Automation in Production Systems and Management
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Cellular Manufacturing System
Lecture - 33
Cell Formation Approaches - II

In the previous the lecture sessions we have discussed two important Cell Formation the Approaches.

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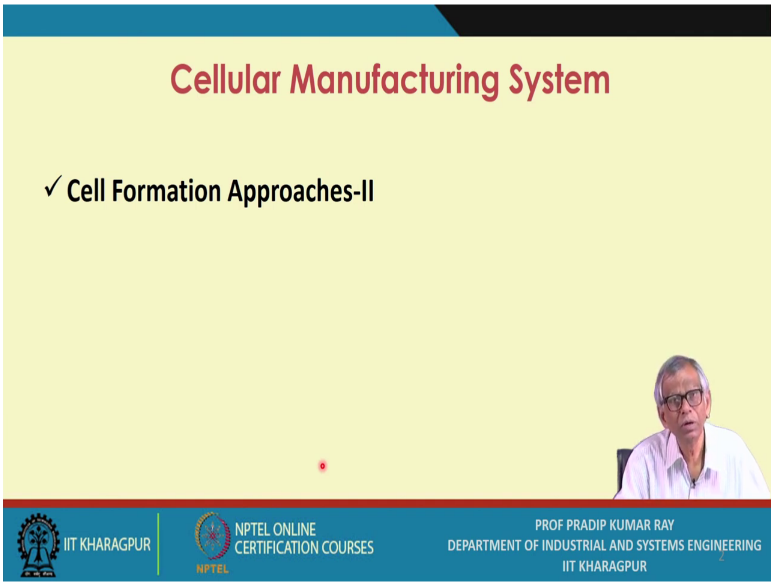

During this lecture session one very important cell formation approach we are going to discuss, but prior to that I will be referring to the previous problem that we have dealt with.

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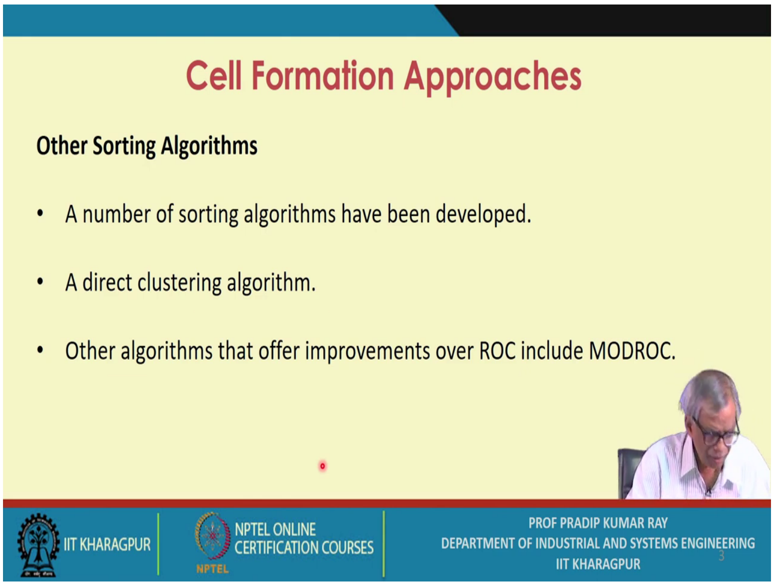

With the given number of subparts and the given number of machines ultimately how many cells machine cells you are going to recommend? So, that is the solution.

when you look at that particular solution then when you start analyzing what type of solution you have obtained. There will be some the good points and there is also will be some limitations, because all these approaches you cannot say that on the majority of the cases, it just cannot be the perfect solution; that means there cannot be any case where there is no exceptional part or there are no bottleneck machines. So, a greater number of exceptional parts or elements you have or a great number of bottlenecks machines you have; that means, more complex manufacturing systems you are dealing with.

As far as possible how many maximum number of machine cells you can form? From all the machines there will be some exceptional machines there will be some exceptional parts. They stand on their own so, you cannot group them with another set of machines.

Prior to the discussing that particular the solution let me just refer to other tools and approaches we use and those are basically the sorting algorithms. In the context of cell formation, we use this particular term called sorting algorithm.

