Operations Management
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Lecture – 42
Sequencing

[FL] Friends welcome to session 42 in our course on Operations Management and in the current week. We started our discussion in the last session on the production control as the major focus and we know that in production control. There are four important functions of operations management that have to be covered and in production control. We start with loading, then we have sequencing, scheduling and finally, the expediting operation or expediting function.

So, basically what exactly is production control? Once the orders are finalized, what has to be produced or the product that needs the manufacturing is identified the numbers are identified that this many number of products have to be produced.

We start the manufacturing activity with our planning of time; that is the scheduling part. The sequencing we have to do the loading that which particular machine will work on which particular product. For how long; who are the people? Who will be responsible for a particular product development process or product I must say product manufacturing process or job manufacturing process. So, calculating the people calculating the machines calculating the time and then putting everything into action on the shop floor will come under the production control.

So, we have to plan we have to execute as well as we have to cross check or verify whether our planning is going, as per schedule, as per requirement, as per the due date or not if we are lacking behind the additional function of expediting will come into picture. So, now, on we will try to answer these four words or try to understand these four words; that is loading sequencing scheduling as well as expediting.

So, expediting is comparing the performance and then pushing the effort. So, that we are able to match up with the due date or to catch up with the due date which is going to be effective or which is going to be the critical for the delivery of the products; otherwise the penalty clause may come into action or come into force.

So, today our focus will be sequencing; now in sequencing our target is that the waiting time of the jobs can be minimized the mean flow time can be minimized. We can see I will try to explain the waiting time and the mean flow time and we are able to justify the time that has been set for a particular set of jobs or we are able to meet the due date which has been set for a particular job or activity. So, our target will be to sequence the jobs in such a way that we are able to meet the due deadline for each and every job. Now, suppose a company is manufacturing 5 or 6 or 7 different products.

Now, for each product there may be certain requirements that product a is required in five hundred numbers product b is required in eight hundred numbers. So, we have different products different quantities to be produced and these have to be produced on different machines. So, all that operational may be management has to be taken into account the proper sequencing means the (Refer Time: 03:58) the proper rooting that what will be the route chart for a particular product and then on the for the product.

When the process starts whenever there is a decision to be taken that how to sequence the jobs in such a way where we are able to effectively match the due date for each and every product with each and every quantity; that is, what is the objective? Where we would like to focus our attention on?

So, today we will study sequencing we will try to see that what is the criteria based of? Based upon which we can sequence the jobs, but prior to that if you remember in the previous session. I have just shown one Gantt chart towards the end which is also the loading chart many times different types of Gantt charts. You can see in which we can have different workers or we can have different machines which job is scheduled on that machine for how long all that can be represented, then that can be called as a loading chart and we will start our discussion today with the loading or the concept of loading.

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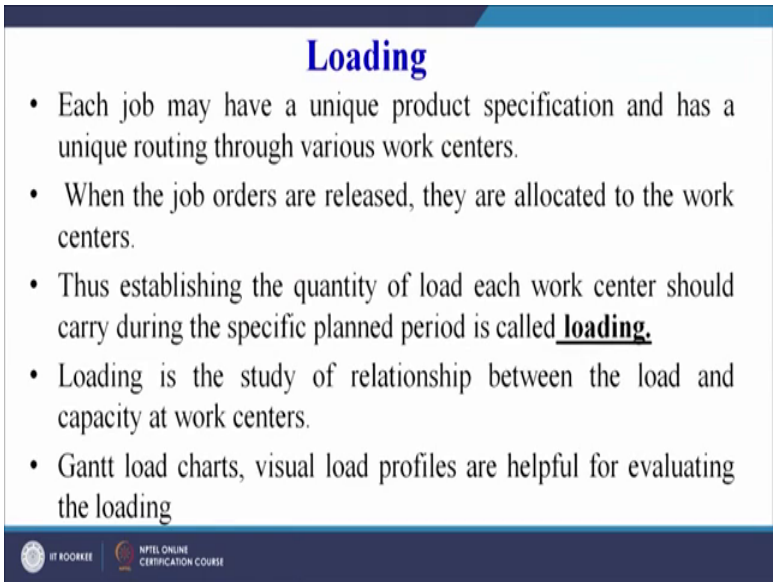

So, as you can see on your screen each job may have a unique product specification and has a unique routing through various work centers. So, if you remember in production planning and control or in the very beginning of our operations management course. We have seen that there are different functions, that have to be achieved and routing is one of the important functions; the each product which has to be manufactured in an organization has to follow a particular route.

So, the route may be the different departments or the different sections or the different shops that the batch of product has to follow in order to be processed into the final product.

