Sustainability Through Green Manufacturing System: An Applied Approach

Prof. Deepu Philip
Department of Industrial & Management Engineering
Indian Institute of Technology, Kanpur
Dr. Amandeep Singh Oberoi
National Institute of Technology, Jalandhar

Lecture – 13
Basic Modeling Concepts for Factory Simulation

Good morning. Welcome to one lecture one additional new lecture of sustainable manufacturing.

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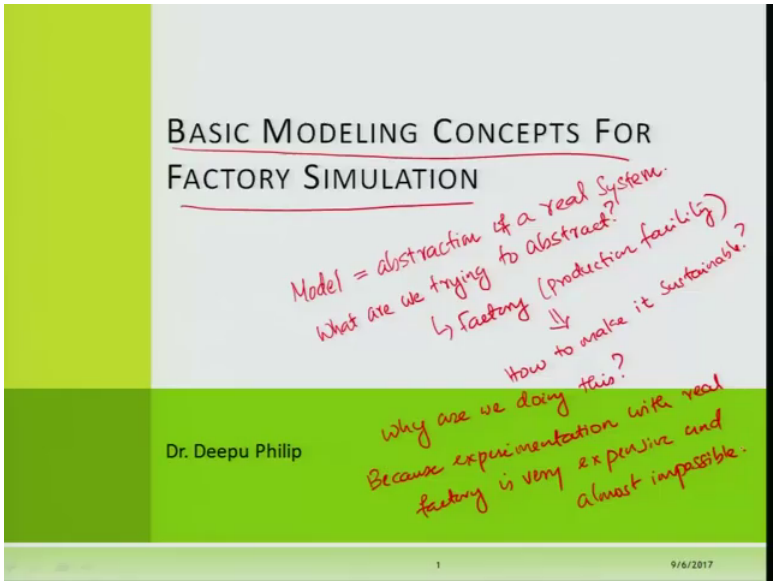

Today we are going to discuss the topic basic modeling concepts for factory simulation. Remember that we talked about what is a model the (Refer Time: 00:31) one of the phrase that I want to recap todays model and which we called it as an abstract abstraction of a real system. So, here we what we are trying to abstract; for this course we are trying to abstract a factory or what we can call it as a production facility and what are we trying to study of that how to make it sustainable and why are we doing this? This because experimentation experimenting or experimentation with real factory is very expensive and almost impossible because nobody will give you the entire factory to say please go ahead take my factory for the next one year run the simulation run the run the test and tell me how the factory to be made green.

So, that is the reason why we how to use simulation to do this study and for that we talked about modelling we studied about why is modelling necessary why is simulation modelling is necessary, but we also now need to see how to make models of manufacturing systems or what are the basic building blocks within you can built complicated manufacturing system models, because at the end of the day you will have to model the factory in a matter what and for modelling that factory you would like you would end of using some those tough that will be learning today to build that model.

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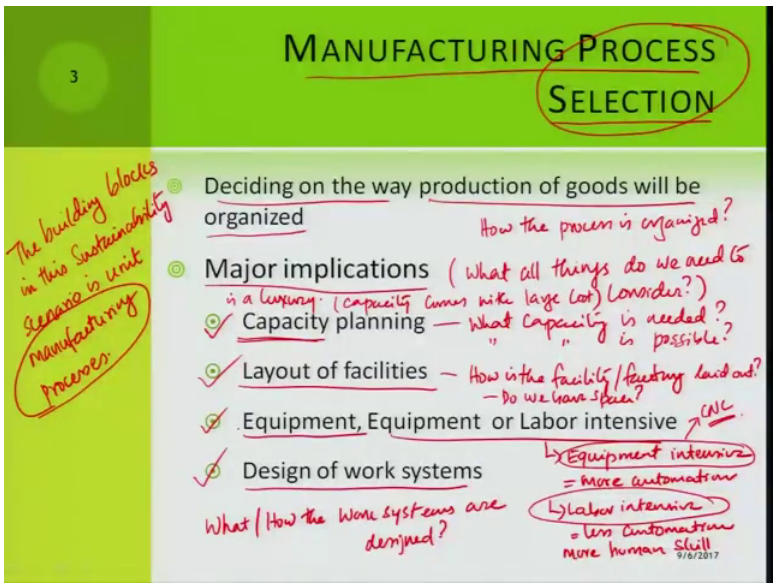

So, and I am Doctor Deepu Philip and I am from IIT, Kanpur. So, today first we will talk about facility layouts in the concept of that. So, the one most important thing that we try to do is the manufacturing process selection and this concept is which process what manufacturing process we will use. Remember when we studied in the class we said that the building blocks in this sustainability scenario is unit manufacturing processes. So, most important thing is you have to decide which manufacturing process you are going to choose, what is a right process selection.