You can always refer to the direct clustering algorithm; you can apply this if the assumptions are matching with the requirements and all. Other algorithms that offer improvements over rank order clustering including the MODROC. So, one particular method is proposed and when you try to test the method in other systems you may find that the original method needs to be improved.

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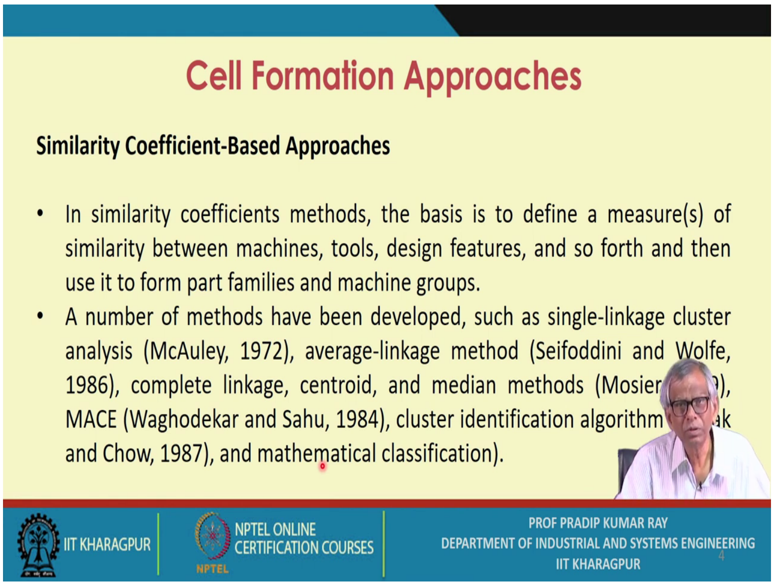

Another important cell formation approach we are going to discuss during this lecture session that is referred to as a similarity coefficient-based approach. Ultimately the entire problem boils down to grouping of parts of similar nature and grouping of machines of similar nature. How do you say that the machine 1 is similar to machine 2 or it is not at all similar to machine 2? Can you measure it? There are certain ways you can measure this similarity. This level or degree of similarity is referred to as the similarity coefficient.

In similarity coefficients methods, the basis is to define a measure(s) of similarity between machines, tools, design features, and so forth and then use it to form part families and machine groups. A number of methods have been developed, such as single-linkage cluster analysis (McAuley, 1972), average-linkage method (Seifoddini and Wolfe, 1986), complete linkage, centroid, and median methods (Mosier, 1989), MACE (Waghodekar and Sahu, 1984), cluster identification algorithm (Kusiak and Chow, 1987), and mathematical classification). (Refer Slide Time: 07:20)

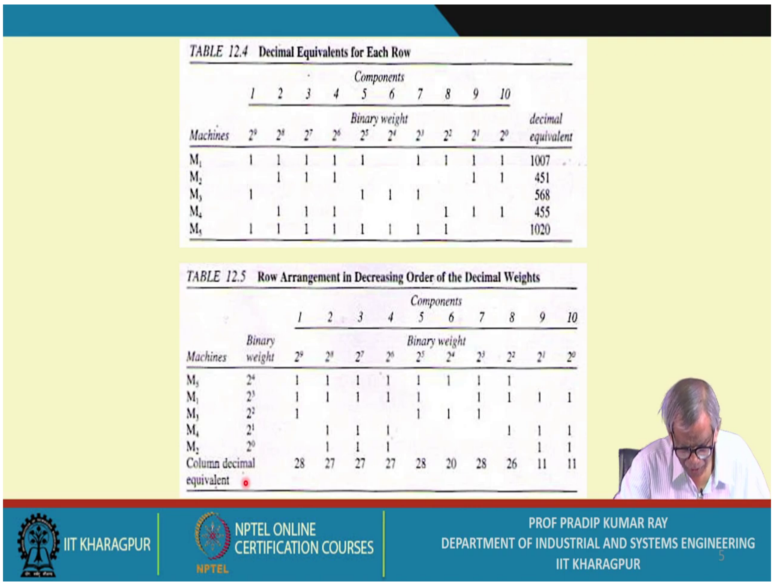

TABLE 12.4 Decimal Equivalents for Each Row

	Components										
	1	2	3	4	5	6	7	8	9	10	
	Binary weight										decimal
Machines	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	equivalent
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

