Automation in Production Systems and Management
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Cellular Manufacturing System
Lecture - 34
Evaluation of Cell Design, Numerical Examples

During this lecture session, I am going to discuss Evaluation of Manufacturing Cell or Evaluation of the Cell Design.

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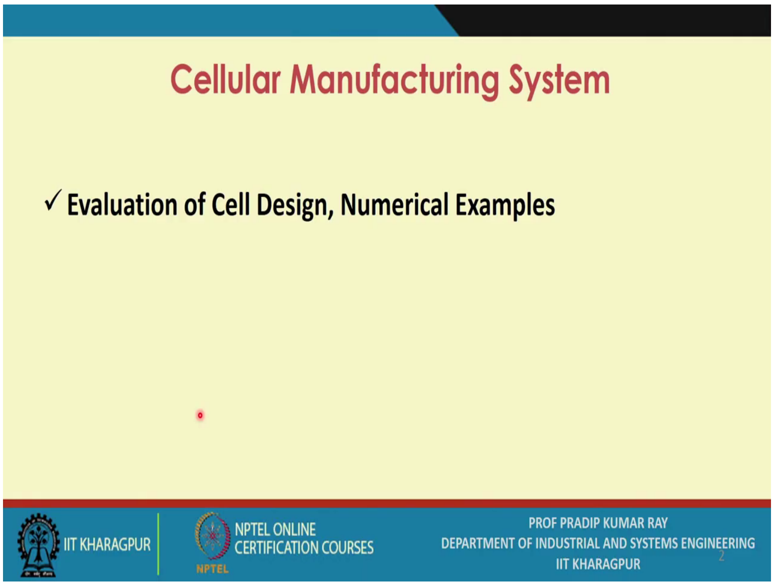

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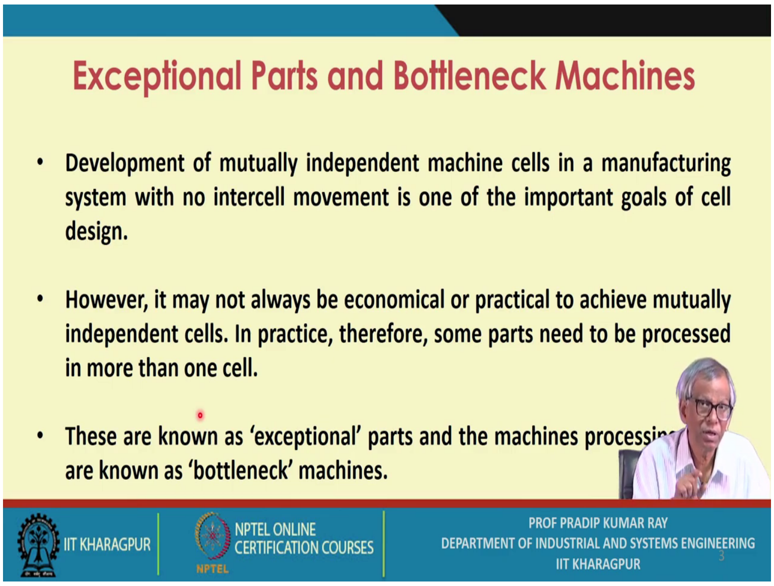

If you refer to our previous discussion, we have mentioned that there could be different approaches for machine cell formation, and machine cell formation is a necessary condition for making your manufacturing system a cellular manufacturing system.

Based on the similarity coefficient based approach you can definitely the go for machine cell formation. But you will be getting not only one solution, but several possible solutions like in the previous case. We have for the given problem for the given machine component incidence matrix.

In order to form the cell, we have five possible configurations and each configuration is a solution. We have referred to one numerical example and we say that yes, you just tell me which similarity coefficient you are accepting or you are proposing and immediately I can tell you as per the dendrogram based approach or solution approach what could be your solution and what could be your configuration.

When you look at a particular a configuration, question is that which one you will select. For that the cell design or the cell configuration is to be evaluated. During this lecture session we will be discussing the cell design evaluation technique.

Development of mutually independent machine cell in a manufacturing system with no intercell movement. You just refer to our first example, first example. It is 100% correct solution you have just 4 machines and 6 parts.

