Production and Operation Management
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Lecture 56
Manufacturing Operations Schedluing-1 (Scheduling and Gantt Charts)

Welcome friends. We have discussed various topics in our previous sessions, and if you recall, in one of the sessions which were mainly focused on facility layout, we discussed the issues related to balancing of the layouts. We discussed that how the layouts which are product focused where we have a fixed sequence of operation.

We discuss the concept of line balancing that how different work centers are designed in such a way that we have combined the task to a particular work center, so that almost all work centers give output at the same rate, so that you have the maximum possible efficiency of that work line and there is no idling of workstations and there is no starvation at any particular workstation. So, that we discussed primarily with respect to product focused layouts.

Now, similar to that in our process organizations where things are like job shop, we do not have a fixed sequence of operation, but scheduling is important issue in those cases also, rather scheduling is a very complex exercise in case of a process focused organization. So, in this particular session, we are going to discuss the scheduling which is primarily focusing on the process focused organizations and the title of the session is Manufacturing Operations Scheduling.

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Now, as I am saying that it is largely a process focused system which we are going to discuss and in that process focus system, we all know that our organizations are like job shops, where in a job shop the characteristic is that the work centers or departments are organized around similar type of functions or departmental specialties. Like all drilling machines will be at one place, all milling machines will be at one place, all lathe machines will be at one place, all painting activities will be at one place, all fabrication activities will take place at one particular department.

So, on the basis of similarity of operations we divide our entire layout. So, that is the typical characteristic of job shop and because of this particular characteristic job shops offer huge flexibility, these are very much suitable for flexible manufacturing systems. So, whenever we are talking of FMS, Flexible Manufacturing Systems you will see the job shops are the kind of layout arrangements in those organizations.

And in these cases, jobs are usually processed in batches. So, you have the quantity of production as per the order size, as per the customer demand. So, if customer is requiring in the batches of 100 units, 200 units or sometimes your EPQ decisions, so EPQ, that is Economic Production Quantity or customer order, these are the two criteria we use to decide the size of batches. So, once you are processing one batch, then you are processing another batch, then you are processing another batch.

And as we are knowing that these process focused manufacturing systems offer the advantage of a huge variety. So therefore, the scheduling of operations become a very complex activity because one particular job or one particular batch has finished from one particular machine then another batch is coming, then another batch is coming, so how you are scheduling these different batches so that your overall time of changer over, your overall cost of processing should be minimum.

So, these are the important criteria whenever we are talking of process focus manufacturing scheduling activities. So each job, as I have already discussed, that each job follows a particular route through various work centers and it is also not necessary, it is also not necessary that each job or each batch follows all the work centers. Some of the work centers may be skipped in a particular batch, some of the batches may use all the work centers.

So, depending upon what type of plan is given to you, what type of specifications are there accordingly route is decided. Job shops usually go for push system of production, planning, and control. This is very, very important. In our inventory control if you remember, we have already discussed the concept of JIT, we have already discussed the concept of inventory minimization.

And in that we discussed, that how things are normally designed on the basis of pull system. The kanban system you remember, we have discussed many a times. In kanban system, the entire production planning is done on the basis of pull philosophy that the station which is at the downstream now there is a need of work, there is a need of some units at that downstream station, so that downstream station gives a signal that I need products and when that green signal is there, then only products move from previous station to the down station.

So, that is the pull system in most of our kanban activities. Here in the job shops, it is a push system of production planning control which is opposite to that kanban system. Here, because of the requirement of operations to be performed on a particular job, job moves from one station to another station, then to another station, and then to further downstream.

So here, there is a fundamental difference between our other approaches which we have already discussed and the scheduling approach which we are going to discuss today, that the kanban system of inventory management that is based on the pull approach, that downstream items are pulling the items from the upstream. But in the case of this scheduling activity, we are thinking

that the entire operations are arranged, managed on the basis of push system where items are being pushed to the next stage. So, that is the fundamental difference between our kanban system and this manufacturing operation scheduling activities.

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Now, when we are doing these scheduling activities particularly the process based scheduling activity, what are the pre-production planning activities, and there are two main pre-production planning activities.