So, it is typically decided on the way the production of the goods will be organized. So, how the process is organized that question to large extent determines the way the production of the goods will be organized. The major implications of this is what are the major consequence or what all things do we need to consider. This is one important thing the first one you need to think about its capacity planning what capacity is needed then

what capacity is possible remember capacity this particular thing is a luxury actually you would like to have infinite capacity, but capacity always comes up with a large cost. So, the problem with the capacity is that capacity comes with large cost. So, you cannot really how infinity capacity because it will require infinite amount of money, which is very hard to rise. So, in that regard you have to decide how much capacity is needed and how much it can actually created that is both is taken into consideration then comes the layout of facilities second one how is the question here is how is the facility or factory whatever you want to call it or is a facility or factory laid out, do we have space can a particular process be incorporated into this or these are thought through as part of this ok.

Then comes a consideration what type of equipment or whether it can be equipment or labor intensive. So, the two options here if you say equipment intensive, then we are talking about more automation whereas, labor intensive implies less automation more human skill. So, you have to decide what you are going to do see if you are in a handicraft business you would probably be more labor intensive because it depends lot on the human skills at the point, but if you are looking at a producing an car or mobile phone or something, then there will be lot more automated equipments where you give the design of the part as well as the production plan or the computerized manufacturing code cam code and then the machine pretty much manufactures it by itself.

So, though such machines sometimes called us CN Computer numerical control machine or digitally control machines and last aspect is design of work systems. So, here is like what or how the work system are designed that also is another aspect that is part of this. So, as you can say that the process selection, selection of manufacturing process is a complicated thing because it you have to consider capacity you have consider the layout you see whether there is space available you have select it depend you have to choose based on the type of equipment that you have or you want to be more automation or less automation and also depending upon what are the type of work systems are available all these factors goes into the design or choice of manufacturing process.

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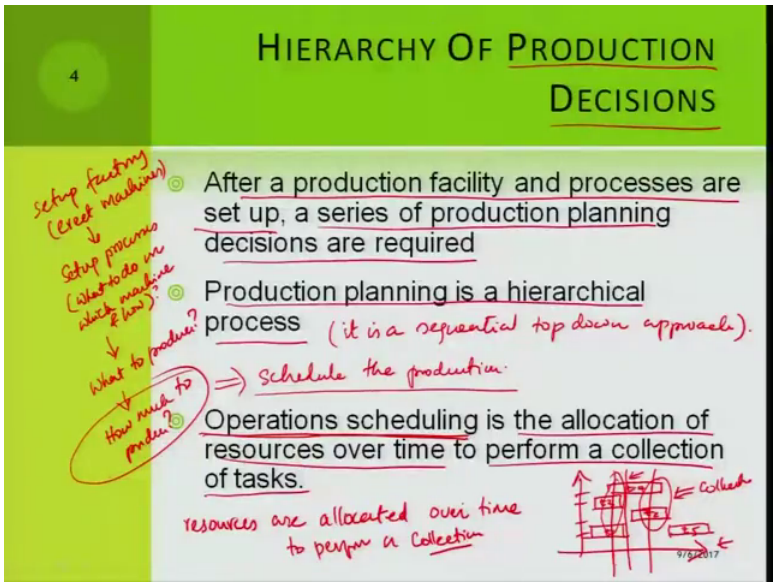

So, the another part also is that you need to consider is production decisions what we talk about it as production decisions there is a hierarchy associated with it once you set up a production facility and a process are set up once you have the factory and the process set up a production set up production planning decisions are required. So, you the sequence is this set up factory which means erect machines, then do you then you have is the setup processes this is where what to do on which machine and how this part, then from there you have to decide what to produce what are you going to produce.