So, that route chart may be different for the different products, when the job orders are released which means that we have now two things available with us that which product has to be produced and, in what quantity it has to be produced? So, once we have this information it is allocated to the work centers where the actual manufacturing will take place; thus establishing the quantity of load each work center should carry during the specified planned period is called loading.

So, we have to decide on the loading of that various machines depending upon the capacity of each and every work center that, how much work should be allocated to a particular machine, to take advantage of the capacity of that machine or to take advantage of the full capacity of that machine and that is basically the calculation that we

do and when the work is assigned to a particular machine we call it loading of the machine.

Similarly, maybe in a any educational institute, suppose 20 different courses have to be offered to the students and there are maybe 20 faculty members. So, there will be a load distribution of each course to one faculty member. So, one faculty member one course so, we call it as a load allocation of teaching among the various faculty members.

Similarly, on a shop floor we have to allocate the complete load or the complete requirement that has occurred or that has come to their department in the form of a purchase orders. So, that has to be distributed among the machines and similarly the work can also be distributed among the workforce or the manpower that is available on the shop floor. So, that will also be called as loading only.

So, the establishing the quantity of load each work center must carry during the specified planned period is called loading. Loading is the study of relationship between the load and the capacity of the work center. So, we will try to take advantage of the maximum capacity of each and every work center that is available at our disposal Gantt load charts visual load profiles are helpful for evaluating the loading.

So, in the previous session if you remember the last slide was on a Gantt load chart only. So, similar type of Gantt load charts you can see in on different sources in different books and you can see that how a pictorial representation? How an graphical representation can help us to do better planning of our operations on the shop floor.

So, this is the basic understanding of the loading process. Now, coming on to the sequencing part so, what is sequencing? So, when a job compete for work centers.

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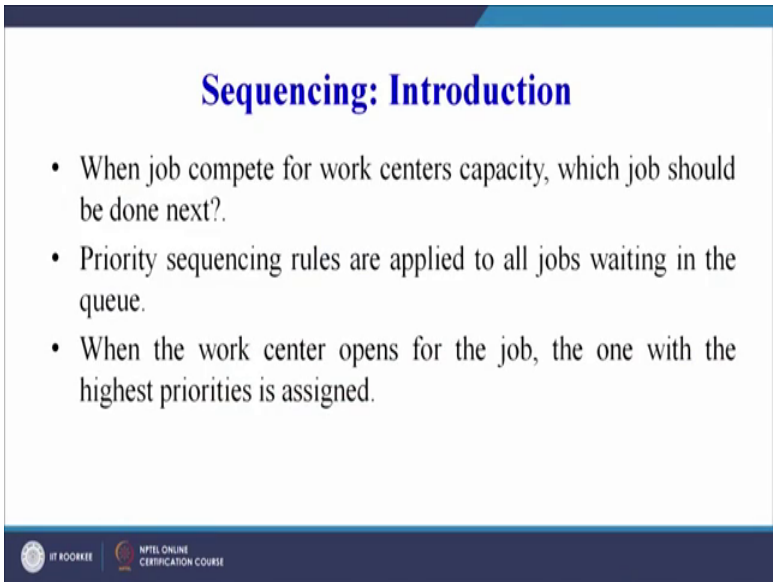

Capacity which job should be done next now for example, there are three different jobs which have arrived at work center a the jobs are p, q and r. So, we have three different jobs p, q and r each has to be processed on work center a. How to identify? How to select that which job must be sent to the work center? A first either, it should be p or q or r. So, there has to be certain criteria based on which it will be decided that how these three jobs will be sequenced it can be p, q, r it can be r, p, q it can be any sequence.

So, that sequence has to be decided and there is a set criteria there is a list of criteria, which is usually followed to sequence these jobs on to the work center. Now priority sequences priority sequencing rules are applied to all jobs waiting in the queue. For example, if we take an example of a bank and there is a queue there. So, the customers are served as per their sequence. So, first come first serve the person who is standing in the queue first will be served first and then the next person followed by the next person.

So, similarly that can be one logic one criteria of allocating the jobs to the machines, but we will see what can be the other criteria that criterion that can be used, because the problem is not. So, simple here the problem is of multiple products waiting for processing on a single machine or multiple products waiting for processing on multiple machines each product. As I have told may have different quantity each product may have different due dates. So, if some of the products may be delayed then there can be some products which require emergency processing.

So, the criterion for deciding the sequence depends upon. So, many parameters and accordingly; we have to have different criteria which we will try to understand today, in our session when the work center opens for the job the one with the highest priority is assigned. Now, how to assign the priorities to the jobs for sequencing on a particular work center is? What we are going to consider in today's session? Now sequencing is a systematic procedure for assigning priorities to the waiting jobs.