One is, the designing the product in a customer's order. According to customers order you have to design; you have to specify the process to be performed in that particular product. And then planning the network of work centers, which the order must pass before it is completed, that there may be let us say works center 1, 2, 3, 4, 5, 6, 7, 8. So now, order 1 is there and order 1 may pass through 1, then it need to go to 3, then it need to go to 4, then to 5, and that to 8.

This is the sequence of operation; this is the route which order 1 need to follow. The other order is 2. It is going from 1 to 2, 2 to 4, 4 to 5 to 6 to 7 to 8. So, 2 different orders are there from 2 different customers and maybe from the same customer, I do not know. But the 2 orders are following 2 different moves, 2 different routes from this job shop.

So each customer order, each customer order on the basis of design, which we are creating based on the requirement of the customer will have a unique path, will have a particular path and for

each order, there may be some kind of, there may be some kind of uniqueness in these paths. So, that is the pre-production planning activity in case of job shop. In case of, you remember the product layout, in case of assembly line, this type of route planning is not required because that is the case of repetitive orders and all orders follow the same path. So in that case, this kind of planning of the route before production activity is start not required.

(Refer Slide Time: 10:06)

Now, let us see what are the some of the common shop floor control activities. In case of scheduling activities, what are the common shop floor control activities And these are the production control department controls and monitors order progress through this shop and how this progress is monitored, what are the different tools, techniques which are used for monitoring the progress.

So first is, assigns priority to orders. Depending upon who is your important customer, who is your less important customer, so many places you must have seen that priorities are given to different customers. So, like in a bank, if you are a regular customer to bank, you are giving huge business to a bank, so bank will give high priority to your requirements. If you are not a regular customer to a bank, you are visiting bank once in a time, so you may not get that kind of priority.

So, in our airlines, so systems like frequent flyer are there, so you join some special clubs of those banks, those airlines. And then you get additional benefits some kind of priority in the

boarding, some kind of priority in getting the seat of your choice, so these kind of priorities are given to the orders based on the customer.

Then issues dispatching lists, then on the basis of priority, you decide your dispatch list, that in this particular month, in this particular week, in this particular day, what type of items, who are the customers who are going to be receiving their products in this particular time duration. So, that is the second important thing. First is priority to the customer, priority to the order. The second is preparing the dispatching list.

Then third is, to track work in process. WIP is, Work In Process and keeps systems updated. This is also very important that we always want to keep our WIP as minimum as possible because this is a cost to the organization. So, you should keep your WIP as minimum as possible. So, you need to have a regular tracking of the WIP, that how much inventory is there in the processing stage.

Then controls input output between work centers. Every work center is having some input on a particular duration, and every work center will produce some kind of output in a particular duration, so there may be some kind of difference between desired input level and desired output level. So because of that, there may be some kind of inventory accumulation or inventory starvation at a particular workstation. So, we prepare the workstation label input output controls for all the workstations, so that you know that in future where that inventory will be piled up and where there will be a situation of starvation.

So, that is another important type of control. And then we finally, calculate efficiency, utilization, and our productivity of the job shop. So, that is the ultimate measures that how productive is my job shop, so that my machines, my all equipments are properly utilized. If we do not have a proper scheduling, it is quite possible that there is enough lateness in your orders because in a job shop it is a very important ability of the supplier, it is a very important ability of your company to guarantee a particular delivery date to your customer.

But if you do not have a proper system of scheduling then it is high chances that every time you will overshoot your delivery dates and that will result in customer dissatisfaction. So, it is important that you have a good system, you have a high productivity of your job shop, so that you can meet the delivery dates.

Otherwise, you yourself will not be sure when the products will be ready. If you have a proper system of scheduling, if you have a proper system of all the things, then only you know that when the products will be delivered and then only you can have a good customer satisfaction level. So, the ultimate objective is true efficiency utilization and productivity to get high customer satisfaction. So, that is the final objective of this particular exercise.

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Now one of the activity, we discussed in our various activities in the scheduling is the input output control. Now input output control is a very simple but very important, you can say way of controlling the progress of your shop floor. Now, this input output control is a very important activity that allows operations manager to identify small problems, such as insufficient capacity, excessive capacity both are undesirable because insufficient capacity you will be delaying the supplies.