TABLE 12.5 Row Arrangement in Decreasing Order of the Decimal Weights

		Components									
		1	2	3	4	5	6	7	8	9	10
	Binary	Binary weight									
Machines	weight	2^9	2^8	2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
M_5	2^4	1	1	1	1	1	1	1	1		
M_1	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_2	2^0		1	1	1					1	1
Column decimal equivalent		28	27	27	27	28	20	28	26	11	11

Now, if you refer to the previous examples find that there were 5 machines and there were 10 parts. These are the binary weights. You start with a particular row: first row, second, third, fourth and fifth row. You calculate the decimal equivalent 1007, 451, 568, 455 and 1020.

Now, arrange these rows in descending order. The first comes machine 5, then machine 1, then machine 3, then machine 4 and the last one is machine 2.

Again, you go for each column decimal equivalent and then for each part you calculate this decimal weight. You arrange the parts in descending order, as per the decimal equivalent column-wise.

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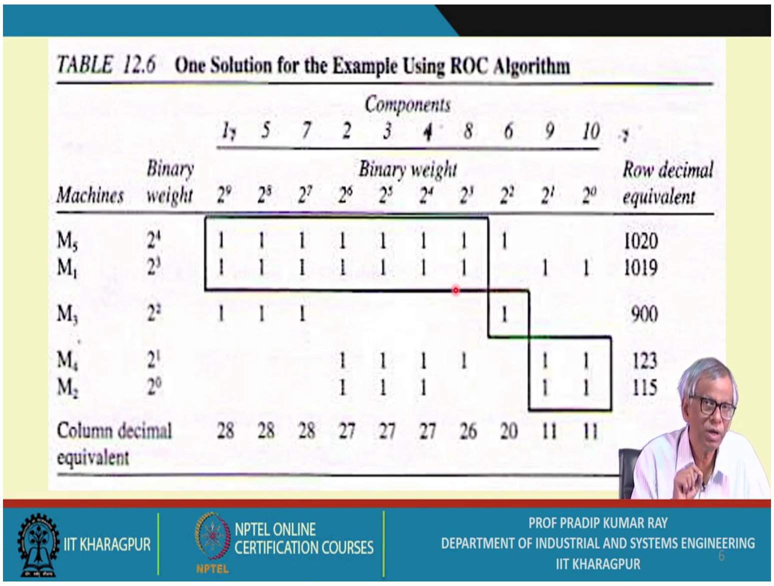

TABLE 12.6 One Solution for the Example Using ROC Algorithm

Machines	Binary weight	1 (2^9)	5 (2^8)	7 (2^7)	2 (2^6)	3 (2^5)	4 (2^4)	8 (2^3)	6 (2^2)	9 (2^1)	10 (2^0)	Row decimal equivalent
M_5	2^4	1	1	1	1	1	1	1	1			1020
M_1	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_2	2^0				1	1	1			1	1	115
Column decimal equivalent		28	28	28	27	27	27	26	20	11	11	

Once you do this; you get the final solution like this one SLCA algorithm. So, here, one cluster of machines was formed and with M5 M1, the second cell consists of just one machine called M3 and the third cell consisting of two machines M4 and M2. This is one cell, this is another cell and this is the third one, there are many parts which are not included in a particular cell.

These parts may be considered as exceptional elements and particularly for machine 4, part 9 and part 10. So, these two parts are processed within the machine cell.

Similarly, part 2, part 3, part 4 to be processed at machine 2, but these parts are to be processed separately, not as a part of the cell. These parts are not included within the machine cell, outside the machine cell they have to be processed. Similarly, this one like for part 1 and part 5 as well as part 7 you need not only machine 5 and machine 1, but you also need machine 3.

Within the cell these parts of 1, 5 and 7 are processed and then these three parts to be sent to M3 which is not existing within this particular cell; that means, M3 forms another separate cell. This is referred to as inter cell movement.

What are the advantages? So, our particular configuration we have to evaluate.

