Automation in Production Systems and Management
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Cellular Manufacturing System
Lecture - 35
Production Planning and Control in CMS

During this week, I have already referred to a number of important issues related to Cellular Manufacturing Systems. As you are the convinced or you are the going through this particular course or this particular topic, you have understood that how the GT principles or group technology principles are being used to create the cellular manufacturing system.

As you may be knowing that when you create such a system called CMS, a number of the machine cells or work cells you have to create or you have to design, you have to implement and within the cells, what are the physical subsystems you need to use.

One particular work cell is dedicated to produce just one part family or a number of part families and several approaches we have discussed in creating or in developing or in designing the work cell or the machine cell.

During these lecture session, some of the important issues need to be the discussed related to say the developing a CMS. The first one is the production planning and control in CMS.

As you may be knowing that when we refer to quality loop, there are 11 specific functions and one of the important function is definitely the process planning and control.

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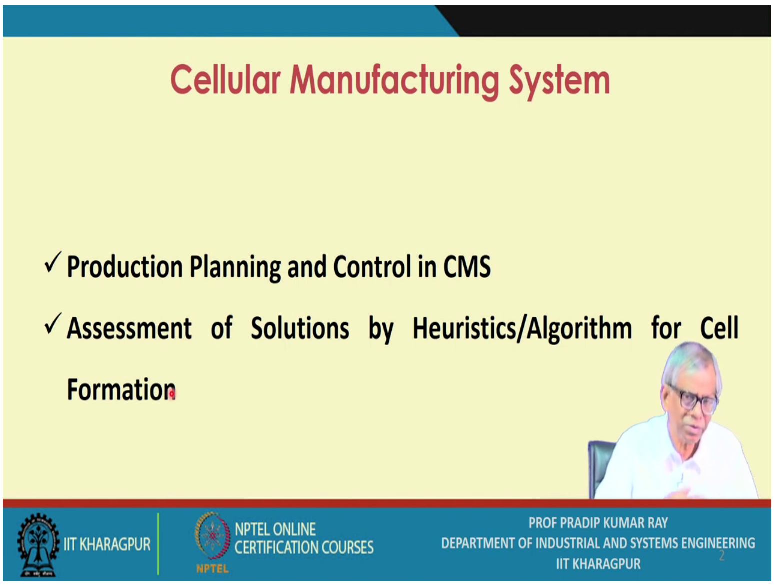

The CMS is one kind of the manufacturing system with some special features.

The second important issue is the assessment of solutions by heuristics or the algorithm for cell formations. If you refer to our previous the lecture sessions, we will find that given a particular the cell formation approach, you create the cell and you start working with the cell and when you reach the controllable and stable condition, you try to measure its performance. In the given example, we have referred for a particular part machine incidence matrix, there could be the five types of configurations and against each configuration, you we have determined the material handling cost.

That means the total cost involving the intracell movement, material cost related to intracell movement of parts and plus the material cost or material handling cost, not material handling cost for intercell movements within the CMS intercell movements of the parts.

One important limitation of these approaches are certain assumptions related to your layout. The procedure is known, whether it is a straight-line layout or the loop layout or the square layout that must be the specified.

The unit distance between the two machines also to be specified. Your cost estimate will be acceptable only when you go for the empirical study, the actual data you get.

It is basically a cost-based approach. For a given part, how many routes you have to follow or how many machines you require and that will vary, this information or this data will be different for different parts.

When suppose these data are not available, can you not assess the performance of a machine cell? Here, we will discuss one particular approach with which you can assess the quality of solution of a particular heuristics you use to create a machine cell.

