Manufacturing Systems Management
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Lecture - 6
Cellular Manufacturing - Unidirectional flow, Capacity Planning, Layout

In today's lecture we continue the discussion on Production Flow Analysis.

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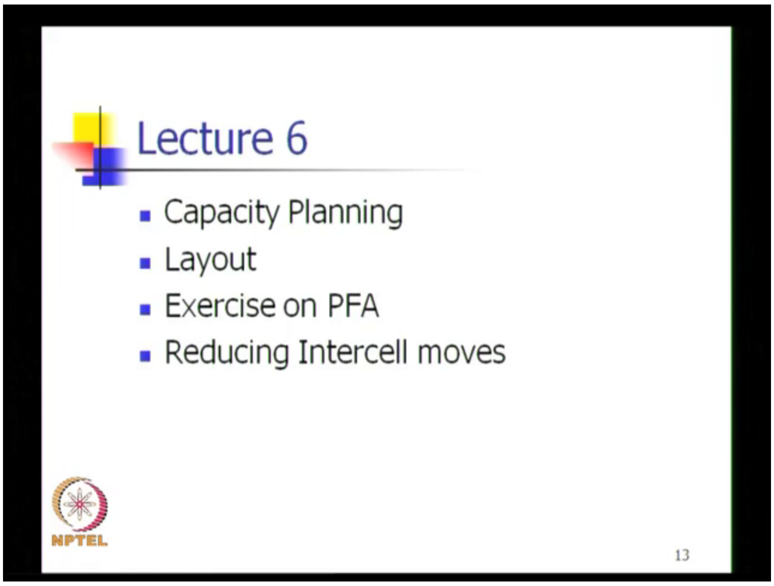

In the last lecture we completed the exercise of creating machine cells and part families for a 16 by 43 matrix, which had 16 machine types and 43 parts.

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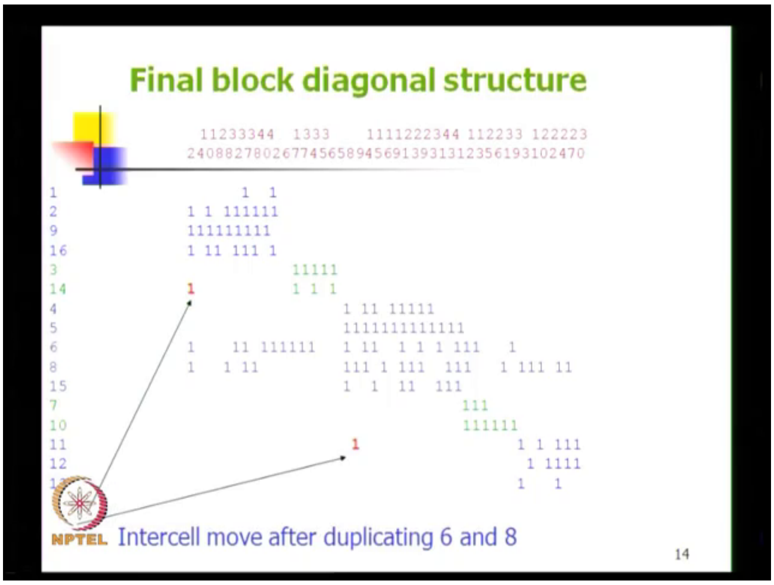

We obtained the final solution like this, where we created 5 cells: this is 1 cell, second, third, fourth, and fifth. And we also said that machines 6 and 8 will have to be duplicated to each of these cells depending on the requirement and if there are sufficient numbers of 6 and 8 then the solution has 2 intercell moves which are given by the ones which are in red colour, where component number 2 moves to another cell to visit machine number 14 and component number 9 moves to another cell to visit machine number 11. Now we have also seen that there are 3 aspects to production flow analysis 1 is called factory flow analysis, group analysis, and line analysis.

This solution is something that we obtain at the end of group analysis and after this solution we have to look at line analysis. So, in line analysis we try and bring in many things that we have not considered during the group analysis. For example, when we started describing the data for group analysis we used a matrix similar to this, but a matrix whose rows were 1 to 16 in that order and whose components were 1 to 43 in the given order.

So, otherwise the matrix is similar. So, when we introduce the matrix we also said that this matrix captures only the incident data, which means it captures data of visit of components on the machines and does not capture data relating to volume of production of these components the processing times as well as the sequence in which they visit the machines.

So, now, when we start creating or planning the required capacity of each of these cells that have been created, now we are to find out whether 1 machine is enough to meet the demand of all the components visiting that particular cell or do we need more than 1 machine of a type simply because of the capacity requirements.

In other words capacity requirements have to be calculated based on which the number of machines of a particular type going to a cell will be determined. Once again if we look at the first cell which has 1, 2, 9, 16 and if we assume that 6 and 8 are also duplicated, so this cell will have 1, 2, 6, 8, 9 and 16 as 6 machines and it will make these components starting from 2 and so on. 242, 2, 4, 10, 18, 28, 32, 37, 38, 40 and 42 are the components made in this. Now we have to do based on capacity calculations whether 1 number of this machine is enough or whether more than 1 number of this machine is required. So, we have to do that capacity calculation. Secondly, the sequence of visits is also not known and the cell in variable has products moving in a unidirectional flow.

So, either if there are reentrant flows or if we have a situation where the root or the order of visiting the machine changes the requirement, we may have to add machines into the cell. So, line layout addresses all these issues and we will now see how we address some of these issues through some examples, now we want to find out what is the requirement of the number of machines in a particular cell.

So, we now say that example if we take this cell and say part number 2. So, if we take part number 2 into this cell, now part number 2 visits machines 2, 9, 16, 6 and 8 it visits machine 14 in some other cell. So, let us not look at that. So, let us look at 2, 9, 16, 6 and 8 if we start looking at. So, if we start looking at the first cell we have machines 1, 2, 9, 16, 6 and 8 and if we take machine number 1 only 2 components 37 and 42 visit machine number 1. So, what is the requirement on machine 1 in cell 1 due to component numbers 37 and 42? So, we describe this that way if volume of part j per year is equal to d j now if we take part number 37 then the volume will be d 37.

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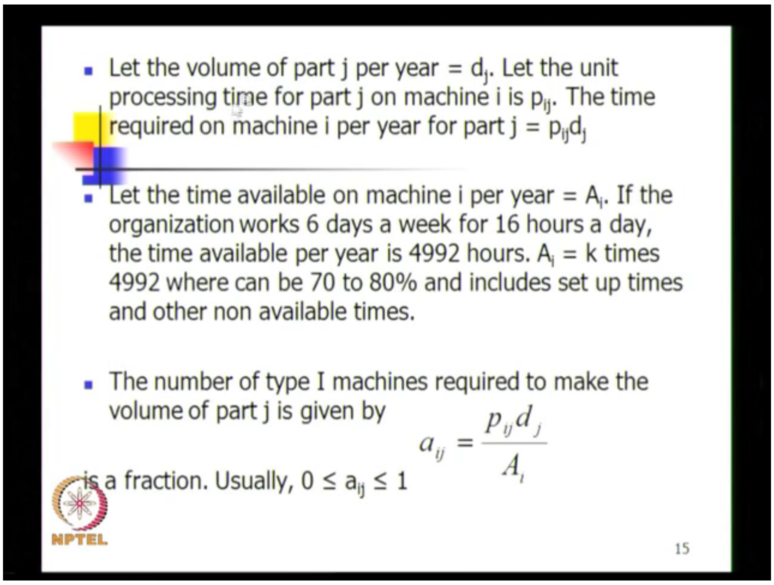

You need processing time v p i j. So, p i j will be the processing time associated with processing part number 37 on machine number 1. So, the time required in machine i per year for part j is equal to p i j into d j, multiply the unit process processing time by the demand or volume of production would give us p i j into d j. Now let the time available on machine i per year is a i. So, if the organization works 6 days a week for and for 16 hours a day then the time available per year is 6 into 16 into 52 which is 4900 and 92 hours. Now the availability which is A i is now taken as k times 4900 and 92 where k can be 70 to 80 percent and includes set up times and non-available times. So, let me explain this further. So, let us take the case of cell 1.