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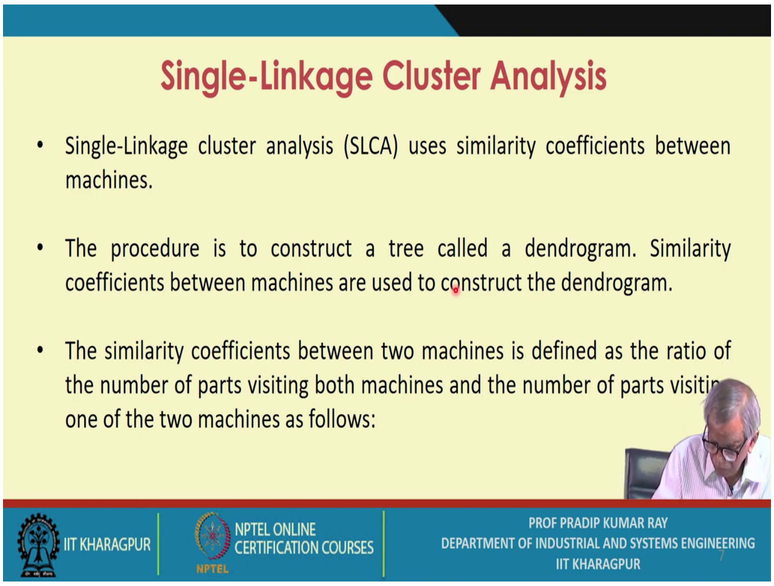

Now, the single-linkage clustering analysis uses similarity coefficient between machines.

The procedure is to construct a tree called dendrogram. Similarity coefficients between machines are used to construct the dendrogram. How do you define this similarity coefficients between two machines?

This is defined as the ratio of the number of parts visiting both the machines and the number of parts visiting one of the two machines as follows:

- $S_{ij} = \frac{\sum_{k=1}^{N} X_{ijk}}{\sum_{k=1}^{N}(Y_{ik}+Z_{jk}+X_{ijk})}$

where,

- X_{ijk} = operation on part *k* performed both on machine *i* and *j*,
- Y_{ik} = operation on part *k* performed on machine *i*,
- Z_{jk} = operation on part *k* performed on machine *j*.

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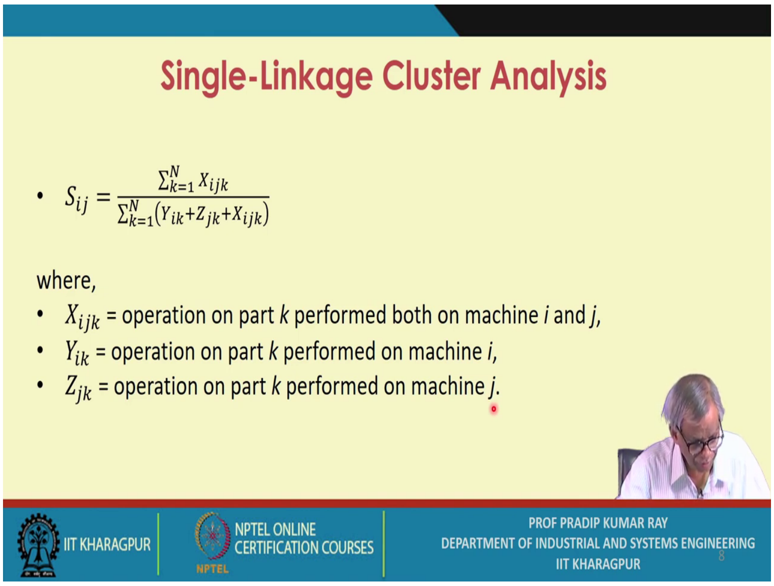