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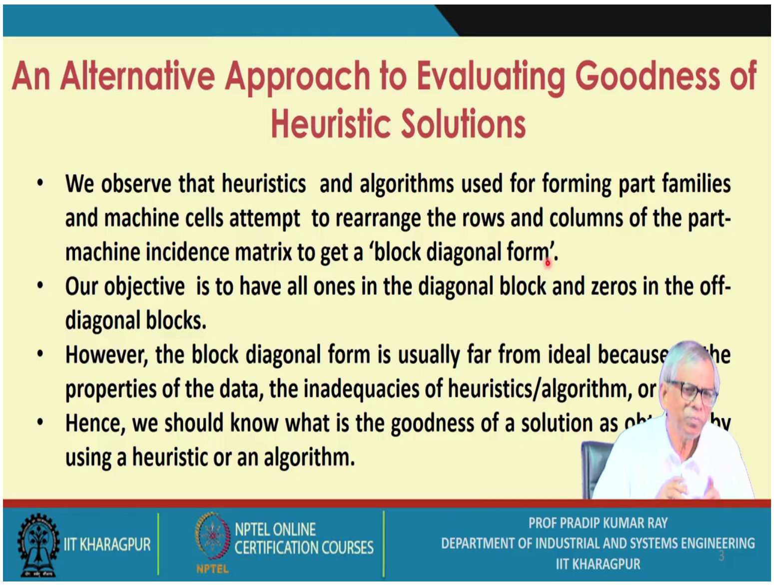

First let us the talk about assessment of solutions. Let me just explain the alternative approach for evaluating goodness of heuristic solution. The solution means you apply a particular approach for cell formation, you form the cells and then you check what is its performance, how good the cell is, that is referred to as the goodness of the cell formation.

We observed that heuristics and algorithms used for forming part families and machine cell attempt to rearrange the rows and columns of the part machine incidences matrix to get a block diagonal form and once you get a particular the block diagonal form, corresponding the part machine incidence matrix, you get the final solution by using a particular heuristic or the algorithm.

Looking at this particular the arrangements of the machines with respect to different parts, you can identify that against a particular configuration how many exceptional elements we have and how many the bottleneck machines we have.

The ideal, the best solution is that in a particular configuration, you do not have any exceptional element or exceptional part as well as no bottleneck machines, that is the ideal solution, but the corresponding approach must also be specified. It is most unlikely that one particular approach, there are many approaches you have, a few approaches you have already come across for cell formation.

For any approach, there are some limitations. In all likelihood, no approaches are sufficient to propose and to get the ideal solution. Our objective is to have all 1s in the diagonal block and 0s in the off-diagonal blocks.

However, the block diagonal form is usually far from ideal because of the properties of the data, the inadequacies of the heuristics and algorithms or both. Like when you determine, you get a particular incidence matrix, already that is prespecified and normally, you go by the kinds of the process planning systems against all these parts. These are independently the decided.

You are trying to use a particular cell formation technique, there will be some limitations of this these approaches. Hence, we should know the goodness of a solution as obtained by using heuristic or an algorithm.

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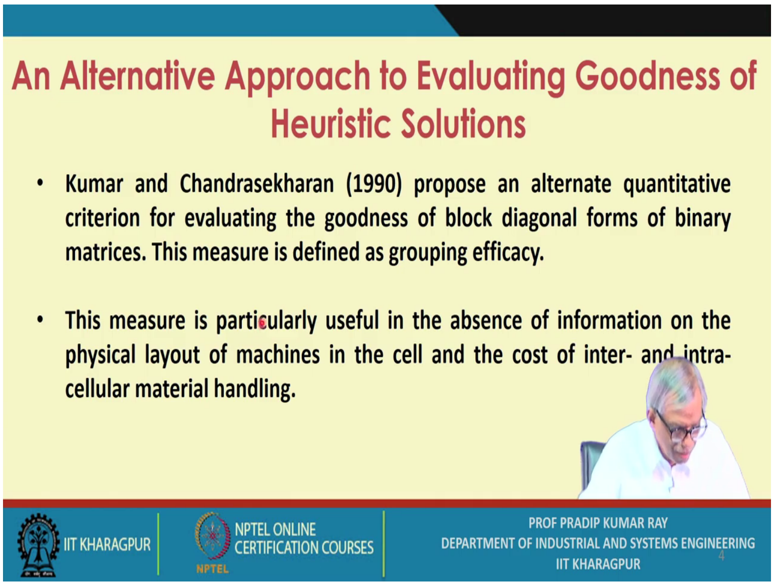

There is a reference to Kumar and Chandrasekharan. They propose an alternate quantitative criterion for evaluating the goodness of block diagonal forms.

