**Manufacturing Systems Management**
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**Lecture - 02**
**Different types of Manufacturing Systems**

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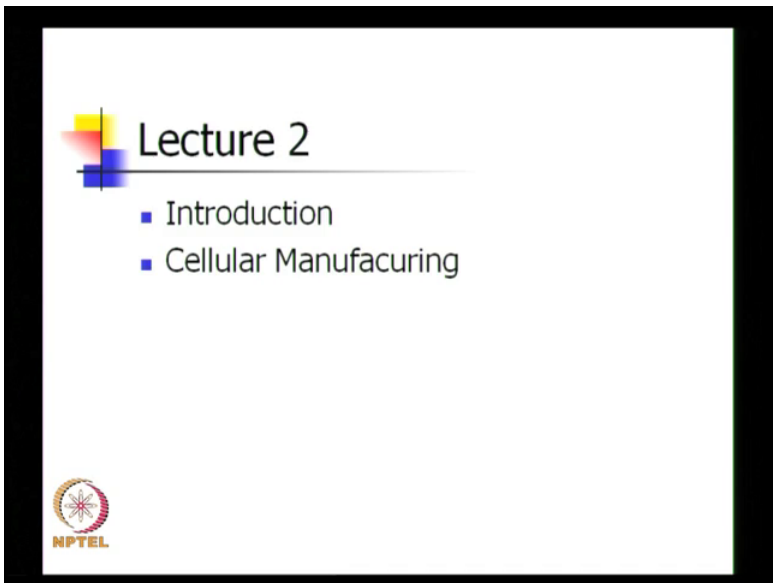


In today's lecture, we continue the introduction to the basic ideas in manufacturing systems management. And we also try and introduce the basic ideas behind cellular manufacturing.

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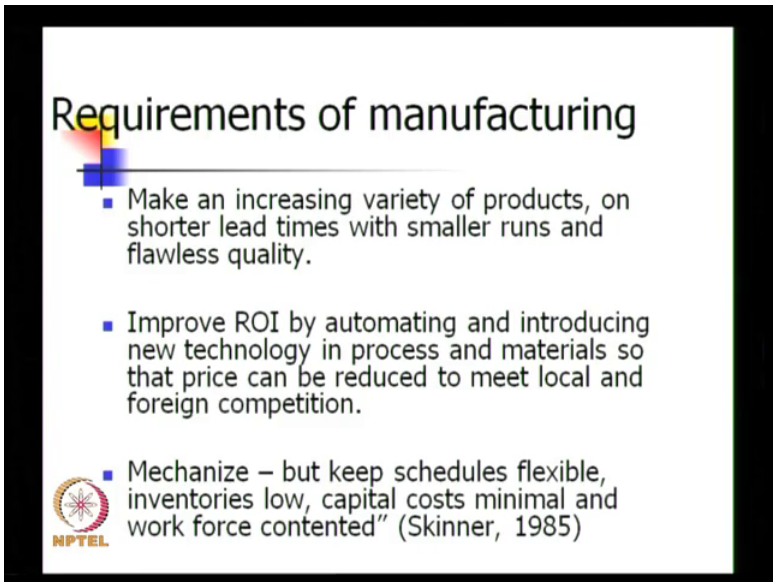


In the previous lecture, we saw what the requirements of manufacturing are, and we also saw the need for manufacturing systems to orient themselves to meet these requirements. So, we start with a very quick recap of the requirements of manufacturing. So, make an increasing variety of products, on shorter lead times with small runs and flawless quality improve return on investment by automating and introducing new technology in processes and materials. So, that price can be reduced to meet local and foreign competition. Mechanize keep schedules flexible keep inventories low keep capital cast minimum and keep the work force contented.

So, this is the definition of the requirements on manufacturing given by skinner about 26 years ago. Now we also looked at these requirements in the context of the background with which we started this course meeting customer expectations. So, to make an increase in variety because the customer wants variety shorter lead times so that newer products can be introduced and more variety can be introduce, shorter lead times would implies smaller runs and flawless quality implies that all customer expectations are met. We also defined quality as the ability to meet the stated an implied needs of customer, many times in the context of manufacturing the needs are stated and in the contest of service some are the needs are implied.

So, a very general definition is to meet the stated and the implied needs of the customer. But in the context of this course we would say at to meet the stated requirements of the

customer in a in a flawless manner, which means no defects and to be able to delight the customer with the quality. Now use automation so that the speed of manufacture can be increased, use automation so that the variation can come down. Introduce new technology in process and materials primarily with the objective of reducing the price. So, customer wants the `product to be price less. So, reduce price and see; what are all the ways by which the price can be reduced. If it requires that new technologies have to be introduced in materials do that so that the price can be reduced.