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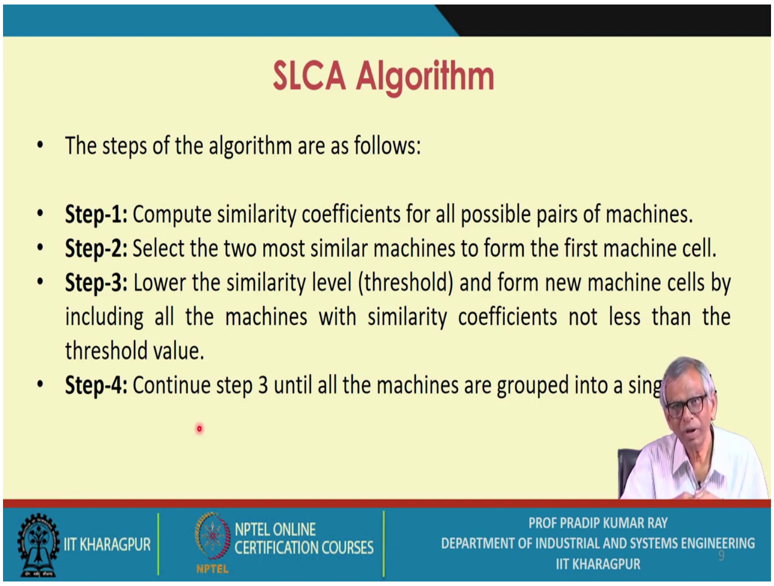

Now, how do you create this dendrogram? Step 1 compute similarity coefficient for all possible pairs of machines. Suppose there are 5 machines. How many possible similarity coefficients you need to calculate? M1-M2, M1-M3, M1-M4, pairwise you need to calculate the similarity coefficient. So, all sorts of the combinations you have to you have to consider and for each combination you need to calculate the similarity coefficient when the data are given to you.

In step 2, select the two most similar machines to form the first machine cell. You will be getting these values and the value will be definitely less than or equals to 1. In the rare cases, it will be just 1. Usually, you y get a value of say 0.9 or 0.8 and for another pair you may get a value of say 0.2 or 0.3, depending on the number of preparations you need to consider for both the machines.

If for a particular pair the maximum value is 0.9, you say, yes, I will form a cell with these two machines first and then I will check, depending on other similarity coefficient values, whether I can add few more machines in this particular cell.

This way you consider one by one all of the existing similarity coefficient values. There will be certain conditions where you will find that that M1 and M2 can form a cell, but the third one you cannot join because it might violate some other rules.

So, there could be other constraints also. Step 3: Lower the similarity level (threshold) and form new machine cells by including all the machines with similarity coefficients not less than the threshold value.

In step 4, continue step 3 until all the machines are grouped into a single cell. Suppose you are dealing with 5 machines and similarity coefficient threshold value is 1.

So how many machine cells you have? You will have just 5 machine cells; that means, in each machine cell there will be just 1 machine, but as you start lowering down this similarity coefficient values and you say that suppose the similarity coefficient value s is 0. Suppose it is 0.2 or 0.4 or 0.5. As you reduce this threshold value of the similarity coefficient you will have smaller number machine cells.

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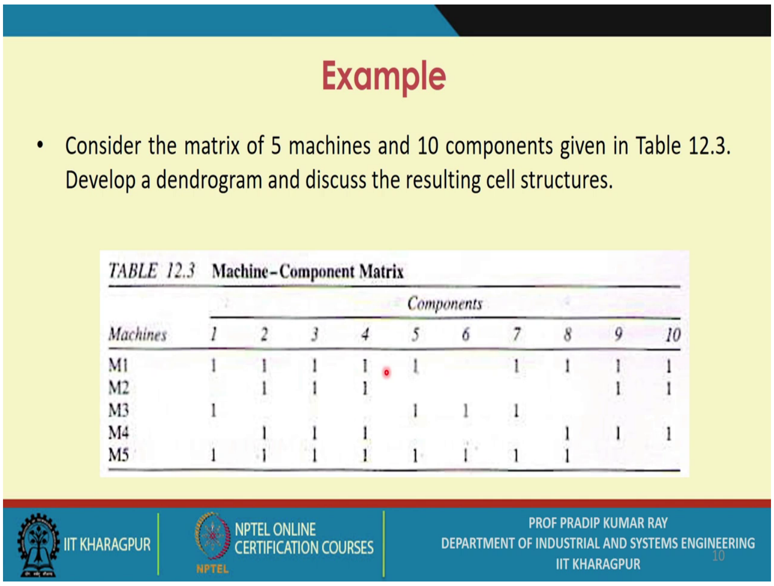

This is one example, the previous example you have taken up. There are 10 components and 5 machines and you are applying SLC algorithm and this algorithm is based on similarity coefficient. This is your incidence matrix. Against each machine say M1 what are the specific parts you need to process; similarly for all other machines.