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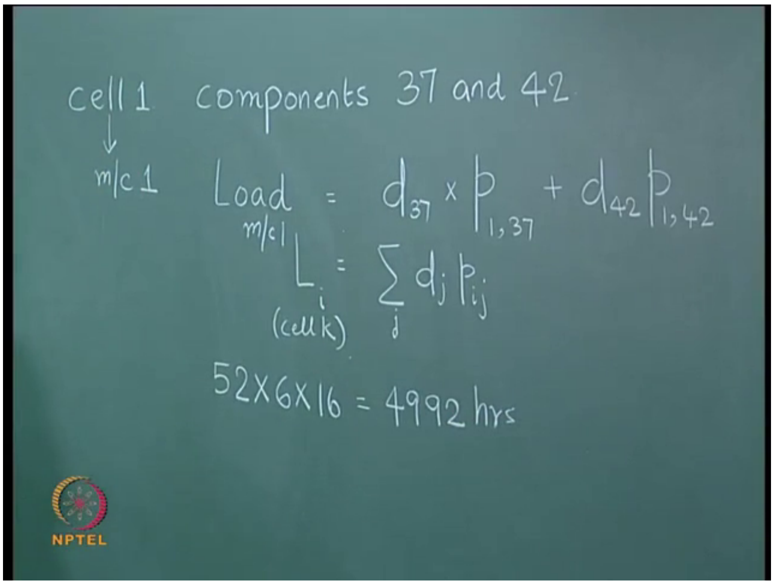

Which has components 37 and 42 which also has components, 37 and 42 cell 1 has machine number 1 that has components 37 and 42 visiting. So, what is the load on machine 1 cell 1?

So, load on machine 1 in cell 1 is equal to d 37 which is the demand or volume of component number 37 multiplied by unit processing time which will be the processing time for component number 37 on machine number 1 now total load plus d 42 into p 1 comma 42. So, if more than these 2 components are visiting this machine then we have to add all of these. Now, this load will be it can be called as sigma d j p i j as load on machine i in some cell k summed over parts j, now let us say we are looking at machine number 1 and say if we work 52 hour 42 weeks into 6 days a week into 16 hours a day we have 4900 and 92 hours available in a year. Now we cannot say that all the 4900 and 92 is available because there can be.

So, many reasons if we see that this 4900 and 92 ideally should be used for processing as well as setup times on the machine. So, this has a setup time component this sum of a large proportion of this will be used to meet this requirement, but some time out of this 4900 and 92 is also used in setting up the machine to manufacture the parts.

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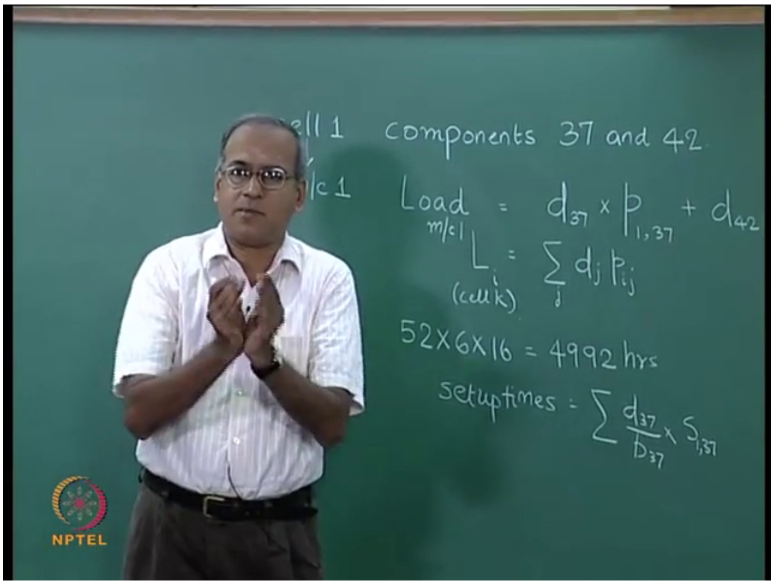

Sometimes setup time component can be if I take this 37. So, d 37 divided by there will be a batch size in which we will be making this 37. So, that will be called as b 37 into setup time S 1 comma 37, which means this is the number of batches that we will make or the number of times that we will make this component 37 and every time we make this component 37 there is a setup time. So, this will be the setup component, plus or if I take the summation then I will do plus d 42 by b 42 into S 142.

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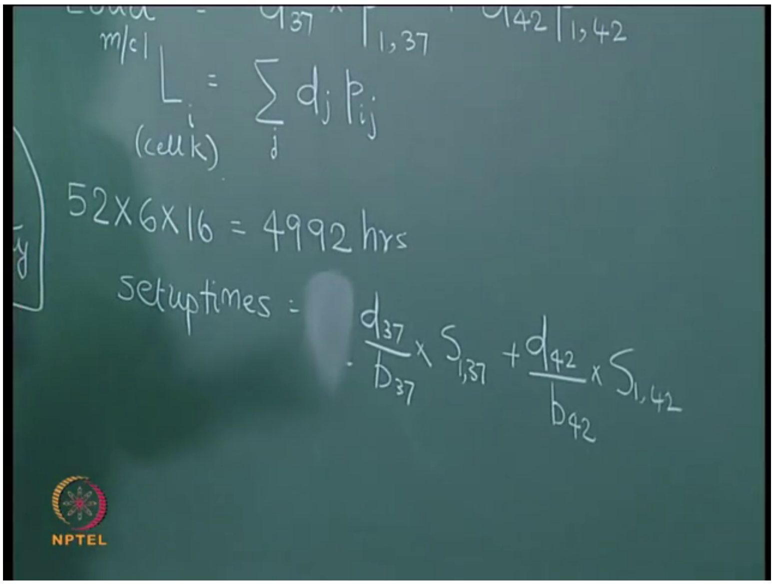

So, this will be the total setup time required.

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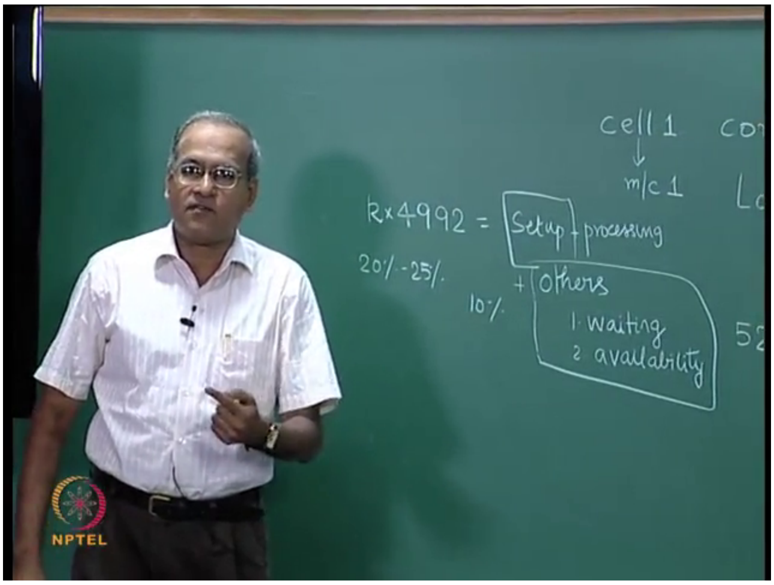

So, this 4900 and 92 can be used as for setup plus processing plus others, now this others would include sometimes machine waiting due to scheduling related issues, sometimes due to availability issues, there could be a breakdown, there could be part not available operator not available consumables not available and other issues.

