Project and Production Management
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Lecture - 28
Product and Process design

In today's lecture we are going to be talking about product and process design. If you recall in the last lecture, we have talked about determining the optimal product mix, so invariably a company would have a number of product to produce and once the decision on the number of products is determined, the design is fixed. One of the crucial decisions that the company has to take is how to manufacture these products, that means what kind of process to adopt? So this particular phase is often known as process planning and in today's lecture we are going to be talking about the interactions between product and process design essentially.

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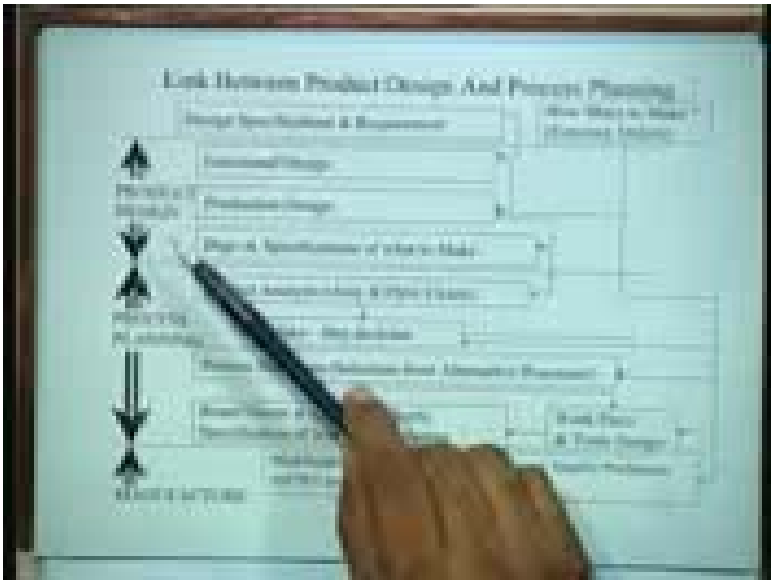

In this diagram we tried to summarize the major activities of product design and process planning and manufacture which generally proceeds in this particular sequence. So let us recall what exactly product design is, what are the inputs and outputs to product design and subsequently how process planning takes place and finally this particular cycle ends with this aspect of manufacture. Product design requires essentially the design specifications and the basic requirements that the customer wants for the particular product and we have already seen in previous lectures that there are various methods available for gathering customer opinion like QFT and talking about developing the design specifications from the customer, from this design specifications and requirements, ultimately we develop what is called a functional design. Functional design of the product is one which focuses primarily on the function and the product

performances and then we talk about the production design where aspects of ease of production are taken care of. Ultimately as a consequence of this entire exercise the output of the product design division is to get drawing and specifications of what to make so that is what it generally is. Notice of course one very crucial decision is the decision on customer demand is how much to make either in terms of forecast or firm order. This is generally available and this governs to a very large extent on aspects like what should be the production design, how should the product we manufacture be so that this quantity is taken care of and so on.

This is a very important auxiliary input to the whole process. Once the product design is made, it is in the form of designs, specifications, drawings and specifications. What to make in the next general phase is what we call process planning. In process planning we are generally concerned with an activity known as product analysis which is actually summarized by the development of assembly charts and flow charts. What do we mean by assembly charts and flow charts? Let us first look at the entire flow of information. The assembly and flow charts will actually specify the various components which go into making the complete product design. Then about each component you have to take the decision on whether to make it or buy it. Many of the components are standard components so you prefer to buy them. The other components might have to be made. So this decision on make and buy for a large number of components which have to make the product has to be taken and component for which you take the 'make' decisions, you have to decide on the process sequence.

Not only the process sequence but for which processes to adopt. Quite often there is a selection from alternative processes. So this decision becomes important at this stage and once you have finalized or taken the decision, you summarize these decisions in the form documents which are known as route sheets and operation sheets. Route sheet is a document which specifies the route to be taken by a particular component as it flows through the factory. So it says that it first goes on this machine. It would perform such and such operations. So details of the operations are available in the operation sheets and the route sheets specify the exact root that you have to take. It is very much like a itinerary you have to go on a long trip, you know I am going from city one to city two, to city three and then what you are exactly doing in city one, city two, city three is actually the operation sheets. This is how these processes are typically documented and they give the specification on how to manufacture. Another important thing in the route sheets and operation sheets is a specification of work place and tools, design that means what kinds of tools are going to be used, what is the specific work place and so on.

Along with the operation sheet this information is generally available. These are the route sheets which governs the manufacturing process. When it comes to manufacturing you may have to modify some of the process plans due to layout, quality preference and machine availability constraint. Those are the things that you might have to do while you are doing the manufacturing. So this basically summarizes the entire sequence of operations starting from the development of the product design to process planning to subsequently manufacture. Now just to clarify some of the major documents which are involved in this exercise take a look at some of the documents for instance, we are talking

at this stage about assembly charts and flow charts. Let us first see what an assembly chart is. For instance the components like a plug assembly drawing are available; this is what has to be made.

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What would normally happen is that the various component which go into making the entire assembly would be shown here in an assembly chart or a Gozindo chart, for instance the plug housing is here and then on the plug housing, the first thing that is done is the air outlet and the pelangi air connection. It is sub assembled then this sub assembly goes on to the plug housing and then on this completed sub assembly you put up the lock ring. The spacer, the rivets, the spring indent etc all these are first assembled in the form of a sub assembly two and then this sub assembly goes to sub assembly to this particular situation here and so on. So a diagram like this gives you a bird's eye view of how various components are going to fit together in generating the final product. This is what we mean by an assembly chart and when we are talking about the beginning of process planning here we are talking about the assembly charts. So this is exactly what an assembly chart is.