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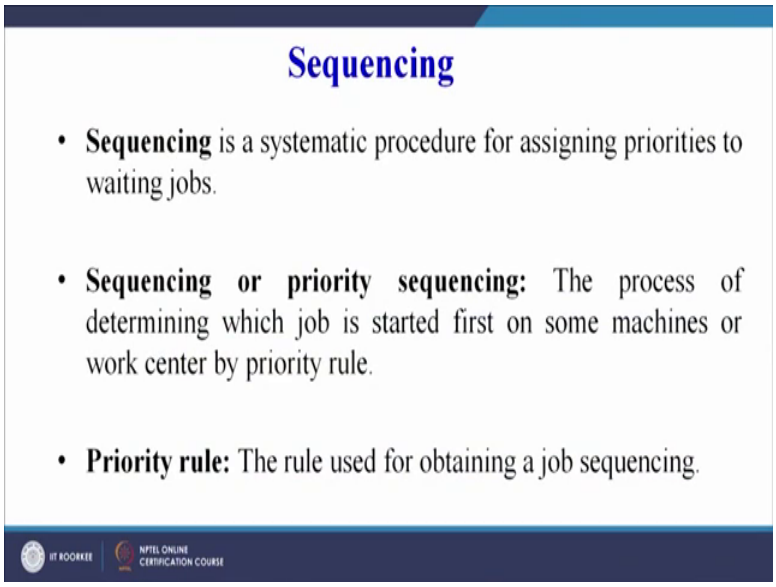

So, that is what as I have taken an example of a queue in a bank. So, that is one example, where the sequence is followed and one after the other the customers are served by the banking official.

Similarly, there can be a series of jobs waiting to be processed on a work center it can be first come first serve criteria, but there are a number of similar criteria which is followed for giving priority for sequencing to the jobs sequencing or priority sequencing the process of determining which job is started first on some machine or a work center by priority rules. So, that is another term that is commonly you will find when you discuss or maybe when you read about sequencing that is priority sequencing priority rule the rule used for obtaining job sequencing.

So, we will see some of the priority rules which can be used for sequencing the jobs on the machines.

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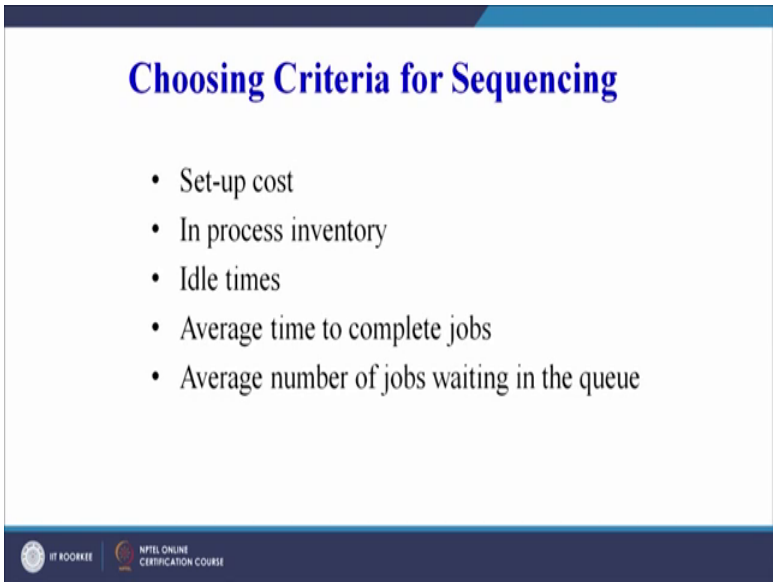

Now, the important criteria which can be followed is the set-up cost, in process inventory, idle times, maybe there are there are four components waiting to be processed and there are two machines on which these four components can be sent both machines are of the same type. Now, the machine which is idle for the longer time can be chosen as a priority for sequencing the next job. So, idle time can be one criteria average time to complete the job can be another criteria that, we can sequence the jobs which have lower processing time first and then focus on the jobs which have the longest or longer processing times.

Similarly, average number of jobs waiting in the queue can also be an criteria which will help us to decide the priority for jobs to be sequenced on the different machines. Now, we can see priority rule evaluation criteria in the previous slide, we have seen that choosing criteria for sequencing will focus on all these parameters then priority rule evaluation criteria we can see the common standard measures are.

