Economics, Management and Entrepreneurship
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Lecture - 41
Production Planning and Control (Contd.)

Good morning. Welcome to the 41st lecture on economics, management and entrepreneurship. In our last lecture, we covered plant location and we started the discussion on production planning and control. Today, we shall continue to discuss and complete the discussion on production planning and control.

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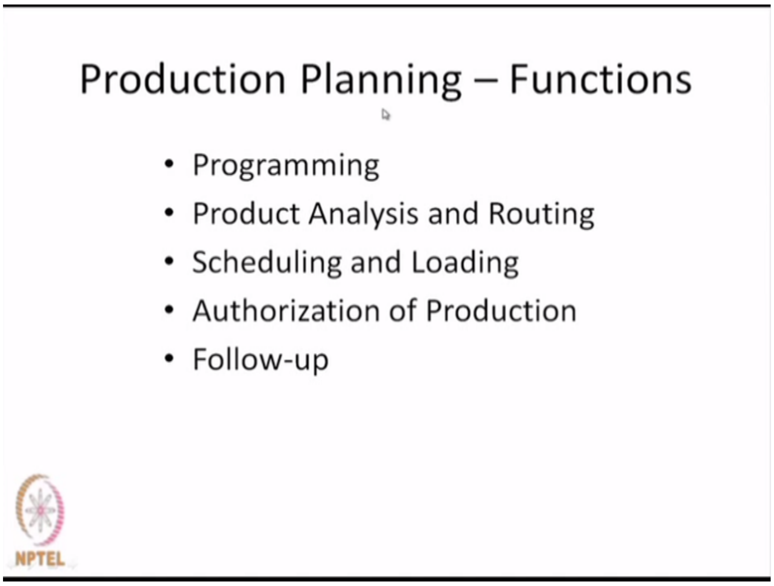

So production planning and control, here we had defined production planning and we had given 5 different functions of production planning. In that, the first was programming in which different forms of mathematical programming techniques could be used. We illustrated the example of aggregate production planning and product mix and then we said that there can be various formulations of different problems both static and dynamic models and deterministic and stochastic models. We did not discuss much on programming aspects.

Then, we went to product analysis and routing. In this, we principally discussed 2 charts.

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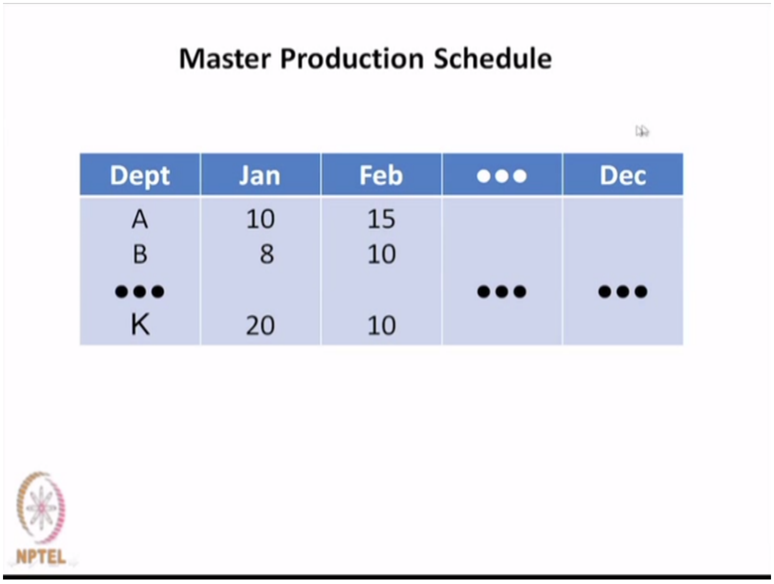

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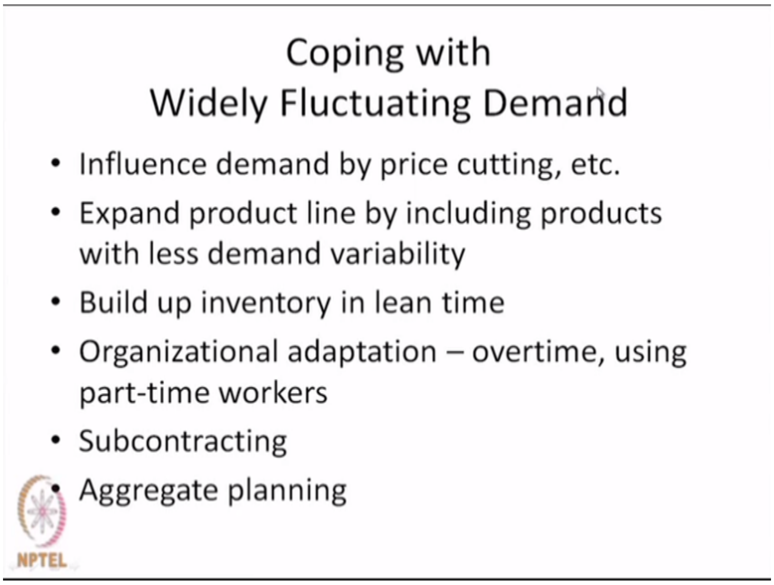

This is programming, aggregate planning we discussed.

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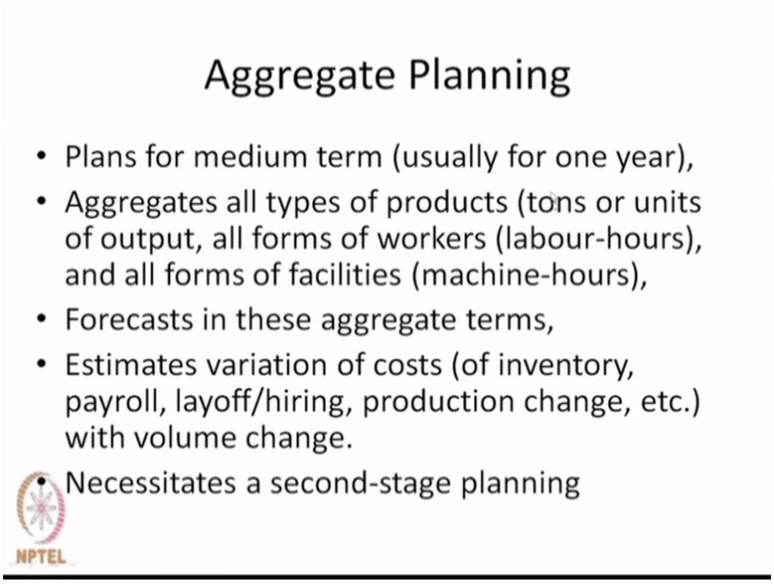

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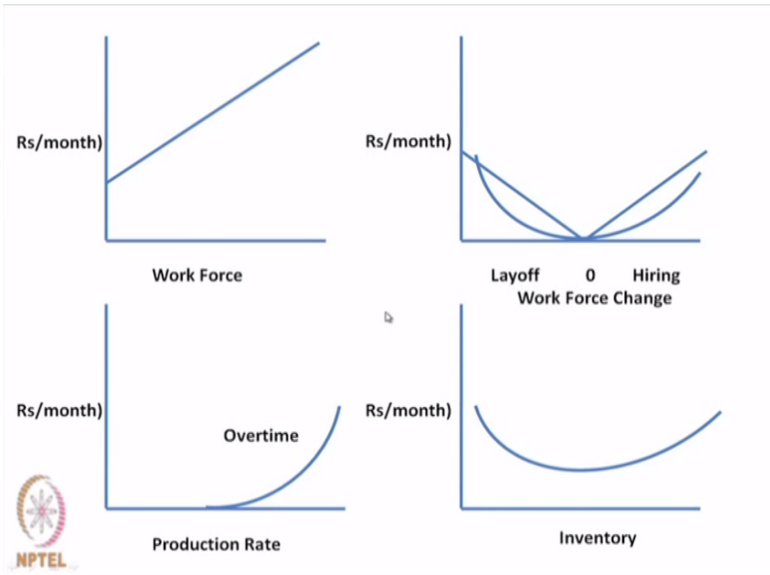

