Sustainability Through Green Manufacturing System: An Applied Approach

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Lecture – 14
Basic Modeling Concepts for Factory Simulation Continued

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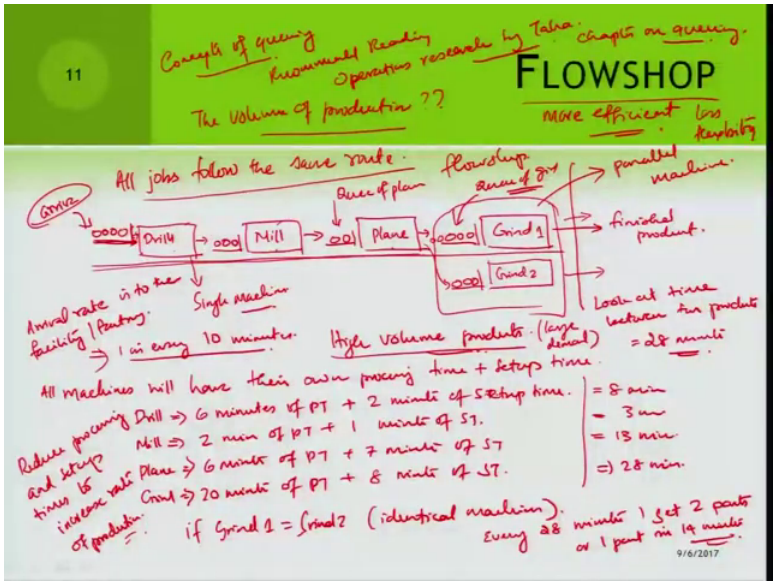

Extrapolating the concept of the single machine to parallel machines from there; now, let us look into something called as a flow shop. So, the flow shop is, there is lot of things that talk about the volume of production, based on which what is this, and how much based on which setup to be used, but here we are going to look at from the layout view point. So, flow shop is a system where, all jobs follow the same route.

So, the machines are arranged in the order of flow. So, think about it as drill, mill, plane, grind something like this. So, then the raw materials arrive here. So, you can think about that there is a drill machine there is queue here. So, arrive, then the milling machine has it is queue. So, once drilling is over, they will join the milling machine queue, from it is over then it will go to the plane. Then from plaining once it is over, it will go to the grind. once grinding is over, the finished product comes out of this. So, they arrive here, we will say that arrival rate is to the facility or factory. So, you can say that, all these things the drill, the mill, plane, grind, they will all have their own all machines, will have

their own processing time plus setup time. So, for example, you can say that drill will take 6 minutes of processing time plus 2 minutes of service time or setup time.

For mill, it could be 2 minutes of PT plus 1 minute of ST plane can be 6 minutes of PT plus 7 minutes of ST, and then grind can be 20 minutes of processing time plus 8 minutes of setup time, something like this. So; that means, if we look into it, and someone says that the parts arrive at the rate of 1 in every 10 minutes. Then you can think that every 10 minute the part will arrive. So, the drilling machine will finish the drill in 6 minutes. I mean 6 plus 2 8 minutes. So, this is 8 minutes, this is 3 minutes, this is 13 minutes and 28 minutes. So, the parts arrive in every 10 minutes. So, they will keep on arriving drilling machine keep on drilling in every 8 minutes, and then move to the milling machine. It will finish in 3 minutes and then move to the plaining machine. So, pretty soon you will see that when it comes to the grinding machine. The queue will increase, queue will be longer, because it takes lot more time. So, if you stand here at this, and look at time between 2 products; we can see it has 28 minutes, because once in every 28 minutes you will see one part coming out, because such when the grinding machine is finished; that is when the part comes over here.