So, many times all these are factored and we could say that about 10 percent is lost in these, sometimes it is possible to accurately estimate this, sometimes it is not possible to accurately estimate this because this batch size can also change with demand and time. So, this is even though it is a constant and can be measured the batch size changes. And therefore, this also cannot be measured very accurately considering a time frame like 1 year and so on. It is very hard to say how many times we are going to make this in 1 year therefore; this sometimes it is difficult to measure this 1 completely accurately.

So, it is customary to say that this plus setup the whole thing would take something like 20 percent to 25 percent of the times. So, the organization based on experience and based on some of these computations would say that about 75 percent of this 4992 would be made available completely for processing sometimes it could be 80 percent and so on, depending on new machines depending on less time last due to some of these, if we have good scheduling practices, if the if good maintenance practices then the availability will increase up to 85 percent ninety percent and so on.

So, it is possible to find out what percentage of this 4992 is actually available. So, now, what we will do is let us call that availability by a certain number k. So, k is between 0 and 1. So, if it is 90 percent then it will be 0.9. Now, this amount of k into 4900 and 92 should be able to meet this requirement of d 37 into p 1 37 plus d 42 because this is the load or processing time requirement of this.

So, at an aggregate level 1 would say that this quantity divided by k into 4992, if it is less than 1 then we say it is enough to have 1 machine in that cell. Now if this quantity the load divided by availability is say 1.5 or 1.6 then we will say that 2 machines are required in that cell. Alternately we can even individually calculate and say d 37 into this quantity this quantity alone divided by k into 4992 will tell us how many equivalent machine loads is required to make this how many equivalent machine loads is made for this for example, if this is 0.4 and this is 0.3 then we could say total of 0.7 is required.

So, with 1 machine it is possible to do if this is 0.7 and this is 0.6 then we say it is 1.3. So, with 1 machine it is not possible to do. So, we include 2 machines into the analysis. So, this is what we have tried to explain through this as some kind of an a i j.

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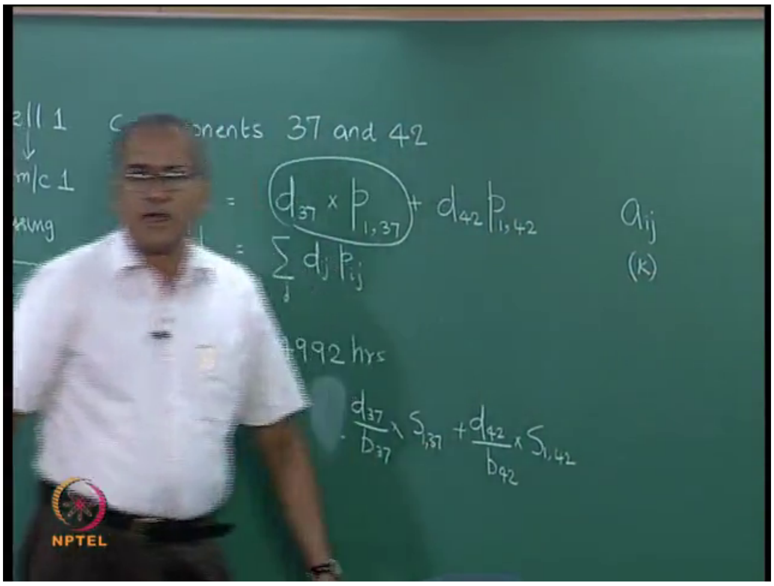

Now, a i j will be the load by the j-th load in terms of equivalent machine loads by component or part j on machine i in a given cell k. So, that is our a i j that is given here. So, we can calculate this and try to find out how many machines are required of each machine type in each cell. So, that is 1 form of being line analysis.

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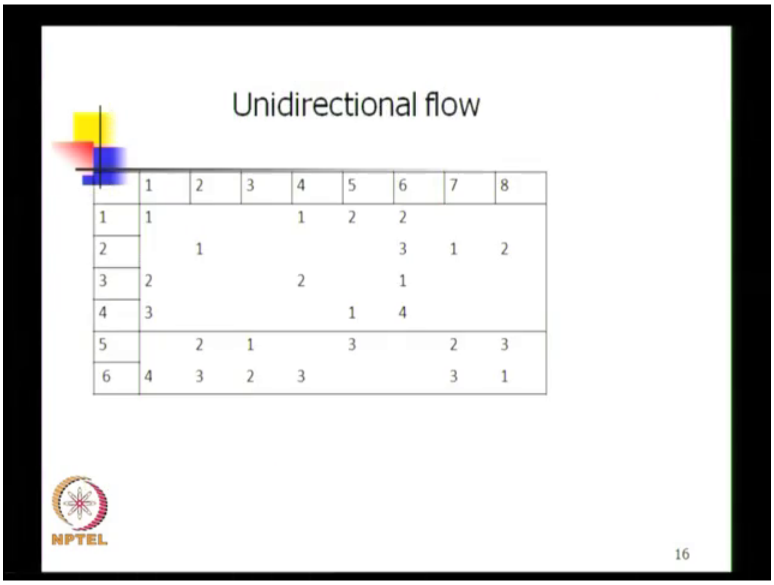

Now, the other thing that we would look at is what is the effect of unidirectional flow on the cell, well in order to explain this unidirectional flow we take a different example, we have not taken the same example, we take a different example, we take a smaller machine component incidence matrix with 6 machines and 8 parts for the purpose of illustration we take a much smaller example. So, this is the given machine component incidence matrix and let us say we are making cells from this. So, let us say 2 cells have been made from this machine component incidence data.

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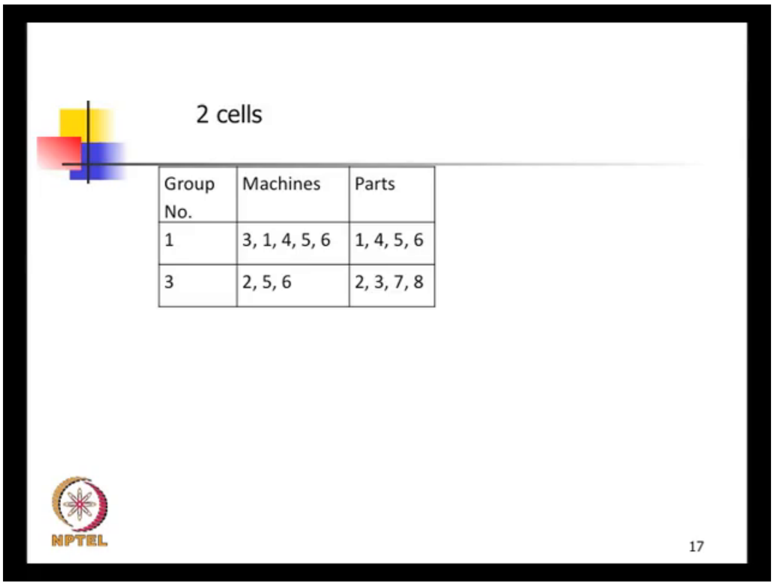

Where 1 cell has machines 3, 1, 4, and 6 that makes parts 1, 4, 5 and 6 it has 3, 1, 4 and 6 and the second cell has 2, 5, 6 and 2, 3, 7, 8. So, there are 2 cells now this is a different example this is not part of our 16 machine 43 component examples a much smaller example of an incidence matrix more for the purpose of illustration. So, the incidence matrixes itself has 6 machine types and makes 8 parts, and let us say at the end of the exercise of production flow analysis we have got 2 cells or 2 groups which make this well.