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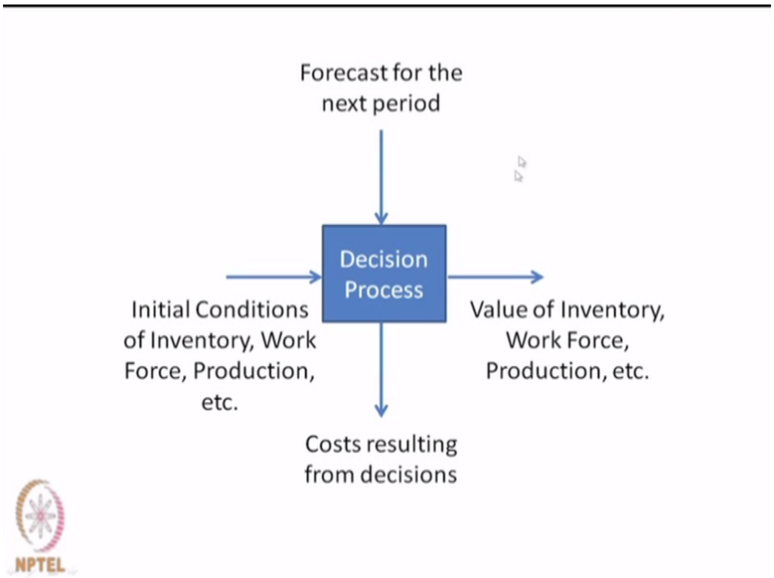

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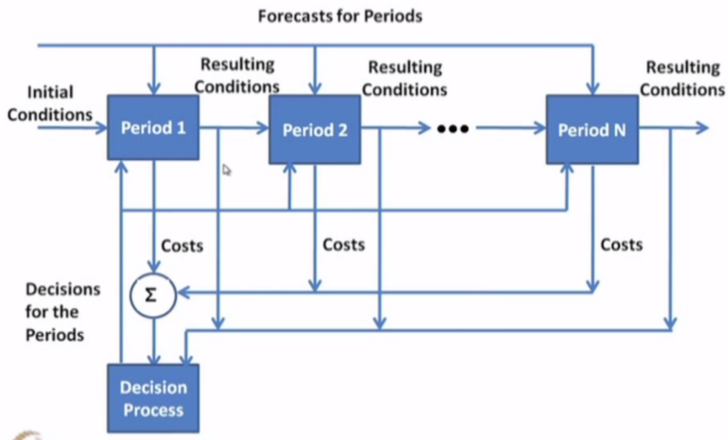

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Optimal Product Mix Problem

Example:

A manufacturer produces four types of household products fabricated from sheet metal . The production rates in hours per unit and available production hours are given known for different departments. Also known are their selling prices, variable costs, minimum and maximum sales. Furthermore, only 2,000 sq. m of sheet metal used for products 2 and 4 are available. Product 2 requires 2 sq. m and Product 4 1.2 sq. m per unit.

Find out the units of the four products that the manufacturer should plan for.

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Production Rates in Hours per Unit					Production Hours Available
Dept	Product 1	Product 2	Product 3	Product 4	
Stamping	t_{s1}	t_{s2}	t_{s3}	t_{s4}	Ts
Drilling	t_{d1}	t_{d2}	t_{d3}	t_{d4}	Td
Assembly	t_{a1}	t_{a2}	t_{a3}	t_{a4}	Ta
Finishing	t_{f1}	t_{f2}	t_{f3}	t_{f4}	Tf
Packaging	t_{p1}	t_{p2}	t_{p3}	t_{p4}	Tp

	Product 1	Product 2	Product 3	Product 4
Net Selling Price	*P1*	*P2*	*P3*	*P4*
Variable Cost/unit	*v1*	*v2*	*v3*	*v4*
Min Sales	*S1min*	*S2min*	*S3min*	*S4min*
Max Sales	*S1max*	*S2max*	*S3max*	*S4max*

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Let *Xi* be the number of products of product type *i*, *i* = 1, 2, 3, and 4.

Machine Constraints:

$$\sum_{i=1}^{4} X_i t_{si} \le T_{si}, \sum_{i=1}^{4} X_i t_{di} \le T_{di}, \sum_{i=1}^{4} X_i t_{ai} \le T_{ai}, \sum_{i=1}^{4} X_i t_{fi} \le T_{fi}, \sum_{i=1}^{4} X_i t_{pi} \le T_{pi}$$

Material Constraint:

$$2X_2 + 1.2X_4 \le 2000$$

Sales Constraints:

$$S_{i\min} \le X_i \le S_{i\max}, i = 1,2,3,4$$

Objective Function: Maximize $Max \sum_{i=1}^{4} (P_i - v_i) X_i$

Non-negativity Restrictions: $X_i \ge 0, i = 1,2,3,4$

Then we talked about the product mix problem where we said that one has to define first of all the decision variables Xi and the different constraints are to be expressed in the form of inequalities using Xi. The constraints in this particular example are machine, material and sales. Then, we had an objective function which was in this case to maximize the contribution to profit from the 4 products.

And then we had the non-negativity restrictions that the number of units of product Xi has to be>=0.

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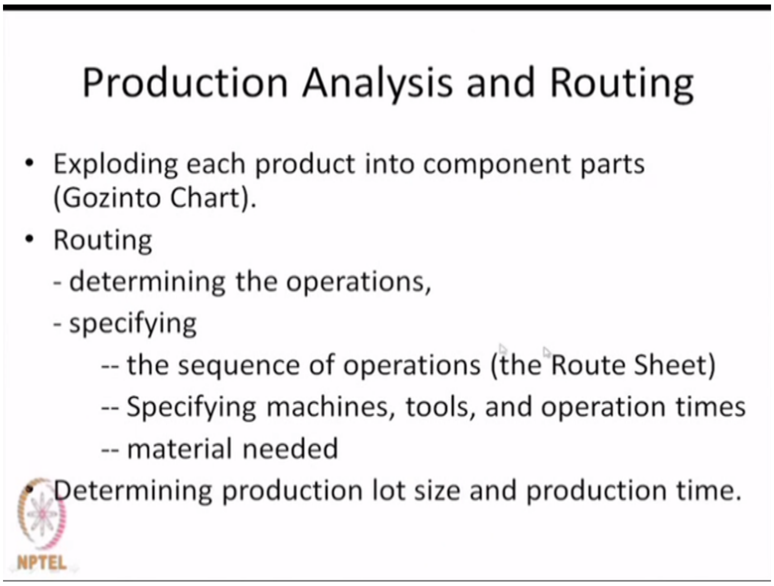

Then we discussed on production analysis and routing.