This is machine component incidence matrix and your source of information must be the process plan. So, you need to develop a dendrogram and discuss the resulting cell structure.

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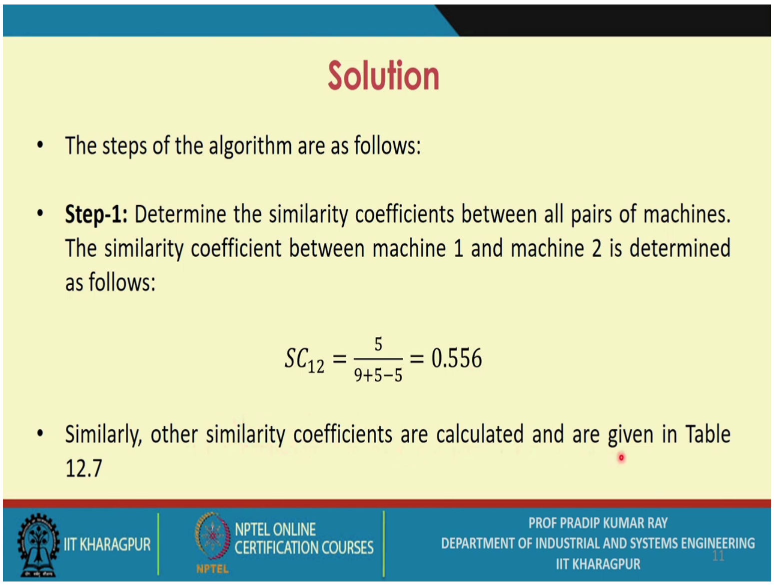

The first step is Determine the similarity coefficients between all pairs of machines. The similarity coefficient between machine 1 and machine 2 is determined as follows:

$SC_{12} = 5/(9+5-5) = 0.556$

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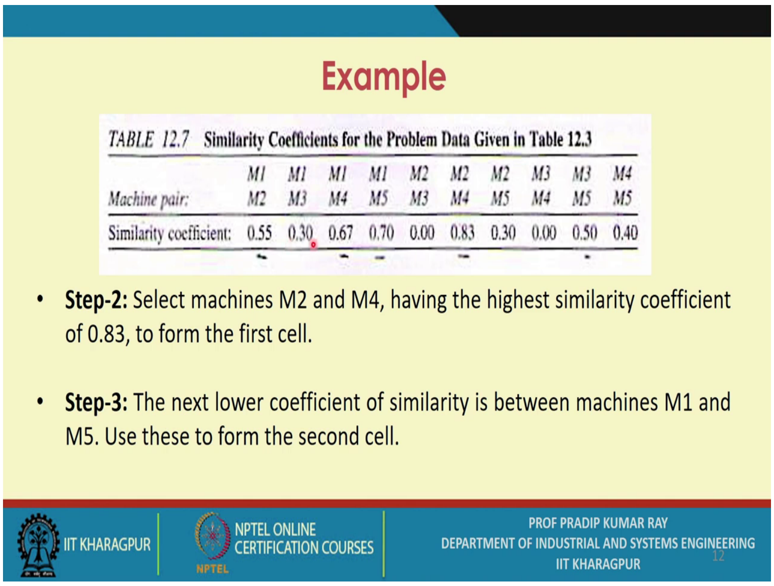

This is the similarity coefficient value table. So, how many combinations you will have between 5 machines. M1-M2, M1-M3, M1-M4, M1-M5, then you have M2-M3, M2-M4, M2-M5, next you consider M3-M4, M3-M5 and M4-M5. So, all combinations we have taken.

Now for each combination or for each pair you need to calculate the similarity coefficient. For M1 and M2 the value you get is 0.556. Third decimal you do not use, up to the second decimal place you consider. So, this is 0.55, this is 0.30, 0.67, 0.70, M2 and M3 value is 0. There is no similarity as far as the operations are concerned.