If you have excessive capacity your productivity, your efficiency level will be lower because then your capacity remains idle. And then production difficulties among a group of connected workstations. So these things can be highlighted with the help of your input output control. Then the input output control report compares planned and actual input, planned and actual output, and planned and actual work in process in each time period.

The time period can be a particular day, it can be a particular week, it can be a particular month. Normally, normally in most of the cases of PPC this time period is generally in week. Normally, we take this time period in which we control this input output system that is in week.

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We have one example also available with us which can help you to understand that how this input output control report looks like. Now in the beginning, we have 70 units as the, from the previous period that is, you can say week minus 1. Now from this particular period you have seen that the plant input for the, and all these are given in the labor hours. And this LH also means, Labor Hours. So you have, this is the input, this is the output, and this is work in process.

So, you can understand that how much deviation is there in the input category, how much deviation is there in the output category, and how much is the ending work in process at the particular period. So, you can see that work in process ending here, it is 0, here it is 10, here it is 20 labor hours. So, that much labor hours, so this is about the capacity that this much capacity is you can say not used.

So, that is how you can understand that how much input is going to come as per actual and as per planned, how much output you are going to produce. And as a result of that, how much WIP is available at your particular workstation. So similar type of input output reports can be prepared for all the workstations in your system.

Then another important issue is assigning jobs to various work centers and how many jobs at a particular day, at the particular work center you can assign. And for that purpose, there are two types of loadings which you can do at your workstations. One is infinite loading that means assign jobs to work centers with without considering the capacity of those workstations; that you are assigning jobs without understanding, without giving any regard to the capacity of that particular workstation. For an example, we are making telephone calls. And now there is a particular tower around us through which our mobile is connected.

But since, we all who are making the mobile calls do not know what is the capacity of that tower and all those who are making calls are disconnected. So, we are making calls without giving any regard to the capacity of that mobile tower that what is the bandwidth of that particular tower. Therefore, sometimes what happens we get a very good quality of call, our calls are immediately get connected if the tower has some additional capacity.

But if tower does not have the additional capacity, our calls maybe dropped may not get connected, it may be in the queue for some time. So, that is example of infinite loading. So, unless excessive capacity exists, long queues will occur; in case of infinite loading. So, if infinite loading is there then long queues are there. I can take an example of Indian hospitals also. In various government hospitals we have excessive loading.

It can be under the category of infinite loading. So, large number of patients, daily visit government hospitals in OPD and irrespective of the capacity of that hospital to handle a particular number of patients in OPD, we find long queues that is because of infinite loading system. The finite loading system, it uses work center capacity to schedule orders; that in a particular hospital, when we say that doctor will see only 20 patients in 3 hours, only 20 patients in 3 hours.

So here we know that, it is having a finite capacity that doctor is going to sit in the morning for 3 hours, in the afternoon for 3 hours, so total 40 patients that doctor is going to see in a particular day. So, it is now becoming a case of finite loading. So, same doctor, when the doctor is in a government hospital, here doctor's capacity is considered to be infinite, that any number of patient that doctor can see in a particular shift.

And therefore, what happens that doctor just spends less than a minute time with a patient, 30 seconds, 40 seconds. Patient is not able to sit properly, but doctor prescribes. So, that is happening in case of government hospitals in India, because of infinite loading kind of arrangement. Finite loading, the capacity is considered to be fixed and only on the basis of that you will assign, you will schedule the orders.

And here you follow some kind of popular scheduling approach, we will discuss that. And this is the integral part of capacity resource planning, CRP is, Capacity Resource Planning that how much capacity you have accordingly you are going to schedule the activities. So in fact, the whole scheduling activity is important when we are considering the finite loading. If we are going for infinite loading, it will have lesser meaning for the whole exercise.