Manufacturing should also gear up to meet local and foreign competition, something that we saw in the earlier lecture. Mechanize keep schedules flexible, schedules have to be flexible to meet the uncertainty in demand, to meet the variation in demand, to meet fluctuations in demand, to take care of other form unforeseen circumstances which could be material not available machine not available and so on.

So, schedules have to be flexible. Inventories have to be low most manufacturing companies today talk of 0 inventories, or having vary minimal inventories. Keep capital clause minimum and keep the workforce continue. Now manufacturing systems have to try and meet these requirements, and before we get into have they have try to do that let us try and look at.

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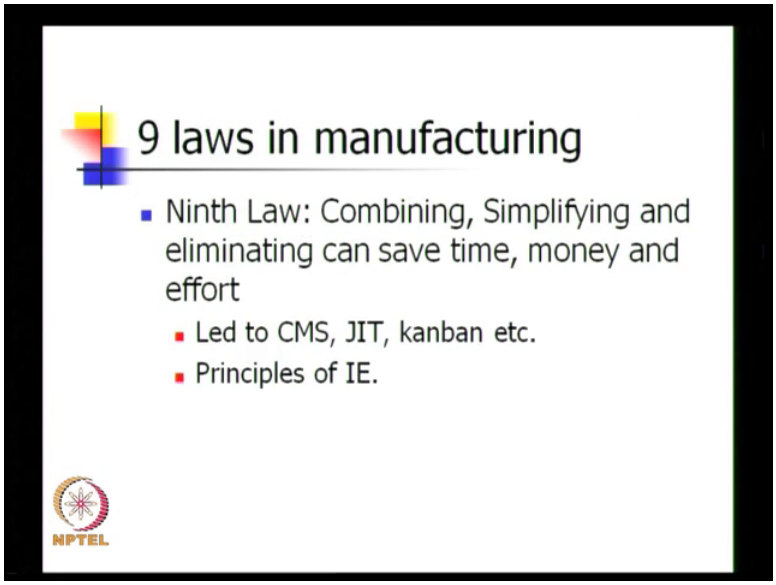

One aspect which is the ninth law which we described where combining simplifying and eliminating can save time money and effort, which means the basic idea of this law is to keep it simple and do not complicated.

So, manufacturing systems have tried very simple approaches, but very effective approaches, sequentially and systematically one over the other so that these requirements can be met.

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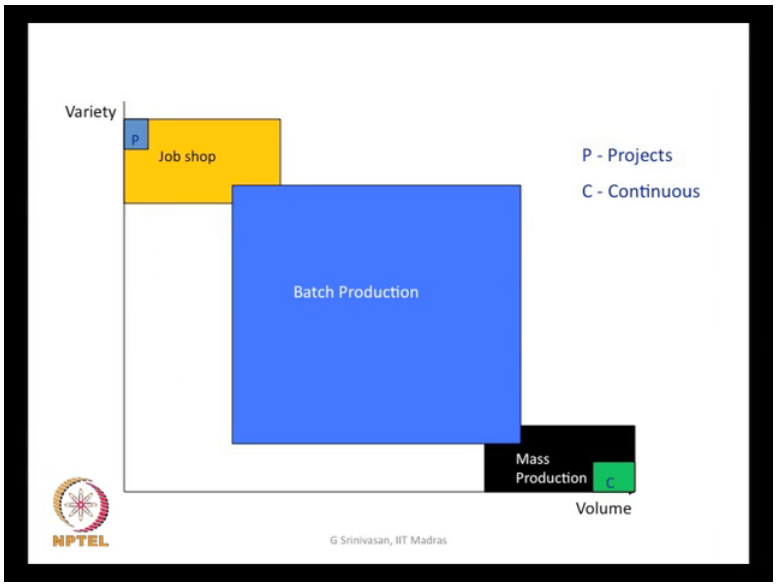


So, we look at another graph or a slide here which talks about the various types of production systems or manufacturing systems and how they are classified. If you see this the x axis is volume, and y axis is variety. So, the x axis represent the volume of the production, y axis represent variety of production this is also called the volume variety graph.

And see carefully there are 3 big area in this graph and still the one in the middle is called batch production, the one to which it is left which is called job shop, and one to it is right and below which is called mass production. You also have 2 other classification which are little small you can see a P here which stands for projects, and also you can see a C here at the end which stands for continuous productions. The batch production system represent the middle volume, the middle variety manufacturing, and as the volume increases the variety comes down, we have high volume low variety systems which are called mass production system, and the volume increases further we have what

are called continuous production system. As the volume comes down the variety increases so low volume high variety manufacturing is called job shop, and still lower volume and very high variety are called projects. In addition the layout is also depends on the type of manufacturing system. Now for the continuous and mass production systems we have the product layout where the machines are arranged according to the requirements of the product. For batch manufacturing systems, we have the process layout where there is functional specialization, or process specialization where machines are arranged depending on the processes that they perform.