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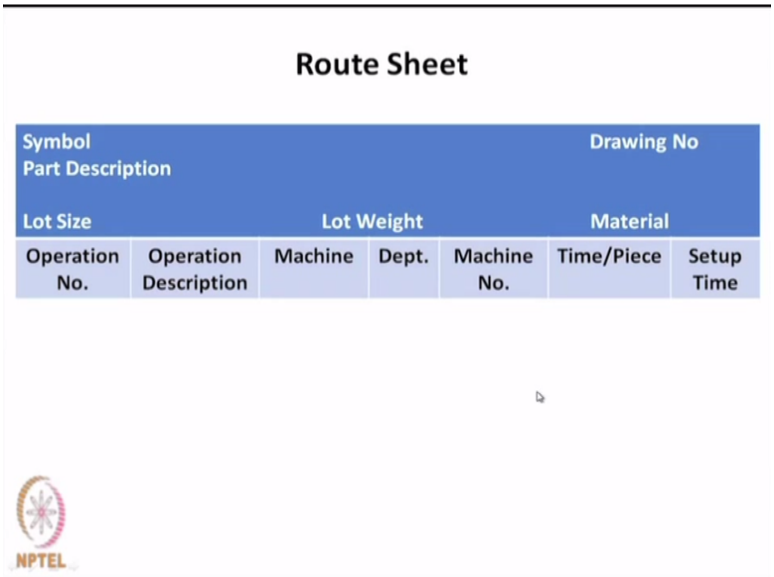

In this case, we talked about the route sheet. Here, this is basically to say that a particular product has to go through different operations. So the drawing this involve of the product, the drawing number, description of the part, how many to produce is lot size, weight, material to be used then different operations that are required to produce a product, the description of the operation, the machine in which this operation will be done, the department in which the machine is installed.

If there is a machine number, what is the set up time for a particular lot and how long it will take to produce one piece. So if various operations are mentioned here that is called route sheet. So in the product analysis and routing, we explode each product into component parts then we also do routing in which we determine the operations and specify the sequence of operations through the route sheet, which we have now shown.

And then we can also specify the machines, tools and different times and material needed and also determine the production lot size and production time. You can see that in the route sheet we have indicated the various operations, description, machine, time per piece, the set of time the material and the specification in the part description and how many to produce.

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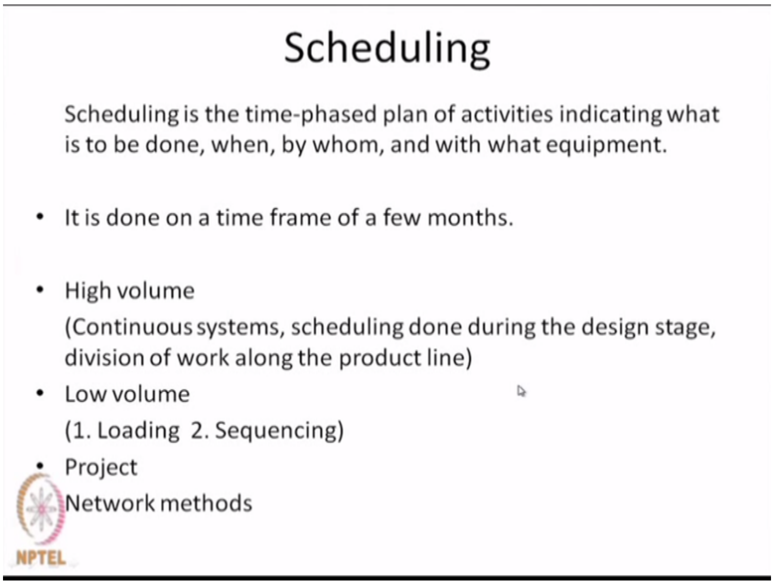

Then, we come to scheduling function of production planning and control. In scheduling, what we basically do is that we plan the activities and we also say when each activity will start and when it will be completed and who will do it, when it will be done, what is to be done and with what equipment it will be done. So basically scheduling is the time-phased plan of activities.

It is like a train time table indicating what is to be done, when it will be done, by whom it will be done and with what equipment. Usually, it is done on a time frame of a few months. Scheduling can be done for high volume continuous systems, for low volume products and for project type of activities.

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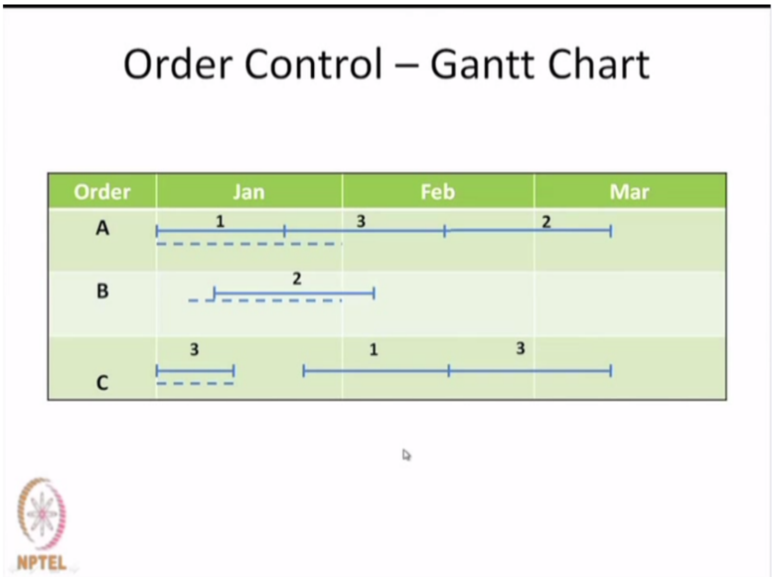

Now we would like to show you certain graphical methods of scheduling. Henry Gantt is credited with the idea about this chart in which he said that in the x axis we can plot time in terms of days or in this case dates in the month of January, February and March and in the y axis we can show different things. In this particular case, we are showing how each customer order is processed.

And what we do basically we draw horizontal bars and we say order A is to be processed in machine 1 up to the 3rd week of June and then it will be processed in machine 3 starting from the 4th week of June to middle of February and the machine 2 will process order A from the middle of February to middle of March. Order B will be processed in machine 2 because machine 2 is idling, it can start here.

And order C can be processed by machine 3 in the beginning of January and then in machine 1 because machine 1 is already booked for order A, machine 1 will be available only after order A is complete. So it is starting late and machine 1 is processing order C only after this is over and then machine 3 once again will process order C that means the operation sequence for order A is 1, 3, and 2.

For B, it is just machine 2 or operation 2 and for order C it is 3, 1 and 3. So the firm line indicates the plan schedule. So you can see that only after machine 1 is planned to complete order A it can take up work of order C. Now this dotted line indicates at the end of January what is the situation? The dotted line says that machine 1 started working on order A but the work could not be complete even at the end of January or it is not yet complete.

This line says that machine 2 was available and therefore work on order B started on this machine sometime in the first week of January and the work is continuing on machine 2 for order B. This is saying that machine 3 took up the work on order C as scheduled and the work was completed as scheduled. So the work for order C in machine 1 could have started at this point but because machine 1 is still processing order A, the work is still not complete.

This work has not even started, so this is usually called order control chart. So once we know that this is delayed, order A work is delayed, the production manager can now be going to the details of why it was delayed in machine 1, was it because the tools were not available or is it because the workers were not working as per schedule or there are some other problems with machine breakdown and things of that type.