So, now you know that fine the grinding machine is slowest in this case. So, what can I do, can I put one more unit of grinding machine. I can say grind 2, this can be grind 1. So, from here it can go to either one of the grinding machine. So, then I can, if both the grinding machines are identical, let us say if grind 1 equal to grind 2, means identical machines, then I can see that, in every 28 minutes. So, every 28 minutes, I get 2 parts, or 1 part in 14 minutes. So, that is. So, here you can see that, this kind of a setup this whole thing, where all jobs following the same route, is called as a flow shop, and here you can see I added account set of additional 2 machines, which is called as a parallel machine. So, factories are built like this. Factories are built, these are all single machines. So, you start with single machines, and then you integrate single machines in sequence, and all jobs following this 1. So, here you can see that, when everybody follows a same sequence, it becomes, it is easy to call it as a job rather than a task, because at the end of the day you get a same product. So, this kind of a setup is typically used for high volume products. So, your aim will be to reduce this processing time; so, here the aim, when you have to produce large quantity, high volume product which means large demand.

If the product has large demand, it is better to set it up in the form of a flow shop or a pretty much what we called as a line, you know production line kind of a system. So, this people call it as a flow line or a production line also is called this way, and it can go in a much longer fashion as well. Then your aim is to you know do reduce processing, and setup times, to increase rate of production. So, that is what we will call as the. So, in this case in our course, we would be studying quite a lot based on a flow shop like system, because it is important, that most of the factory is the large volume production factories high volume production, where multiple shift happens that is, where you can actually do the maximum amount of sustainable manufacturing initiatives, where you can reduce energy consumptions, reduce the coolant and all those kind of aspects.

So, this concept of flow shop is important for us in this particular course. I hope you these are all clear with this, and we can also see that the length of queues here. So, this is the queue of plane, queue of grind etcetera. So, these queuing concepts, the concept of queuing are also important. So, concepts of queuing is necessary, and I would request you to recommended reading for this case, reading is the book on operation research by Taha. Take this and read the chapter on queuing, read that and look at the simple examples you would be able to understand. I will try to come up with a one small lecture on the aspects of queuing. So, that you can actually, it will actually help you in understanding the concepts, but the detail readings, and how to solve those problems you are supposed to learn by yourself.

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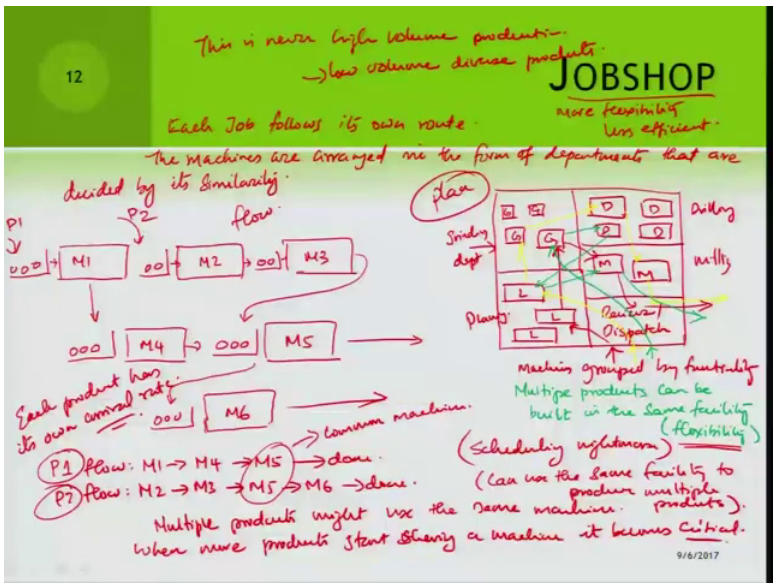

So, then comes the third concept called job shop, and job shop is like a, in a simple sense you can say that; each job follows it is own route; so, in this case, the example if I have to do this. The main thing is, the machines are arranged in the form of departments; that are decided by it is similarity. So, let me give an example in this case, let us look at a factory from the top, I will, kind draw it one side, because I can draw the other you know flow layout on the other side. So, if you look at a small factory like this. I can have let us say, G GG and G. So, this will become I am drawing here, like this way L LL transfer the lathe, and then you have D DD and D, this transfer the drill, and then let us say M and M transfer the mill. So, this will be your grinding department. This will be your drilling department, this will be your milling department, this will be your plaining department or lathe department, whatever you want to call it. You can see that the machines are grouped by their functionality. So, machines grouped by functionality.