Some of the job shops also have a processes centric specialization, now in the area marked P there we look at projects there we also have something called a fixed position layout, particularly in situations where we manufacture very large bulky products or sometimes, we manufacture very fragile products we used the fixed position layout where the people and the equipment are brought to the place or the site where the product is made. The example is ship building where all the material people and machines are brought to the place where the product is made or assembled.

Now, several example can be given for each one of them, the projects type manufacturing would be making for example, in the areas of ship building airplanes and so on. Where we have a lot of variety coming in and every time a new batch is made or a new set of products are made the product specification change and the variety increase. Now the job shop is essentially a small shop which can handle job orders as they come. So, there you can expect the volume to be smaller and the variety to be larger. Batch production systems are essentially where we have a lot of assemblies, so we have a middle volume, middle variety manufacturing which you could see in automobile industry in machinery manufacturing and certain other areas.

So, if you move towards mass production then you could have products which involve less of an assembly or could involve smaller components coming into the assembly. So, the volume can go up and the variety will come down to resultant mass production, continuous production could mean very high volume, for example you can make a single chemical and so on. We also observe that from this graph as well as from data that a very large proportion of manufacturing happens in the batch manufacturing context, where we do middle volume, middle variety manufacturing many times the product is assembled out of lot of components the majority of these components are brought out and the small

number of these components are manufactured, but still the number of components and parts that are manufactured is large enough to separate to have separate lines for each.

Therefore batch production systems are use what is called as a process layout or a functional layout. Incidentally the type of layout also changes with the type of the manufacturing. So, very large the 3 broad classifications of layout are called process layout, product layout and we also have the layout where the product is static and processes are brought inside towards the product fixed position layout as they are called, but we concentrate on 2 important types of layouts, which is called the process or functional layout for batch manufacturing and product or line layout for mass and continuous type of manufacturing.

So, each of these production systems have an associated kind of a layout which have been used traditionally. Now in this layout which is called a line layout we have a production line for each of the products that are being made. So, this layout is called product layout or line layout, where there is a line for each product that is made which means each lines will have machines in the order in which the product visits the machines. So, since the volume is the variety is very small which means very few numbers of products are being made with very large volume it is possible to have a separate line for the each of the product.

So, these line layout is a very efficient way of carrying out mass production where we have dedicated machines in each line and each line handles one or sometimes more than one product, but the variety is small and the volume is large and now when we have these batch manufacturing systems they use what is called a process layout or a functional layout which concentrates on what is called functional specialization or departmental specialization. So, the manufacturing system or the layout is divided into several areas where each area is specialized in a certain function, where certain types of machine similar machines similar in terms of functions are kept.

For example one could think in terms of a lathe shop where there lots of lathes are kept here one could in terms of a drilling area where a set of drilling machines are kept here. So, that is called functional specialization or departmental specialization. So, in the batch manufacturing system the products depending on the root will move from one of these functional areas to another and all the manufacturing is carried out and the final product

comes out. Little later we will show a schematic diagram has to how a functional layout works. Now this diagram helps us in classifying a manufacturing systems primarily into batch mass and job and in this course we most of the times we will be looking at the batch production systems and how to make them more efficient. And we also understand that the batch production system have what is called process layout or functional layout, right.

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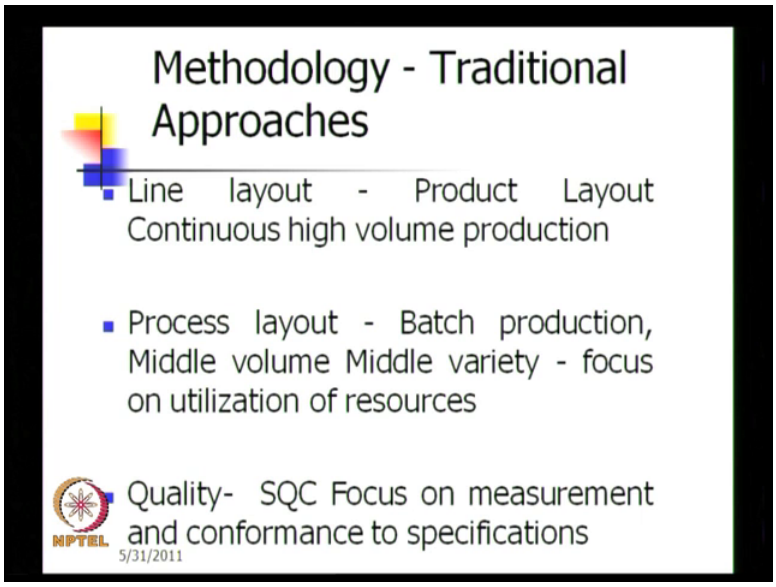


Now, from coming back from requirements of manufacturing to the various methodologies and approaches that manufacturing systems have used over period of time. So, the next few slides I am going to classify the methodologies into many the first thing will be called methodologies based on traditional approaches then comes the changes.