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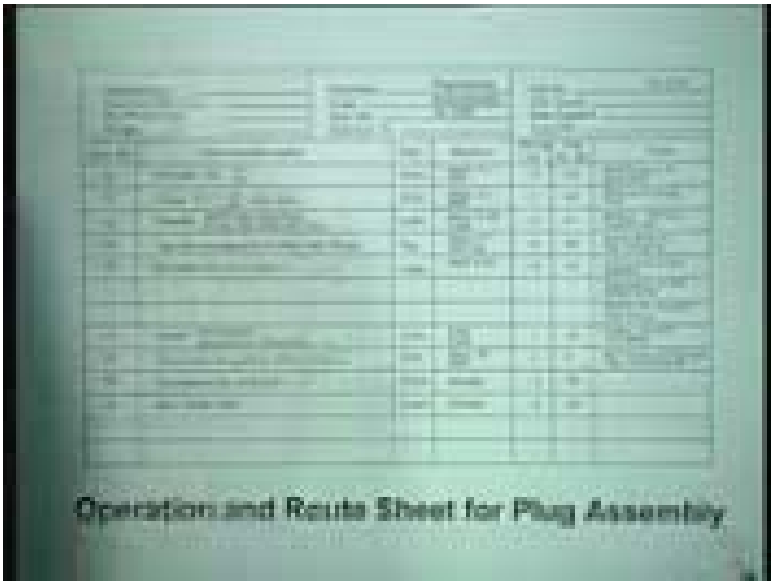

This is typically what an operation on a route sheet for the same product looks like, what it describes is for instance is the plug assembly that we are talking about. Now the plug assembly is one of the components of this whole thing. So this is the plug assembly, let us say the first component which goes into the assembly chart. This would describe the various operations that have to be performed on the plug assembly, say the first operation is to drill hole of 0.32. The tolerances are given; this would be done in this department called drill. This (Refer Slide Time: 10:05) is the machine which would be used for doing this. The set up time required for this is 1.5 hours. The rate emphasis per hour is 254, the tools and fixtures are also specified here. So the details here describe the operations and this is otherwise a route sheet because it describes how this particular component, the plug assembly will keep moving from one stage to another and what exactly will happen to that particular component. So for instance as youngsters you go to a new factory and are interested in finding out what happens and what is the sequence of manufacture. You should be asked for assembly chart and the operation and the route sheet which will describe exactly what information you typically require about the component.

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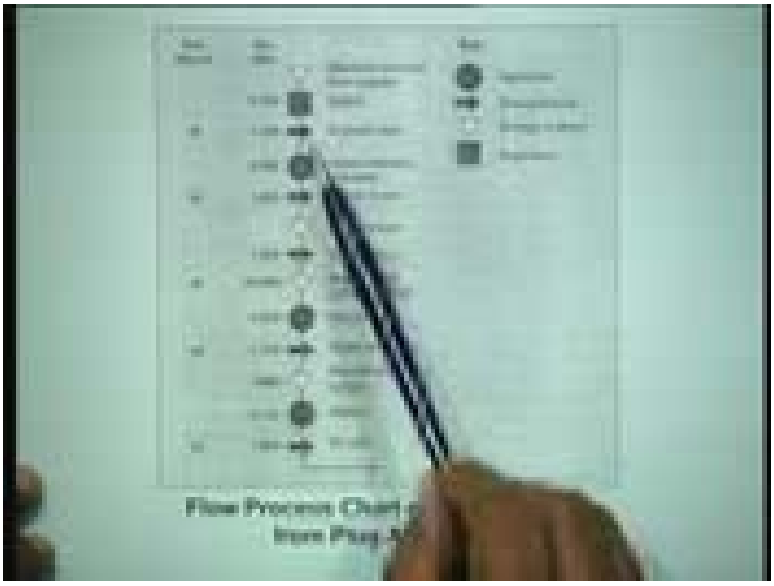

This particular diagram is called a flow process chart. In a flow process chart essentially we are using a standard industrial engineering symbol of circle for operations, transportation, storage or delay and an inspection. What is being said here is that this particular chart describes how the plug housing from the plug assembly that is that particular component will move. What are the timings? So it shows then it moves. Material is received from the suppliers and storage and then the time required to inspect it is given here and then from inspection it moves to the finish department. From the finish department you apply corrosive treatment then it moves to raw material store. So it describes here whether it is an inspection or a movement or an operation as per this situation and ultimately it comes out and keeps going like this. Even the distance moved can be put on this chart so that this chart would be very valuable for identifying the material handling movement for individual parts. So that subsequently if you are trying to suggest an improvement in the process, you can compare one process with another in terms of the total material handling movement. So these are some of the basic charts and other kinds of information which is utilized for consolidating information about the product and the process and how exactly the product flows with the process.

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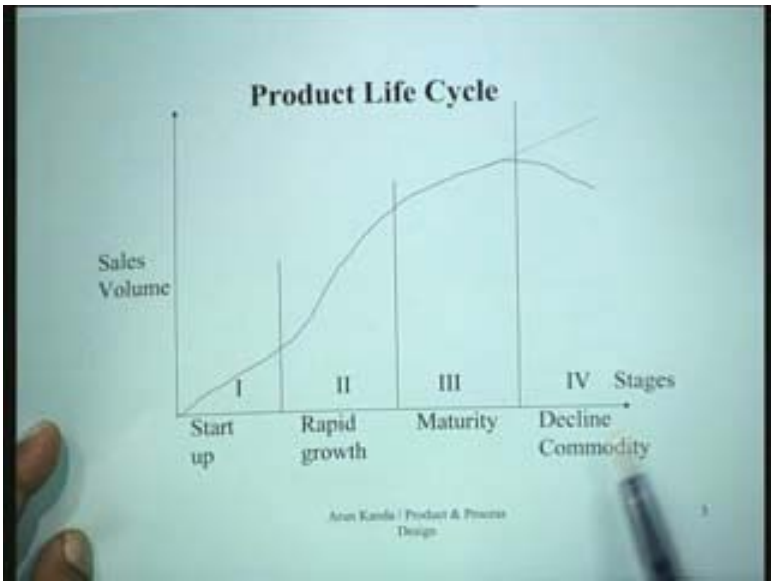

