Automation in Production Systems and Management
Prof. Pradip Kumar Ray
Vinod Gupta School of Management
Department of Industrial and Systems Engineering
Indian Institute of Technology, Kharagpur

Cellular Manufacturing System
Lecture - 32
Cell Formation Approaches - I

During this week we are discussing various aspects of Cellular Manufacturing System.

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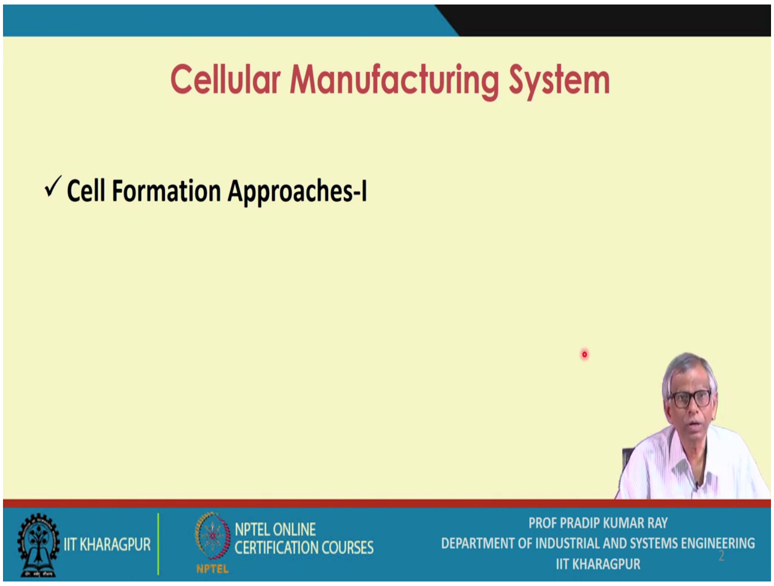

We have already defined a cellular manufacturing system, basically it is an application of group technology principles in a manufacturing system or in a production system.

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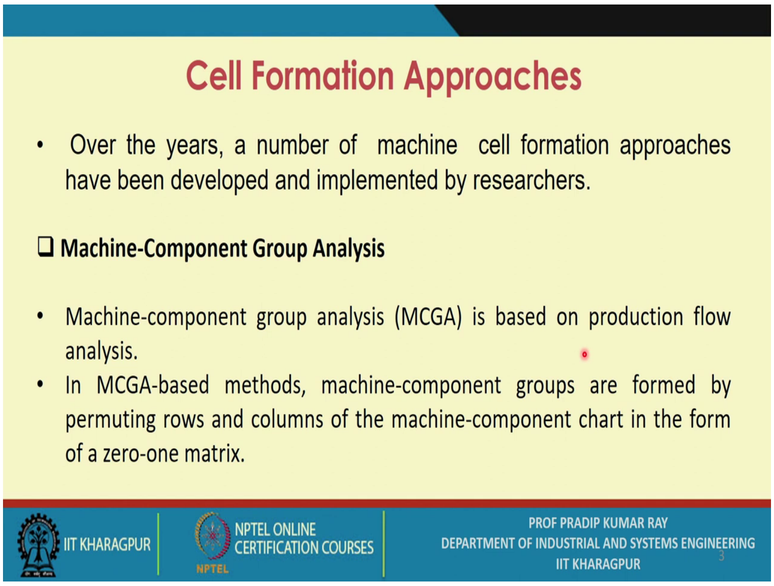

And the basic approach we follow, which starts with cell formation, that means the entire manufacturing system must be able to convert into a number of manufacturing cells or work cells, sometimes they are referred to as machine cells. And each machine cell that is dedicated to manufacturing the parts in a given part family.

Part family formation approach is already we have discussed. Now, once the part families are formed, the next step is creating machine cells or work cells. Now, during this lecture session.

Over the years, a number of machine cell formation approaches have been developed by a large number of researchers and the practitioners.

Particularly the companies or manufacturing plants, where cell manufacturing, cellular manufacturing system has been established or has been installed, the machine component group analysis. During this analysis focusing on the production flow analysis, you establish given a particular part the process plan were given a manufacturing system, you can the identify its process production flow which is based on production flow analysis. And in this particular method, machine component groups are formed by permuting rows and columns of the machine component chart in the form of a zero one matrix.

