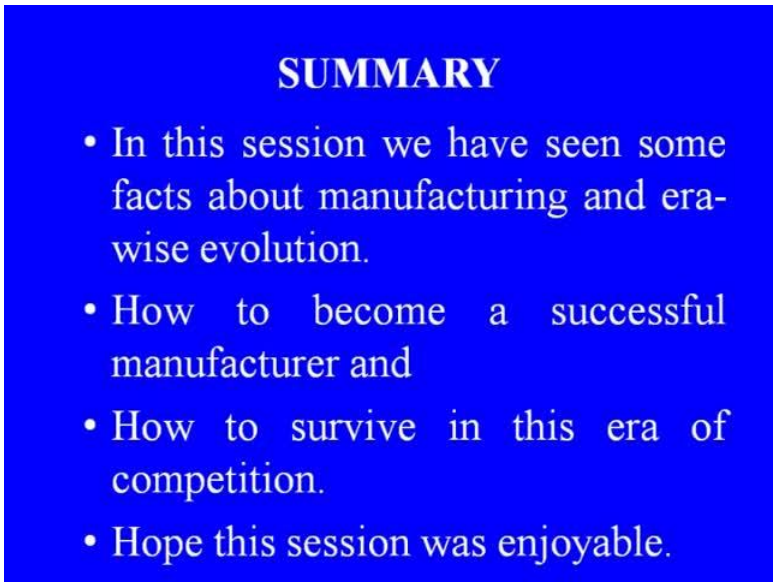

Now, let us summarize what we have studied in this particular session. In this session we have seen some facts about manufacturing and era wise evolution of manufacturing. Then we have seen, how to become a successful manufacturer, what are the conditions required, then how to survive in this era of competition. These things we have seen and also we have seen the new trends towards sustainability or green manufacturing and hybrid manufacturing. What are the next steps to be taken or are coming up in near future. Hope this session was enjoyable and informative.

Thank you.