In group of machines M1 and M2 you are processing three parts and another cell M3 and M4 you are processing three other different parts, and there is no intercell movement. If you get this sort of solution that is the best one. These two cells are mutually independent and there is no relationship. However, it may not always be economical or practical to achieve mutually independent cell.

In practice, some parts need to be processed in more than one cell. If you refer to the second example, I have already mentioned that there are three cells formed, but certain parts are to be processed within a cell and certain other parts to be processed by outside of the cell, but the same part exists in the cell.

Once the operations within the cell operations are over then you send those the semi-finished components to another machine and that machine may be belonging to another cell. This is referred to as basically the intercell movement.

These are known as exceptional parts or the elements, for processing that particular part you need not only one machine cell but also more than one machine cell and the machines processing them are known as bottleneck machines. Exceptional elements that are the parts you have to identify, looking at the solution matrix and then you need to identify the bottleneck machines.

With respect to these two aspects, how many exceptional elements or parts you have, how many bottlenecks bottleneck machines you are dealing with? you try to evaluate a particular cell design.

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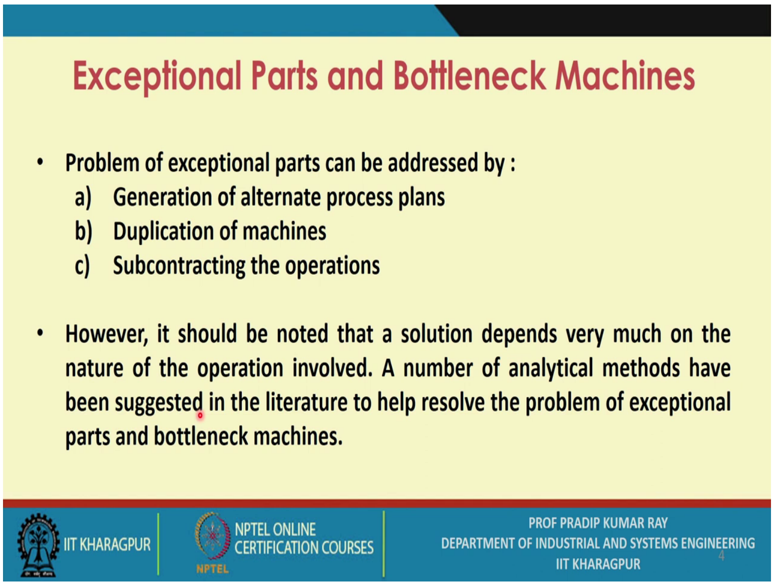

For all types of manufacturing systems, you face problems with the exceptional parts always. They are considered as a part of its special category parts. You can generate alternate process plans.

When you deal with the process planning and for a given part or for a given component or for a given product when you generate the process plan, in almost 100% of the cases you do not generate just one process plan; there will be always some alternate process plans.

There are the common cases where for this particular part or this particular product, you may have some three or four process plans. Under a given condition you may prefer one particular process plan, but suppose the conditions change, obviously, you feel like opting for the next the process plan. So, such alternatives must be given.

This is a very common practice. Second one is duplication of machines. Whether it is a feasible alternative or not; it may be a desirable alternative, but may not be feasible, but this could be a solution and the third alternative is why do not you subcontract the operations.

Instead of making those parts in-house you just ask someone else to manufacture it and supply it; it is basically your decision is changed; it is not a make decision, but this is a buy decision.

For the given part listed in the bill of material either you go for making it in-house with your own manufacturing system or you can get it supplied by your supplier; you are going to purchase it. However, it should be noted that the solution depends very much on the nature of the operations involved.

A number of analytical methods have been suggested in the literature to help resolve the problem of exceptional parts and bottleneck machine.