Let us now talk about the product in little greater detail. Every product has a product life cycle and typically if you look at the stages of the product life cycle we can identify four different stages of the product life cycle. The first stage is the start up stage when the product is introduced typically the sales. Volumes tend to grow at a smaller rate so that the slope of this line is generally small. Thereafter comes a stage when the product picks up in popularity where there is a period of rapid growth of the product. So the slope here tends to grow up suddenly and then after the product has grown to a significant extent, comes the stage of maturity where product volume tends to stabilize so that is the stage of maturity of the product. And finally you have the stage where the product can take two possibilities. Two possible roads it can either decline or it can grow at a steady state in the form of what is called commodity. That means the product has become so popular and it is like a commodity. It is like a household commodity which is needed everyday from period to period. So instance the product like soap for instance which we use of a particular brand might have become a commodity and therefore is now at this stage of the life cycle. Now when we talk about the product life cycle we have different behavior of the products at different stages. We can actually look at the characteristic of the product at different stages.

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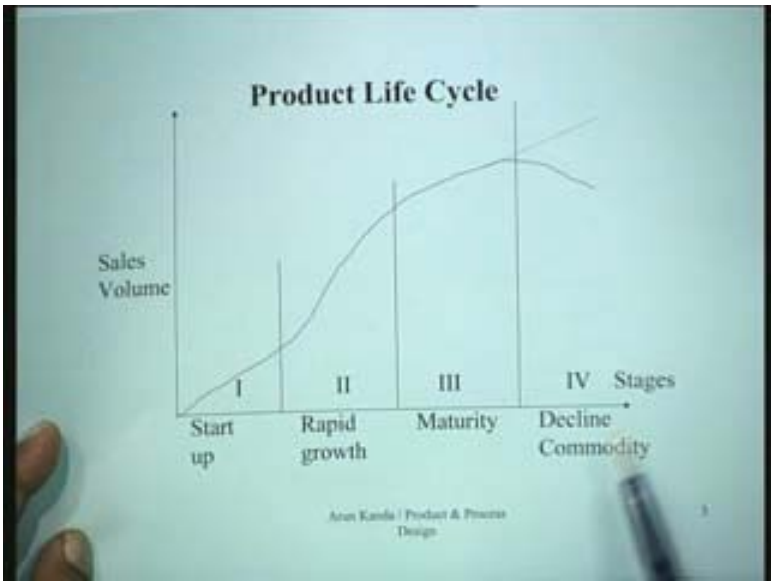

We had identified the four stages, one, two, and three, four as start up, rapid growth maturity and decline or commodity as the case may be.

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Now you look at these four stages one, two, three, and four in that order and try to see exactly what happens to the product at different stages. We will study for instance the behavior of the typical product with regard to product variety, product volume, industry structure and the form of competition. For instance it is generally felt when a product is introduced there is a great variety of manufacture to come up on the scene and they try to manufacture and give you a lot of variety in the beginning. However as the product tends

to stabilize, there is a period of rapid growth. What happens is there is an increase in standardization and ultimately at the stage of maturity there is an emergence of a dominant design and all other designs are generally washed off from the scene. And in the fourth stage there is a high degree of standardization and there is a commodity characteristic which becomes a household commodity. So there is high degree of standardization at this stage and so on. So product variety generally is high. It tends to fall and finally you settle most company would settle for one dominant design and the product variety as far as that is concerned would tend to go down. Look at product volumes as far as the product volume is concerned it is low in the beginning because there is an initial reticence on the part of the customers to adopt new products and therefore there is a low product volume. It generally tends to increase at the second sage it becomes high during the stage of maturity and remains high.

Let us see what the industry structure is. Industry structure means to look at the entire set of people who are manufacturing that particular product. Normally when the product is introduced what happens is that the large number of small competitors come on the scene to manufacture the product. What happens is that the product sales grow. There is a fall out and a consolidation, so the number of competitor who remains gets much reduced and moreover there is consolidation among the competitor themselves so that they have larger company. At this stage only a few large companies remain who are manufacturing this product and out of these few large companies in the last stage, only a few survivors will be there. So you see the impact of this particular product on the industry structure in terms of how competitors grow, fall and subsequently there are a few survivors who actually manage the show. If you take the case of soft drinks for instance Campa cola and Pepsi, these are the few large companies who have survived and all other small manufactures in the Indian context have actually been on a fall out or consolidated or bought out the various companies.

Let us see the form of competition. Initially the competition is based on product characteristic because when you buy a new product you are very careful to choose to find out what the product characteristics are so competition among product is based primarily on product characteristics such as sales volume increases. The competition generally is on the basis of quality and availability that is the main thing. At the third stage it just depends on price and dependability. You should be able to get a suitable price and the supply should be dependable. And generally at the last stage, the form of competition is governed mainly by price and not by other aspects because it is like saying that as you go along you have to cross a number of barriers. But the final barrier at the fourth stage is the price, so this I think gives you an idea of how different products have behaved as different ‘friends’ during their various life cycles. Let us now talk about some of these. What we understand by process design and process technology?

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Basically when we are talking about manufacturing process technology, what we mean in very simple terms is the equipment, the people and the systems that constitutes process technology which are used to produce firm products and services. So equipment, people and systems all these three things are important and there could be growth and development in all the three. But let us now try to see what would happen to the processes when one comes to talking about process technology.