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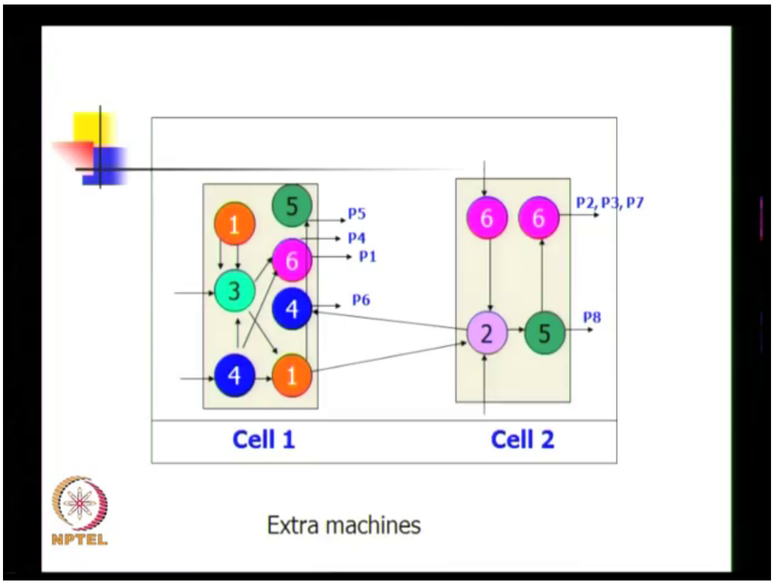

Let us go back and see how the 2 cells are going to be laid out the first cell has machines 3, 1, 4, 5, and 6 and the second cell has machines 2, 5 and 6. Well you realize that this picture has 2 machines of 1 and 2 machines of 4 and this has 2 machines of 6. Let us assume we start with 1 machine of each type we will have 1, 3, 4, 5, and 6 that are here and 2 5 and 6 which are in the other 1 now let us take each of these parts. So, part 1 the sequence is machine 1 and then 3 and then 4 and then 6 these numbers represent the sequence or order of visit of the parts on the machines.

Now, the machine components incident matrix is created in such a manner that it is not a binary matrix it is not a 0 1 matrix we are capturing the insurance data. For example, this component visits this machine this component does not visit machine 2. So, incidence data is captured volume and processing time data are not captured, but the order of visiting the time machines or the sequence of machines is captured. So, we say that part number 1 visits machines 1, 3, 4, and 6 in the order 1, 3, 4 and 6 whereas, component number 8 visits machines 2, 5 and 6, but in the order 6 first followed by 2 and then followed by 5.

So, with this additional information of the order of visit of the machines let us go back and see how our cell will look like. Now for part 1 it visits 1 3 4 and 6. So, you realize part 1 it visits 1 3 4 and 6 and part 1 comes out. Now look at the second 1 which is part 4 part 4 visits in the order 1 3 and 6. So, part 4 visits in the order 1 3 6 and part 4 comes out. Now look at the third 1 part 5 part 5 is 4 1 and 5. So, you see 4 1 so 4 1 and 5. So, we assume that machine number 5 is brought into the cell it is duplicated. So, 4 1 and then 5 you can see from 4 1 and then 5 it goes out. So, there is an extra 5 that comes into the cell and then we look at part 6 which has 3 1 2 and 4 now you see the 3 1 it goes to 2 it comes back to 4 and then it leaves.

So, we could also say for example, that 3 1 2 and then it could come back to this 4 and then it could leave, but the point that we make is because of unidirectional flows we may have to increase machines as it comes because if you see this very carefully now there is 1 2 3 4 and then you find and then you find part 6 which has 3 1 2 and 4. So, you cannot have machines 1 2 3 4 if you look at part 1 as 1 3 4 and 6 part 6 has 3 1 2 and 4. So, there is a part which moves 1 and then 3 and 3 is another part which moves 3 and then 1.

So, if we let the cell of unidirectional flow like this starting here and going this there is definitely a need to duplicate machine number 1 I order to maintain unidirectional flow. Similarly we can do this analysis for the second cell, second cell has 2 5 and 6 machines and parts 2 3 7 8, now 2 5 and 6, now let us go back to this 2 3 7 8 part 2 the visit is 2 5 and 6. So, you could start with 2 5 and 6 part 2 goes. Now look at part 3 part 3 it is 5 and 6. So, it fits in 5 and 6 part 3 goes, now we look at part 7 the visit is 2 5 and 6.

So, once again 2 5 and 6 part 7 is 5, but look at part 8 which is the last part it is 6 and then 2 and then 3, whereas here it is 2 and then 6. So, this would necessitate that if we want to maintain unidirectional flow then we have to have another 6 that comes. So, the flow will be in this direction. So, line analysis has multiple components 1 of which is to find out extra machines based on machine load and other is to find out extra machines based on the requirement of unidirectional flow.

A unidirectional flow is required in a cell. So, that there is much more control in the cell if we do not have unidirectional flow and if we let bidirectional flow within the cell then we will very quickly lose control. So, for this purpose most situations whenever we implement a cellular manufacturing the material movement within the cell is unidirectional. So, to ensure unidirectional flow it may be necessary to create extra machines in the cell.

So, line analysis takes care of all the analysis of machine capacity number of machines required the specific layout which ensures unidirectional flow. Let us carry out 1 more exercise and production flow analysis to try and understand some aspects of p f a which were not addressed in the earlier example. Now we will take another example and carry out the p f a and try to show the possibility of alternate solutions plus the tradeoff between intercell moves and duplicating or adding extra machines.

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	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	TOT/	UNU TILIS	No. of
A	10		8		18					10	20		15			20	15		30		146	54	2
B	30		20			15			30		25			30	20	25	20		40		255	45	3
C	20		20		16			19		20		25				20	30		20		190	10	2
D				30			40							20	10	20		30		20	170	30	2
E	10	20		20									15				15		20		100	0	1
F		15				20	20	15			20		15		15			20			140	-40	1
G			10		20					10		20									60	40	1
H						30		20			20							20			90	10	1
I				10					15					15						10	50	50	1
J		10		20										15						15	60	40	1

So, let us look at this example this example is 1 which has 20 parts or components which are being made which are shown as columns 1 to 20 there are 2 machine types which are A to J. So, the incidence matrix is up to this column 20 10 rows and 20 columns and you will observe that the incidence data that we have shown here is slightly different from the 2 types of data that we have seen, the very first example we showed a binary matrix which either had a 1 or a 0 and captured the incidence data alone. In this incidence matrix we had the data as non-binary, but it captured the order of visit of the machines, in this we said that component number 8 will visit machines 2 5 and 6, but in the order machine 6 followed by machine 2 followed by machine 5 now here we have given like 8, 18, 30 and so on.

Now, we have to look at these numbers and say that actually this number is not 10 it is 0.1 this number is not 30, but it is 0.3, this number is not 18, but 0.1 8. So, the incidence data represents the equivalent machine loads required by this component on that machine. For example, the data that we have here is actually this value that we set what we have is the equivalent of D 37 into P 1 3 7 divided by k into 4 9 9 2.

For example, this number 8 represents that component number 3 visits machine a and the volume of component number 3 multiplied by the processing times of component number 3 divided by 4 9 9 2 is 0.0 8 8 percent is 0.0 8. So, 1 would say that this component takes 8 percent of the load of machine A and visits machine A. So, this is another way of representing input data to production flow analysis. Now we have also added a few things here and said the total load on machine A is the sum of all these numbers in that row and it is 100 and 46, which means the total load on machine a is 1.4 6 equivalent of 1 machine or 1.4 6 machine load and we therefore, say that 2 numbers of machine A is currently available in the functional layer.

Similarly, 200 and 55 is the requirement on b which is 2.5 5 machines and we say that 3 machines are currently available, 100 and 90 or 1.9 is the requirement on C 2 machines are available 100 and 70 is the requirement on D 2 machines are available 100 is the requirement on E right now 1 machine is available we will come and discuss about this, 100 and 40 is the requirement on F, but only 1 machine is available the requirement itself says 1.4, but 1 machine is available, 60 on G 1 machine is available 90 50 and 60. Now we have to talk about 2 things this 100 load and 1 machine 100 and 40 load and 1 machine.