So, it is kind of a hierarchical what you have to how factory before we setup the process you have to have the process setup before you decide what to produce and then you have to know what to produce, then you need to determine how much to produce after this comes the how much to produce. So, this process keeps on going hierarchically is one after another. So, that is why the production planning is obviously, always called as a hierarchical process hierarchical is in a it is a sequential top down approach and you cannot start decide how much to produce unless you have the factory setup, so that kind of a thing, so that is one aspect the production decision.

Then there is another aspect is when you decide how much to produce, then you have to do is schedule the production. Here we use the concept of operation scheduling. So, schedule the production means you have to decide which machine will produce how much and what time that kind of a thing. So, that is the typically called as operation

scheduling. Operation scheduling it is the allocation of resources over time to perform a collection of tasks. So, your resources whatever you want to call it as resources are allocated over time. So, you have a time going on here and you have multiple resources they are allocated to different task here you will have task 1 going on, task 2 going on task 3 will be going on like this task 4 going on like this something like this you have different processes than task will come after this here something like this. So, what we are trying to say is this resources are allocated over time to perform a collection of tasks.

So, the word collection means at this time period if you take this as a particular time instant if you take this you can see that we are producing we are only doing the T 4, this particular task; however, if you take this as a time instant then you have these two we are working on. So, this is a collection, this particular time instant you have all the three being worked on. So, that is another collection. So, depending upon what time you look into this process you will end up deciding the set off task which task you are going to work upon. So, this is the importance of operation scheduling. So, the operation scheduling comes in once you decide how much to produce then you end up deciding how to schedule the production.

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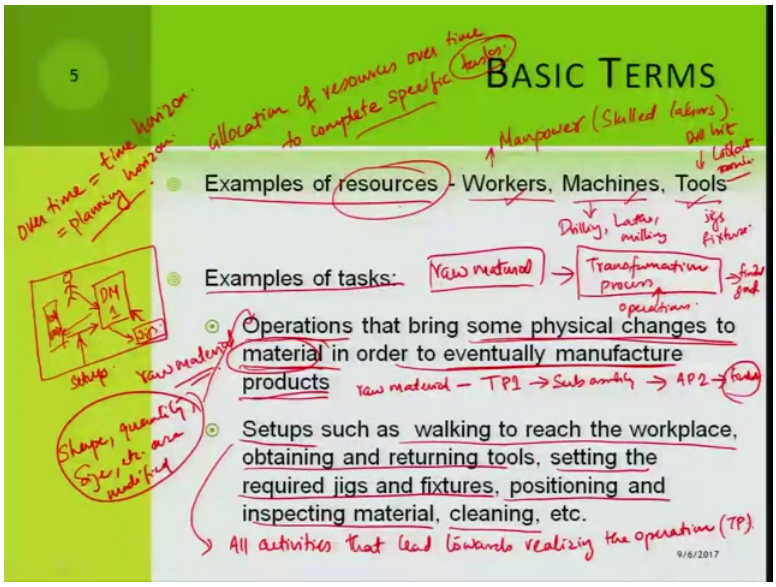

So, as I said earlier some of the definitions is do you like resource what do you mean by a resource. So, the examples of resources are workers, machines, tools etcetera. So, workers you can think about it as the manpower or the human beings associated with that

all right or you can think about it as the skilled labors laborers. So, these are all terms are used for the workers machines are the you can think about it as drilling, lathe, milling etcetera. So, all of these comes under the machines. So, use machines and then you can have tools where will be drill belt, cool and nozzle etcetera the rather jigs fixtures all these will come under the tools aspects of broadly come under the tools aspects of the.

So, all of these things are resources because you require it is allocation of resources over time to complete specific tasks. So, this is what we call as operation scheduling. So, this is this is what we are try to allocate you are trying to allocate workers, you are trying to allocate machines, you are trying to allocate tools over a time period over time horizon. So, here that concept when we say over time, this implies a time horizon. You will come across this term we will later call this as planning horizon and we will discuss what it means is planning horizon, but it is what we are taking is we are taking is specific unit of time and then we are allocating this resources over the time period.