So this is a very useful chart a visual or a graphical chart through which we can know how the orders are being processed in different machines.

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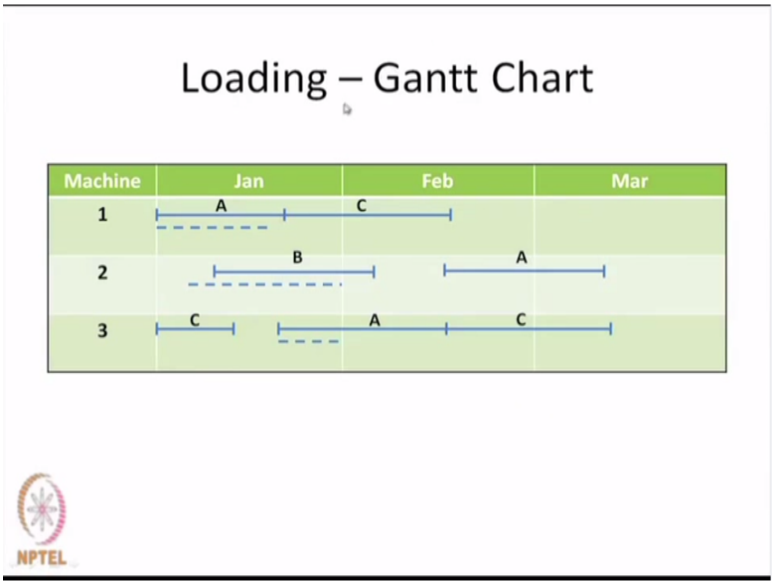

We can also see from the machine loading chart. This chart shows how the different machines are loaded in these months. In fact, this chart is derived from the previous chart. Machine 1 takes up order A and then order C. Machine 2 takes up order B and then order A. Machine 3 takes up order C and then order A and then order C. You can see that A after the work in machine 1 is complete, the work for A can start in machine 3.

And after the work on machine 3 is complete, work on A can start in machine 2 only after that. That is why this line and this line they are vertically aligned and the end point of this and the starting point of this are also vertically aligned. In a similar fashion, order C work completes in machine 1 somewhere here in February and only after that the operation on machine 3 for order C can start.

So this diagram shows how the different machines are loaded at different points of time and we can see that for example here machine 2 is not being utilized fully or that machine 3 is not being utilized fully. Once again as before, the firm lines indicate the planned schedule and the dotted line indicates how actually things have happened. Once again this chart and the order control chart together they are very, very useful techniques.

And normally if you go to a company you will see that such charts are put on the walls in the shop floor for everybody to see and then on every day the updation on the chart or at least at the end of every week the chart is updated that means the dotted lines are put so as to indicate whether the work has started ahead of time or the work has completed on time or the work is behind schedule.

So these charts are very important and are called Gantt charts for order control and this is Gantt chart for machine loading.

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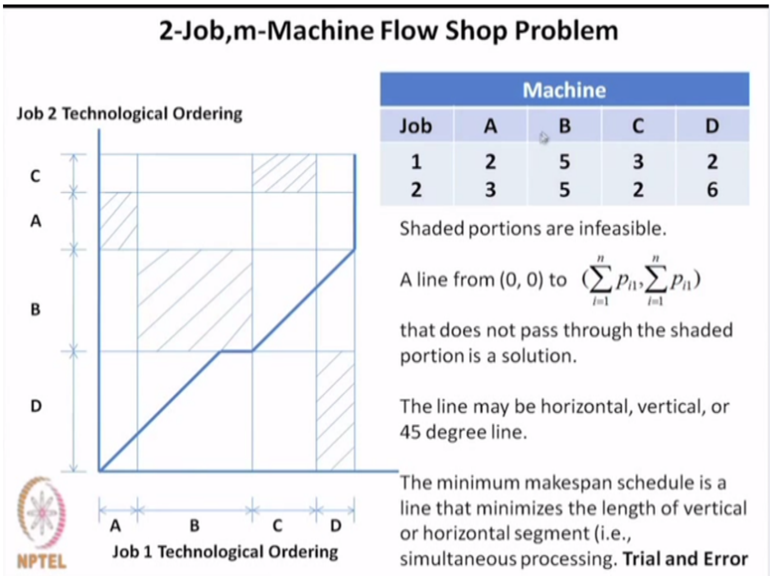

Now we shall consider a problem that we are saying 2-job, m-Machine flow shop problem. Flow shop basically means that the sequence is the same that means this job suppose there are

2 jobs, job 1 and 2, each job has the same sequence A, B, C, D; A, B, C, D and suppose that we have 2 jobs, the technological order in the sequence of operation for job 1 is A, B, C, and D and for job 2 the sequence is D, B, A, C. So the technological ordering is different but both the jobs require to go through all the 4 machines and these are the operation times. Job 1 requires 2 hours, 5 hours, 3 hours, and 2 hours in different machines.

Job 2 requires 3 hours, 5 hours, 2 hours and 6 hours; however, the sequence of the job is different. Job 1 has a sequence of first machine A, then B, then C and then D whereas job 2's technological ordering is first D, then B, then A and then C. This is known as a 2-job m-machine flow shop problem. Now normally, I have shown this in the form of a diagram. The x axis shows the time for job 1 and the y axis shows time for job 2.

Now job 1 the sequence is A, B, C, D therefore A here 2 hours, B 5 hours, C 3 hours and D 2 hours, total time here is 5+2=7+3+2=12 hours. Now on the y axis, the sequence is D, B, A, C, so if machine A is working on job 1 then naturally machine A cannot take job 2 if operation A is to be done. So this is an infeasible zone. So shaded portions are infeasible that means if machine A is working on job 1, it just cannot take job 2 so this is the infeasible region.

Similarly, when machine B is working on job 1 then it cannot work on job 2, so this is an infeasible area. Similarly, C and C this also is an infeasible area and D and D this is an infeasible area. So we have shaded these areas or zones as infeasible and we should proceed from this point which is the 0, 0 point and on this axis what is the total time, 3+5=8+2=10+6=16 hours.

So we should travel from this point to this point at the minimum time. The minimum time of travel would be the diagonal line but if you draw the diagonal, it will pass through certain shaded zone, which is infeasible. So we cannot pass through an infeasible or shaded zone. So what we should do? We should go on the diagonal as much as possible then travel in the horizontal manner or in the vertical manner.

And that would be the shortest distance to go from this point to the diagonally opposite point. Now what is the meaning of this? It means that machine A would work on job 1 first without any problem. Then, machine B can take up job 1 there is no problem and meanwhile when machine A is working on job 1, machine B can work on job 2, there is no problem. So up to this there is no problem.

That means machine B is working on job 2 and at this point machine A has completed its work on job 1 and machine B has taken over. Now machine B's work is over at this point, machine C is now available to work on job 1 and at that point of time proceed diagonally that means machine B which is now free will take up the work on job 2. So this will continue till this time when machine B will continue to work up to this time.

But at this point or at this time, machine C would have completed its operation on job 1 and then machine B can start work on job 1. Now at the 12th hour, machine D has completed its task and B also has completed its task on job 2 and therefore job 2 is now available to be working on or it can be assigned to machine A and machine C in sequence for its operation that is the meaning.

So a line from 0, 0 to this point which is summation this and this that does not pass through the shaded portion is one of the solutions. The line should be a horizontal line or a vertical line or a 45-degree line and the minimum time or minimum makespan schedule is that line that minimizes the length of the vertical or the horizontal segment that is simultaneous processing and usually one does or goes for a trial and error method.