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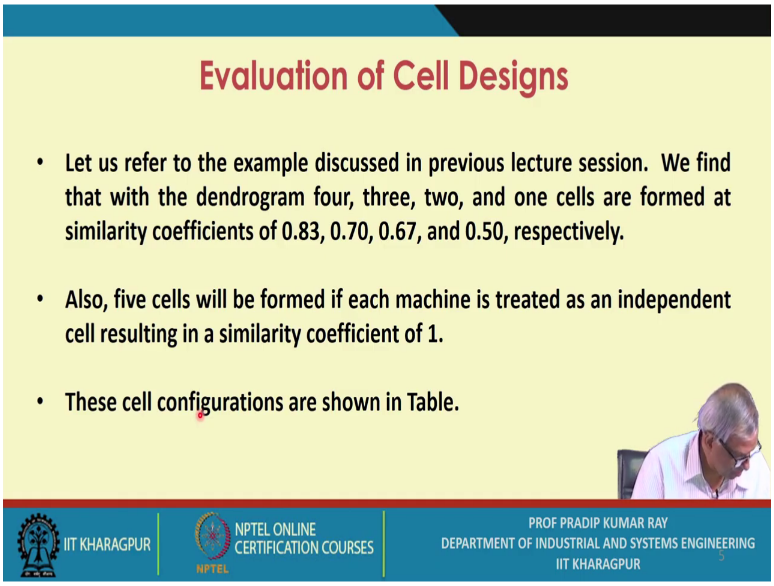

Let us refer to our previous example where we have applied the similarity coefficient-based approach for cell formation.

We find that with the dendrogram, 4, 3, 2 and 1 cells are formed, at similarity coefficients of 0.83, four cells were formed with 0.7, three cells were formed with 0.67 threshold value you are having two cells machine cells and, if this threshold value is reduced to 0.5, then you can just manage with one cell having all these five machines. Five cells will be formed if each machine is treated as an independent cell resulting in a similarity coefficient of 1.

When you have just one machine in 1 cell and another machine in another cell, then they can act independently absolutely.

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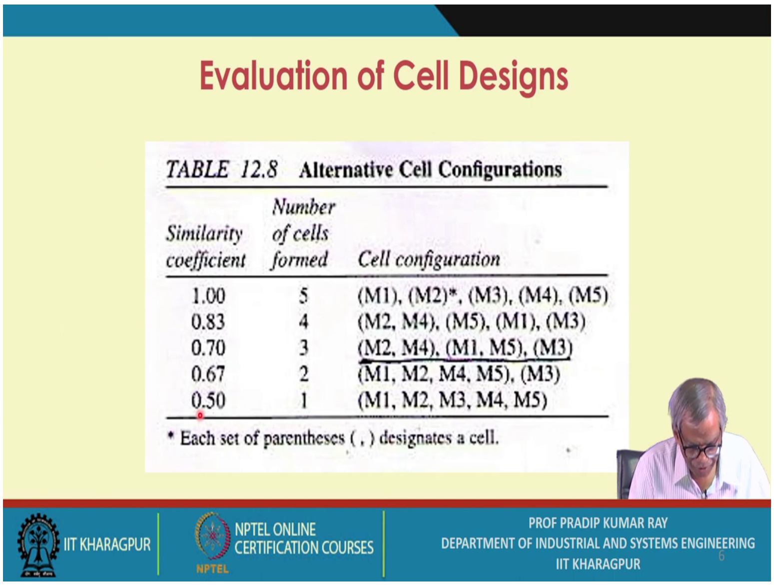

When the similarity coefficient is 1, how many the cells you have formed? 5 and each cell is having just one machine for this particular example. If it is 0.83, 4, 0.7, 3, 0.67, 2 machine cells. M1, M2, M4, M5 and the second cell consisting of just one machine M3 and if it is 0.50 just 1 machine cell you form; that means, M1 consisting of all the five machines.

Now, let us talk about the third one, the number of cells is 3 and your similarity coefficient value is 0.7. The first cell you have M2 and M4; in the second cell M1 and M5 and in the third cell is having just one machine M3.

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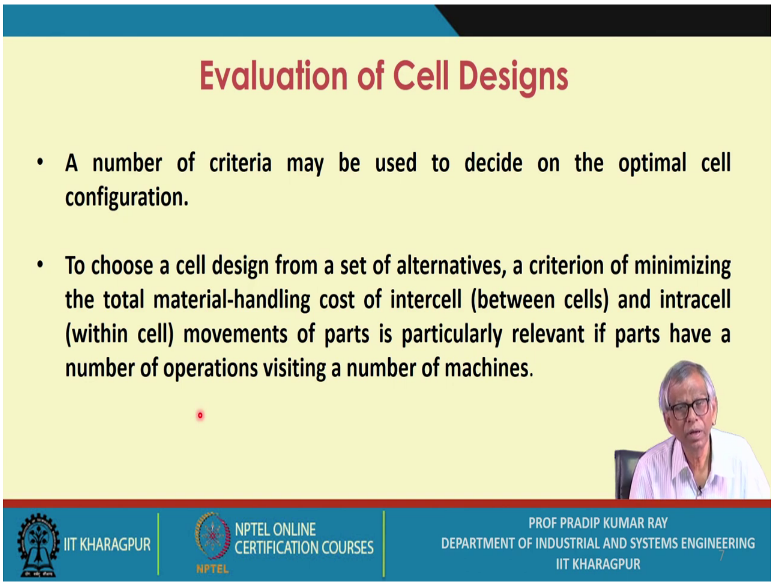