Then similarly another term that we talked about is this task what are tasks examples of tasks task in a broad sense they are operations that bring some physical changes to the material in order to eventually manufacture products. So, you have a raw material this is raw material and then it goes to what we call as a transformation process, then you get a finished good this is a simple thing. So, this transformation process is where the operations happen operations. So, this raw material some physical changes are made to the material the material here implies raw material. So, this is a raw material. So, raw material is changed some physical change or raw material the shape, quantity, size etcetera are modified this is all done modified through operations, to eventually manufacture the product. So, the operations might result in.

So, one sequence will be raw material transformation process one you get a sub assembly will go to another assembly process 2 and get a finished goods something like this. So, eventually somewhere down the road you will get the finished good that is the idea. So, operations again it is one that bring the physical change to the raw material in order to eventually manufacture the final finished good or the product. So, that is the one example of task.

Another one is setups setup task, this include walking to reach the workplace. So, if you think about a factory if you look from the factory from the top view and let us say you

have a this is your drilling machine 1 and here is your you know tool box. So, the human being he walks to the drilling machine then walk to the tool box and walks back this much obtaining and returning tools, these are all part of this setups. So, these are all setups let us say you have a collection of jigs here. So, then this person walks from here to get the jigs and walk back that is also you know there that is that is one other example and picking up and setting the required jigs and fixtures is an example loading the job on to the jig and fixture is another example positioning and inspecting material then cleaning the workplace all of these things are setups.

So, setups in another way to think about it is all activities that lead towards realizing the operation or what we can call is or the transformation process either one we can call it that way. So, these activities setup need to be done before you can start. So, you have to load the work piece on to the machine before we can start machining, but before you can load the load the work piece on to the fixture you have to go get the fixture and before that you have to come to the machine clean, the machine setup the machine, all those kind of things. So, all these setups are task or task that are precursor before the actual operation or the transformation process begins ok.

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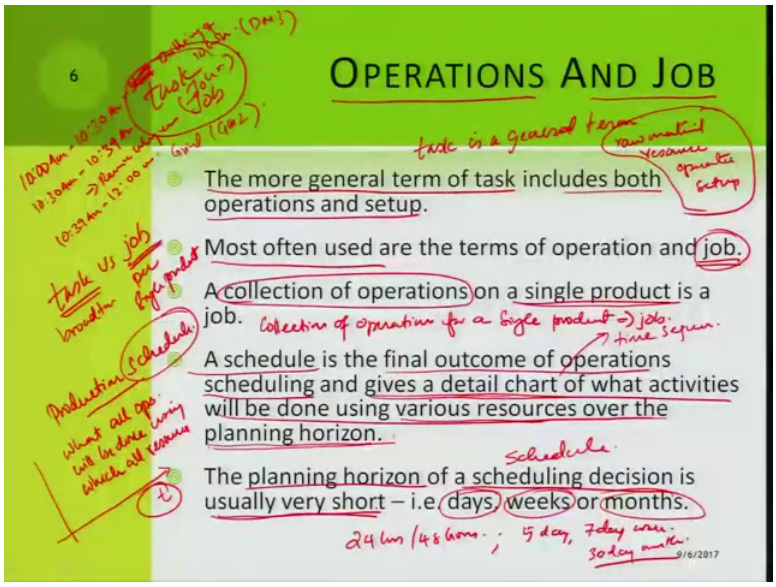

Now, we talk about in manufacturing one other term that is heavily use this operations and job. So, people sometimes use this term task and then there is job. Many a time people kind of use this interchangeably, but that is different actually both are quite

different the task it is a more general term. So, task is a general term is a general term why is it a general term? Because includes both operations and setup. So, here in a task you have the raw material, resource operations setup all these things are considered as part of the task is a more broader term. So, in the operation side whenever we think about it is we more use usually use the term job instead of the term task.

The difference between a job and a task is that task is a general term which includes both operations and setups for anything very broad whereas, for as if you taking a single product and all the collection of operations that are necessary for the single product it becomes a job. So, collection of operations for a single product it becomes a job. The confusion usually happens between task and job is where because the example that is use to study task and job usually is the single machine. So, in which the task and job can be used interchangeably because each job each task is a job actually.