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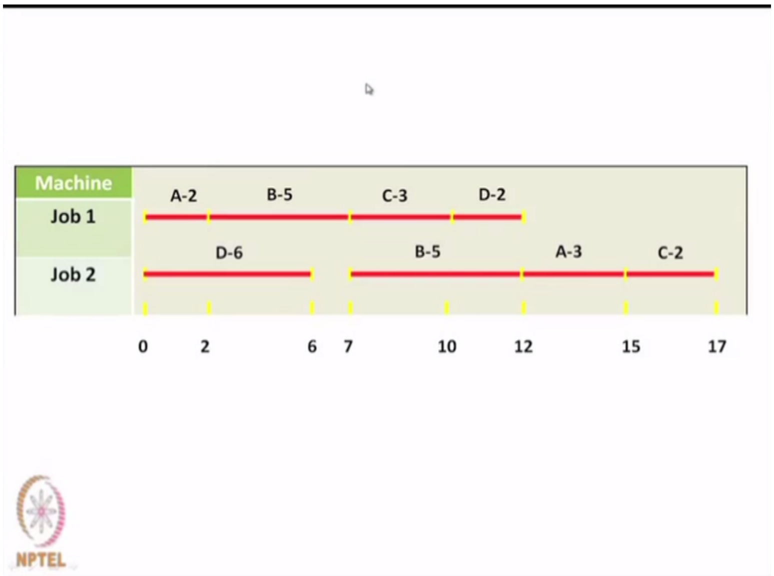

Now for the solution that we have given this is the Gantt chart and here it shows job 1 and 2 how they are loaded. Job 1 is working machine A this is sequence A, B, C, and D. Machine A takes 2 hours, machine B 5 hours, machine C 3 hours, machine D 2 hours. So the work is complete at the end of 12th hour, 2 this is 7, 7+3=10, 10+2=12, so the work is complete on job 1 at the 12th hour and job 2 will be having a operation sequence D, B, A and C.

D takes 6 hours but job 2 cannot be given on machine B because machine B is already busy working on job 1. It will be free only after the 7th hour and at that time only the job 2 can be assigned to machine B. It takes 5 hours and then A works on job 2 for 3 hours, by that time C is also free and C then works on job 2 for 2 hours. So the total time, total makespan is 17 hours.

So we see that this is the time for which job 2 remains idle. So this is the Gantt chart for the job.

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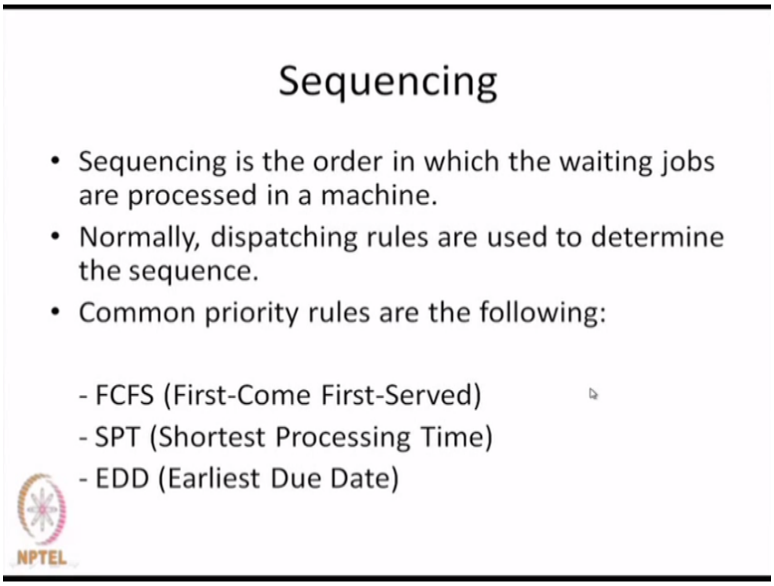

So we now know how a schedule is to be made for a very simple situation where we have 2 jobs and many machines. Now unfortunately, we do not have general solutions to N job and N machine problems. It will be highly enumerative in nature and many algorithms have been cited in the literature. We have just given one of the simplest method and we can see that this requires judgment and trial and error.

But some ideas are given and in this particular case, we have suggested a graphical method in which one is required to plot the operation times in order of their operation sequence both in the x axis and in the y axis and you travel from the origin 0, 0 to the diagonally opposite point not passing through the infeasible region, either you go horizontally or vertically or proceed in a 45-degree line.

Now we go to a problem which is known as sequencing. This is an outcome of a scheduling problem. Sequencing is the order in which the waiting jobs are processed in a machine. That means if there are more than 1 job waiting for processing in a machine then what should be the order in which they should be processed. This is called the sequencing problem.

Normally, dispatching rules are used to determine the sequence, dispatching or priority rules and we will illustrate 3 priority rules. First-come first-served that means whichever job comes first the machine takes up that job first. It could be shortest processing time that means of the waiting jobs whichever has the shortest time for processing take that job first or it could be the earliest due date.

Normally, certain dates are promised to a customer and those due dates have to be maintained whichever due date is the earliest take that due date. There are many more other priority rules but these 3 are the most common and we are going to discuss these 3 priority rules.

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Example: One-Machine Five-Job Problem

Job	Operation Time (days)	Due Date (Days)
A	12	15
B	7	24
C	15	20
D	3	10
E	8	6

FCFS		SPT			EDD		
Job	Order	Job	Job Time	Order	Job	Due Date	Order
A	1	A	12	4	A	15	3
B	2	B	7	2	B	24	5
C	3	C	15	5	C	20	4
D	4	D	3	1	D	10	2
E	5	E	8	3	E	6	1

Let us take a very simple problem of one machine and five jobs. Suppose that we have 5 jobs waiting to be processed in the same machine and let the jobs be A, B, C, D and E and let the operation times be it could be days or hours or whatever 12, 7, 15, 3 and 8 and let us say that the due dates promised to the customer is 15, 24, 20, 10 and 6. This 6 seems to be quite infeasible if the operation time is 8.

So we could change it but this will require me to change all my calculations, so let it be 6 but let us understand that a more realistic value would have been larger than 8 okay. Now suppose that it is 6 then we apply the 3 rules, first the first-come first-served. Suppose that this was the order in which they arrived at the machine which means first A, then B, then C, then D, then E.

So you will have the same order A will be taken up first in that machine, B the second, C the third, D the fourth, E the fifth. If instead it is shortest processing time, then we write down the job times and the shortest is D, so that is taken up first that is order 1 first in the list or in the order. Then this 7 is just higher than this so this is order 2. Then E order is 3, then A order is 4 and then C is the highest that is the fifth that should come in the last.

So the order is D, B, E, A, and C and then the expected delivery date. If the expected delivery dates are written down here, so they are repeated here, the least is this so the order becomes this followed by this it is this that means E, then D, then A, then C, then B. Now we have found that if we use different priority rules we have different ordering of the jobs. Now there should be some way by which we can compare these priority rules and we can decide to use one of these rules.