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So, you would find methodologies based on process improvement you would find methodologies based on human resources and processes, you would find methodologies based on information systems and decisions.

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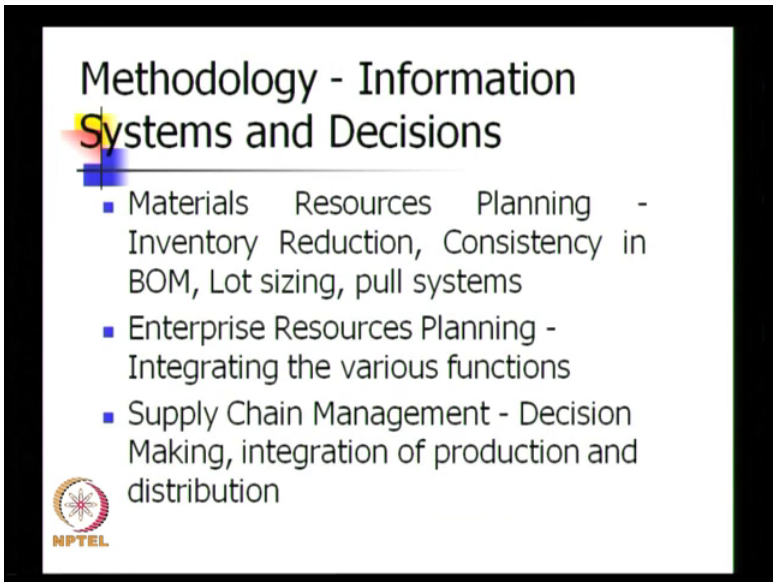


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And you would find methodologies which talk about an overall business perspective. So, we will talk about each of these methodologies in some detail before we introduce cellular manufacturing, which is one of the main areas that we are going to look at in the course. So, what I had explained to you in the last few minutes is what I highlighted in this slide now the this slide talks about line layout or product layout as well as the process layout for example, I just mentioned that line layout or product layout is used in this area that is for high volume low variety manufacturing, while the process layout is used in this area which is middle volume middle variety manufacturing. Nearly 70 to 80

percent of manufacturing happens in this area that is one of the reason why this area is shown bigger than the other areas in this figure.

So, traditionally manufacturing system operated using the line layout, or product layout for continuous or high volume production systems and I had mentioned each product would have a separate line depending on the volume 2 or 3 products would have the same line some of the products would skip some of the machines, but we would have unidirectional flow and the machines are laid out in a manner that the product can enter continue processing in same direction and the finished product comes out.

We also have process layout which was there for batch production for middle volume middle variety and the focus was more on utilizations of the resources in the process type layout, quality was largely based on conformance to specifications, quality was the focus was more on measurements and tools of statistical quality control. So, percentage rejects etcetera where measured and there was constant monitoring to see whether the quality of the product conformed to specifications in the traditional approaches there was not. So, much emphasis on quality with respect to the customer rather than with respect to measurement and conformance to the specifications laid down by the customer. So, the quality aspects where largely confined to methods of statistical quality control process control measurement and so on.

Now, we move to 3 important aspects of process improvement as I have listed here and these classifications I have made based on my own observation and based on way I have understood how improvements have happened in manufacturing systems. So, there could be many more areas in the process improvement, but we restrict ourselves to these 3 under this heading. Now these 3 are group technology or cellular manufacturing just in time manufacturing which can also be called as Japanese management systems, because they originated from Japan and flexible manufacturing. Now, in a sense this slide captures nearly 70 percent of this course on whatever is shown in this slide will be expanded to about 70 percent of this course. So, as manufacturing systems started understanding the requirements they also started looking at what are the pit fall or limitations of the batch manufacturing.

Traditionally batch manufacturing had the process layout. So, they were trying to understand what are the limitations or difficulties of the process layout. So, the process

layout had some advantages and also had some disadvantages. The main advantage of the process layout or the functional layout is the focus on utilizations of resources, similar resources were pooled into single area I had mentioned for example, there could be an area that comprises of all lathes all drilling machines. So, similar resources were pooled into an area and products parts and components requiring these machines came and visited these areas. So, the main advantage was that of pooling synergy in the sense that when there is a requirement for these machines the products came to that area and any one of them in principle could meet the requirements. So, the focus was largely on optimally utilizing the resources.