Whereas in the case of a factory where you are going from multiple machines. So, whichever you are producing that determines whether it is a task or a job depending upon the see you are let us say in a auto motive company your manufacturing two type of cars are say Saruthi Suzuki is an example. All the operations that are required to produce like Maruthi 800 will be one job or you can think about it as you know all the operations as required to produce Maruthi Baleno is another job.

So, it is for a single product you know whatever the collection of operations that are required. So, that is a distinguish between task and job. So, the task verses job this is the broad term this is per single product this is collection of operations. So, when you have a task and a job then we talk about the time called a schedule some people call this as a production schedule also lets not worry about production schedule for the time being, let us just talk about the term schedule what is a schedule it is a schedule is the final outcome of operations scheduling and it gives a detail chart of what activities will be done using various resources over the planning horizon. So, here comes about planning horizon.

So, if you have a time period t and then you are determine you are going to determine what all operations what all operations will be done using which all resources and you make a chart of it detail chart of it then that becomes a schedule. So, one chat will be like at 10 am to 10:30 am start drilling or drill drilling of 10 hours or whatever it is 10:30 am

to 10:39AM remove work piece then 10:39 AP to 12 noon some something else and remove work piece you will say john will remove this work peace something like that.

So, here you are saying that drilling of 10 hours drill machine three. So, we will of we will say we are using drilling machine three to drill 10 hours on a work piece at 10 am to 10 thirty am then after that john will come and remove this work piece from the machine it will take 9 minutes for them to do that then after that 139 to 10 you will do something else on the work piece on grinding or something like that using grinding machine two something like this. So, you have a detail chart it is a chart there is a time the chart will tell you the time sequence of what activity will be done at what time and which resource will be used for that.

So, the planning horizon what we talk about this time what we talk about the planning horizon of schedule scheduling decision or the schedule the planning horizon of a schedule is very short usually you either do planning worth of days or weeks at the max a month. So, you typically going 24 hours or 48 hours or something like this though or you might go to you know 5 days week or seven day week something like this or you will go into 30 day month something like this. Rarely we go to that long of a duration we usually play within days and weeks you do not may take the plan you do not do the production scheduling for huge long time period you can have a like a rough schedule, but the actual schedule is done for very very short time period the time period is usually short that we need to remember ok.

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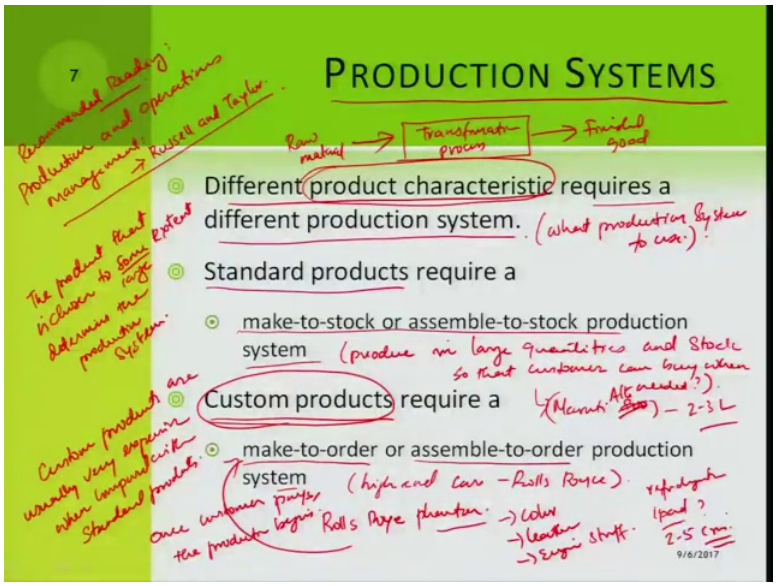

So, with that basic concepts ready, we will go into the next one of the production systems because we also need to know some details about what is a production system and I know you many of you have studied this many of you have absolutely no clue what it is. So, we will try to view or an over view of this and I would recommend you guys to read a little bit more on this once on what is a production system and stuff like that and there is one book that is very famous for this it is production and operations management a systems approach I believe is still there in the title, but it is by Russell and tailor this is a book that will give you lot of the fundamentals on various production systems and importance of those things. So, I would recommend you guys to read this book as a part of the problem. So, this is a recommended reading all right.