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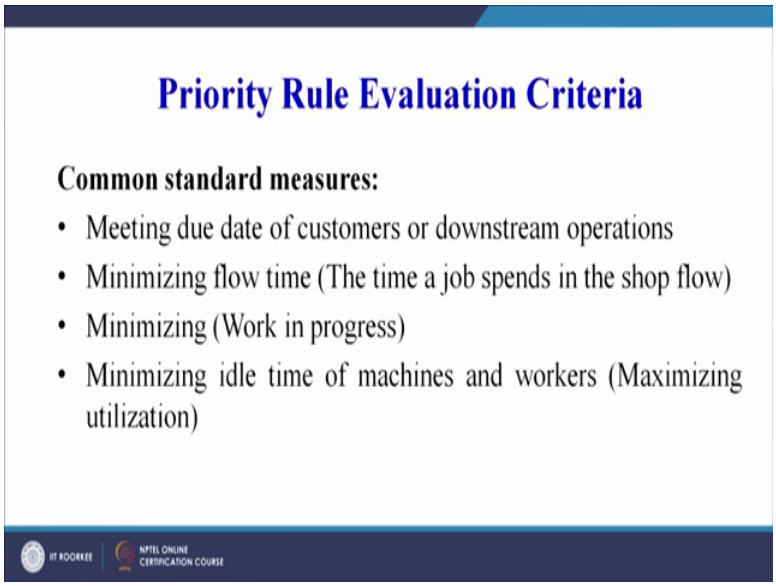

Now, there can be number of priority rules. So, we have to see that which particular rule we may follow.

So, first common standard measures for evaluation criteria for priority rules can be: meeting due date of customers or downstream operations. So, first thing is that due date is very very important. So, the criteria must focus on the due date minimizing the flow time that is a time a job spends on the shop flow. So, that is another criteria minimizing work in process. We do not want that lot of work or a lot of components or parts are waiting to be processed in front of the different machines or different work centers in the shop flow.

So, we want to minimize or reduce our working process. So, that is also kind of a criteria which can be followed or which can be taken into account, when we are deciding a priority rule and minimizing the idle times of the machines and worker, that is we have to ensure the maximum utilization of the available resources in order to be productive and in order to be profitable. So, we can see all these four points are very very important and based on these evaluation criteria. We can have a set of priority rules which can be used for sequencing the jobs on the various machines.

So, again this is important, I am emphasizing it once again first thing is meeting due date of customers or downstream operations. So, one thing can be the products that we are processing is directly going to the customer. So, we have already agreed upon with the

customer that this is going to be the due date for this batch of products. So, we have to honor that due date or the product that we are producing is a maybe a sub assembly or a sub part of the final product which is being processed by some other company.

So, therefore, we have an agreement that we will be able to supply this many number of sub assemblies by such and such date. So, they have to be sent as per the deadline for the downstream operation. So, we have to meet the due date. So, that is one of the important criteria, then the flow time has to be minimized.

We have to minimize the time the job spends on the shop floor many times it will be waiting to be processed. So, that time has to be minimized, and then the work in process inventory has to be minimized the job shop sorry our floor must not be cluttered with a lot of work in process inventory and the idle times of machines and worker also has to be minimized.

So, that based on this we can frame a set of rules or criteria which can help us to achieve our major objectives. Now, elements of the job shop scheduling we can see an assembly line is an example of the flow.

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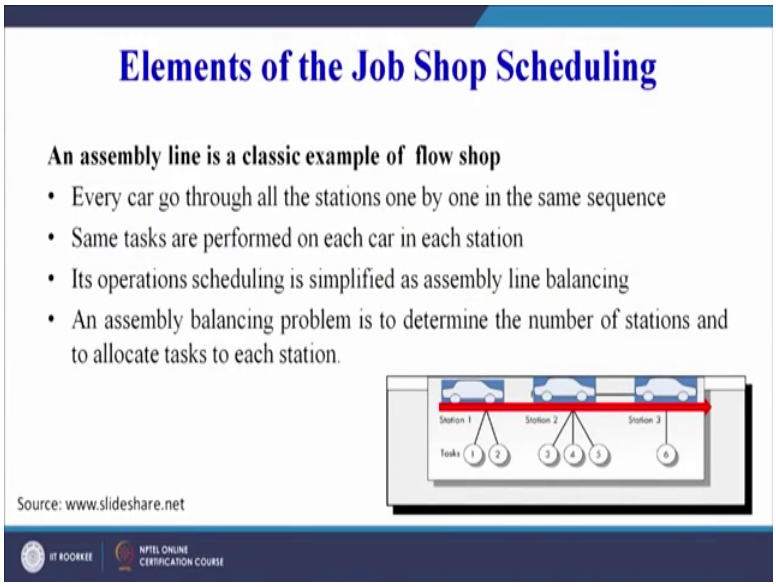

Shop where maybe; we are starting our assembly from one end of our assembly line, that the final product comes out from the other end of the assembly line. So, an assembly line

is a classic example of a flow shop. So, we can see every car go through all the stations one by one in the same sequence.