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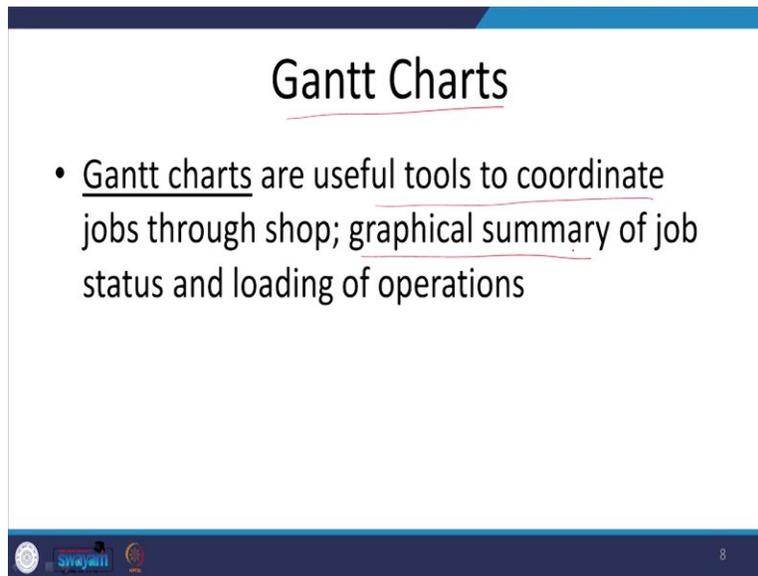
Then another important activity, another important tool in the case of production planning control, that is Gantt chart. We have already discussed about Gantt chart in our one of the earlier discussions also, particularly in the project management that how are we going to control the performance of the projects.

So, Gantt chart are very useful tool and now with the help of graphical summary or the visual display of various activities of the project, various activities to be scheduled you get an idea that on what particular day, which type of activity will be loaded on a particular machine.

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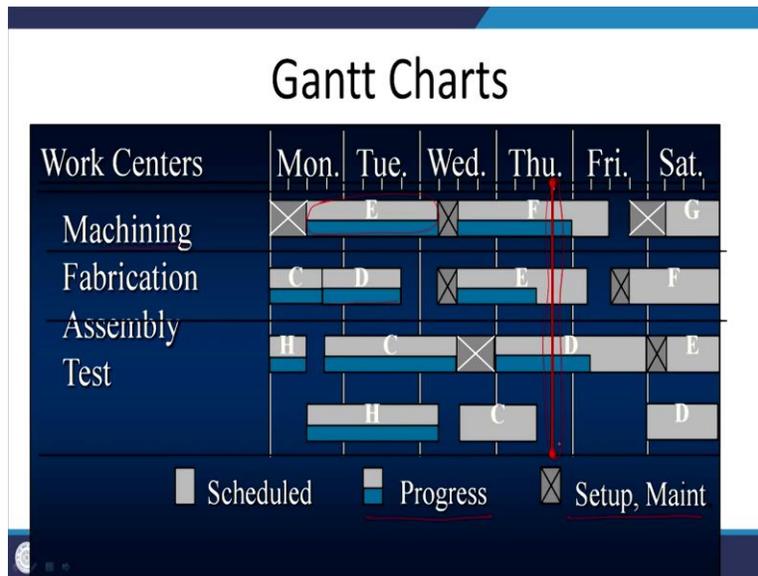
So, a kind of example is there. Here you see, that different type of activities are there and these are the different machines centers, work centers where machining, fabrication, assembly, testing, etc. is being done.

And you see, that on Monday there is no schedule in this particular case it is under the setup or maintenance. Then from Monday afternoon to Wednesday morning, this particular E activity, E job is on the process, and then in the Wednesday again the setup and maintenance will take place of the machining activity, and then the F job is going to happen, and so on in this way you have all these things.

Here you see that in the friday afternoon, in the friday afternoon there is no scheduled activity, in the friday afternoon there is no scheduled activity and it is empty space at this place. Similarly, you can see in the fabrication that from monday morning to monday afternoon, the job C is in progress, and then job D is in progress. So, there is no setup required in between C and D. The same setup can help in performing the C and D job, once you finish C you can start D.

And that, therefore you can see in the fabrication line also that how various activities are taking place, various activities means various jobs are scheduled in the fabrication work center, similarly on assembly work center, the testing work center So, these are the different activities which are being scheduled on these different, and on a particular day, like I have drawn a red line

on thursday. Today is thursday, and I am seeing whether these things are happening on thursday or not.