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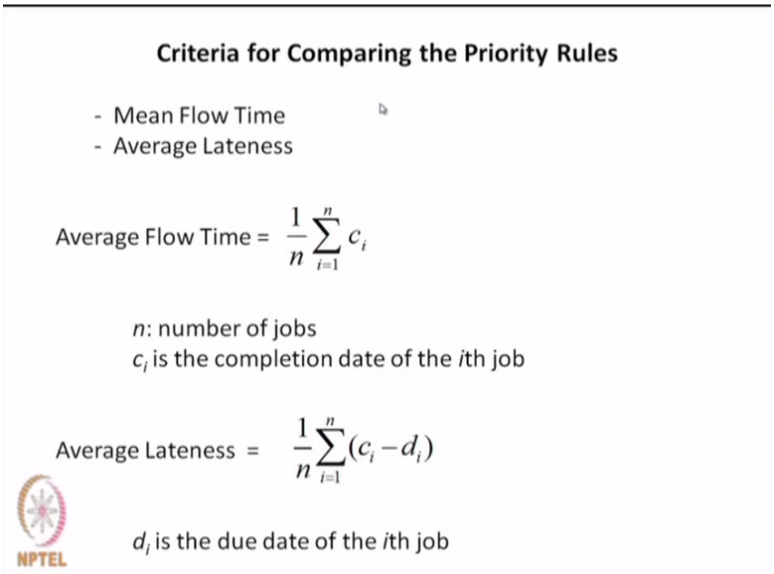

Now there are usually 2 or 3 priority rules used. I have indicated here 2 rules, one is the mean flow time and the other is flow time. So this is the completion time for each job and take the average value. Completion time means the time at which the particular ith job is completed, so ci is the completion date of the ith job. The second criterion which is used is the average lateness.

If the completion time is known and the expected delivery date is known, the difference is the lateness of that job. So the average lateness is 1/n so these 2 criteria let us use and see of this 3 priority rules, which one is better.

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FCFS

Job	Operation Time (d)	Waiting Time (d)	Completion Time (d)
A	12	0	12
B	7	12	19
C	15	19	34
D	3	34	37
E	8	37	45

SPT

Job	Operation Time (d)	Waiting Time (d)	Completion Time (d)
D	3	0	3
B	7	3	10
E	8	10	18
A	12	18	30
C	15	30	45

EDD

Job	Operation Time (d)	Waiting Time (d)	Completion Time (d)
E	8	0	8
D	3	8	11
A	12	11	23
C	15	23	38
B	7	38	45

NPTEL

Here we have written for each of these rules the waiting time and the completion time. Now the operation times are given here. This is the sequence A, B, C, D, E. For SPT the sequence is D, B, E, A, C and for expected due date the sequence is E, D, A, C, B. Accordingly, the operation times are mentioned here 12, 7, 15, 3, 8; 3, 7, 8, 12, 15; 8, 3, 12, 15, 7. They are just corresponding operation times of the jobs.

So these are written down in sequence. Now if for first-come first-served A is processed fast, so its waiting time is 0, completion time is 12. Now job B has to wait for 12 days before work can start. So 12 is the waiting time and 7 days it takes so 19th day work will be complete. Job C has to therefore wait for 19 days before work on job C can start, therefore the date on which it will be completed is 34.

So this 34 becomes the waiting time for job D and it will be completed on 37th day because operation time is 3 days and job E can start on the 37th day and because it takes 8 days' time to complete the work will be completed on the 45th day. So we now found out the waiting time and the completion time. Similarly, we can find for the shortest processing time, the sequence is already we have found out.

D waits for 0 time and completes on the 3rd day, B's waiting time is 3 days, it completes on the 10th day etc and the similar thing is done for expected due date. Now we call these 2 criteria the average flow time and the average lateness.

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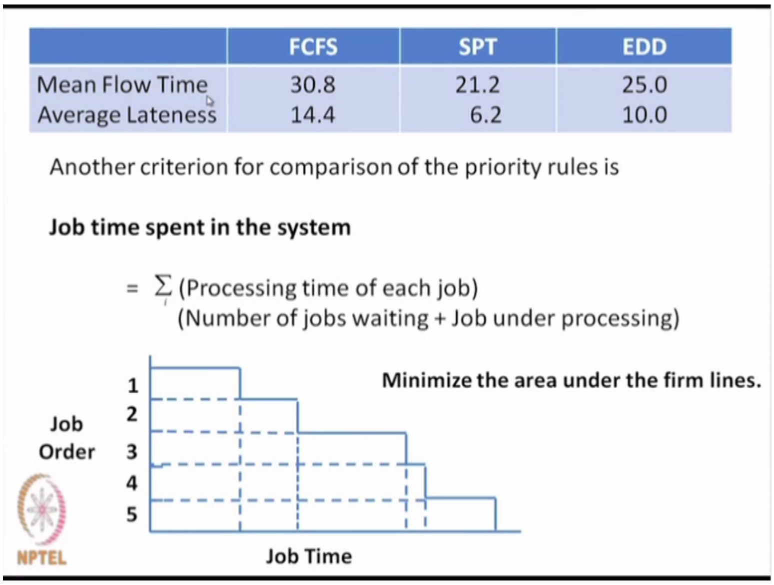

	FCFS	SPT	EDD
Mean Flow Time	30.8	21.2	25.0
Average Lateness	14.4	6.2	10.0

I have calculated the mean flow time is the completion time average, so the completion time you add all of them and divided by 5. Although, they are all completed on the 45th day but the completion dates are different for different jobs. So the average flow time, the average time to complete is 12+19+34+37+45/5, similarly here and similarly here. These values are coming to 30.8 days for the FCFS priority rule first-come first-served.

For shortest processing time, it takes 21.2 days, for expected due date it is taking 25 days. So according to the mean flow time, shortest processing time gives the best result of these 3 priority rules following these criteria. If we follow average lateness as the criteria, now we call the average lateness is the completion time-the due date average value. The due date values are given here.

So completion times are known, so I use that formula and calculated the average lateness for the 3 priority rules and I found that the shortest processing time also gets the list value of 6.2. So following these 2 criteria, I found that the shortest processing time is the best priority rule that one should follow. Now here we are suggesting still another criterion which is look at this.

This is the job time and this is the job order for the first-come first-served priority rule. What is for first-come first-served priority rule? It is 1, 2, 3, 4, 5, so the y axis is the job order plotted from top to down and the corresponding job time. So job 1 is processed fast and it takes I think 12 hours, 12, 7, 15, 3, 8, so 12, 7, 15, 3 and 8. So job 1 takes 12 days and it remains in the process for 12 hours.

Although, its waiting time is 0 but its operation time is 12 days, therefore 0+12 is the total time it is spending in the system. Now for those 12 days, job 2, 3, 4 and 5 were all waiting. So this total area is the time for which all the jobs are in the system for 12 hours. Waiting time for 2, 3, 4, 5 and processing time for job 1. Then, job 2 is taken up, its processing time is 7 hours.

So that time job 1 work is complete, so job 2 is being processed so this is the additional time it has to spend in the system while it is in operation and for that time 3, 4, and 5 are waiting. So this additional area indicates the waiting time of job 3, 4 and 5. After job 2 is taken up, job 3 is now being processed, so this is the processing time for job 3 but this is job 4 and job 5 waiting for 15 hours.

And similarly job 4 is being processed, job 5 is waiting and lastly job 5 is processed. So this complete area indicates the job time spent in the system that is the criterion that is minimize the area that is the criterion. Minimize the area under the firm lines, this is the firm line. So which is expressed as summation of processing time of each job*number of jobs waiting+job under processing.