Now, how to evaluate? A number of criteria may be used to decide on the optimal cell configuration. To choose a cell design from a set of alternatives, a criterion of minimizing the total material-handling cost of intercell (between cells) and intracell (within cell) movements of parts is particularly relevant if parts have a number of operations visiting a number of machines.

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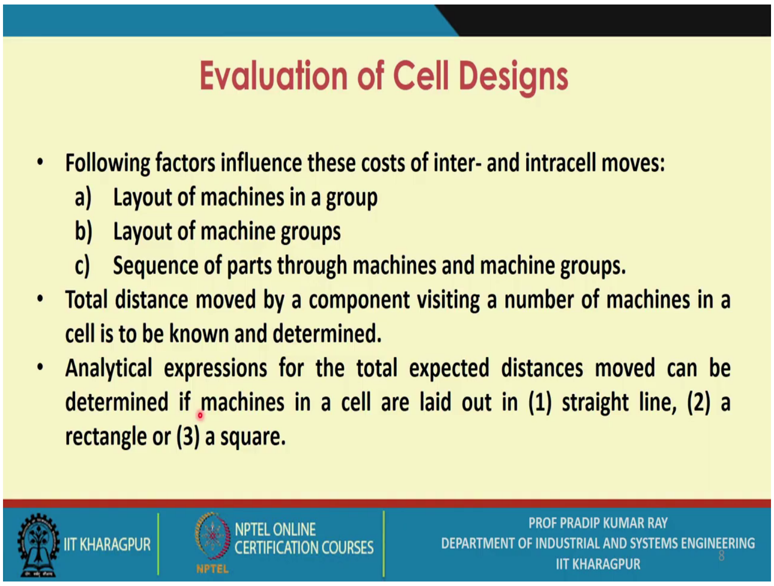

The following factors influence these costs of inter and intracell moves or the movements of parts. First one is the layout of machines in a group. The second one is the layout of the machine groups.

And, the last factor is the sequence of parts through the machine groups. This information you collect from your process plan documents. Total distance moved by a component visiting a number of machines in a cell is to be known and determined. That means you need to consider both intercell movement as well as intracell movement of all the parts under consideration.

Analytical expressions for the total expected distances moved can be determined if machines in a cell are laid out. You go to the workplace, you go to the manufacturing plant or the shop floor and you get this information on the kinds of layouts.

Then you take you start collecting data and you go for an empirical study. Here what basic idea or the basic purpose is that to know that once the layout is known how do you calculate this total material handling cost against the part movement within the cell and between the cell.

Possible types of the pure layouts we will be considering. First layout is straight line layout. These are the pure layout. Second one is the rectangular and one particular case of rectangular could be the square layout. For each type of layout like straight line, like rectangular or for the square layout, we will be calculating the intercell movement and intracell movements both, and the corresponding cost estimates will be there and then you consider both the cost elements and you get the total cost against a particular expected cost against a particular configuration, and you select that particular cost which is for that particular configuration for which the total the cost of material handling is minimum.