So, the production systems as we said earlier it is a you know you have a black box called transformation process and here you get the finished good here you get the raw material raw material goes into a transformation process to get the finished goods. So, the transformation process depending upon the product that you are going to produce the product that is chosen to some extant not some extant to large extant actually large extant determines the production system or what we are talking here is the product characteristics requires different production systems depending upon the characteristics of the product this product characteristics it to a large extant determines what the production system to use what production system to use ok.

So, standard products when people talk about standard products, it is like you know very is an automotive those kind of things or like we talk about it as toothpaste those kind of stock you predict to make to a make this stock production system where you actually produce in large large quantities and stock. So, that customer can buy when needed. So, it is unlike that you go to a shop and say well I need a toothpaste and then there is a oh you need a toothpaste give us an order we will produce one and send it to you in like 10 days nobody does that, you go there give the money pick the toothpaste go home. So, the make to stock system which is standard product toothpaste is a standard product everybody knows go buy the toothpaste whichever you want you like. So, that is the situation where they produce an stock and people just buy and use it. So, that are productions is large volume quite large quantity and make it an stock it with you ok.

Whereas custom products the other hand is a different story, custom products they are pretty much make to order or assemble to order production system an example of this is high end cars like rolls Royce they Do not make rolls Royce and just keep it on the shop floor like a. So, here you can think about Maruthi 800 is you know make to stock system whereas, Rolls Royce phantom is definitely not a make to stock it is a make to order. So, you go there and say I want to buy a rolls Royce then they will say fine what are your specifications ,what is your color, what type of leather, what should be the engine stuff what are the other paraphernalias you need do you need a refrigerator do you need ipad all those kinds of weird things you will probably get a like thousands of choices and you pay all those thousands of choices you pay the money calculate whatever it is you pay the money and then you wait, wait because then once you pay the money then the production starts.

So, once customer pays the production begins, these are meant for highly customized products it is further discussion of the customer it is not a standard product so; obviously, the main difference between custom products and standard products are custom products are usually very expensive when compared with standard products. For example, you could get may be a Maruthi 800 or something now I do not thing no longer Maruthi 800, I think its alto or something like this you will get for two to three lakhs whereas, a Rolls Royce it will run to 2 to 5 crores that will be difference so ok.

So, custom products are usually more expensive and depending upon what you are trying to make whether you trying to make a custom product or a standard product, your production system decisions will change.

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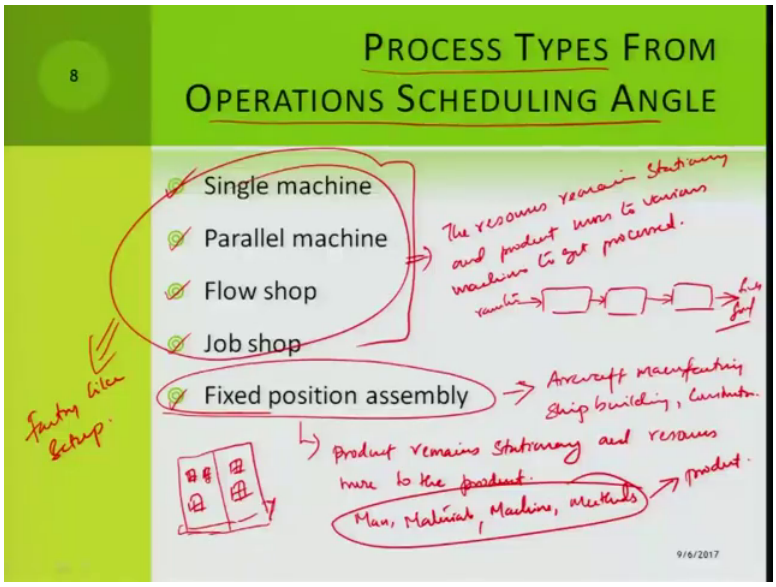

So, the production types from the operation scheduling angle mostly when we talk about processes when we are trying to do the operation scheduling or when we are trying to build the factory model, we need to look into these aspects the number one we look into single machine then the parallel machines flow shop job shop fixed position assembly. So, this we will not spend too much time on this because this is more like you know aircraft manufacturing or ship building or construction etcetera. The major thing here is that the product remains stationery and resources move to the product. So, the man materials machine methods everything all these move to the product and product remain stationery where as these guys the resources remain stationery and product moves to various machines to get processed. So, that is the major difference between these two setups. So, here you are saying that you are going to build this building something like this you have a building.