Now, 100 load and 1 machine implies that when we have calculated these numbers we have actually multiplied that 4900 and 92 by k which represents the availability. Otherwise expecting 100 percent is very difficult the k has been factored or availability has been factored in the denominator when we actually divide, it if we had used 4900 and 92 and got it then we should again say that 100 percent we cannot handle we will be able to handle only 85 percent and so on.

So, right now because of this 100 1 can assume that with 1 machine we get 100 even then it is a little tight, but we would continue to assume that this hundred is alright for us with 1 machine possible to, but how are we going to explain that the requirement is 140 and there is only 1 machine available. So, we give additional data onto this problem and say that the additional data would say that.

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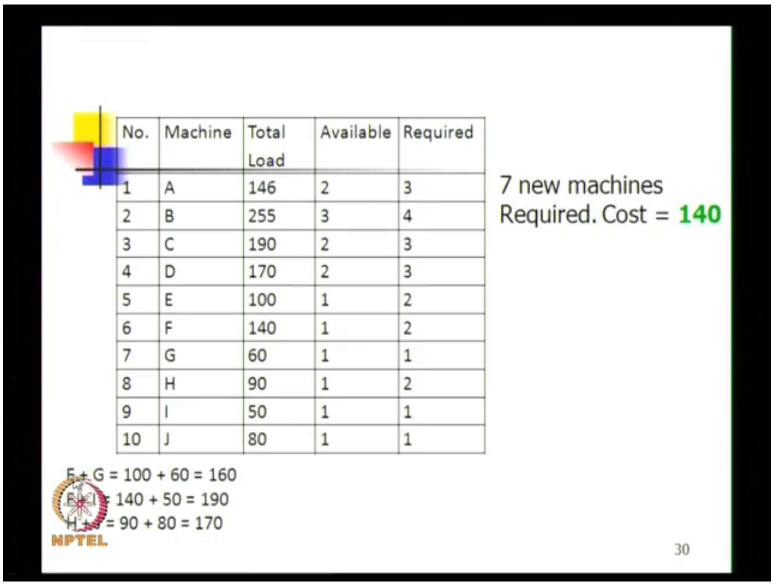

Now, E and G, F and I, H and J so when you look at these machine combinations E and G, F and I, H and J so we write these combinations E and G F and H F and I and H and J.

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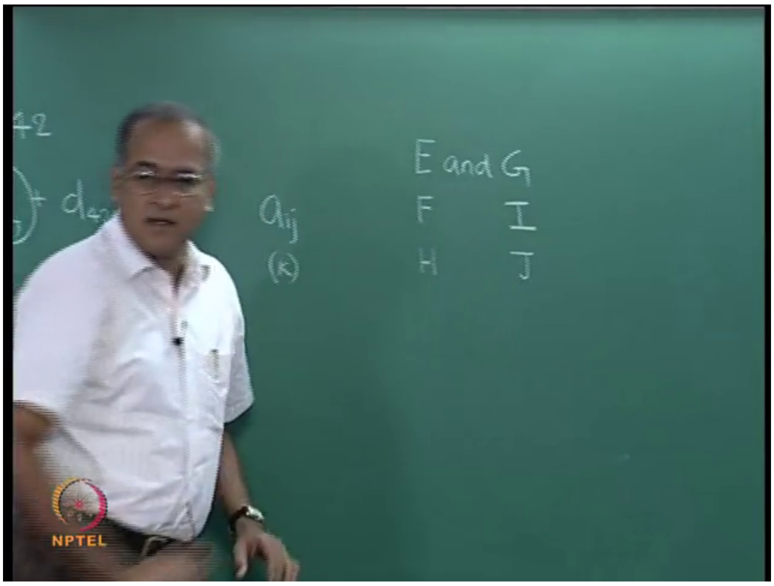

So, what we are going to say that these machines can be used interchangeably, which means which means when required some load on machine E can be taken up by machine G some load on machine.

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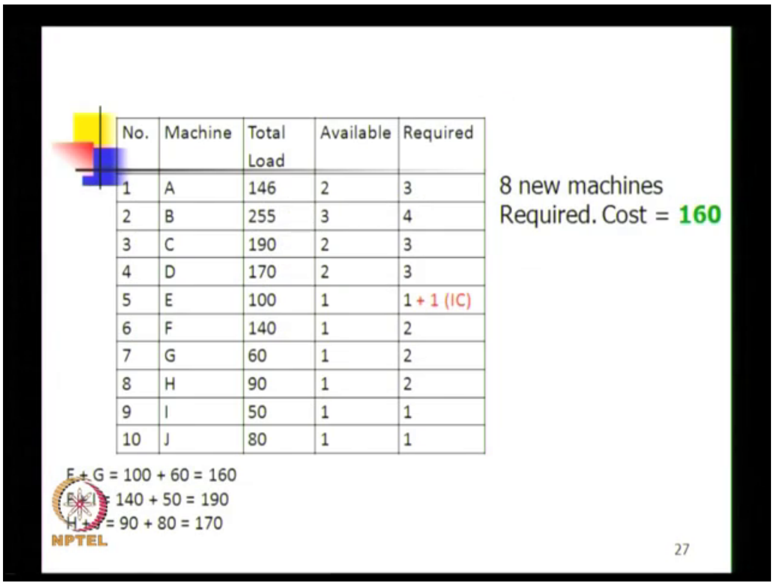

No.	Machine	Total Load	Available	Required
1	A	146	2	3
2	B	255	3	4
3	C	190	2	3
4	D	170	2	3
5	E	100	1	1 + 1 (IC)
6	F	140	1	2
7	G	60	1	2
8	H	90	1	2
9	I	50	1	1
10	J	80	1	1

F can be taken up by machine I and some load on machine H can be taken up by machine J.

So, now if we add the loads we get E and G the load is 100 and 60 we go back E and G the load is 100 plus 60 100 and 60, but then we have 1 machine here 1 machine here. Similarly F and I the load is 140 plus 50 100 and 90. So, we could say that we have 1 machine of F and 1 machine of I some load is shared by I from F. Similarly H and J 90 plus 60 we have 1 machine of each, therefore we could say that there is enough capacity on the existing system to meet the requirements of the components, now let us do production flow analysis and see how we make machine groups and part families.

So, we can do a few things now that we have done these load calculations we can now replace all these loads by 1 and 0 and create a binary matrix which we can use to do production flow analysis.

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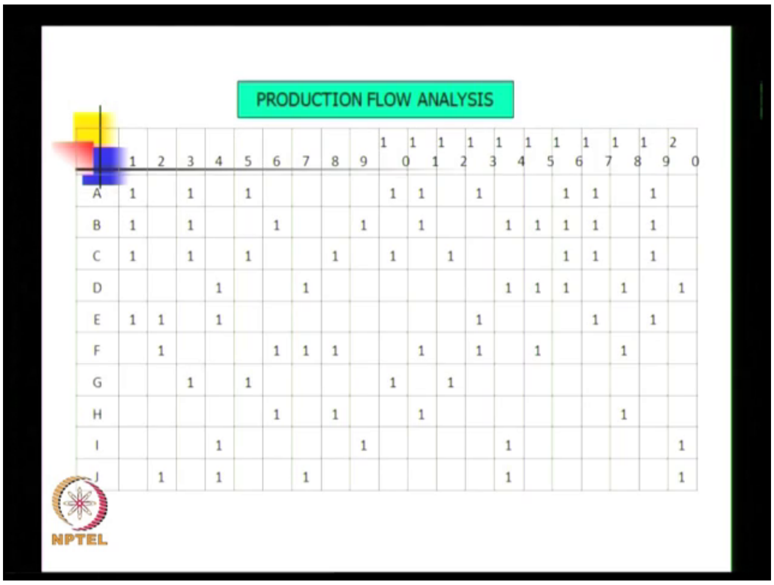

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A	1		1		1					1	1		1			1	1		1	
B	1		1			1			1		1			1	1	1	1		1	
C	1		1		1			1		1		1				1	1		1	
D				1			1							1	1	1		1		1
E	1	1		1									1				1		1	
F		1				1	1	1			1		1		1			1		
G			1		1					1		1								
H						1		1			1							1		
I				1					1					1						1
J		1		1			1							1						1

So, the binary matrix has been created and the binary matrix looks like this now all the loads have been replaced by ones which say that this component visits this machine.