Similarly for other combinations, in step 2, select machines M2 and M4 because out of so many values you have obtained, first you start with the maximum value. The maximum value you have got that is 0.83 that is for the combination M2 and M4 and they form the first cell.

The next lower coefficient of similarity is between machines M1 and M5-0.70, next one is 0.60, next one is 0.55, next to next one is 0.50, then 0.40, then 0.30.

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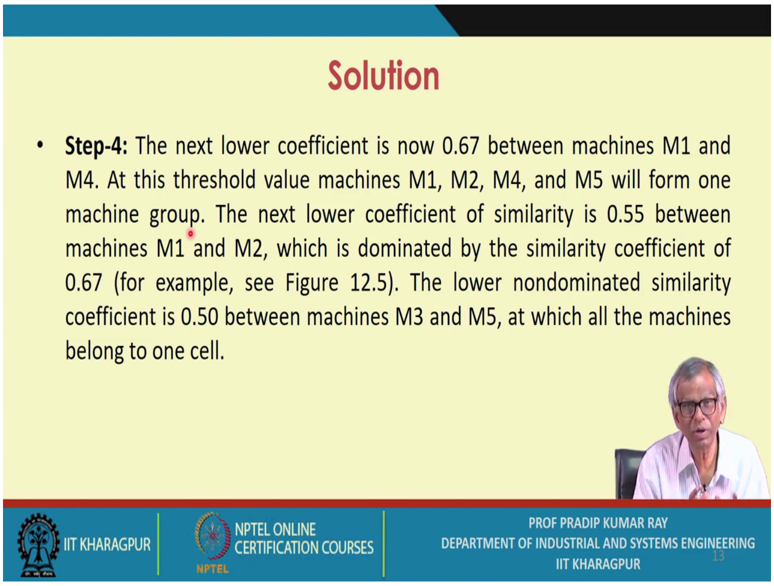

The next lower coefficient is now 0.67 between the machines 1 and M 4. At this threshold value, machines M1, M2, M4 and M5 will form one machine group. The next lower coefficient of similarity is 0.55 between machines M1 and M2, which is dominated by the similarity coefficient of 0.67. The lower nondominated similarity coefficient is 0.50 between machines M3 and M5, at which all the machines belong to one cell.

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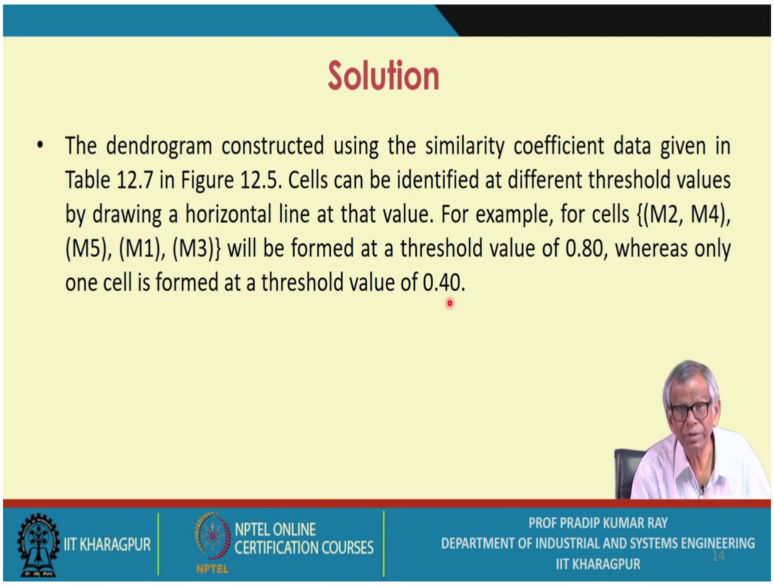

Now with this analysis you can create the dendrogram. When you look at this dendrogram, you can identify against a particular similarity coefficient value or the threshold value, how many cells you are forming.

As you lower the value of the threshold similarity coefficient then a greater number of cells or the smaller number of cells you can opt for. So, we say that one cell is formed at the threshold value of 0.40, but you have to the consider many machines which may be different from one another.