So, as I have already discussed the raw material may be enters into the one end of the production flow line, and then it moves in a particular sequence which is well laid out and well defined and finally, the product comes out from the other end of the line. So, every car goes through all the stations one by one in the same sequence same tasks are performed on each car in each station it is operation scheduling is simplified as assembly line is balanced or as assembly line balancing can be easily carried out.

An assembly balancing problem is to determine the number of stations and to allocate tasks to each station. So, we have to balance the assembly line that the sequence the sequence is very very clear the product has to move from one end to the other end and during this movement of the product the all assembly has to be built on top of the product or on top of the chassis. In case of an automobile if it enters on one side all assembly operations have to be done and the final product comes out. So, the line can be balanced by assigning different tasks at different workstation.

So, maybe the product is moving in this case on the assembly line therefore, the mean flow time will be less in this case in this particular case moreover the scheduling will be easier in this particular case, because we have different workstations each workstation is assigned a particular task. So, the flow will be well regulated well controlled well balanced and continuous in nature and the product or the overall production rate will be quite satisfactory or on the other hand I can say the production rate will be very very high in case of a assembly line type of flow shop.

Now, we can have another concept of parallel processing versus sequential processing in sequential processing the M machines are distinguishable, and different operations are performed by different machines.

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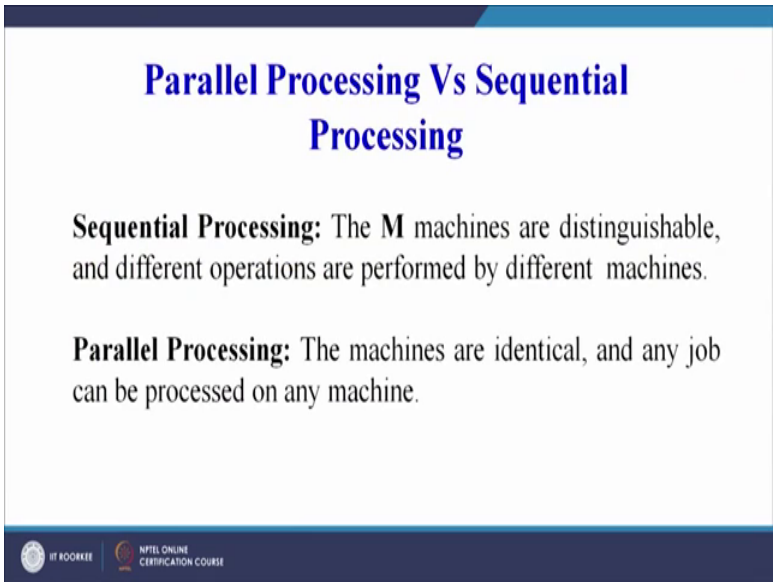

So, if you take the example, the previous example that we have taken of a flow line or a maybe a assembly line it will be sequential processing only, because there are M different machines or M different workstations in the line and each one of them is performing a different task. So, M machines are distinguishable all machines are different and different operations are performed by different machines. So, that can one example of sequential processing, then the parallel processing is the machines are identical and any job can be processed on any machine.

So, you have maybe 5 machines in one row each machine is of same type and then hundred parts are coming suppose. So, these 100 parts have to be processed on 5 different machines each machine is of same type all may be lathe machines each lathe machine having same maybe swing diameters same distance between the centers of; I mean to say all lathe machines are same dimensions everything same.

So, these 100 components can be processed on any one of these lathe machines or maybe distributed among these 5 lathe machines. For example, whenever we travel by air we go to a aircraft we are maybe there is a long queue of the passengers to take the boarding passes and there are a 10 to 15 different centers each official can book or give you the boarding pass or book your luggage.

So, the queue the first person will just see that which table is vacant. So, the person can walk to that table the next person will see that which table is vacant or which center is

vacant and go to that particular table. So, similarly all machines are of same type there can be number of parts which have to process. So, the first part that has to go can go to any of these machines maybe three of them are working 2 or idle. So, it will go to the idle machines only among the idle machines the sequence can be that the machine which has been idle for a longer time can be chosen for this component to be processed.

Now, 4 are working 1 is idle. So, the next one can go to the next machine all machines are of same type. So, that we can say as the parallel processing sequential, as I have already told previous example we have taken it is a flow line or it is a assembly line each work center is assigned a particular task. Now this is just an example we can see here.