So, if a part come into the system. So, here is the receive, dispatch. So, the parts arrive raw material arrives. So, one part will go to a lathe machine, then it will go to a grinding machine, then comes to a milling machine, and then it will come here, and it will go out. Another part will come in, and it will go to the; we will use a different color for. Sorry different color for this, so that it can be seen differently. So, another part will come here, and then it will go from here to the another lathe machine, from this lathe it will go to another grinding, then it will go to a drilling, from drilling it will go to milling, from milling it will come here and it will go.

Then the third part will be, it will come here, it will not go to lathe. It will actually go to grinding, then go to drilling, then from there will come back to lathe, then go to milling, and then it will get out like this. So, you can see that multiple products can be built in the same facility. This is amount to flexibility. So, if you look into this, you can understand that the main aspects of this job shop system is flexibility. So, if you look into the flow aspect of it, then you can have something like a, you know we can say, it is a grinding machine, then there is a lathe machine, then this is drill machine something like this. Then you have another machine lying out here, third machine lying out here, and another machine here kind of a thing. So, the products will. So, you can have a, you know machine 1 machine 2 machine 3 machine 4 machine 5 machine 6, I am just drawing it this way.

So, one product may come to machine 1. So, this has it is own queue. So, leave it to me, redraw this part. So, it will have it is queue and part will arrive here, and then it can go from there to machine 4, from there it can go to machine 5, and it can get out. Other part might arrive on machine 2, then will go to machine 2, then from there it will go to machine 3, and then from machine 3 it will come to machine 5. From machine 5 it will come to machine 6, and then it will get out. So, this is part 1 and this is product 2 or product either way. So, the product 1 flow, is M 1 to M 4 to M 5 done. Product 2 flow is M 2 to M 3 to M 5 to M 6 and done ok.

So, we can see that each job has it is own route, and multiple products might use the same machine. So, here an example is M 5, both of them uses M 5. So, here is a common machine. So, when more products start sharing a machine, it becomes critical. We can see that this shop has the issue of. So, typically we called this as a scheduling nightmare, is because it is not very easy to schedule a system in which all sought of have a surflows happen, but the main advantage of this is, it has, can use the same facility, to produce multiple products. So, you have flexibility, but you have a scheduling nightmare. So, hence this is never high volume production. So, these are low volume diverse products, and job shop is a common system also. Almost all the machining shops that we can think about are job shops typically. So, this is like the, you know the plan view what we talk about, and this is kind of the flow view, we can think about it.

And in between if a machine breaks down and all the hell bricks loose in the system. I hope you guys understand what I am talking about. So, that is like, in this case depending upon the product, each product has it is own arrival rate, and because of that your queuing is also a big mess, because it goes, depending upon what rate the systems are the parts arrive, your queue will also goes crazy. So, I hope that you guys are now understand the criticality of dealing with a job shop like system. In this course we are more interested in dealing with a flow shop like system, where things follow a unique uniformed flow in this regard, and this is much more, what we call much more efficient. So, the advantage of the flow shop is, it is more efficient, compare to the job shop, but it has less flexibility; that is a disadvantage.

So, as we said earlier, here it is more flexibility, but less efficient. So, then; obviously, whenever you have 2 extremes, you would try to see. Can I come across a scenario

where I can kind of merge both of them. Obviously, yes people are done that and some people call this as a batch production system.

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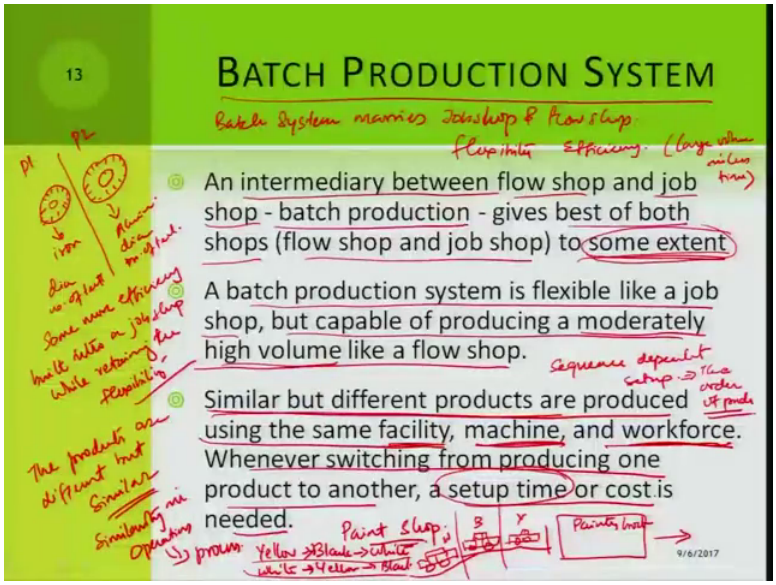