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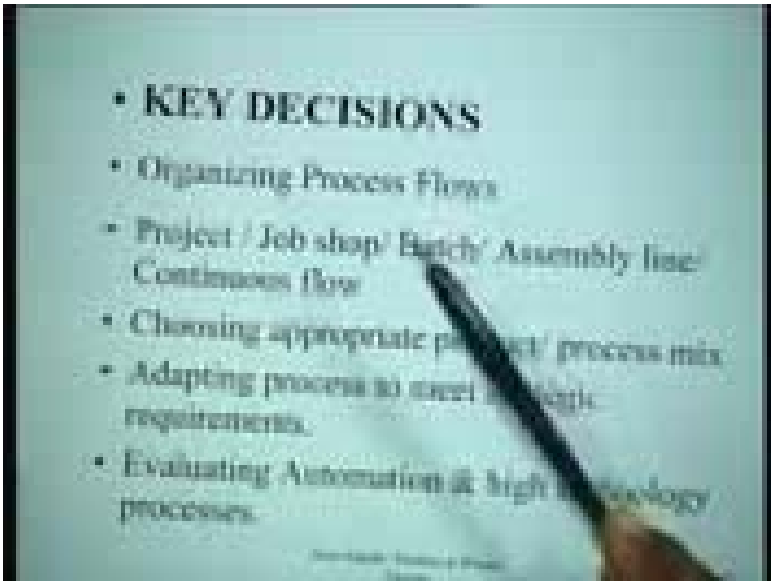

The key decisions that are there in selecting an appropriate processes are, we can talk about organizing process, flows, it is very important how your materials will tend to flow

through the plant, through various machines and what kind of process flows, do you design? Normally you would like to have a smoother flow of materials through the plant as possible, but generally this does not happen in all situations. Depending up on the type of process, you might adopt a process which is a project. Now a project would be relevant only when you are making something only once and you are probably involved in setting up a new process, in designing a new building or introducing a new product, where the task would be essentially to identify the requirements to be done and then develop a relationship between those tasks and then make a schedule by using a typical project net work which will tell you when to do. That is the kind of thing that happens here. So this is a very personalized kind of treatment that you are given in a project because the kind of problem that you are handling is not essentially repetitive.

If you take a job shop, what would happen in job shop? Job shop again is something where you have a number of machines and these machines are general purpose machines that you have. I by a lath, I buy a milling machine or buy a grinder and I set up a job shop. Then I look for jobs to make whatever I can with these three machines and I can make a variety of components, variety of products so what happens here is you created a large variety with standardized machines but because of the nature of your variety what happens is the flows get pretty complicated. Each job will go through the job shop depending up on its own requirements and therefore it would create lot of confusion as far as movement is concerned. This confusion has to some extent reduce in batch production because you are organizing your flows in terms of batches of products and you are also trying to get the advantages of a common set up for various parts. Assembly line obviously as you know, is something that you use when you want to manufacture a single product without changes in design and you want to make it in relatively large quantities. So you can set up an assembly line and that is the feature of this. It will be that you have relatively smooth flow lines and continuous flow.

Continuous flow is generally different from assembly line. Assembly line flow is what we often call discrete manufacture. When you are manufacturing cars for instance, you get one car and then the next car and everything comes out in digitized units. Whereas continuous flow is something in which I do not think you can imagine cars coming out continuously. You know like coming out of a tap of water. The first five millimeters generates may be the first car or whatever it is, does not happen. So continuous flow refers primarily to chemical where the output is coming out continuously and normally. In such case also the flow is pretty smooth and they can be controlled by controlling the environmental parameters at the control parameters in the whole process. So these are some of the key decisions that you have to take as to how you are going to manufacture. You have choices available and this is what we are looking at. We can be talking about choosing the appropriate product process mix. That means we can say for instance that you might decide that you have 5 products to make, 5 car models, let us say if you consider the components you might have something like 20,000 components to make, out of these 20,000 components you might have decided 10,000 of components that you buy from outside.
So you are left with 10,000 components to make and then for each of these 10,000 components, you have to decide as to what kind of a process it will go through. So within

the context of the factory you might have a combination of a job shop, a batch production assembly line and even continuous flow and all are taking place together because each of these is creating to different components; say 10,000 components which you are now going to make. And then you have to talk about adapting the process to meet strategic requirements. What we mean by this strategic requirements is could there what kind of strategic requirements we have been talking about adjustment of process flows to meet strategic requirements. You see product design and redesign could be strategic requirements. What may happen is that you have competitor who has introduced certain features in the model of star. You might want to introduce more features or something. What we are trying to say here is that your processes should be flexible enough to be able to accommodate these changes in the design and adapting the process to meet these strategic requirements which are necessary. This is again another important aspect and then another key decision here is evaluating automation and high technology processes because the degree of the automation and high technology which could vary from product to product. It is basically a decision on what is the level of automation that you should have and how exactly you should use this for planning your processes within the factory so these are this gives us a broad idea of the kinds of processes which are involved and the decisions that have to be taken to manage these various processes.

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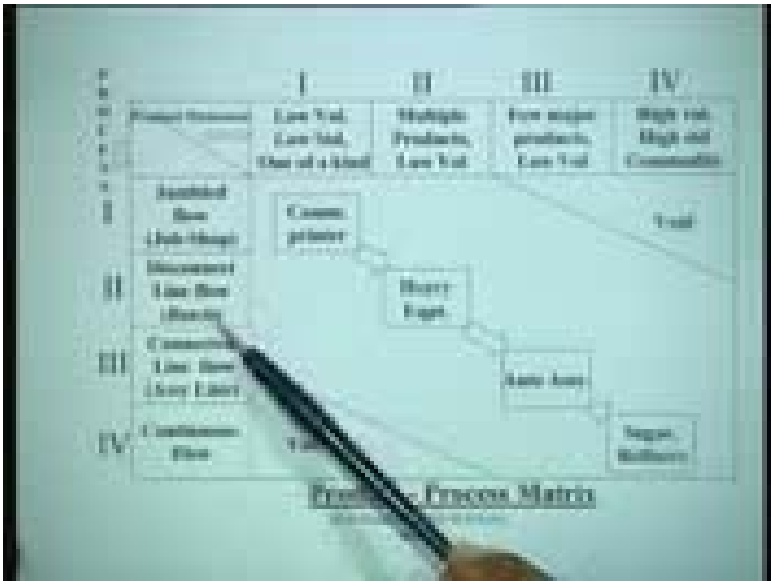