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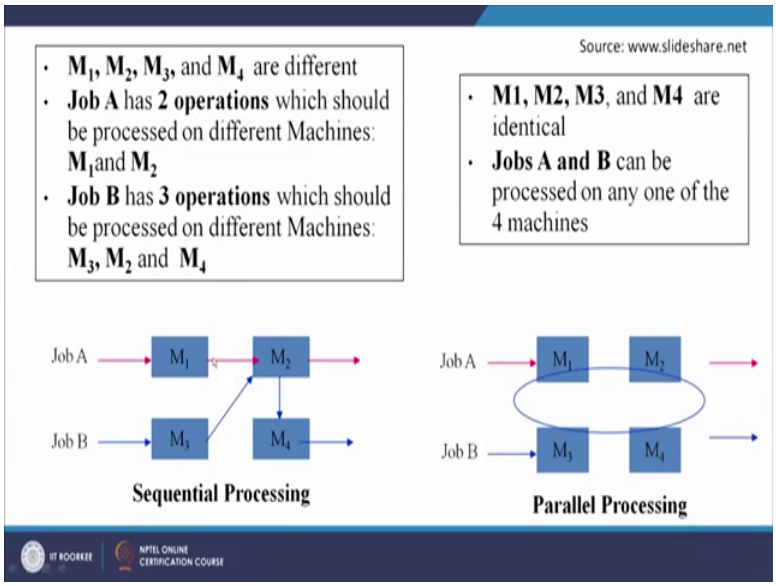

These are four machines M 1, M 2, M 3 and M 4 and all four machines are of different types. This is an example of sequential processing M 1, M 2, M 3, M 4 are different job A has two operations which should be processed on different machines M 1 and M 2. So, job A goes to M 1 and M 2 and finally, goes to the next level.

Similarly, job B has three operations which should be processed on different machines M 3, M 2 and M 4. So, job B goes to M 3 first, then it goes to M 2, then it goes to M 4 and finally, goes to the next station. So, all four machines are different in case of sequential processing whereas, in parallel processing we can see M 1, M 2, M 3, M 4 are identical jobs A and B can be processed on any of the four machines depending upon the

operations required. So, we can see that we can either have a parallel processing unit we can have a sequential processing and accordingly our priority rules will be decided.

Two more terms that will be that we will be quite oftenly; using in our discussion will be tardiness and lateness. So, lateness all of us know if I if I am engaging a class and four students are coming late. I will definitely say that they are late students. So, they are coming late similarly there is a due date identified for a batch of products to be ready and if we are not able to deliver those products as per the due date it means, that we are late and that difference between the due date and the actual delivery date. We can say is the lateness whether it is 5 days delayed or it is 10 days delayed. So, that is lateness.

And tardiness is somewhat similar to lateness only, but tardiness is always given in the positive sign only. So, tardiness is the positive difference.

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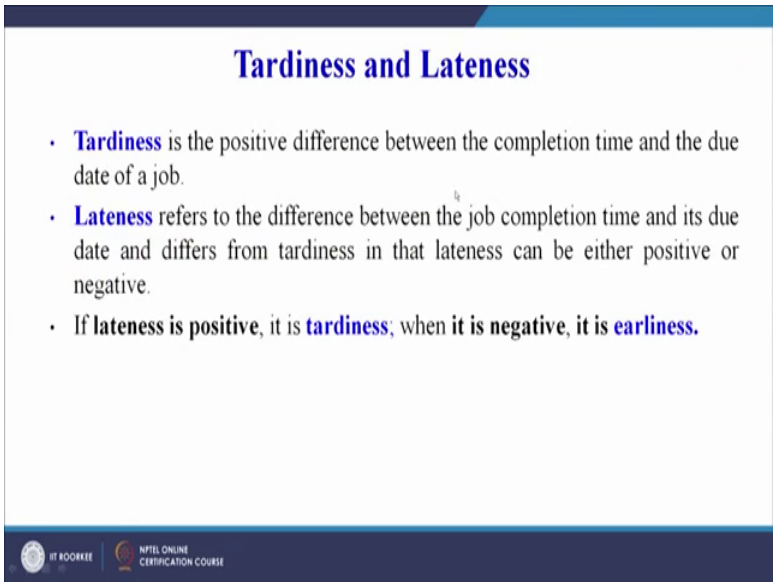

Between, the completion time and the due date of a job so, we always we will see the positive difference only; we negative difference we will eliminate or we will not report lateness refers to difference between job completion time. And it is due date and that and it differs from the tardiness is the in that the lateness can either be positive or negative.