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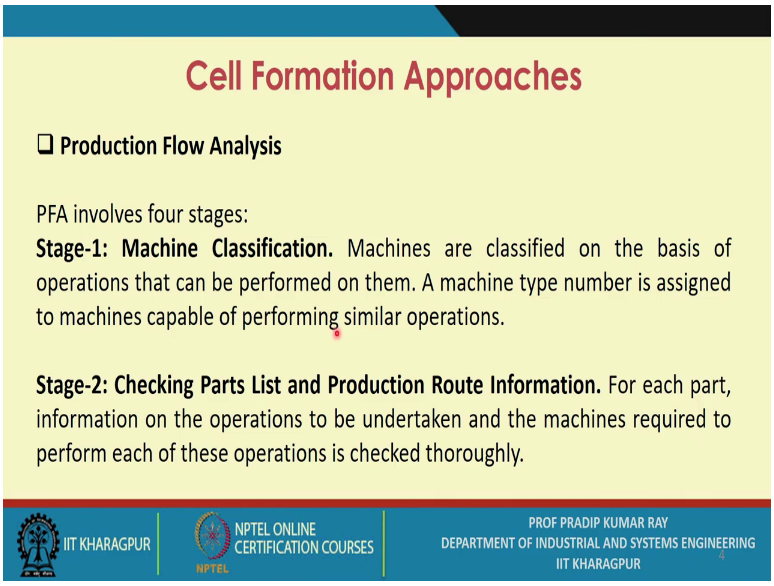

When we refer to Production Flow Analysis. PFA involves four stages:

Stage-1: Machine Classification. Machines are classified on the basis of operations that can be performed on them. A machine type number is assigned to machines capable of performing similar operations.

Stage-2: Checking Parts List and Production Route Information. For each part, information on the operations to be undertaken and the machines required to perform each of these operations is checked thoroughly.

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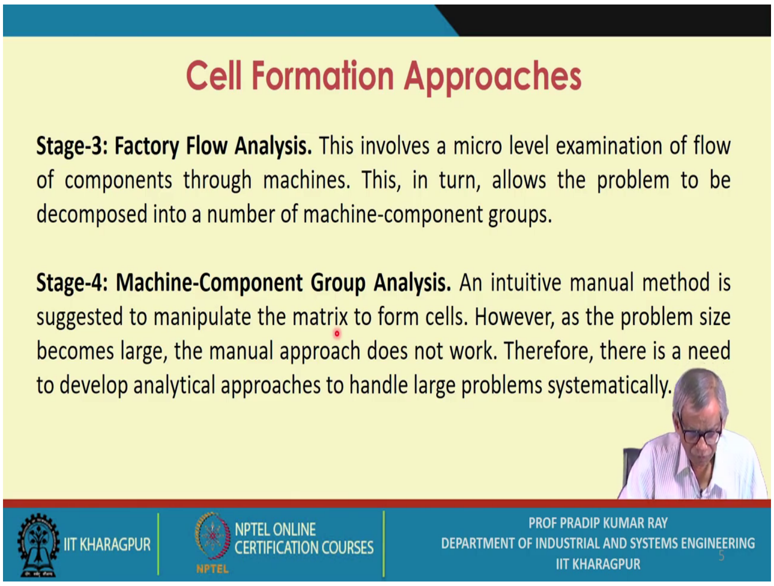

Stage-3: Factory Flow Analysis. This involves a micro level examination of flow of components through machines. This, in turn, allows the problem to be decomposed into a number of machine-component groups.

Stage-4: Machine-Component Group Analysis. An intuitive manual method is suggested to manipulate the matrix to form cells. However, as the problem size becomes large, the manual approach does not work. Therefore, there is a need to develop analytical approaches to handle large problems systematically.