The disadvantages perhaps were that the focus was more on a particular process that is happening in that area rather than on the overall product. So, if a particular product or component visited a department for a particular requirement the ownership and responsibility of that department was only towards that particular process which is a part of the overall product and there was not much of product ownership.

Now in addition the products has organizations expanded has volumes also increased, machines were added and the it was quickly understood that the products move very large distances and that had to be reduced, because as products moved large distances the inventories were also on the increase. Quality suffered because the ownership was more on the process then on the product setup times and change over times on the machines were more largely, because of the functional specialization and if you take a particular function or a area 2 or 3 products that are going to be machined on a particular machine one after another were not similar and required a lot of change over time.

So, in terms of simple measurements such as setup times, quality, inventory and material movement it was observed that the functional layout for batch manufacturing had a lot of difficulties and limitations, now because of all these the cost of manufacturing was going up and time to manufacture was also increased. So, keeping that in mind people started looking at now if we have these 2 systems. Now if we advantage of this system is in control because we said that there would be a line for a single product or more than one product depending on the requirement there is unidirectional flow and each line is associated with a product or a set of products where there is ownership set up times are less and so on. So, whatever are the disadvantages that people saw in process layout were actually advantages of line layout or product layout and whatever is the advantage of the

line layout was a disadvantage in the process layout and what was the advantages of process layout was a disadvantages in a line layout, process layout could show higher utilizations of machines, whereas line layout were unable to show higher utilizations of machines.

So, this issue came up can I get the best out of these line layout for this into the process layout and create a different kind of a layout from which I create a different kind of manufacturing methodologies which can get the best of both, now that thinking let to what is called group technology or cellular manufacturing. Now we will see about the group technology and cellular manufacturing in much more detail as we move along. So, I would simply introduce 2 or 3 ideas at the movement and expand these ideas as we move along in this course.

So, group technology and cellular manufacturing the 2 terms are used interchangeably though there are times people associates a few things with group technology and associates few things with cellular manufacturing, but why an large these 2 terms are used interchangeably and mean the same thing. So, the fundamental idea is to reorganize the machines or group the machines and group the parts in a such manner that we have a group of machines we have a group of parts. Now we assign one group of parts to one group of machines or very rarely multiple groups of parts to one group of machines such that all the requirements of the small subset of parts are met by this group of machines which is a subset of the exiting set of machines.

So, the basic idea is for example, if I have some 50 machines and I making some 200 and 300 parts now can I divide this 50 machines into 6 groups or 7 groups each having about 8 machines and. So, and can I divide these 300 parts into 6 groups same number of groups each having roughly about 50 to 60 parts, or 40 to 60 parts such that I can make all these 40 to 60 parts using these 8 machines, I can make another set of 40 to 60 parts using another 8 machines and so on.

Rather than saying I am going make all the 300 parts using 50 machines. So, when you have a system were all 300 parts were made using 50 machines it is large and complex, where as I can divide this into smaller groups and make them independent it becomes simple and you could have more control. Now that fits with in the ninth law that we saw here it is says combing simplifying and eliminating can save time money and effort. So,

which is a very big game that is a reason I have also writ10 led to principles like cellular manufacturing systems JIT etc.

So, we focuses on reorganizing the machines grouping of parts and once groups of parts are assigned to groups of machines automatically ownership and responsibility for the product will increase, because product or part or component am using these terms interchangeably in this context. Now the entire ownership of doing this rests with the machine groups. So, the ownership and responsibility shifts from that of process to that of product. So, automatically quality increases inventories come down set up times come down. So, group technology cellular manufacturing will seen as a very logical way or trying to get the best out of these 2 and apply it in the context of middle volume middle variety manufacturing. So, this is a first thing that happened and if you go back to history the very first idea started the concepts started somewhere in the 1920, but well after 1960 people have been using this expensively and after 50 years today we find several companies using this even today and benefiting through the use of group technology and cellular manufacturing.

Now, around the same time the Toyota production systems are just in time manufacturing systems came. Now the one could say that some of the ideas are similar and some of the ideas are different the first basic idea in these Japanese management systems is produce what the customer wants. So, manufacturing systems moved from what were traditionally called pushed systems to what are called pull systems, in a push systems it was centered around a lot of forecasting production planning scheduling and the products were made and once the products were made the products were sold, in a pull system the products are made based on demand where as in push system the products were made based on the forecast of the demand.

So, more and more production happened in pull systems based on the demand which ties in with idea that produce what the customer wants and what the customer is willing to buy. And once we start producing what the customer wants and customer wants to buy one has to keep down or bring down the time to produce and that was possible by reducing the set up times and change over times if multiples products have to be made because of which the production quantity is came down and because of which the inventories came down.