Now, we can carry out the steps of the production flow analysis and we can create the frequency table and we can create the modules. Now let us assume that we have done all that and our frequency table will look like this.

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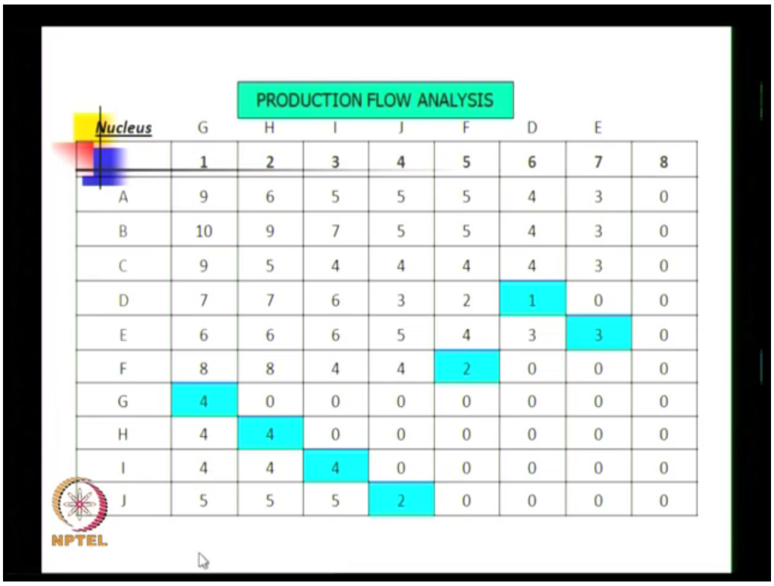

Nucleus	G	H	I	J	F	D	E	
	1	2	3	4	5	6	7	8
A	9	6	5	5	5	4	3	0
B	10	9	7	5	5	4	3	0
C	9	5	4	4	4	4	3	0
D	7	7	6	3	2	1	0	0
E	6	6	6	5	4	3	3	0
F	8	8	4	4	2	0	0	0
G	4	0	0	0	0	0	0	0
H	4	4	0	0	0	0	0	0
I	4	4	4	0	0	0	0	0
J	5	5	5	2	0	0	0	0

The first frequency table will look like this. So, we will start with machine number G as the nucleus machine.

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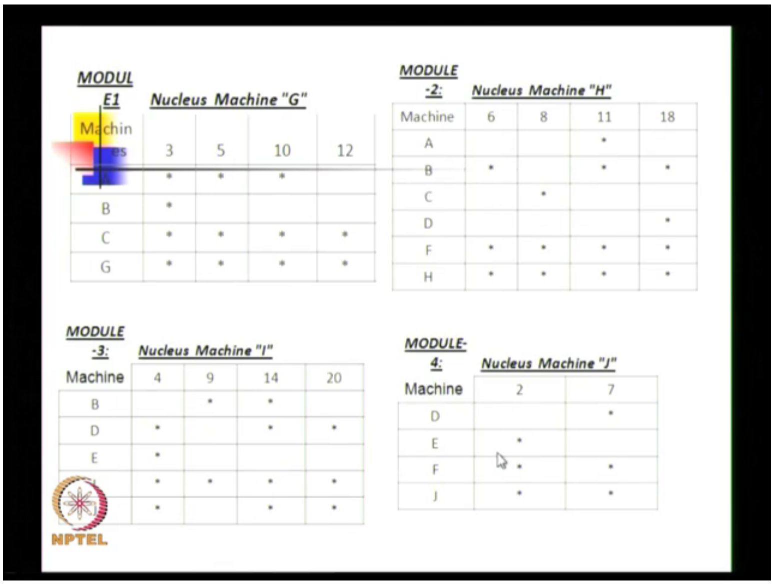

And we will create the first module, the second module, the third module, the fourth module, fifth module, sixth module, and seventh module.

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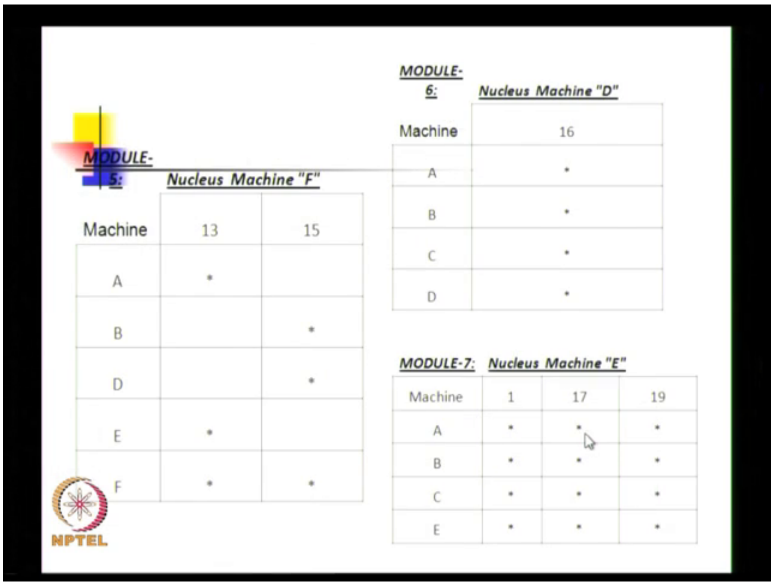

So, there are 7 modules that are created and the 7 modules along with the components look like this.

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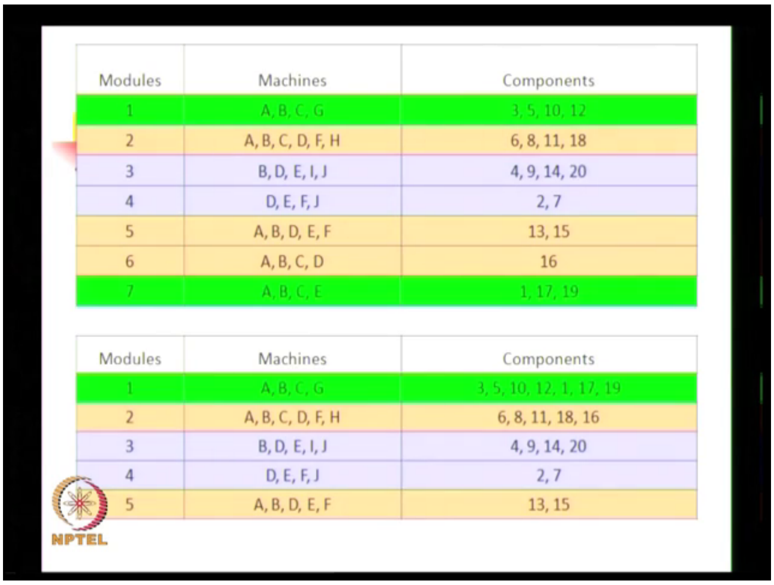

Modules	Machines	Components
1	A, B, C, G	3, 5, 10, 12
2	A, B, C, D, F, H	6, 8, 11, 18
3	B, D, E, I, J	4, 9, 14, 20
4	D, E, F, J	2, 7
5	A, B, D, E, F	13, 15
6	A, B, C, D	16
7	A, B, C, E	1, 17, 19

Modules	Machines	Components
1	A, B, C, G	3, 5, 10, 12, 1, 17, 19
2	A, B, C, D, F, H	6, 8, 11, 18, 16
3	B, D, E, I, J	4, 9, 14, 20
4	D, E, F, J	2, 7
5	A, B, D, E, F	13, 15

So, we will assume that this up to this part we have already carried out because we have seen in the earlier example as to how to get these modules and how to create the 5 the table that has all the modules with the associated machines and components.