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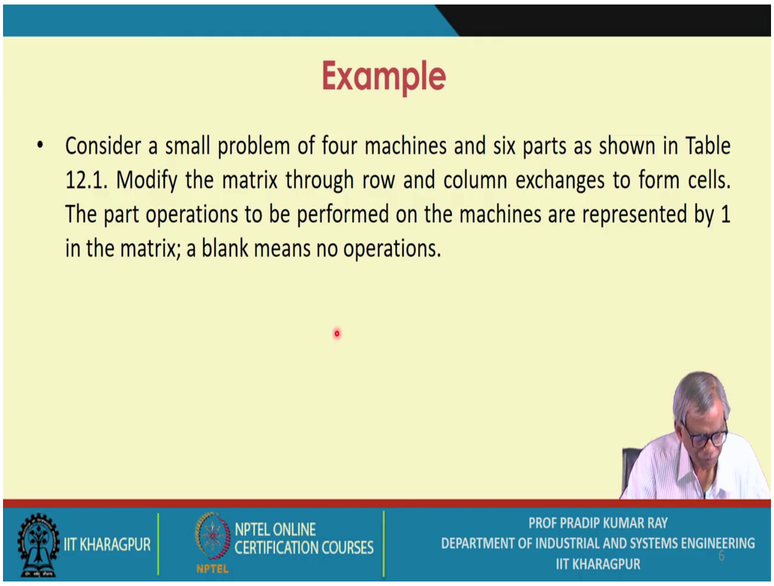

Let us Consider a small problem of four machines and six parts as shown in Table 12.1. Modify the matrix through row and column exchanges to form cells. The part operations to be performed on the machines are represented by 1 in the matrix; a blank means no operations.

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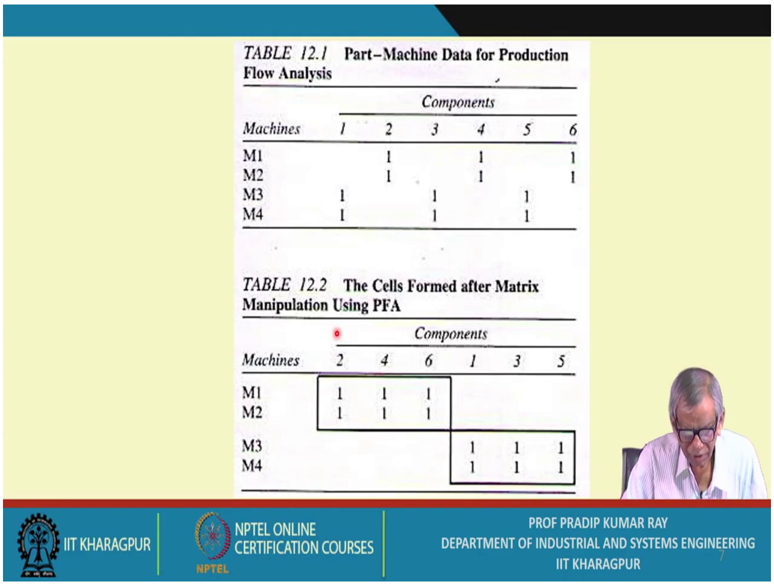
TABLE 12.1 Part–Machine Data for Production Flow Analysis

Machines	1	2	3	4	5	6
M1		1		1		1
M2		1		1		1
M3	1		1		1	
M4	1		1		1	

TABLE 12.2 The Cells Formed after Matrix Manipulation Using PFA

Machines	2	4	6	1	3	5
M1	1	1	1			
M2	1	1	1			
M3				1	1	1
M4				1	1	1

This is the actually your machine part incidence matrix and approach or technique which you are applying is the production flow analysis technique, there are four machines M1, M2, M3, M4.

And components are marked or are coded and there are six components. Now, if you look at this incidence matrix, you find that M1 machine is required to process part 2, part 4, and part 6. Similarly, M2 machine is required to process part 2, part 4, and part 6.

To collect this information, you will be referring to the process plan. Then the third machine M3 is engaged to manufacture part 1, part 3 and part 5. And similarly, the fourth machine is engaged to process part 1, part 3 and part 5 or the component 1, component 3 and component 5, once this information is known then you just go for the permuting the rows and columns.

First I will group M1 and M2 as one single entity or one single cell and you find that, part 2, part 4 and part 6 they can be processed with machine 1 and machine 2 whereas this group consists of two machines M3 and M4 and then you have this incidence matrix, means part 1, part 3 and part 5.

For processing you need machine 3 and machine 4. One machine cell and this is the second machine cell, look at this figure, immediately you identify the number of cells.

And when you look at this particular cell. Now it is the ideal solution, in the sense that it is 100% correct. Here, there will be intracell movement within the cell between machine 1 and machine 2 for a given part.

Similarly, there will be perfect intracell movements of parts between M3 and M4; whereas there is no case of intercell movement, that means part 2, part 4, part 6. For processing these parts, you just the need one particular machine cell, you do not need the second machine cell, M3 and M4 not required. And similarly, for part 1, part 3 and part 5 processing; you need only M3 and M4.