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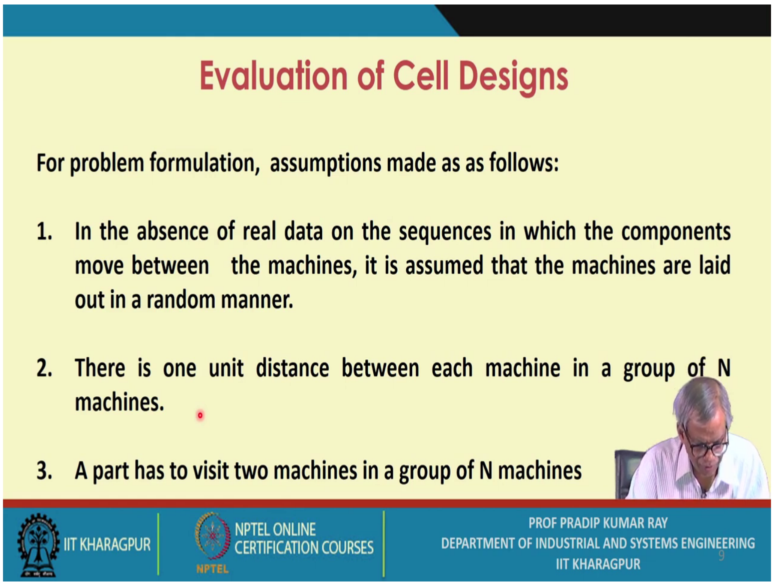

For problem formulation there have to be some assumptions. In the absence of real data on the sequences in which the components move between the machines, it is assumed that the machines are laid out in a random manner. Otherwise, you need to collect the actual process plan, The data related to the actual process plan for a given part and for all parts.

There is one unit distance between each machine in a group of N machines. You have to define that one-unit distance depending on the type of operations type of processes you carry out. A part has to visit two machines in a group of N machines. So, this is your assumption, because we do not know the routing information for a given part as the process plan is not known.

Another assumption is out of N number of machines for a given part only the two machines will be used and this the two machines; two operations at least are to be the selected at random.

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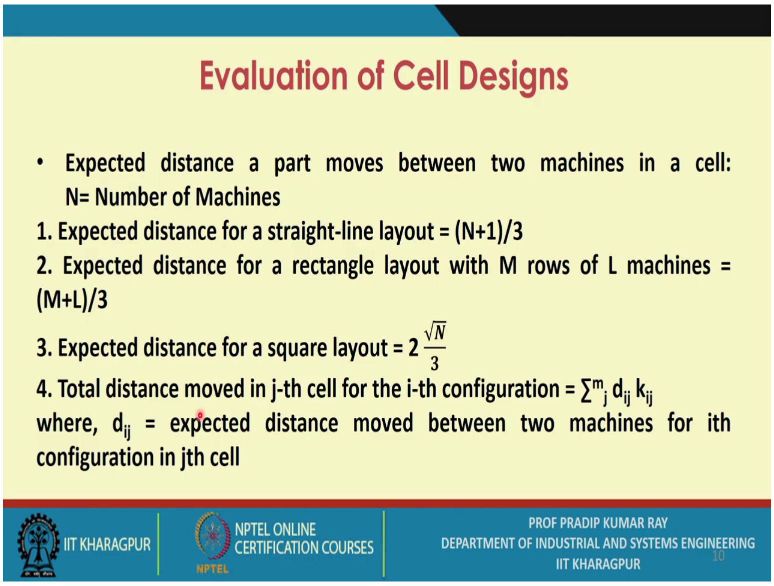

Expected distance of a part moves between two machines in a cell of say N number in a cell and you are considering N number of machines. Expected distance for a straight-line layout = (N+1)/3.

Expected distance for a rectangle layout with M rows of L machines = M+L/3

Expected distance for a square layout = $2\sqrt{N}/3$

Total distance moved in jth cell for the ith configuration = $\sum^{m}_{j} d_{ij} k_{ij}$

where d_{ij} = expected distance moved between two machines for ith configuration in jth cell.