So, we now assume that this up to this table the first table we have done by following the steps meticulously following the steps that we have described in the earlier production flow analysis. If you observe very carefully up to this point the production flow algorithm is reasonably consistent in the sense that whoever carries out production flow analysis will eventually get up to this table and there will be no difficulties and all the solutions will be the same till you get this table. Now after this table we now start merging the modules we start merging the modules such that if there are 2 modules where the machine set in 1 is a subset of another, then we merge both the machine sets and get the super set and we also combine all the parts and bring all the parts together into 1 module.

So, we have to carry out that. In fact, if we look at that part of the algorithm carefully a particular subset may be a sub set of 2 other sets not with reference to this example, but with reference to the previous example, if we had 1 module say which has machines 5 and 6 and above that there is a module with 3 5 6 and further above there is another module with 8 5 6. Now this 5 6 can be merged either with 3 5 6 or 8 5 6. So, the merger can create different solutions depending on how we actually merge. So, depending on who is doing it or depending on the algorithm for the merger or a local rule for the merger the solution can be different because the same machine set can be a subset for 2 other machine sets.

Keeping that in mind we still continue to do this and see whether we can merge. So, when we merge the first thing that comes to our mind is this A, B, C, D is a subset of A, B, C, D, F, H and therefore, this module will merge directly with this and 16 will go to this.

So, that is carried out and then we have these 5 modules or these this goes to this and then what we do is we look at this 1, 17, 19 module number 7 that has A,B,C,E and we also said that E and G are interchangeable which is very specific to his problem. So, we assume now that with the additional condition that E and G are interchangeable or can be used interchangeably, we will now assume that A, B, C, E and A, B, C, G are either 1 and the same or subsets and then we add this 1 also. So, that the 13 or 1, 17, 19 gets added to 3, 5, 10 and 12. So, from 7 modules we get 5 modules. So, we now have a solution with 5 modules with A, B, C and G making these set of components A, B, C, D, F, H and so on we have 5 modules which come into the solution.

Now, after we do this we can carry out 1 more step where we look at these modules in detail and try to see whether we can either eliminate a module or we can reduce machines in a module by carefully looking at individual modules. So, that we do now and then we say using interchangeability of machines what do we do now F and I are interchangeable merge modules 3 and 4. Now B, D, E, I, J D, E, F, J so F and I R interchangeable, we again use the interchangeability idea and merge these 2 modules 4, 9, 14, 20, 2 and 7.

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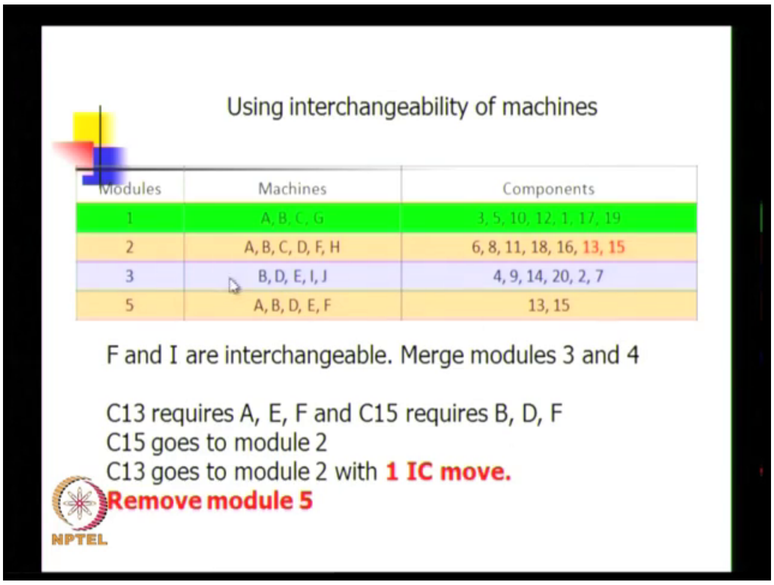

So, we do that to get this one.

Then we start looking at this module then we start looking at this module which has A, B, D, E, F and has 13 and 15. So, do that and see that this is the requirement 13 and 15 A, B, D, E, F now 15 requires B, D, E and F. So, 15 requires B, D, E and F we have B, D, E and F here. So, 15 goes to module number 2 directly 13 requires A, E and F. So, 13 goes to module 2 with an intercell move to either g or e because e and g can be used interchangeably. So, 13 goes to module 2, but with 1 intercell module.

So, we create 1 intercell move and we remove this module 5 from here A, B, D, E, F. So, that we can remove this module and save 5 machines and we get a solution which is like this.

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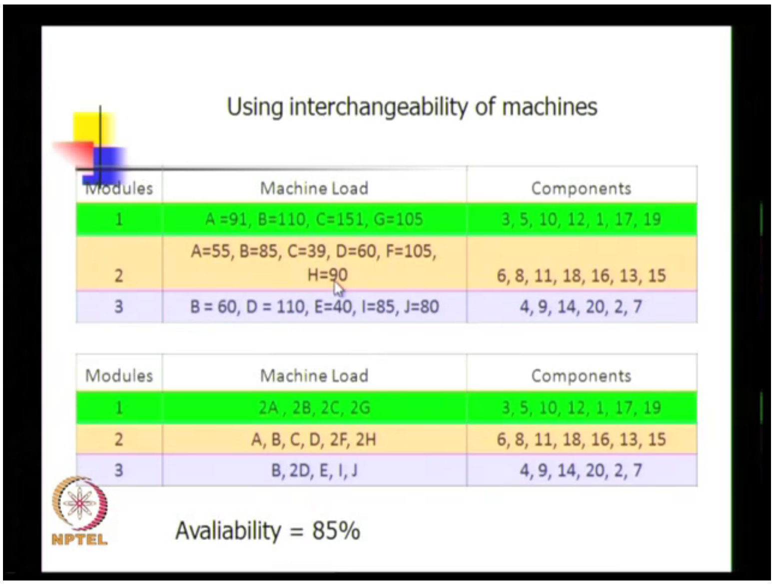

Modules	Machine Load	Components
1	A =91, B=110, C=151, G=105	3, 5, 10, 12, 1, 17, 19
2	A=55, B=85, C=39, D=60, F=105, H=90	6, 8, 11, 18, 16, 13, 15
3	B = 60, D = 110, E=40, I=85, J=80	4, 9, 14, 20, 2, 7

Modules	Machine Load	Components
1	2A , 2B, 2C, 2G	3, 5, 10, 12, 1, 17, 19
2	A, B, C, D, 2F, 2H	6, 8, 11, 18, 16, 13, 15
3	B, 2D, E, I, J	4, 9, 14, 20, 2, 7

A, B, C, G which makes these components A, B, C, D, F, H which makes these components and B, D, E, I, J which makes these components. So, there are 3 modules or 3 cells that we make and the first cell has 4 machines or machine types which makes 7 components, the second cell has 6 machines or machine types it makes 7 components the third cell has 5 machine types which makes 6 components. So, we come to this solution, now after we come to this solution we also start doing a little bit of capacity calculation primarily because the given incidence matrix already has the load requirements built in to the incidence data.

Therefore, we now do the part of line analysis we do it in the group analysis and see; what is the workload on each of the machines in each of the cells. So, we go back and check that now we realize that first module or cell has A, B, C, and G and now we go back to these components and see how many of them require A and then add the workload onto a for example, we have 1, 3 now we look at A in this.

So, this is these are the components that require A and then we go back to this and see 3 5, 10, 12, 1, 17, 19, 3, 5, 10, 12, 1, 17, 19, 3, 5, 26, 10, 36, 12 does not require 3, 5, 10, 12. So, 36, 1, 17, 19, 36 plus 10, 46, 46 plus 15 is 61 plus 30 is 91. So, you see that as requirement is 91. So, we have written a is requirement as 91 91 means 0.9 1 of the machine like this we have written all the requirements for all the machines now we want to find out the number of machines that are needed for this.