Let us now look at the interaction between the product structures which occurs during the four stages of the life of the product cycle. We are talking about the product structure on these axes and we are talking about the corresponding processes 1, 2, 3 and 4 which are characterized by these features for instance the first kind of process might be a jumbled flow which is what we call a job shop. The second kind of process might be a disconnect line flow which we call batch production, the third kind of processes might be a connected line flow which is essentially the assembly line and the fourth kind of process might be continuous flow which is talking about this. Now similarly on this side we have the four stages, the product structures as it goes through its life cycles and what happens

is what the typical characteristic we have summarized them here are. At the first stage we have low volume low degree of standardization and one of a kind of product which we are trying to make, and then we have multiple products, low volume in the second stage here. We have few major products but relatively low volume. Relatively low volume means of course volumes are higher than this volumes are grown but typically and in the fourth stage high volume high standardization commodity products in that sense. So if you see that for different types of products, in the life cycle of the product, you need different types of processes and typically the processes tend to move on this diagonal. What happens is that for this kind of product structure low volume low standardization you typically require a job shop. So a typical example is commercial printer where which operates generally as job shop.

The typical printing process that we talk about it operates as a job shop and you have this particular scene. Then maybe we make a transition to some kind of heavy equipment where for heavy equipments you are trying to manufacture let us say plates, the kind of activity that may be HMT is engaged, where it makes machines on order for different components. So essentially when we are talking about heavy equipment it could be a disconnect line flow. There is a batch production; they aggregate the orders of different kinds. We are talking about multiple products with variations of the machines and you come to this particular feature again. Then this product could then graduate to a situation where we have something like automobile assembly. An automobile assembly is we have few major products and this is the connected line flow in the form of assembly line and you have come here.

Finally we could give an example of continuous flow which could be sugar production or a refinery where you are talking about the whole product as a stabilized commodity and this stabilize commodity like sugar, is a household item. Everybody consumes it and similarly product on the refinery, you have the operations are taking place. So this matrix is called the product process matrix which shows that there is intimate relationship between the product which shows there is a intimate relationship between the kind of products you want to make, what stage it is and the kind of processes you have to adopt. You typically find that in this region there is nothing but a void. Similarly this region is a void and normally all companies tend to grow from here to here to here and that is how typically the product process matrix actually identifies how evolution in the process companies tends to take place.

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We were talking so far about the product life cycle. If we now talk about the process life cycle, the process life cycle essentially as we had seen from product process matrix would have these four spaces. Initially you tend to deal with the product during the start up space of the product as a job shop and then during the rapid growth stage typically you graduate to a batch production system. During the stage of maturity you graduate to an assembly line which is required and then once it becomes the commodity then you have a continuous flow and the manufacturing cost per unit typically tend to go down from the job shop to the batch production to the assembly line. They could stay minimum but normally in this region raise the little. The raise of the manufacturing cost per unit in the commodity space could be due to variety of factors. Look at them and see but typically again here the costs are relatively low and generally the minimum cost would occur somewhere here the cost per unit.

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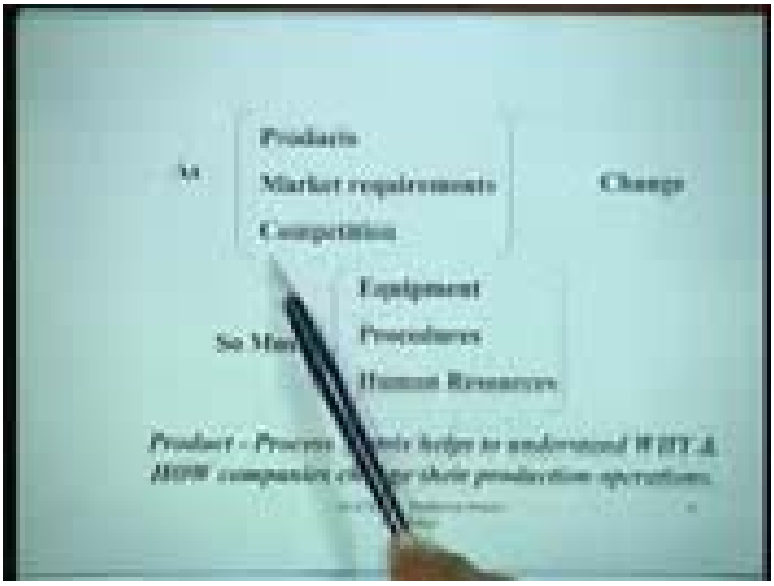

So the lesson is that as the companies product market requirements competition change, these are major things for the company products keep changing, market requirements keep changing, competitions keep changing, so must the equipment procedures and human resources. This is kind of fact that emerges from the product process matrix. The product process matrix helps primarily to understand why and how company changes their production operations. There is an intimate link between product and processes. As Products mature, the process that you adopt to make them also needs to change. Let us now spend some time on talking about services and service processes. This world is increasingly becoming a place where services are more important. More and more people in this country and in the world are earning their livelihood through services rather than through manufacturing or through other areas now.

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So in the design of services what are the key features and how is it that we talk about designing, since we are talking about designing of both products as well as services. Service design is very similar to product design. There is not much of a difference but there are certain differences. The differences are that certain services may not require, for instance we are talking about developing a service. We are talking about say hospital services, you can talk about postal services, and you can talk about setting up an insurance company or something like that or a banking system. These are all examples of service systems, so certain services may not require engineering. It is obvious we are talking about bank and you are not dealing with heavy machinery. But yes you are dealing with automated teller machine and you are dealing with various other kinds of equipments but they might not require engineering in the same sense as for instance you may need while setting up refinery. It might not require testing in the usual sense; it might not require components analysis. It might not require prototype building of the product. You see one of the things that is done in a product is that you build a prototype by using rapid prototyping machine or otherwise off the product before you launch but for a service you might not have to do that.