So, the wood windows all those kinds of things will move to this place wherever it is bricks cement everything moves to this because you cannot really it is not really very easy to move a big building like this. So, this is a fixed position layout whereas, in this case you have various machines lined out like this the products moves from one

machines to another. So, that (Refer Time: 32:05) are the raw material and comes as a finished good ok.

So, the idea, so what we are going to look into in this course is mostly these aspects, because these are the ones that creates what you call as a factory like setup it is imperative for us that we learned what are these things in a much better fashion. So, we will take one by one and go from there.

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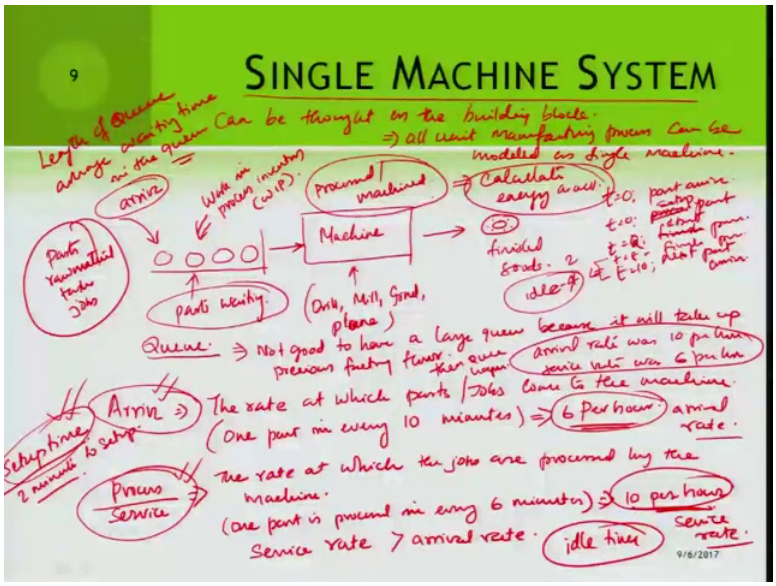

So, the first one you will talk about is a single machine system, which is the building block single machine system can think about it as can be thought as the building block which means all unit manufacturing process can be modelled as single machine. So, if you think about it in a schematic fashion a single machine system is something like this you have a machine, this machine could be anything it could be you know it can be a drill a mill grind plane whatever you want to call it there are many any of them can be modelled like this way and then what you have is you have parts or raw material or tasks or jobs either one all of these things you can call whichever you want to call as we will talk about much more detail and they come in to this machine and they come and wait.

So, this is individual parts waiting and then one the machine is free it gets processed and then the finished good move moves out of the machine. So, the major aspects of this is the parts arrive they wait in a queue then they get processed or machined and then they leave. So, there are couple of aspects that we need to look into this. So, the place where

the parts are waiting this is typically called as queue, the concept of queuing gets used in any manufacturing.

So, this queue if you have too many parts waiting here then that is also called as not good to have a large queue because it will take up space take up precious factory floor. So, this kind of a lot of items waiting there, this is also sometimes called as work in process inventory or commonly known as WIP. So, the parts they come another concept is the arrive. Arrive means the rate at which parts or jobs come to the machine. So, if I say that one part in every t10 minutes is an equivalent arrival rate of 6 per hour. So, I will say that parts arrive at the facility at the rate of 6 per hour. So, this is called as the arrival rate. So, this determines how quickly how it.

So, every 10 minute you get a part. So, now, the other one is the process, process or what we call as you can think about as service process or service. What happens is the rate at which the jobs are processed by the machine this case this is called the machine. So, I will say that you know I can say one part is processed in every 6 minutes, if I say that I can say that I can pretty much do what 10 per hour. So, this is called as the this 10 per hour is called as the service rate ok.