So, lateness can be positive or negative tardiness will always be positive. So, you can see that if lateness is positive. So, lateness you can see, what is lateness? It is a difference between a job completion times. Now, suppose job completion time is September 13th

and it is due date due date was September 21st. So, September 30 minus September 21st it is 9 it is on the positive side. So, 9 is the lateness, but suppose we say that the due date was September 13th due date was September 21st and we have been able to job complete the job on September 15th.

So, September 15th minus the due date; that is September 21st it comes out to be 6. So, that is minus 6. So, it is negative. So, our lateness can be both positive and negative. So, negative lateness automatically, we will call it as the earliness. So, if the lateness is positive it is tardiness and when it is negative it is earliness, because tardiness will be always positive sequencing rules. Now, we can see that how we can give the priority to the jobs which have to be undertaken or which have to be processed on different machines. Let us see the sequencing rules first rule there are there is a lot there are a lot.

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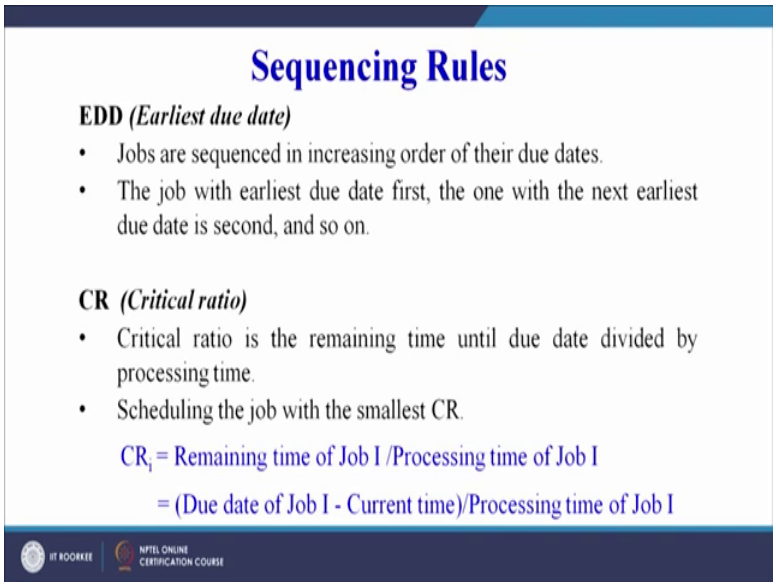

Of rules which are followed and we are just going to cover maybe 3 or 4 important rules.

But, if you go by the literature you are if you read good books on this topic of sequencing and scheduling, you will be able to see that there are number of rules which can be followed for allocating jobs to the machines we are going to take simpler rules only the first one is first come first serve. So, jobs are processed in the sequence in which they entered the shop. So, the job which entered the shop first will be served first or will be processed, first on the machine and then followed by the 2nd, the 3rd, the 4th, the 5th,

as and when the job come they are given a sequence and each see each job is processed by the time it is entering.

So, if you enter first you will be served first as the simplest and natural way of sequencing as in the queue in case of a bank. So, usually we see more wherever we have a queuing system for example, we are standing in a queue to board a bus. So, the first person will board the bus first the second person after the first person the sequence will be followed. So, that is the first come first serve simplest method, then the second one is a shortest processing time the jobs are sequenced in increasing order of their processing time, that is; first we will sequence a job which requires less processing time, then we will sequence which is having slightly higher processing time and then in the similarly ascending or increasing order.

The job with the shortest processing time is done first one with the next shortest processing time is second and so on. In the increasing order of the processing time, the third one can be the earliest due date as we have seen that one of the important criteria for deciding the priority rules is the due date. We do not want to delay our due date or we do not want to invoke the penalty clause. So, therefore, we would definitely like to honor the due date and we can focus on those jobs for which the early due date is approaching fast. So, jobs are sequenced in increasing order of their due date.

So, whichever may be whichever job is having the earliest due date we will do it first and whichever is having the latest due date we will do it later. So, we are arranging it in an increasing order of the due dates and in previous slide we have.