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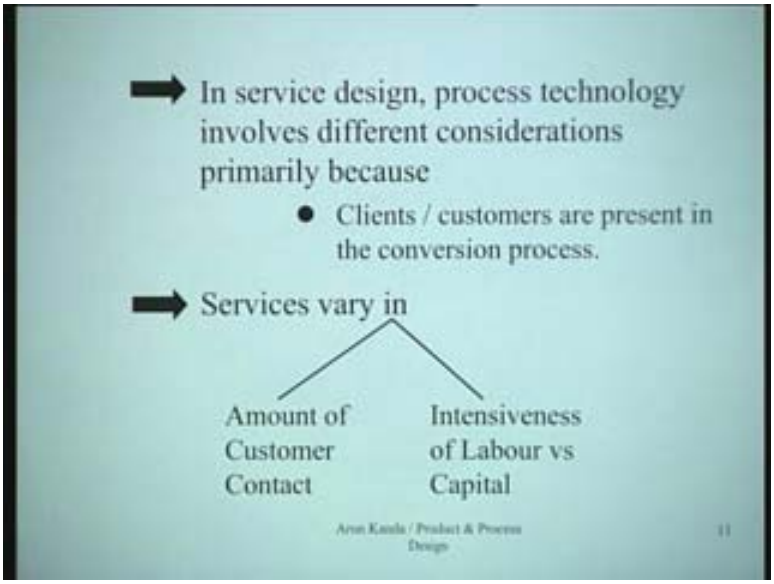

Another feature of services is where in service design process technology, it involves different considerations. Why? primarily because clients and customers are presented in the conversion process. This is the significant difference between service design and conventional factories. If you are designing a hospital the customer will be a client in the whole process and in fact he will go through the entire process. He will have to go for registration, he will then have to go to the appropriate doctor, he will have to go for medical diagnostic then he will have to go to the doctor for prescription and so on. So he actually flows through the system very much like the components that flow through a manufacturing process unlike say factory, again like Maruthi udyog they are making cars. The cars frequently go through but the person is going to buy the car never even sees the factory. Whereas in hospital the customer is a very much a part of the process, so the same is true in banking, the same is true in postal services, that the clients and customers are presented in the conversion process. Therefore the implications are that you have to take care of that, you are dealing with the people and services have to be designed appropriately for these people. Services vary in the amount of customer contact and also in the intensiveness of labor versus capital.

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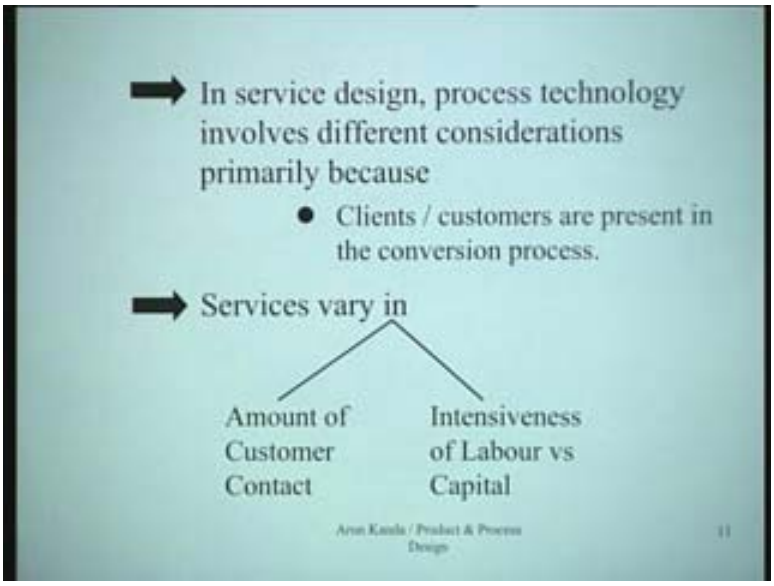

Services can be like the number of customers interacting through the service. That is one thing and then of course the intensiveness of whether you are using labor or capital primarily.

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We can try to summarize this information about service processes by looking at capital intensive versus labor intensive. When we say services, we are talking about services and low customer contact versus high customer contact, we can have a great of four essential

classifications and we can therefore look at service processes of four types. These four types can be called quasi manufacturing very similar to manufacturing.
Customer shop services are a second variety. Mass services are the third variety and the professional services are the fourth variety and therefore let us see what the difference would be in designing these kinds of services and what would be the kind of situations in which they would be relevant?

When you are talking about quasi manufacturing, you are essentially talking about something which is capital intensive and something where there is low customer contact relatively low customer contact. This thing is something like manufacturing but quasi manufacturing and examples are typically postal services or even banking services which are very similar to postal services, automated area housing is typical examples where you could design services based on something like manufacturing. In that sense you can look at a postal service design or a banking service design which will be essentially capital intensive. Let us say fewer customers and you can design the process in terms of whatever objectives you are looking at on the other hand what do we mean by a situation where there is high customer contact?

Customer shop services are essentially capital intensive and they have high customer contact high customer contact means typically when we are talking of for instance things like medical treatment, there is high contact. The customer has to be presented for each test that he has to undergo. If we are talking about a medical services like Maxcare or some other care, they have to give medical treatment which is involving high customer contact and the kind of equipment and other things involved is pretty expensive so here is an example. Similarly chartered travel is another example of service where the customer has to be given high contact if there is a tourist air line or a tourist agency which takes you on chartered trip may be Singapore and brings you back and so on.

So it has to constantly keep on interacting with you because you are involved there and you have high customer contact and capital intensive kind of a thing. Now let us look at service processes which are essentially labor intensive labor intensive but low customer contact it might come as a surprise the most of us. Teaching is put in this category where you have labor intensive. See lecturing for instance I am lecturing to you a labor intensive processes and I am not using any machines or anything. Only it is a labor intensive process and I am teaching a set of 55 or 60 students at one time and it is a mass service in that sense, it is teaching. It is labor intensive and there is low customer contact in this particular case. So do you agree with this classification or not.