Number of jobs waiting here is 4+1 job being processed, so 5 jobs*the processing time of first job. Similarly, the next one and similarly next one, similarly next one and next one. If all of these are added, this is the area under the firm lines and one has to minimize that area. Once again as I said unfortunately there is no general solution to the job N problem, sequencing problem.

But one can always use such priority rules and can use trial and error method to get a feasible solution.

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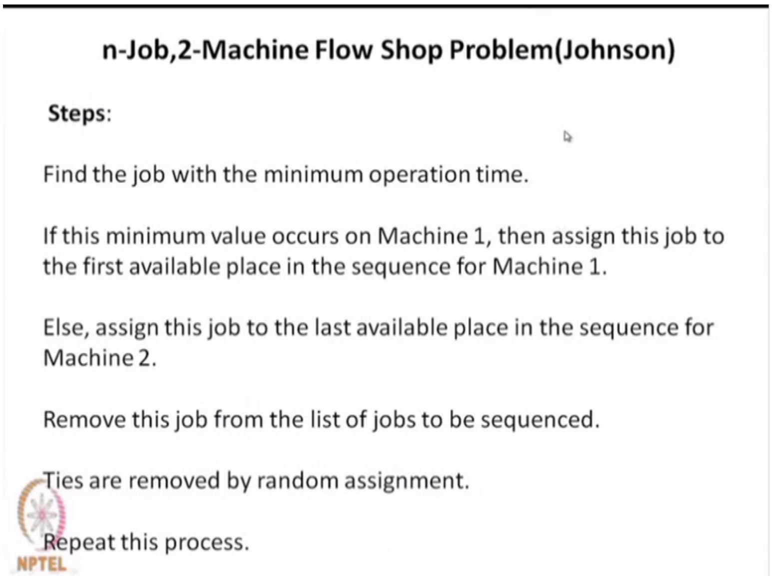

Now we take up yet another problem which has been well documented in the literature and Johnson has credited with the idea of developing this. This is called n-job, 2-machine flow shop problem that means we have just 2 machines not 1 machine, 2 machines and there are many jobs and their sequence is given. Find the job with the minimum operation time. Johnson has suggested a method of solving this problem.

Find the job with the minimum operation time if this minimum value occurs on machine 1, then assign this job to the first available place in the sequence for machine 1 else assign this job to the last available place in the sequence for machine 2. Once assigned remove this job from the list of jobs to be sequenced. Ties are removed by random assignment and repeat this process.

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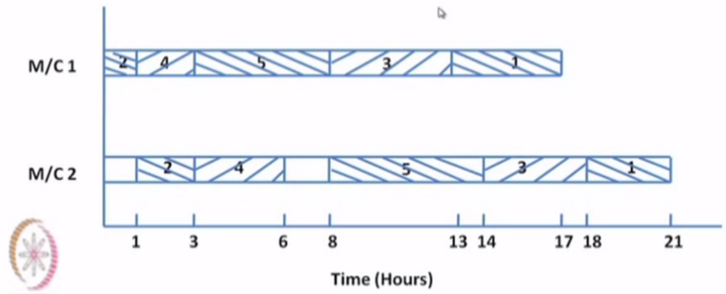
Job	Machine 1	Machine 2
1	4	3
2	1	2
3	5	4
4	2	3
5	5	6



Now let us apply this to this problem. Now here there are 2 machines, machine 1 and 2. A job goes through this machine in the same sequence, first machine 1 and then machine 2. Job 2 also in the same sequence, 3 same sequence, 4 same sequence, 5 same sequence but the operation times are different. Job 1 takes 4 hours in machine 1 and 3 hours in machine 2 like that 1 and 2 hours in machine 1 and 2.

Now the algorithm here says find the job with the minimum operation time. Now minimum operation time is 1 and 1 appears in machine 1, 1 is for job 2. So assign job 2 to machine 1 that is what we have done here. Assign job 2 to machine 1 because its operation time is the least among all. So 2 is assigned to machine 1 once assigned then take it away from the list we have 1, 3, 4, 5, left.

Now what is the minimum here? We have the minimum is 4, 5, 2, 5, and 3, 4, 3, 6, 2 is the minimum. If 2 is the minimum that occurs for job 4. So assign job 4 to machine 1 because the operation time 2 occurs for machine 1. So 4 is assigned here. Now 4 is removed also. So we are left with 1, 3, 5; 1, 3, 5 what is the minimum? These are the values, the minimum is 3, 4, 3, 5, 4, 5, 6, the minimum is 3, 3 occurs in machine 2 and not in machine 1 for job 1.

So since it appears for machine 2, job 1 should be assigned last to machine 2, should be assigned last that is 1 is assigned last to machine 2, 1 that is assigned we are taking away 1 now we are left with 3 and 5. The minimum is 4 that occurs for job 3, so that should appear just before 1 and lastly 5 that should appear just before 5. So the sequence is therefore first 2, then 4, and then 5, 3 and 1 for machine 1.

Now you see for machine 2, the job 2 can start only after its work on machine 1 is over. Therefore, job 2 can start only at this point, machine 1 takes 1 hour for job 2 so at the end of 1-hour machine 2 can take up job 2. By that time, machine 1 is taking up job 4 which is taking 2 hours, 2 also requires 2 hours, so simultaneously at time 3 at the end of 3 hours both machine 1 and 2 are free to take up the next work.

So machine 2 takes up job 4 because by that time machine 1 work on job 4 is complete, it can take 4 and work on 5 can start on machine 1. Machine 1 completes its work on job 5 at the end of 8 hours because 5 hours it takes so 5+3=8 hours. Therefore, machine 2 has to remain idle during this time. It can take up work on job 5 only here at the 8th hour and it takes 6 hours' time so that is at the 14th hour the work will be over on job 5.

Meanwhile, machine 1 takes up job 3 and it takes 5 hours. So 13th hour the work will be completed there and thereafter job 1 work can be done and when machine 2 is free at the end of the 14th hour, the work on job 3 starts and gets completed on the 18th hour and then work on job 1 starts and gets completed at the end of the 21st hour. So this is the Johnson's algorithm for solving 2 machine, n job problem.

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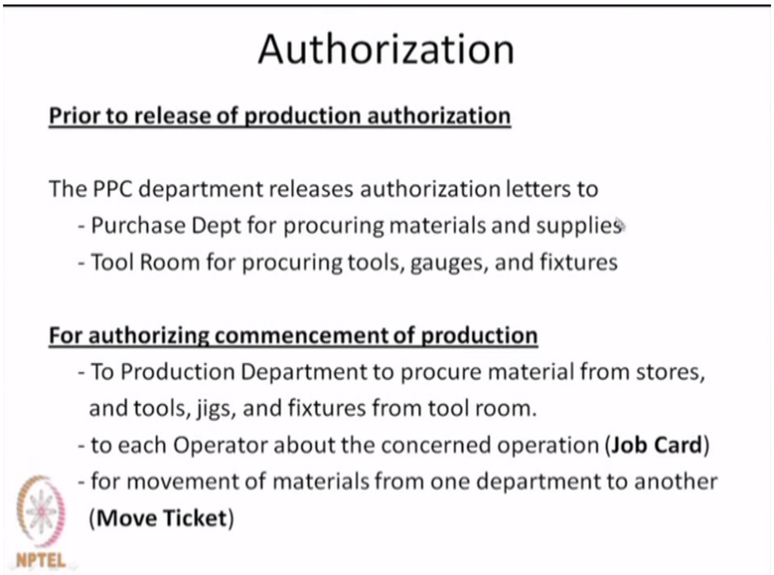

Now we take up the next function of production planning and control authorization. Now authorization meaning that various departments must be authorized to carry out their activities. Production planning department has to release production authorization, PPC department releases authorization letters to purchase department for procuring materials and supplies.