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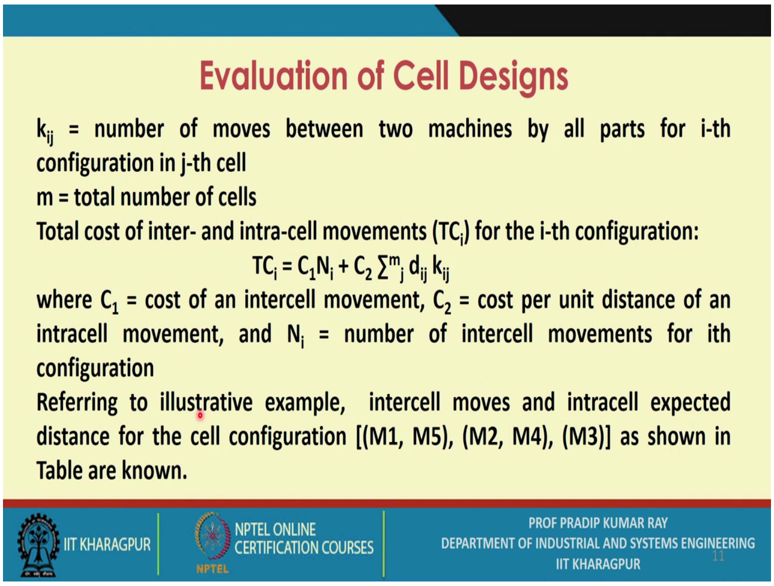

K_{ij} = number of moves between two machines by all parts for ith configuration in jth cell

m = total number of cells

The total cost of inter- and intracellular movements (Tc_i) for the ith configuration: $Tc_i = C_1N_i + C_2 \sum^m_j d_{ij}\, k_{ij}$

Where C_1 = cost of an intercell movement, C_2 = cost per unit distance of an intracell movement, and N_i = number of intercell movements for ith configuration

We now illustrate the calculation of intercell moves and intracell expected distance for the cell configuration [(M1, M5), (M2, M4), (M3)] as shown in Table 12.9.

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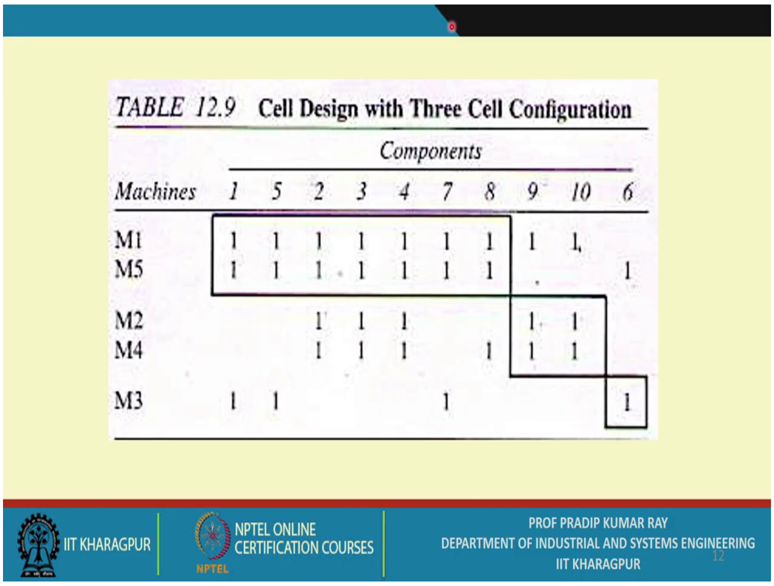
TABLE 12.9 Cell Design with Three Cell Configuration

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

This is this problem already we have dealt with. You have five machines. One particular cell is M1-M5; the second one is M2-M4 and the third one is M3. This is the final solution. How many the cells you have? 3 cells. It is basically configuration number 3.

Look at this table and you just check how many intracell movement and how many intercell movements you have. Intracell movements are 9. How many intercell movements you have? 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, so, then 11, 12 then just you check whether it is 13 or not.

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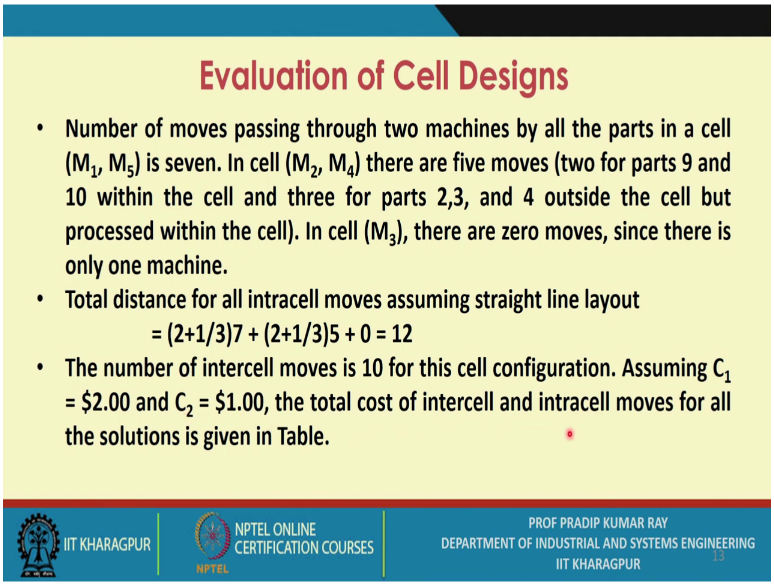