Why will you not agree with this classification? In fact the distinction has been made here between teaching and tutoring. Tutoring is an activity which requires high customer contact. So when we talk about tutorial s we have to interact with you. There is high customer contact and it is also a labor intensive thing, so you can say the aspect of tutorial and practical or tutors and so on and that process is here. So I think that takes care of it whereas during the process of teaching via lecture it is an impersonal process because it is a one way process. Generally there can be questions, there are limited interactions but it is essentially a process where there is low customer contact to some

extent because I keep talking. So that is the reason. So this is teaching and then similarly lives entertainment if somebody gives live on a show, say Lata Mangeshkar comes and gives, what is going to happen? It is a live entertainment. Essentially it is like lecturing. She just gives the performance; there is very little customer contact. So it falls in this category. Similarly they say cafeteria for instance is essentially something here. There is low customer contact so you have this whereas these are called mass services. Mass services are those which are essentially labor intensive but you are using low customer contact. On the contrary you use high customer contact. These services come under the category of professional services where, if a lawyer has to take up a case, he has to understand the case very well, and understand. Some legal counseling would involve high degree of customer contact. Similarly medical diagnosis involves high degree of customer contact because the doctor has to prepare a medical history and listen to you talk about everything. Similarly tutoring is if I have to teach you something I give you a problem, you do it, you bring it back to me and then I tell you that is tutoring where there is high customer contact. Essentially what you find is that for this entire stage, generally the process technology is rigid and for this stage the processes technology has to be more flexible. Whenever you have dealt with high customer contact, technologies that you adopt could be more flexible to meet the requirements of different customers, whereas here you can afford to be a little more flexible.

So this matrix actually gives us an idea of different types of service processes and how exactly they can be designed. Automation is an interesting part of everything. In fact we can keep on automating the various processes that are there. Remember on one side we are talking about rigid processes, on the other side we are talking about flexible processes. So we have to accommodate both. Different kinds of things have involved. When we are talking about automated banking for instance you have many of the rigid processes going on, you use your car in an ATM machine and automatically the money would come out, so that kind of a situation is an actually an example of automated banking where you have used technology and automation for solving these problems. Next, electronic grocery scanner, if you go to any shopping mall, for instance all items have their cost and barcode written on each item. It can be picked up very easily through a barcode reader and you can very easily have billing inventory and all other related information very quickly as a consequence of these kinds of grocery scanners. So that is another example of automation.

Then we can talk about office automation. Office automation in the context of the modern office would be the use of pisces, the use of various software like word processing software, spreadsheets that are used to make things simple and try to help us generate knowledge from information. That is the basic idea of office automation. Of course apart from this there could be other facilities that we have like teleconferencing which is again office automation which would help us to have interactive dialogues with somebody else at different locations. So, one to one personal talks can be made available through these.The point is that in various categories you can use different kinds of automation depending up on the situation. Let us now talk about the choice of the appropriate process. When we talk about the choice of the process what are we essentially talking about is we are talking about choices which specifies for instance that

different processes have different features in terms of their costs. So we can talk about a fixed cost and variable cost.

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For instance at the initial stages you might want to just buy items directly so there is no fixed cost. You have something like this, for batch production you might have to set up a small facility and the unit variable cost will come down or you might set up an assembly line at much higher cost which is the fixed cost and then you have a situation like this. So this diagram simply shows that the job production, batch production and assembly line would obviously be relevant only in certain ranges of production volume depending up on the break even points and therefore it is an important economic decision to determine which process you have to take. You have to be aware of not only the options but also the various types of volumes that you are dealing with.

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So in that sense, the choice of the processes itself is actually an economic decision and important since we are talking about process design and talking about the various process features. Although we have already tried to mention some of the basic features of various processes, nevertheless it is worthwhile to look at the various important processes which occur in real life and see the features. For instance if you are talking about the first kind of feature, it is a project which is generally adhoc. If you want to make something either on the adhoc basis or you are doing something which you have not, on an adhoc basis but on a continuing basis but you are doing it for the time, then what has to be done is basically you have to identify what you want to do. From your objective you have to identify the various tasks that you have to perform. Once you have identified these tasks, you have to plan and execute the task and this entire thing is generally one time activity. So it is not repeated again and again. You set it up for one situation and then do it on a job shop. What happens is you are using general purpose equipment, so on general purpose equipment, we produce a variety of jobs and each job chooses its route. So first job goes from one machine to another machine and keeps on going around in the job shop.

The second job might select its own route depending up on its requirements and then go through the jobs. This is typically what happens in a shop. These features mean that it is complicated or a very typical kind of flow patterns emerges in the job shop. However what is the advantage? The major advantage is that you get a lot of variety you can produce variety but this kind of a thing will happen, we then talk about various process features in terms of batch production. What is batch production?

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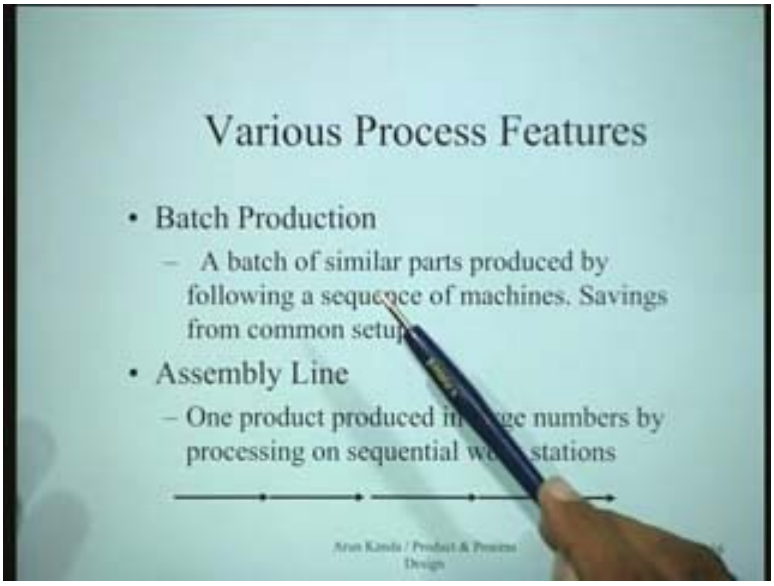