It also releases authorization letters to tool room for procuring appropriate tools, gauges and fixtures. It authorizes commencement of production by giving appropriate letters to production department to procure material from stores and tools, jigs and fixtures from the tool room. It authorizes operator about the concerned operation in the form of job card and it also authorizes various departments to move materials from one department to another. They are called job card and move ticket.

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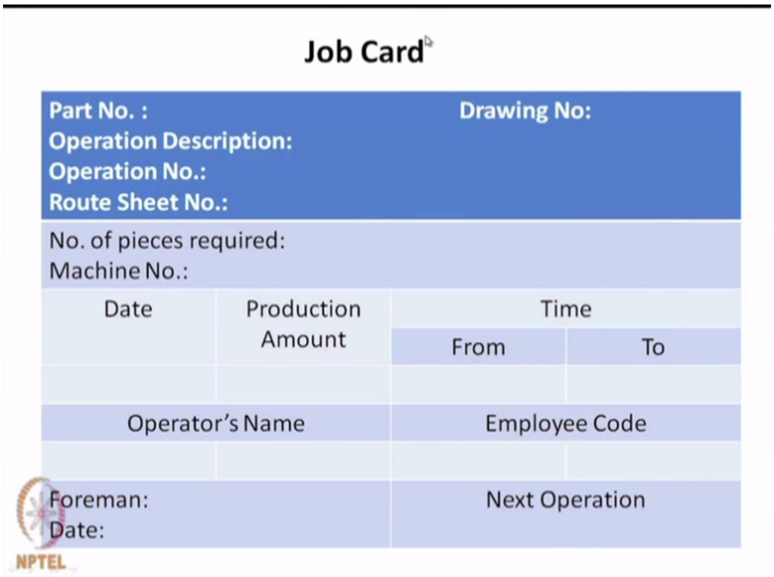

Job Card

Part No. : Operation Description: Operation No.: Route Sheet No.:		Drawing No:	
No. of pieces required: Machine No.:			
Date	Production Amount	Time	
		From	To
Operator's Name		Employee Code	
Foreman: Date:		Next Operation	

We give an example of a job card. In a job card, the operator, the operation sequence or operation description is given, part number, drawing number, operation number, corresponding route number and then number of pieces required, which machine it will be worked on, work time, how many, from what time to what time, the operator's name, his code, foreman's name and the date, and what is the next operation.

This is given to an operator and the operator knows that this is what he has to do. This is a sample of sample job card giving details of what is the name of the operator, name of the operation, machine required and the schedule and the next operation.

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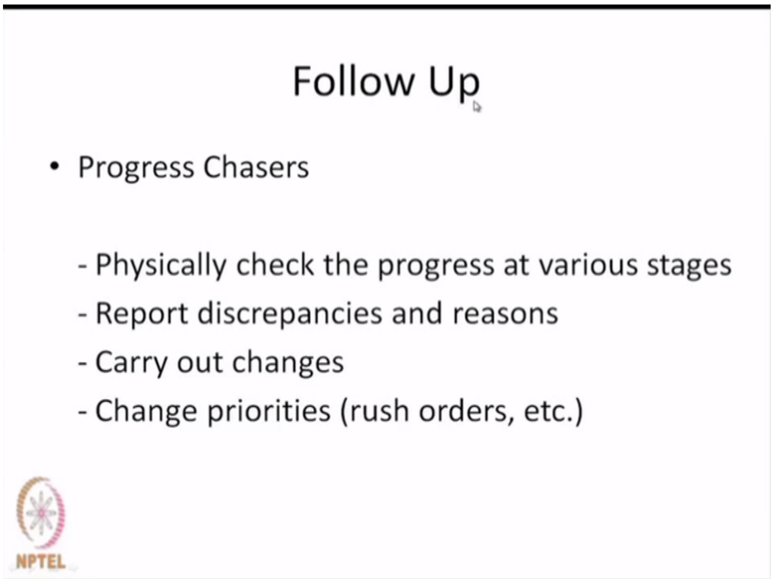

Now we talk about the follow up. Basically, when the work of production starts and continues, it has to be seen whether things are getting delayed. Conventionally, in the shop floor there are persons who are basically called progress chasers who physically check the progress of the work at various stages and report discrepancies and reasons for any such discrepancy.

They suggest how to carry out changes, they can also change priorities. Suppose for example there is a press order or important order that may be given higher priority and therefore production plan may have to be changed.

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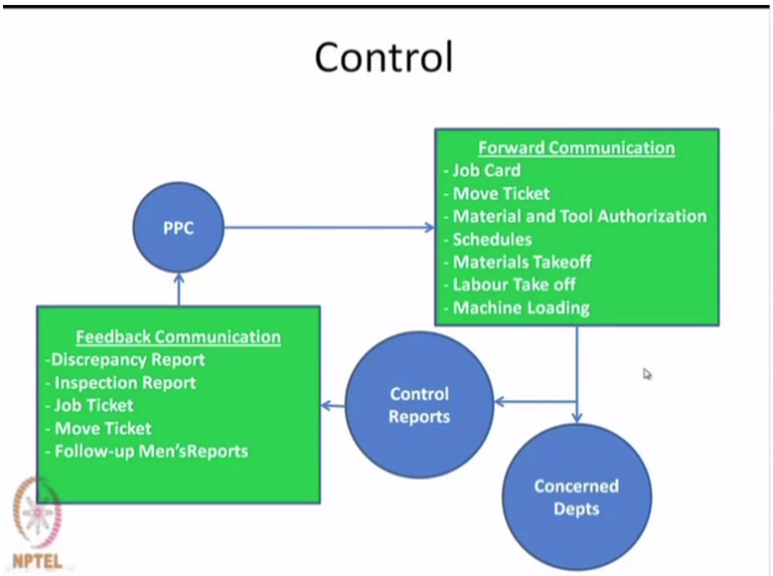

Finally, the control aspects, control is carried out almost everywhere but as you can see PPC releases various forward communication in the form of job card, move ticket, authorization for material and tool procurement, prepare schedules, authorizes materials takeoff, labour takeoff, machine loading, all these are planned and are available and are sent to concerned departments.

And then at different points of time, the actual progress is reported and in the form of reports and discrepancy report, inspection reports, job ticket, move ticket and follow-up men's reports, these are available on the basis of which production planning keeps a control on the activities. So friends, production planning is like the brain of production activity in an enterprise, it make long-term plans, converts them into schedules.

Planning one can use different mathematical models, models of mathematical programming and these plans are converted into time tables, which machine should be loaded, from which date to which date, which job is to be processed in which machine in what sequence. We give some heuristics for simple situations, one machine many jobs, 2 machines many jobs, and different other situations.

But there are large number of cases but one has to always use judgment. There are various priority rules that one can use after the scheduling comes the authorization letters for carrying out the activities like procurement of material, hiring people, procuring tools, gauges and fixtures and then finally follow-up and chasing and control. So we have covered only the most essential elements of production planning and control.

I hope that if one is interested to go into details of this topic, one has to read some books and get to know various other details. In our next lecture, we shall discuss certain aspects of materials management. Thank you very much.