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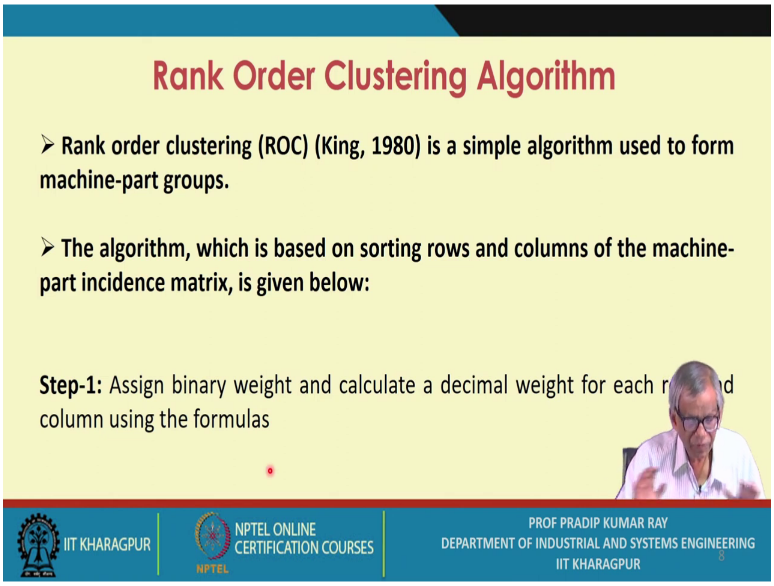

This is a typical case, where there is only intracell movement, but not intercell movement, that means the movement of parts between two machine cells. So, this may be considered to be an ideal solution. And as we have noticed that, this particular method is a manual method, you are dealing with say six parts and four machines.

But suppose you deal with fifty parts and say suppose 11 machines or 12 machines; this manual method may not be applicable, this is your starting point and only for simple manufacturing system, having very a smaller number of parts and a smaller number of machines, this method the PFA method is suitable, otherwise not.

We have to think of other approaches also, because after all we know that manufacturing system is a very complex system, in terms of the number as well as the varieties of parts, you are required to produce as well as the number and the types of the machine tools you are going to use, it is a very complex entity, keeping in view, there are several other conditions to be satisfied.

And the type of manufacturing systems and with its characteristic features, now you have to suggest and as well as when the problem dimension increases, if you say the problem dimension is very high now, you search for alternate methods. One such alternate method is rank order clustering algorithm. With the numerical examples, I am going to explain this rank order clustering algorithm or ROC algorithm.

Almost the forty years back it was introduced and still it is in use. The rank order clustering is a simple algorithm used to form machine part groups. The machine part groups; essentially machine part group is nothing but the machine cell.

The algorithm which is based on sorting rows and columns of the machine part incidence matrix. You have to follow certain steps and these steps you have to follow in sequence. In the first step, assign binary weight and calculate a decimal weight for each row and column using certain formulas.

First you have to assign the binary weight and when after you assign the binary weights, then you calculate the decimal weight for each row, this binary weight you actually provide or you assign to or give it to each part. Once these binary weights are assigned, then you calculate the decimal weight considering all the parts against a particular machine.

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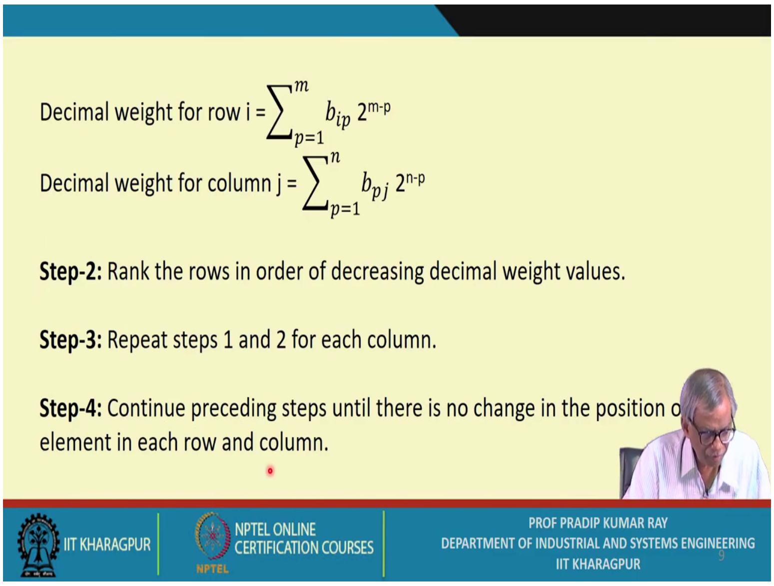