The number of moves passing through two machines by all the parts in a cell (M_1, M_5) is seven. In cell (M_2, M_4) there are five moves (two for parts 9 and 10 within the cell and three for parts 2,3, and 4 outside the cell but processed within the cell). In cell (M_3), there are zero moves, since there is only one machine.

Total distance for all intracell moves assuming straight line layout

$$= (2+1/3)7 + (2+1/3)5 + 0 = 12$$

The number of intercell moves is 10 for this cell configuration. Assuming C_1 = \$2.00 and C_2 = \$1.00, the total cost of intercell and intracell moves for all the solutions is given in Table 12.10

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TABLE 12.10 **Cell Configurations and Their Analysis of Intercell Moves, Intracell Moves, and Total Cost Assuming Straight Line Layout**

	Cell Configuration	*Number of Intercell Moves*	*Total Distance of Intracell Moves*	*Total Cost of Intercell and Intracell Moves*
5-cells	(M1), (M2)*, (M3), (M4), (M5)	22	0	$2 \cdot 22 + 1 \cdot 0 = 44$
4-cells	(M2, M4), (M5), (M1), (M3)	17	5	$2 \cdot 17 + 1 \cdot 5 = 39$
3-cells	(M2, M4), (M1, M5), (M3)	10 ✓	12 ✓	$2 \cdot 10 + 1 \cdot 12 = 32$
2-cells	(M1, M2, M4, M5), (M3)	4	30	$2 \cdot 4 + 1 \cdot 30 = 38$
1-cell	(M1, M2, M3, M4, M5)	0	44	$2 \cdot 0 + 1 \cdot 44 = 44$

* Each set of parentheses (,) designates a cell.

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This is the solution. The number of intercell moves is 12, 10 and the total distance of intracell moves that is 12. So, it is (2*10) + (1*12) = 32. We find that among all these five configurations, the 3-cell configuration is the best one.

You just check intercell movements 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 and then there is a 12. So, here you have 7, this one 2 + 7 + 5 = 14.

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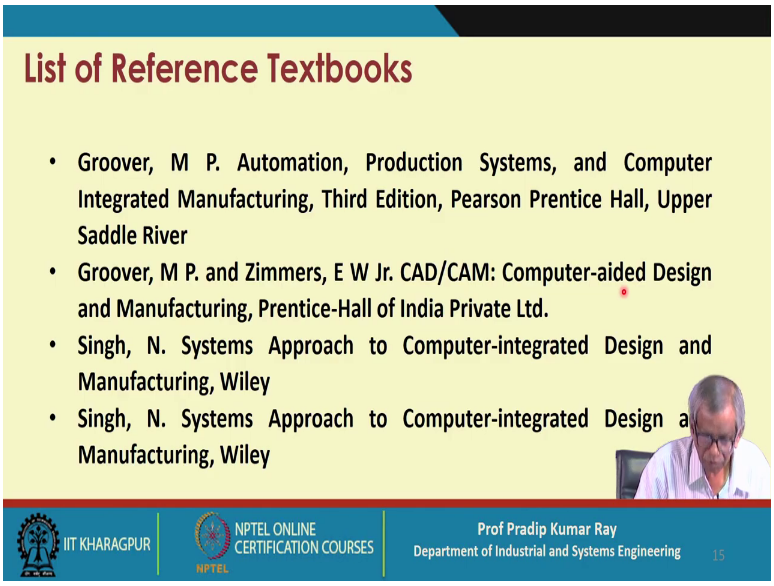

We have concluded that the cell formation you do and there could be many solutions. Now, always you will get not only just one solution, but also several solutions; several solutions mean several configurations, you may propose. Out of this the possible cell configuration which one will you select? This is called basically that evaluation of cell design.