Now, the next table shows the number of machines that are needed. So, 91 we have still said 2 machines of A the reason is we have now keeping 85 percent as a realistic estimate that it can handle. Now let us go back to an earlier discussion when we started this exercise we justified by saying that for a 100 percent requirement of e there was 1 machine of E at that time I justified it by saying that the factor would have been incorporated in the denominator the availability factor is incorporated in the denominator.

But that was for a functional layout now for a cellular layout I am deliberately trying to create some extra capacity or cushion within the cell by assuming that the availability is only 85 percent. So, let us stick to this availability of 85 percent which will over estimate the requirement in the cell and that additional capacity will act as some kind of a cushion for the cell. So, if we keep 85 percent as the availability and do the computation then we would say that we need 2 machines of A here 2 of B 2 of C and also 2 of G then 1 of a like that we are carrying this out. So, this cell would require 2 plus 2 4 plus 2 6 plus 2 8 machines this would require 4 plus 4 8 this would require 1 plus 2 3 plus 3 6 machines to do this at an availability of 85 percent.

So, we now translate this into this table and say that when we started the exercise machines A to J where available these are the loads and the machines A to J this is the original availability of these machines, now this is the requirement based on our calculation. For example, A is 2 plus 1 3 of A is required I have said 3 of A is required if you look at B 2 B plus B plus B 4 B is required. So, 4 B is required plus I have added of 1 more E or G because of the intercell move that we created that would require 1 more machine. So, this is the requirement calculation. So, 8 new machines are required if we create.

Now, the problem also has another data which I did not mention at the beginning the problem also says for example, cost of a new machine can be taken as 20 lakhs while the cost of an intercell move can be taken as rupees 50,000. So, the cost of new machine being 20 lakhs would give us a additional cost of 100 and 60 lakhs, but with no intercell move and with lot of additional capacity inside. So, 1 could argue that a built in lot of capacity inside for example, 1 would go back and say that for this 91 there is no need to ask for 2 machines it is enough if you ask for 1 machine, because it is well within 100 plus we would have made an assumption that availability is factored in already, plus if necessary a small part of this load can even be shifted to this machine through an intercell move because this has a lot of unutilized there. So, 1 could do that and 1 could say that I have overestimated the requirement whereas, actually 2 is 2 is enough.

So, like this 1 could go back and by the process of creating intercell moves 1 could increase the number of intercell moves and 1 could say that the number of additional machines required is much less. For example, if we start doing something like this where we are going to create a lot of intercell moves modes to balance the capacity. So, that we do not add the new machines then the solution would look like this.

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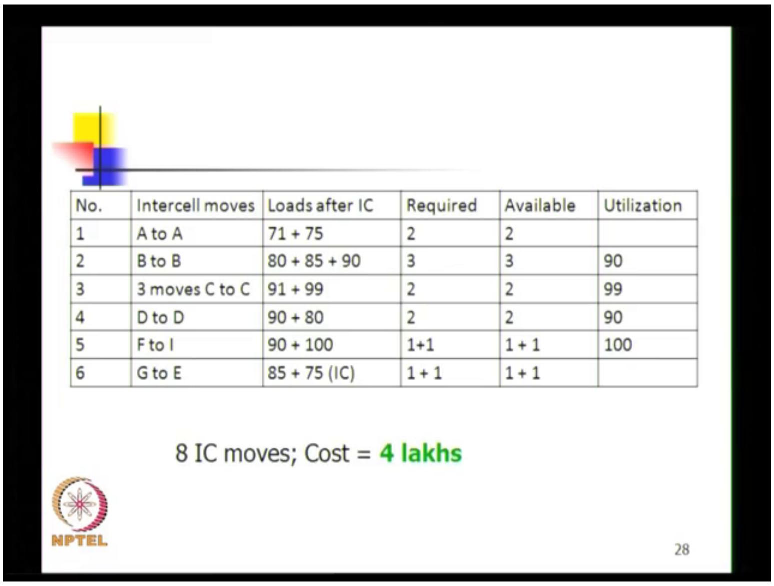

As I said from A to A which means from this A to this A, you can have 1 intercell moves. So, that this load becomes less than 85 percent. So, if you do that then this will become 71 plus 75 required is 2 available is 2.

Similarly, B to B which means somewhere here I have said 2 plus 1 3 plus 1 4. So, from this B to this B I can send 1 intercell move and I can reduce 1 B, like that I can do this I have shown this in the form of anther table and we can also adjust that f to I adjustment 1 could do this, but if we do this you will observe very carefully that the loads after the intercell moves, would be as high as 90 in 1 of the B machines, it would even be 99 in 1 of the C machines, it would be 90 again in 1 of the D machines, it would be total of 100 and 90, but 100 plus 90 together it is and 85 plus 75.

But if we do this process with about 8 intercell moves we need not have any additional machines, but the cost will only be 4 lakhs because the problem says that the cost of an intercell move is 15000. Now there are a few other issues 1 of which is the cost of an intercell move matching it versus cost of a new machine for the cost of a new machine a new machine has a certain lifetime. So, that can be divided as per year equivalent cost and so on. The intercell move cost will be the number of times the intercell move happens per month or per year and then that has to me multiplied by unit cost of intercell move. So, there will be issues matching these 2 there will be issues related to time and related to frequency of visits for us to match the cost of an additional machine and compare it with the cost of an intercell move.

Now let us assume that this is an illustrative example which is going to bring out some interesting things by comparing these 2. So, let us assume that this 15000 is going to be compared with 20 lakhs, I mean on phase of it a solution with 8 intercell moves and a cost of 4 lakhs is suddenly desirable than 8 new machines is the cost of 100 and 60 lakhs. So, purely from a cost point of view creating intercell moves is cheaper and advantageous, but 1 has to keep in mind that the very purpose of cellular manufacturing is to avoid these intercell moves, when the moment we start doing this what is shown in this figure we are actually replicating the old functional layout through the intercell moves except that these machines are kept in different places.

So, 1 should also have the solution where we actually create more capacity and duplicate machines and avoid intercell moves when we actually create manufacturing cells in cellular manufacture. So, we would propose that this solution of 160 or if this 160 is a little expensive at least some new machines and very minimal intercell move would be a desirable solution that we can propose we would also look at this example.

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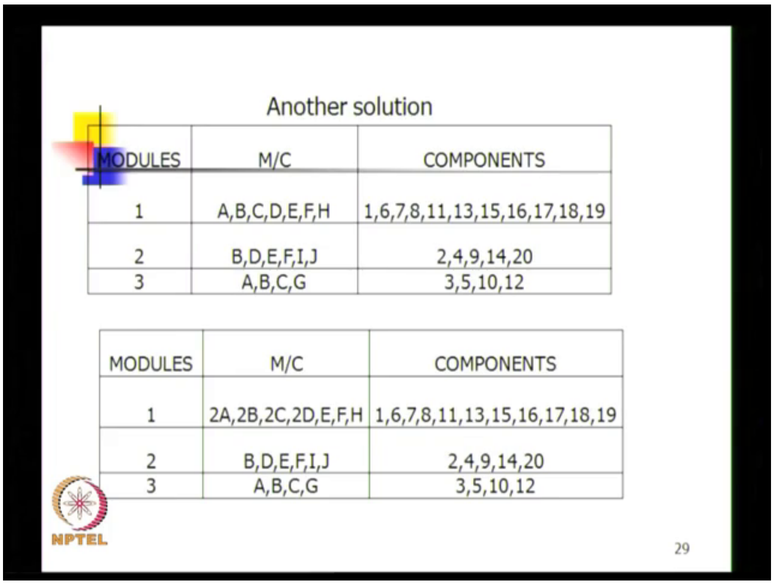

Through another solution and understand that we could have different solutions for the same problem this exercise we will carry out in the next lecture.