If the value is 0.40; that means, certain operations in one particular machine and only few of these operations may be the carried out by another machine so, that risk is there.

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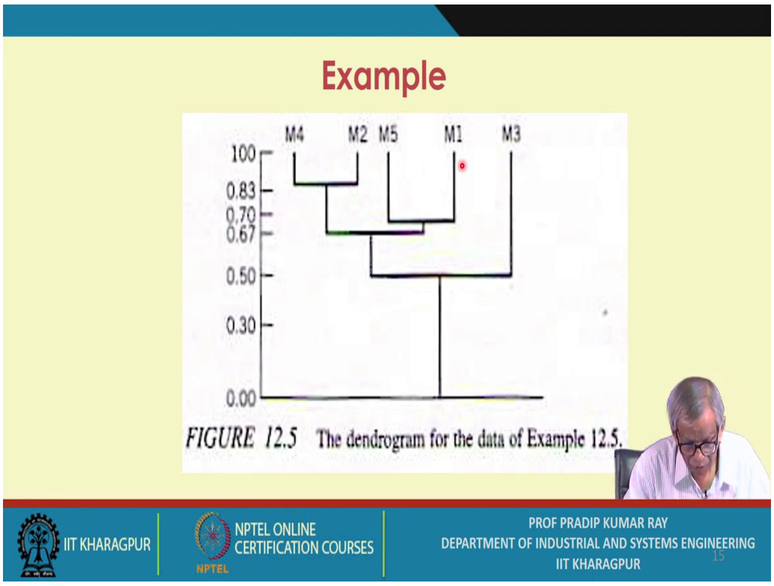

But sometimes to make the work easier, you try to consider many machines within one particular machine cell. When it is 0.83, one first machine cell M4, M5, second one is M5, third one is M1 and fourth one is M3.

Suppose your value is 0.7, how many machine cells you have? M4-M2, M5-M1 and M3 When you reduce the threshold value 0.67 how many machine cells you have? You will have two cells- one cell consists of M4-M2, M5-M1 and the second one is M3. You are lowering it further; when the threshold value of similarity coefficient is 0.0, you form one cell.

So, this way you create the dendrogram.

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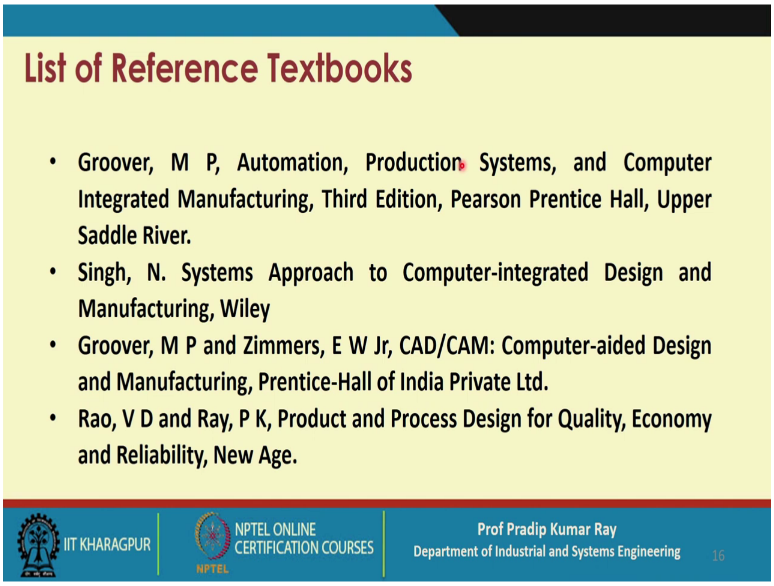

How many possible cell configurations you have? There are 5.

The first one is 5 cells, each consisting of one machine tool, the second one is the 4 machine cells and the corresponding threshold value you can specify, similarly there could be 3 machine cells, there could be 4 machine cells and there could be first one is the 5, next one is the 4, then you will have 3 machine cells, next 2 machine cells you have and ultimately you may have just 1 machine cell.

So, this way you form the table. The question is which one you will select?? The selection procedure we explain in the subsequent lecture class.