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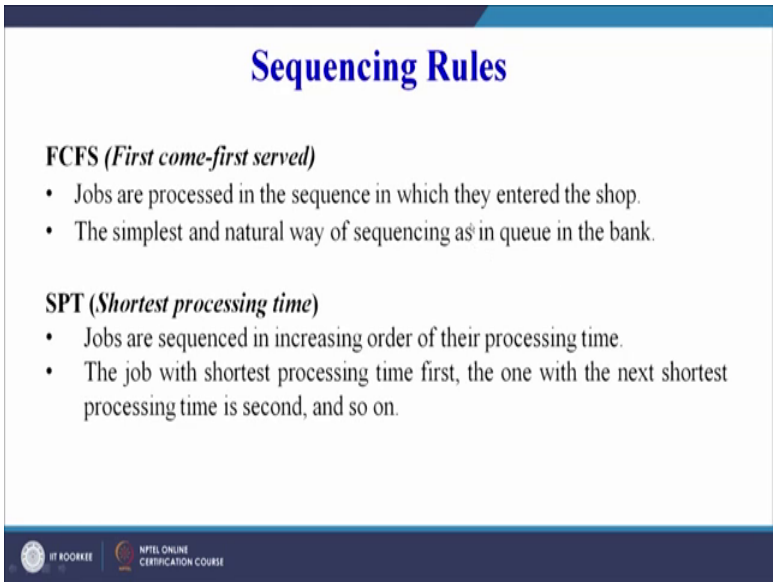

Seen that we; the from the shortest processing time also we arrange them in a increasing order the shortest time first and the longest time later similarly if the due dates.

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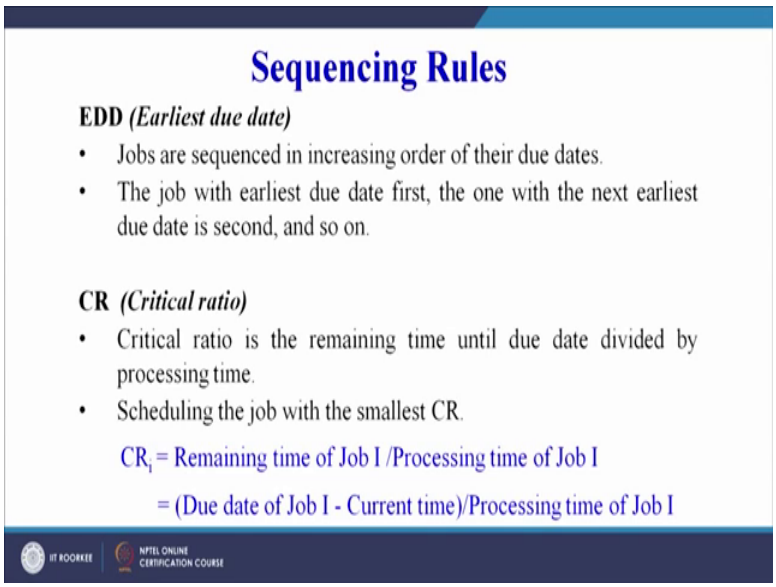

Also the shortest due date we will try to focus first the those jobs, which are having the earlier due date and the jobs which are having a delayed or a later due date we will focus on those jobs later.

The jobs with the earliest due date is done first, the one with the next earliest due date is second, and the one with the latest due date or which has and a may be number of days

for it is due date we will focus on it or we will sequence that job later then the next criteria is critical ratio. So, critical ratio is the remaining time until due date divided by the processing time. Now, let us take an example. Now, suppose the processing time is 10 days and today is suppose September 10th and the due date is September 12th. So, today is September 10th due date is September 12th. So, what is the difference 10 days divided by the processing time? That is 10. So, the critical ratio is equal to 1.

So, the we can see that the critical ratio is 1, if the critical ratio is more than 1 which means the today's date and the due date the difference between the 2 is greater than the processing time. So, if the critical ratio is more than 1, which means that we have still have time to complete the project whereas, if we see the critical ratio is less than 1 or very very less than 1 which means that the today's date and the due date the difference between the 2 is may be much much less as compared to the actual time processing time required for that job. For example, the actual processing required for the job is 10 days and the difference between today's date and the due date is 5.

So, today's date minus the today's date and the due date, that is; today's date and due date difference is 5 divided by the processing time as I have (Refer Time: 30:53) 10. So, 5 divided by 10.5; So, which is less than 1. So, we will focus on those jobs for which the critical ratio is less than 1. So, that we try to expedite the things and meet the due days due date as far as possible. So, that is due date of the job as we have taken an example maybe September 10 minus the current time may be September maybe 1. So, 10 minus September 1, 10 days divided by the current sorry divided the processing time that is 10 days for the job.

So, 10 divided by 10 our critical ratio comes as 1. So, means we are on target. So, accordingly, we can see focus on those jobs for which the critical ratio is much much less or less than 1. So, with this I conclude the today's session and in this session we have tried to see the different types of sequencing rules that can be followed while assigning the jobs to the various machines. When the jobs are waiting to be processed we have also tried to understand, the basic concept of sequencing and in the next session we will try to understand these various rules with the help of numerical examples.

Thank you.