We will not spend too much time on this, because this is still complicated for understanding the concept of sustainable manufacturing, but you need to be exposed to a system like this.

So, batch production system, batch system marries job shop and flow shop. So, it is an intermediary, at the end of the day it is an intermediary between flow shop and job shop; that is called as batch production. Why do we marry this? It gives best of the both. What is best of the both? It is what you are trying to do is, flexibility and efficiency. So, efficiency means you can produce large volume in less time all right. So, you should understand that is the best of the both to some extent. This is the most important part. It does not mean that you will get all the benefits, the same exact rate, to some extent you will be able to get the benefit out of it. So, the batch production system, at the end day is flexible like a job shop, but is capable of producing moderately high volumes like a flow shop. The most important term was moderately high volume. So, you can, how some more efficiency, some more efficiency built into a job shop, while retaining the flexibility; this is the concept that we are talking about here.

So, what we would argue in this case is, we can say that, what happens in a batch production is similar, but different products are produced, using the same facility. You

have the same factory in which similar, but different products are produced. So, you might be producing, here we will like helical gears, but different diameter helical gears are used something like that. So, different products, but they are similar. The products are different, but similar. Similar means, similarity in operations or processes. So, the shape might look different, or some other performance characteristics might be looking different.

So, like for example, you are making the same; like let us a, this is a gear wheel, you are making the same gear wheel. My gear wheel drawings are horrible, but still I think it gets a point across. One could be of iron as could be aluminum, this is 1 possibility. Another is there diameter differs number of teeth so, but these are by 2 different products, is can be a product 1 and is can be product 2 easily, but they are similar, because at the end of the day they are both gear wheels.

So, in this case such kind of a system, similar, but different products are produced, using a same facility machine and workforce. So, the factory remains a same, the machines remain the same, the workforce remain the same, but what happens is when you switch from one product to another .Whenever switching from producing one product to another happens a setup time or a cost is needed. A classical example of this is a paint shop. I would like to bring here attention to this. So, if you have a painting booth, let us call this is painting booth. So, the cars are lined up here, my cars does not look like a car, but still kind a gives you the dumb idea.

So, the cars are waiting to be painted, and the painted cars get out. So, here what happens is, you will have a car that is, this car should be painted yellow, this car should be painted black, then there is a car that comes at the back that should be, this should be painted white like this. So, cars are waiting to get painted. Now here the problem is, once the you paint the car with yellow, you need to change over the color to black. So, the changeover of the color, changing the color from black to yellow, yellow to sorry, yellow to black, black to white, it creates a problem; that is where a setup time, because we need to clean the nozzles and everything.

So, it would have been nice, if the painting was currently it will be yellow to black, to white. This is the painting sequence. Whereas, if was been white, yellow, and black, then you would have resulted in much lesser setup time, because flushing the nozzles and

everything with a after black paint or white paint, is quite time consuming, than flushing from yellow to black or white to yellow. So, it is usually better to paint from lighter color to a darker color. So, this kind of a setup, this is called as sequence dependent setup. The sequence dependence setup means, the order of production determines how much of the setup time is used.

So, in a batch production sequence dependence setups do take a significant stuff on this, but that is outside the ambit of this course. So, we would rather like not to spend too much time on it, but you should know that there is a option like this. So, then now, that we talked about the concept of sequence. So, let us see what is sequencing, and then we will kind of conclude after this, and then we will move towards optimizations in the next lecture.