So, the basic idea was to produce in time to produce in small quantities and to bring down the inventory. So, in addition to bringing down the inventory they defined waste we are going to see later in these course very formal definitions of wastes, but waste is defined as anything other than the minimum amount of effort required to carry out an action. So, once we start looking at all the things that happen in a manufacturing system and wherever we found that there is a waste, which means more effort is made to execute something the emphasis shifted to reducing the waste. So, the primary idea of just in time manufacturing system is what is called waste reduction and waste elimination. Now the Japanese management systems are Toyota production systems are just in time manufacturing systems came in 1962 it also place where about 50 years and has been used extensible by several companies in Japan as well as all over the world.

Much later around this since both these group technology as well as just in time systems came about the same time people quickly understood that the combination of cellular manufacturing or group technology with just in time would help get better results and manufacturing companies started doing that a combination of cellular manufacturing and some ideas from kanban controlled manufacturing systems which we will see a little later to reduce the inventory, both of them essentially talk about the inventory reduction also. So, it was possible to seamlessly merge and integrate both them to get benefits the automobile sector in particular has been immensely benefited by combining these 2 together is successes in other types of manufacturing discrete manufacturing or batch manufacturing is also seen when these 2 are combined.

Then came an era of what is called flexible manufacturing systems flexible manufacturing systems came around the same time or slightly later in the 70 were the emphasis lot more on automation. So, high capacity and high capability machines were brought up and because of a lot of automations it was possible to make a large variety of products at the same time high aggregate volume, example you normally do not get to see automobile manufacturing happening with FMS completely or entirely where as if you see products which are smaller which have far more variety electronics goods in particular example of cell phones, televisions and products which have lot of electronics in it we would find that they are closer towards a flexible manufacturing idea or high automation manufacturing idea.

Now, the accuracy and speed are 2 very important characteristics here. So, flexible manufacturing system by definition is a network of computer controlled machines where not only the machining and manufacturing, but also all the support functions are carried out using computers and in many instances material movements also happens through computer controlled system. So, flexible manufacturing systems help in getting very high accuracy, ability to produce a very large aggregate volume, ability to produce a lot of variety, but the cost of installing and running a flexible manufacturing system is very high. Therefore it becomes economical and usable in products with very large and aggregate volumes and also involving a lot of variety.

So, these 3 can broadly called as 3 aspects or areas in process improvements of course, synchronous manufacturing or theory of constraints which we will talk about I have not listed it here, but we will list in some other classifications, but can also be talked about as a process improvement.

Now, we look at briefly we look at some methodologies based on human resources and other processes, now if you actually happened to see the manufacturing how the product is made now there are set of machines and there is a layout where the manufacturing actually happens and the products come out.

Now, this actual manufacturing is supported by manufacturing systems examples are cellular manufacturing come down controlled systems flexible manufacturing etcetera which are the heart now around that we are going to have lot of supporting systems some of them are integral to the manufacturing itself some of them are slightly on the periphery, but they also support. So, these support systems come in the form of human resources and process related to human resources information systems and so on. So, we will see them as we move along.

So, total quality management came along side total quality management has focus on people employee empowerment TQM is a separate area by itself closely related to manufacturing systems and managements, TQM talks about how essentially people are empowered and people create quality both in the manufactured product as well as on support systems around manufacturing some examples could be involvement of the operator themselves in handling day to day issues such as formation of quality circles

and so on. Essentially on focusing on people who make the product and focusing on employee empowerment.

These also fix in to one of the definitions in the requirements of manufacturing that towards the end we say that keep the work force contented, to keep work force contended by empowering them and by making them an integral part of the manufacturing systems. So, TQM essentially looks at that.

Now, alongside TQM we also had a methodology called business process reengineering which came alongside the TQM, BPR or business process reengineering is an example of radical and dramatic solutions to an issues while TQM represented as slow bottom up approach BPR was always on fast radical and top down approach, BPR has an important component which is the information system component. Now several examples of business process reengineering could be given many times a business process reengineering which comes out of extensive usage of automation computers and so on in a way takes a way human from that, but there is an I have classified TQM and BPR together is that they many times go together even though very conceptually they are 2 different things.

Several examples of BPR can be given for example; an ATM machine is a very good example of business process reengineering. The ATM machine did many things one of which was it a kind of took away the manual teller for certain number of operations and most importantly it changed the way by which we go the bank to take money, before the ATM machines were introduced or before the ATM machines were available 24 by 7 our visit to a bank to barrow money was restricted only to a certain hours now it change way people do something; the idea of a credit card which now tells us that we need not carry cash or a checkbook when we go and buy something.

Now, earlier days when sometimes we would not even be sure of how much money they are going to buy. So, one always either carried a extra money and in some extreme situations would find himself or herself short of money that needs to be paid when we buy things, now credit cards takes away from that discomfort. So, business process reengineering is to try and look at a process and largely centered around automations, but then help make the process better, but even though BPR parse can be applied to various

aspects of manufacturing, but it is not. So, much into manufacturing TQM is, but TQM and BPR indicate 2 different ways of approaching something.