Decimal weight for row i = $\sum_{p=1}^{m} b_{ip} \sum_{p=1}^{m} b_{ip}$ 2^{m-p}

Decimal weight for column j = $\sum_{p=1}^{n} b_{pj} \sum_{p=1}^{n} b_{pj}$ 2^{n-p}

Step-2: Rank the rows in order of decreasing decimal weight values.

Step-3: Repeat steps 1 and 2 for each column.

Step-4: Continue preceding steps until there is no change in the position of each element in each row and column.

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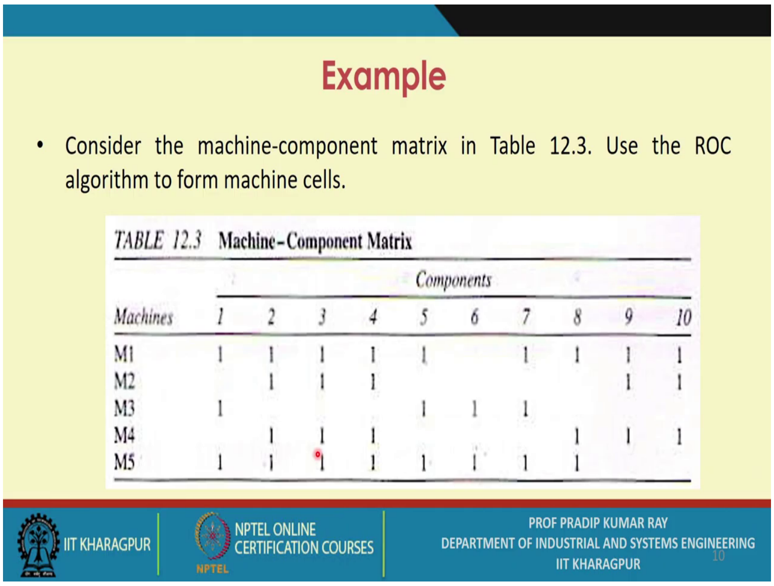

	Components									
Machines	1	2	3	4	5	6	7	8	9	10
M1	1	1	1	1	1		1	1	1	1
M2		1	1	1					1	1
M3	1				1	1	1			
M4		1	1	1				1	1	1
M5	1	1	1	1	1	1	1	1		

This is the stopping rule and when you stop, then the current incidence matrix you check. And at this stage subjectively you try to create or manually you try to create the number of cells.

When you look at the final the incidence matrix which you have obtained, in all likelihood you will find that clusters are formed, the clusters of the machine part.

There may not be too many the exceptional elements or bottleneck the machines, these two terms we use, what you find over here. Let us take one example, consider the machine component matrix in table, use the rank order clustering algorithm to form machine cells.

There are 10 parts. There are 5 machines. Now, this incidence matrix you have created; for example, part 2 will be processed by machine 2.

Similarly, say suppose you say that I refer to part 6, for processing part 6; you do not need M1 or M2, but definitely you need M3 and M5. When you have this sort of information and this particular five machines are required to process 10 parts, that sort of information you have. It is not that all the machines you need for processing all the parts.

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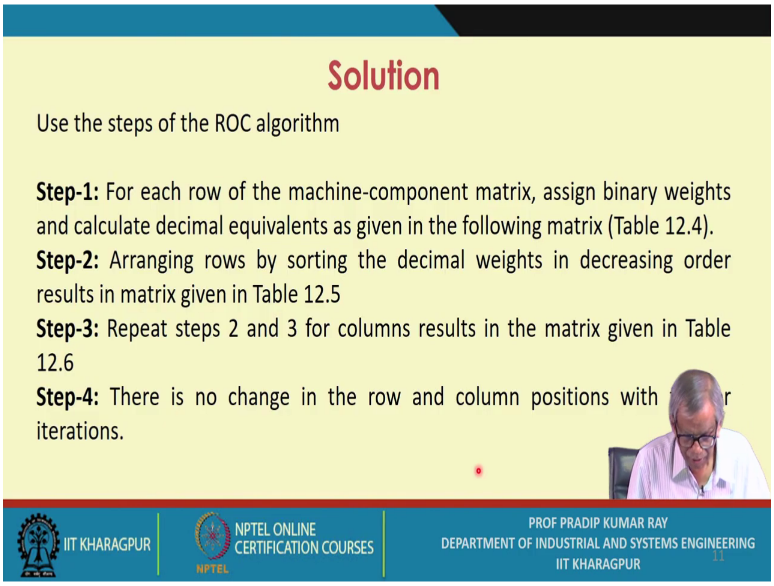