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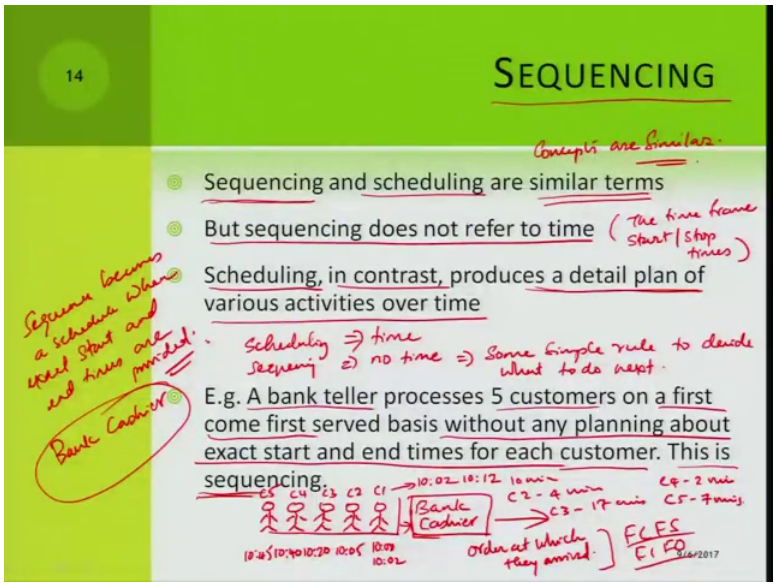

So, sequencing and scheduling, when we have been talking about schedule. Schedule is that allocation of resources over time, and sequencing is also something, but they are similar. The concepts are similar. The major difference is sequencing does not refer to time. The time frame or this start stop times, are not part of the sequencing. So, that is a difference between sequencing and scheduling. In scheduling, in contrast produces a detail plan of various activities over time. So, scheduling considers over time, sequencing does not considers the time. So, scheduling has time, sequencing no time, or some people we can say that some simple rule to decide what to do next.

So, this is a sequencing. So, what we talked about here is, here is an example for you; a bank teller, a bank teller in another way to talk about is a bank cashier. The cashier processes 5 customers on a first come first serve basis. The first come first serve means, the person who comes with. So, like if you think about this as the bank cashier. There are 5 customers; 3 my stick figures looks like human beings. So, this is customer 1, customer 2, customer 3, customer 4, customer 5. So, this guy came at 10 a.m. This guy came at 10:05, came at 10:20, 10:40, 10:45 something like this, and here is a cashier, and processes the customer in the order, order at which they arrived. So, here, even if they, it does not matters, even if they came at 10:02 does not matter, customer 1 will be processed. So, this kind of a system, where the order in which they arrived, is processes called as a first come first serve, or first in first out. These are the terminologies that is used.

So, there is no planning, you basically say whoever came to the queue first, will be processed first. So, without any planning the exact start and end times of each customer. Customer came in, whoever came first gets processed first. This kind of a mechanism is called as sequencing. You can see that, still you know this guy is processed first, there is some point. Once this processing is over, we can say this customer was processed from 10:02 to 10:12. So, took, you know customer 1 took 10 minutes to process, and customer 2, it took 4 minutes to process. Customer 3, it took 17 minutes to process. Customer 4, it took 2 minutes to process etcetera, customer 5 it took 7 minutes to process something like this. So, each customer can have take different time, but the order in which they are process is, that order in which they arrived into the system. So, whoever came first was processed first.

So, given such kind of a system is what we called as a sequenced, just a sequencing system not a scheduling system. A sequence becomes scheduled when you do a time frame, sequence becomes a schedule, when exact start and end times are provided all right. So, that is what is all about. Now I guess with this, we have covered sufficient concepts to learn the aspects of manufacturing, especially moving towards sustainable manufacturing. We have seen; what are the difference ways, we can actually create models of various manufacturing processes, depending upon the layout and as well as a process flow.

And how the single machine concepts can be elaborated to do a parallel machine, flow shop, job shop, and what is a batch production, and what is scheduling sequencing that aspects. And we also talked about arrival rate on those kind of stuff. In the next class we will look into some other basics distributions that are used in different manufacturing processes. Then we will look into optimization and then other aspects of supply chain as well. So, I hope you guys are enjoying this course, and we will see you next time.

Thank you very much.