So, I can just check that on Thursday, okay the F job must be in progress here. At the fabrication the E job must have finished in the thursday morning and now it is under some kind of scheduled maintenance or schedule activity. And at assembly, the D work is in progress and for testing there is no scheduled activity at this moment. So, that is how you can have a very good control on your activities with respect to various work centers and over a period of time.

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Then, assigning jobs to various work centers which jobs gets built first. So, now we are going to decide the priority of the jobs at different work centers. So, there are two approaches which are possible, one is forward scheduling and the other is backward scheduling. In the forward scheduling, jobs are given earliest available time slot in operation. And normally, it may result in to a very heavy amount of work in process inventory, because as soon as jobs are coming, you are giving them earliest available time slot in the operation.

So, you do not follow any other kind of logic and it normally results in a huge pileup of inventories. The backward scheduling start with promise date, that which job is going to be delivered first, so that job becomes your priority. So, start with the promise date and work backward through operations reviewing lead time to determine when a job has to pass to each operation.

And it normally results in to less work in process, but must have accurate lead times, that how much time it is required to make a particular job. So here in the forward scheduling, as the orders are coming, you are putting those orders into the operation, whether the delivery is required tomorrow or after 1 month. And maybe, if it takes only 2 days to process, then it is going to be there in your warehouse for 28 days because the customer wants that product at the end of 1 month.

So, backward scheduling says that you start processing those orders first which are immediately required to be delivered. So, first you produce those items and that calculation must be based on the lead time, that how much time it is going to be taken in the processing.
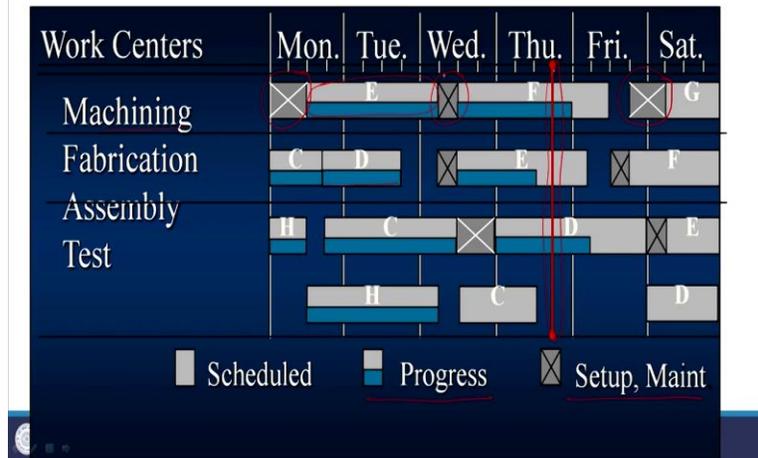
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And based on that, based on this particular aspect, that forward and backward scheduling, our important issue comes that is order sequencing problems, that orders sequencing problem, that what are the different types of sequencing rules we have.

So, we will discuss in one of our next session that there are different types of sequencing rules like first come, first serve, another is shortest processing time, then another is critical ratio. So, these are some of the popular sequencing rules through which you can sequence your various activities, your various orders. Then you find some type of criteria that which particular criteria like efficiency, productivity, average lateness, these are some of the criteria through which you can evaluate these different sequencing rules.

So maybe the productivity, average lateness, average idleness, all these are the different type of criteria which you can use for evaluating the performance of your sequencing rule. Then you compare these different sequencing rules based on these criteria.

And then you also need to control the changeover cost because you are producing multiple variety and A, B, C, D, E are the different types of products. And when you are shifting from product A to product B, there may be some changeovers required.

Like in the previous diagram Gantt chart, we saw that some changeover is taking place here, some changeover is taking place here, in the machining, some changeover is taking place here also. So, these changeovers are involved with some cost. Because you are changing the dies, you

are changing the tools, you are changing the jigs and fixtures, so all these changes may require some investment. So, you need to see that your changeover cost should be as low as possible. You need not to go for major changes with respect to these change of products. And then you also need to see that you have total production time as low as possible.

So based on all these issues, we will have a particular type of sequencing output which will help us in achieving the best results with respect to criteria. We should minimize our changeover cost and we should also minimize our total production time. So, with the help of some numerical example, we will see that how we do this kind of sequencing in our process focused organizations in our next session. So with this, we come to end of session. Thank you very much.