Now, you apply ROC algorithm. In the step 1, for each row of the machine component matrix, assign binary weight and calculate decimal equivalents as given in the following matrix.

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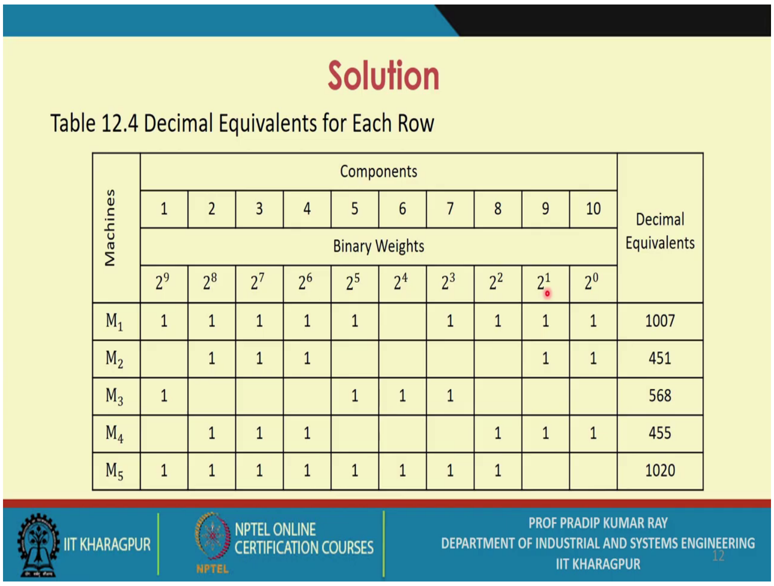

Machines	Components										Decimal Equivalents
	1	2	3	4	5	6	7	8	9	10	
	Binary Weights										
	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
M_1	1	1	1	1	1		1	1	1	1	1007
M_2		1	1	1					1	1	451
M_3	1				1	1	1				568
M_4		1	1	1				1	1	1	455
M_5	1	1	1	1	1	1	1	1			1020

Here you apply the formula, the first one will be 2^0, that means (n-1)th one.

This will be 2^0, 2^1, 2^2, the binary weight is $2^{(10-1)}$.

Now, just look at the first row. In machine 1, these are the allocations; that means how many parts you can process, like part 1, part 2, part 3, part 4, part 5. Part 6 do not need machine 1; but part 7, part 8, part 9 and part 10, you need machine 1.

Now, you apply the formula and you find that, this is $1*2^9+1*2^8+1*2^7$. So, this way you proceed. And ultimately you come down to the part 10 and you add them and you get the total decimal equivalent weight 1007. Same approach you follow for all other the rows. For M2, M3, M4, M5 you get these values.

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Solution

Table 12.5 Row Arrangements for Decreasing Order of the Decimal Weights

Machines	Binary Weights	Components									
		1	2	3	4	5	6	7	8	9	10
		Binary Weights									
		2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
M_1	2^4	1	1	1	1	1	1	1	1		
M_2	2^3	1	1	1	1	1		1	1	1	1
M_3	2^2	1				1	1	1			
M_4	2^1		1	1	1				1	1	1
M_5	2^0		1	1	1					1	1
Column Decimal Equivalent		28	27	27	27	28	20	28	26	11	11

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Then you go for rearranging in the descending order. 1, 2, 3, 4, 5, 6, 7; now the binary weight 2^8, this is M1, M2, M3, M4, M5; so, 2^4, 2^3, 2^2, 2^1, 2^0, you have to rearrange and then same rule you apply and the columnwise you calculate the decimal weight.