So, if your service rate is higher than arrival rate. So, ideally what happens, you can you really take minutes to process something and parts arrive in every 10 minutes. So, if you look at it at time t equal to 0 1 part arrives part arrive machine is free. So, immediately t equal to 0 process part t equal to 6 finished process then t equal to 10 next part arrive this means there is four minutes of the time where the machine is idle time. So, the concept of idle, idle means the machine is not doing anything you staying not doing any job. So, the concept of idle time is also part of this. So, the arrival rate the rate at which the part arrive to the system the service rate or the processing rate the rate at which at which it actually processes those kind of things.

So, one other aspect also is that we can say that fine there is also something called as a setup time you can consider separately. So, we can basically say that we can say that takes 2 minutes to process to setup. So, then you can think about here it will be like part arrive t equal to0 instead of process it will be setup part and t equal to 2 start process then t equal to 8 finish process then you have an idle time of 2, these kinds of concepts. So,

the understanding these aspects of a production system the single machine is the best way to go over there ok.

So, the concept whichever it is even it is multiple machines, the arrival is a phenomena that we need to model at what rate the parts or the raw materials arrive into the system that is the first thing. Second one is the service rate or the processing rate the rate which what is the rate at which we can process the part that have arrive at the system that part then comes the setup how much setup time is required for that.

Then once you know the, if this times were the other way round if the arrival rate was let us say 10 per hour ad service rate was six per hour then you will get something called as a queue then queue happens then aspects of the queue like length of queue average waiting time, time in the queue all these aspects are studied at that point. So, this is the concept that the basic single machine allows you to model the unit manufacturing processes as I said earlier and it allows you to study the various aspects of the system. So, in this if you can measure out what is a processing time clearly then you can calculate energy as well. So, you might now get an idea that if by breaking down the entire factory into unit manufacturing processes we would be able to measure finer aspect of the system ok.

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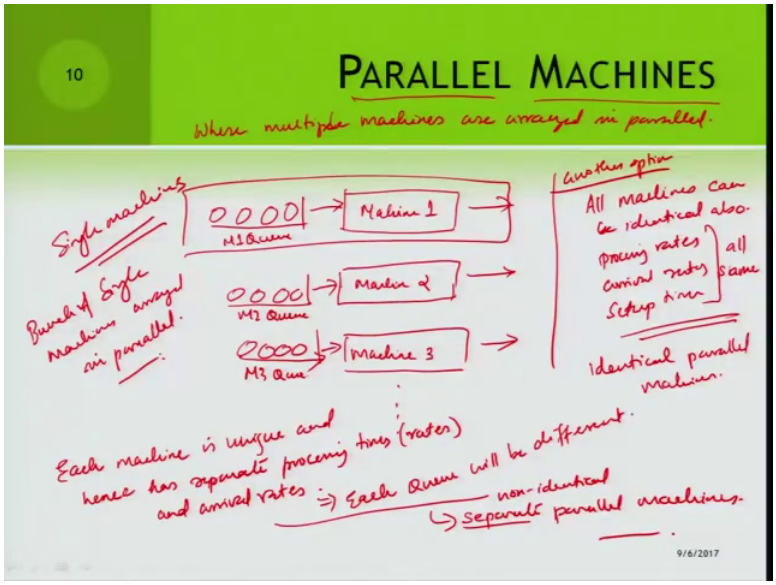

So, then; obviously, if you there is one machine there can be multiple machines also. So, in one setup parallel machines another setup that we talk about is where multiple

multiple machines are arranged in parallel. So, here an example would be this is a machine 1 machine 2 machine 3 like this and each machine has its on queue. So, m 1 queue m queue m three queue and the products come out of this this is also another setup.

So, the parts arrive here and then they get processed here say various aspects if you can consider is each machine is unique and hence has separate processing times or rates and arrival rates so; that means, queues which means each queue will be different it can also be a situation where you can say that all machines another option all machines can be identical also so; that means, processing rates arrival time arrival rates, all same setup time these are all part of they are all same. So, this kind of a setup is called as identical parallel machines, this setup what we just discussed is called as not identical is separate called parallel, this can also be called as non identical parallel machines right. So, if you look into this we would have a scenario we can study again it is we can see this by in itself is a single machine concept. So, here is a bunch of single machines arranged in parallel that is one way to look into this all right.

So, now, after this we will look into the concepts of flow shop and job shop, but I think what we will do is we will take a short break here and then we will join for the rest of the session.

Thank you.