Now, as organizations move towards total quality management they also move towards certifications and recognitions of systems in place, which let to organizations having several certifications such as ISO 9000, Q S 9000 and so on. ISO 9000 is a certification given to an organizations for creating and maintaining a quality management system it is not given for a product it is given for an organization which has a process by which quality is maintained.

So, ISO 9000 and other certifications there ways by which an organizations told it is customers as well as it is competitors it is commitment to quality and more importantly through that commitment their ability to expand their business and get more business and of course, their ability to convince and tell the customers that they have good systems and place. So, when you have good systems and places you automatically go back and clean up your manufacturing systems and manufacturing systems are able to provide products with good quality at short lead times and so on.

The next set as I classify them come under what are called information systems and decisions. Now that is one level of support to manufacturing where we are going to talk of 3 things.

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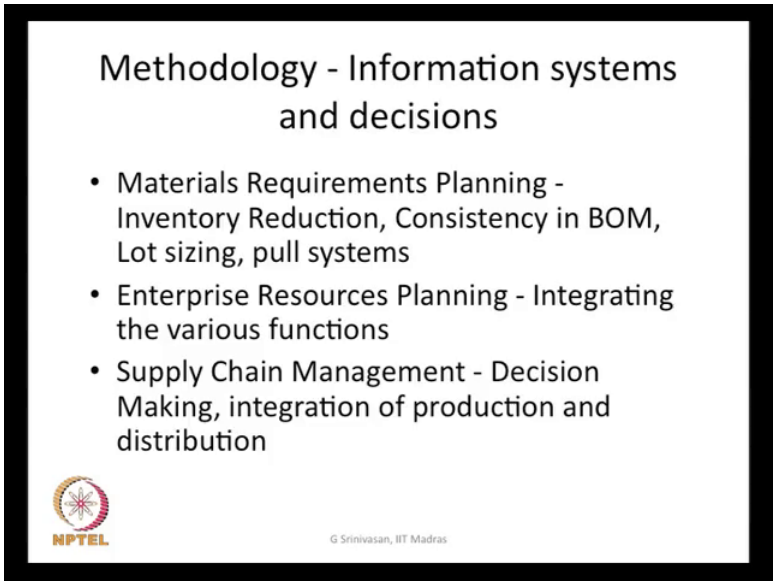

Which are material requirements planning, manufacturing resources planning, enterprise resources planning, supply chain management. We are not going to very deep into all of these we are going spend only few minutes on each one them now material requirement planning as it first it was called as MRP then it became manufacturing resources planning which is MRP 2 also spoke about the bill of materials lap sizing and so on.

So, now the bill of materials a structure where we relate final product to it is sub assemblies and it is components. Now traditionally before the advent of computerization bill of materials were actually kept in note books and so on. And once computerization information systems happened it was easy to get consistency in the bill of materials once computerization came in started off with pay roll. And then went into purchasing and all other activities and then it moved into manufacturing through the MRP, MRP softwares were developed now along with that we had a MRP 2 which is manufacturing resources planning where the resources required to carry out were also put into the software to provide support to manufacture.

Now, computers providing support to manufacturing is a very integral part of what is happening today. If you go back to the last lecture there was one particular slide which spoke about certain events and history were I tried to trace the combination of the advent of computers and fields such as operational research and decision making, which together help manufacturing organizations make very good decisions on optimal usage of resources.

So, manufacturing support comes through these forms they come through 2 form one is called informational system and the other is called decision support systems. So, initially lot of information systems have happened even today information systems are extremely important and are used, now they are used under what are called enterprise resource planning or EPR software where the various functions in the organizations are integrated though initially it started of as MRP, MRP 2 where certain specific functions were addressed using computers helped in bill of materials and so on.

Now, at this point it is also necessary to say if there are 2 ways of looking at ARP, there are set of people who look at ARP as a logical extension of MRP, while there are set of people who believe that ARP is separate area by it iself and should not be looked upon a logical extensions of MRP. Now irrespective of how we look at what is important today

is the existence of are of information systems or a computer support to manufacturing which helps in good decisions, but primarily with good data reliable and timely data, linking data coming from various sources and understanding the implications of particular data or information on some other functions and then helping in over all decision making. So, that is what these 2 areas do which is ARP and MRP.

Now, since the last 25 to 30 years we have been talking of supply chain management, where supply chain management encompasses many things there are 4 important things in supply chain management, now from a flow point of view supply chain management talks about 3 things procurement and purchase of materials conversions of these purchased materials into manufactured products and the distribution of the manufacture products along a network or a chain to the ultimate customer.