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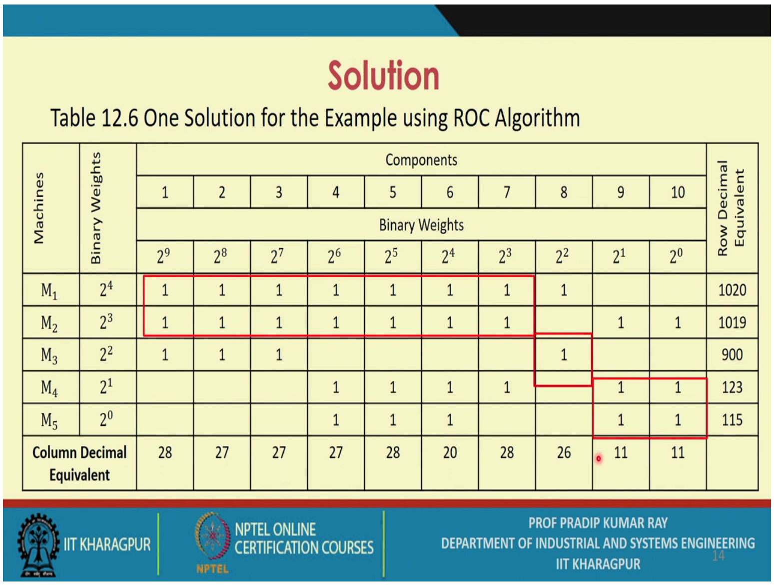

Machines	Binary Weights	Components										Row Decimal Equivalent
		1	2	3	4	5	6	7	8	9	10	
		Binary Weights										
		2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
M_1	2^4	1	1	1	1	1	1	1	1			1020
M_2	2^3	1	1	1	1	1	1	1		1	1	1019
M_3	2^2	1	1	1					1			900
M_4	2^1				1	1	1	1		1	1	123
M_5	2^0				1	1	1			1	1	115
Column Decimal Equivalent		28	27	27	27	28	20	28	26	11	11	

You rearrange the column positions as per decreasing values of the columns, if this process continuous; you will find that M1, M2 is forming one cell and this cell will be used for processing 1, 2, 3, 4, 5, 6, 7.

So, you try to find out the parts you are supposed to produce in machine 1 and machine 2. Once you calculate this decimal weight; the first value is 1020. That means, the first machine that is 5, the second one is M1, the third one is machine 3 and the fourth one is machine 4 and the last one is M2. So, this rearrangement is to be made over here.

Then you go to column level and what do you get? Basically 28, 27, 27 these values you get. First you take say part 1, the next one will be part 2 and third one third part, then the fourth one. Against column 5 the weightage is 28. So, first is first part 1 and then next part 5, then you take 2, 3, 4.

There is another value that is 28; that means 1, the next is your 5 and third one is 7. So, that is the first sequence; next one is 2, 3, 4. Then comes part 8, then part 6 and then part 9 and part 10.

Here you change the row positions and these are the steps we follow.

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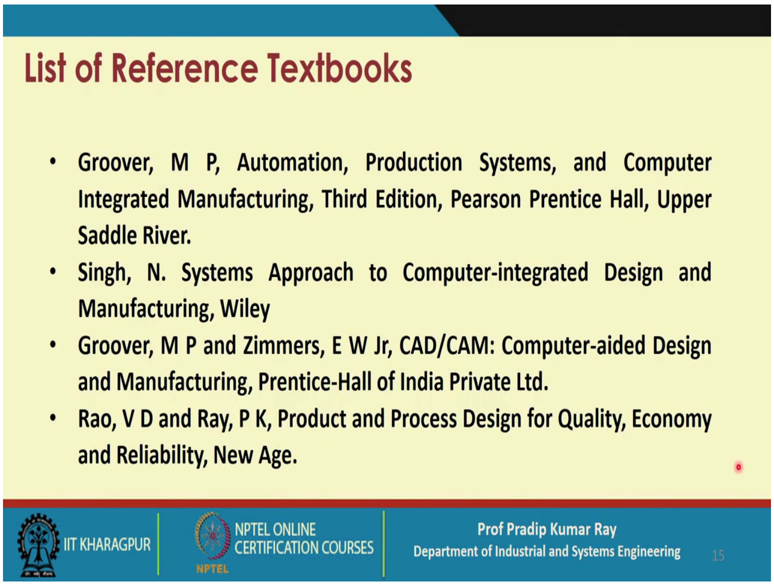

In this particular lecture sessions, we have referred to two specific the techniques or approaches for cell formation.