It is like typical job shop where volumes becomes larger and would graduate to a batch production system. What could happen? A batch of similar parts would be produced by following a sequence of machines and there would be savings from common setups that are the typical advantage of batch production. So now you are producing may be 50 of these parts then the next batch is 200 then 50 again, then 500. Whatever it is and you have therefore variety and normally the variety here is limited as compared to a job shop. Finally what happens in an assembly line is you have one produced in large numbers by processing on sequential work stations and in first it is processed on one, then it goes to the next then it goes to the next and so on. Obvious advantage of this is that the flows are very smooth and the volumes can be large the production times are reduced why production time reduced here not because of operation times are reduced in anyway if you even produce this job in a process layout the times would be there so I take two minutes to produce this, three minutes to produce this. The total time will be some of these times. What actually is saved here is that there is very little transfer of material from one department to other which takes a lot of time otherwise. So here you are on one operation, you go to the next machine which is immediately waiting. So setups and waiting times are reduced as a consequence this becomes a much faster process. In continuous production example like chemical plants and refineries, the product flows continuously with characteristic governed by environmental and control conditions such as temperature, humidity, chemical composition, catalyst etc.

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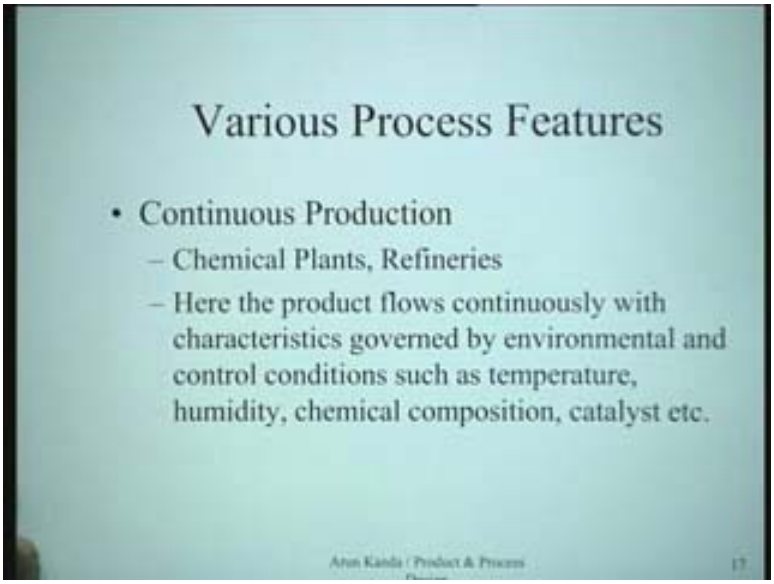

These are the things that you control to open control the quality and the speed at which the process is moving. Finally let us see try to summarize what we have talked about today. I think the first important lesson for us was that the product undergoes varying requirements during its life cycle. We saw the product life cycle and we saw that there were requirements which varied as the product went through the life cycle. Then we saw the different processes serve different needs and typically as the product matures different processes are required to capture those needs. So the product processes matrix which we talk about was capturing this relationship between the product and the process essentially. Then we looked at the process life cycle which talk about how process matures that means the nature of the process keep changing depending up on how products are grown.

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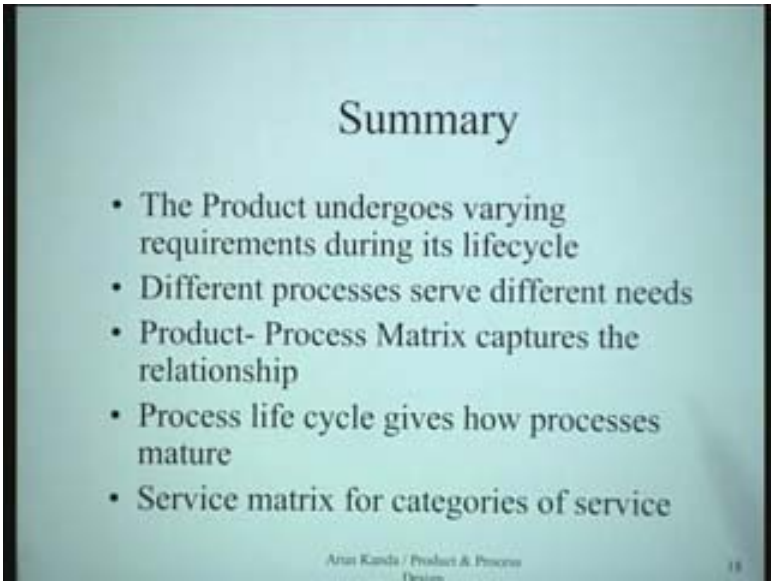

We finally looked at service matrix for categories of service and service matrix meaning there by that we had different kinds of service depending up on whether it is labor intensive or whether it is capital intensive and then depending up on the element of customer contacts. We could divide services into four categories. Finally we had looked at some of the features of different processing modes like projects job production, batch production, assembly lines and continuous production and I think we must emphasize on the points that the choice of the processes are essentially an optimal decision based on economic. So depending up on the situation and the context you have to use an appropriate process. I think apart from this, one of the important things we saw in this particular lecture was how product process and manufacturing decisions were interlinked and we did look at some of the common charts and information sources for compiling this information and also like assembly charts route sheets and operations process sheets. Because these situations will be things that you will have to consult while you are talking about or gathering information pertaining to the process. So I think in the next lecture we will talk about another major strategic decision about products. That is the choice or the setting up of the plant location or the facility location which is the major strategic decision after you have designed the products and the services which is the next stage of the life cycle of a production system.

Thank you!