So, in some way manufacturing is central core of the supply chain when we are talking of supply chain for products or manufactured products. So, supply chain management helps in integrating or in providing good decisions by combining the 3 activities of procurement, manufacture and distribution. Traditionally these 3 were done separately these 3 were done separately for multiple reasons one of which was data dependability, data correctness and data availability and timeliness. Now today with more and more information systems and ARP systems in place today with more and more trust among different companies to share data we look at ideas like vendor management inventories so on.

As well as ability to pick up point of sales data, ability to pick up customer preferences all these things put together have helped us achieve and create a system there by the accurate data comes in and manufacturing now gets access to exactly what the customer wants and what quantities. Now another reason how all these could be integrated together is fact that today the power and ability to solve large problems or large sized problems is very high and therefore, when we integrated 3 process of procurement, manufacture and distribution and solve them as an integrated model or a problem it is possible to economize further and reduce the cost further.

So, supply chain management systems leverage largely again on gains in computers, information technology and transportations particularly in the logistic and distributions part there is a core manufacturing component in supply chain management. So, this

classifications looks at from the informational systems and decisions point of view how computers and computer support helps a manufacturing in meeting the requirements. It meets several requirements if we go back to the requirement slide one can go back and see how it helps, keeping inventories low is a very primary gain in doing supply chain management, price can be reduced is another place where the effect of supply chain management is there and helps manufacturing

So, if primary thing is to keep in inventory is low and to reduce price of the product, which in turn reduces the cost of making the product supply chain management helps as a manufacturing support activity. Then we move to the last one which we have business process reengineering, we talk of constraint managements synchronous manufacturing as well as goal as well as agility, we will talk about these briefly I had mentioned about business process reengineering earlier as a radical and dramatic way to solve the problem. Let us spend a little bit time on constrain management or synchronous manufacturing or theory of constraints or the goal, now this is an idea that was introduced by (Refer Time: 45:57) in his first book called goal which was published in 1983, where he in the form of a descriptive novel brought out various issues in manufacturing and much later the idea for the area of synchronous manufacturing, or theory of constrains was formulated.

Now there are 7 basic principles of synchronous manufacturing and there are about 5 steps in the TOC decision making process, now these are very simple and common sensational approach which looks at essentially the physic of the manufacturing system or how the manufacturing systems behave and how through simple rules and simple means one can achieve a lot of control in manufacturing. Later the idea of synchronous manufacturing and constrain management was also expanded as a solution to business problems rather than solutions to manufacturing problems alone.

We will spend a little bit time on constrain management in this course. So, last of these points that we will see what is called agility, the word agility has been in existence in manufacturing context for well over 25 years, there are several definitions of agility different peoples have defined agility in different ways, there are times agile manufacturing is equated to a lean manufacturing there are times agile manufacturing is defined as something else, but by a large agility also talks about the responsiveness, agility talks about the ability to meet the customer requirements, agility talks about

empowering customer and help use customer ideas in decision making, agility also talks about cooperate and complete in certain areas.

For example if there are 2 organizations, one let us say strong in marketing and other is strong in manufacturing for example, if an organizations can get the marketing can get 2 x amount of business where it can make only x amount of products and there is another organization which can get only x amount of business, but it has a capability to make 2 x amount of products, then if you bring them together we could have a marketing which would get 3 x of the product and the manufacturing which gets 2 x 3 x of the products. So, they may be competitors, but it is possible for them to use their cores skills to cooperate.

Sometimes we have seen this happen almost competing companies particularly when they cooperate and get into a new product. Now agility talks about all of that sometimes we can get into a new product, some time we can get into old products were we compete at the same time cooperate. So, agility is another methodology which has been used extensively some of these components are similar to other things like constrain management or quality management and so on.

So, this kind of brings us to classifications that I have used there I have classified them as several perspective and amongst these perspectives we would concentrate a lot on this particular thing called process improvement. We would concentrate lot on group technology cellular manufacturing just in time systems, flexible manufacturing systems and synchronous manufacturing systems. From the next lectures we will be doing that, but before I complete this lecture we take one last look again at the ninth law in manufacturing which is combing simplifying and eliminating can save time money and effort if you see 3 out of the 4 methodologies that we are going to concentrate here they all based on simple idea that you combine simplify and eliminate.

Now, cellular manufacturing is simplification making smaller systems out of larger systems. JIT is about eliminating waste synchronous manufacturing is also about simplifying and have very simple production rules, flexible manufacturing to an extends does not come into this, but it also has it is own way of simplifying, particularly combining because it is going to exploit the power of the computer control systems to make manufacturing systems better.

So, the next lecture we will formally introduce cellular manufacturing and then proceed to understanding various algorithms and methods that are related to cellular manufacturing.