This measure is defined as grouping efficacy of a particular solution. This measure is particularly useful in the absence of information on the physical layout of machine.

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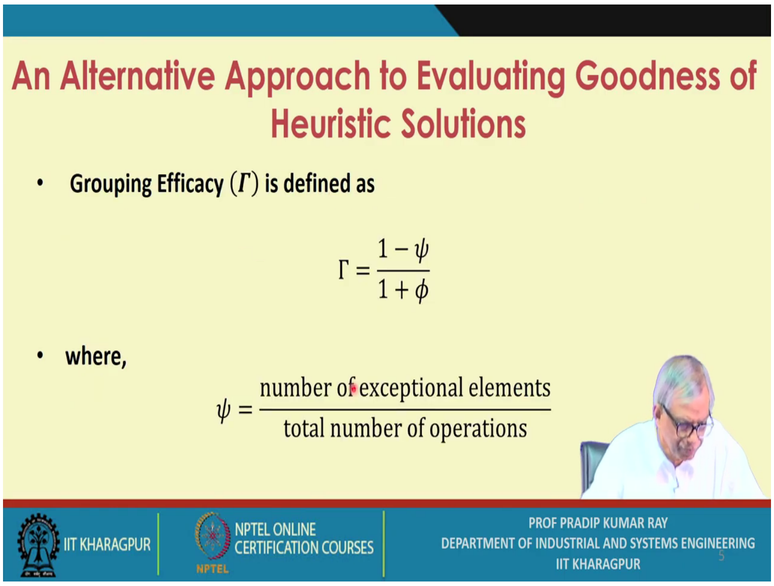

- The grouping efficacy (Γ) is defined as

$$\Gamma = \frac{1-\psi}{1+\phi}$$

- where,

$$\psi = \frac{\text{number of exceptional elements}}{\text{total number of operations}}$$

What is an exceptional element? that particular element or the part for which all the operations you cannot carry out in one particular cell.

You must take this part to another cell where the remaining operations will be carried out or maybe the third cell you have to move. Still, all the operations are completed. These are referred to as exceptional elements and there are machines which are actually processing these exceptional elements. They are also referred to as the bottlenecks one.

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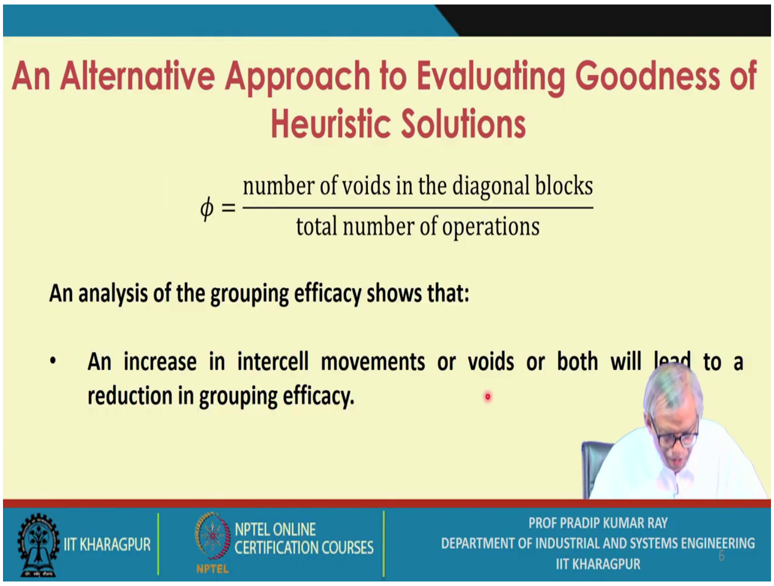

An analysis of the grouping efficacy reveals the following:

An increase in intercell movements or voids or both will lead to a reduction in grouping efficacy.

Change in the number of exceptional elements has a greater influence than change in the number of voids in the diagonal blocks. At lower efficacies, the voids in the diagonal blocks become less and less significant. It is worth mentioning here that the grouping efficacy-based approach may yield a different cell configuration than that suggested by the cost model.

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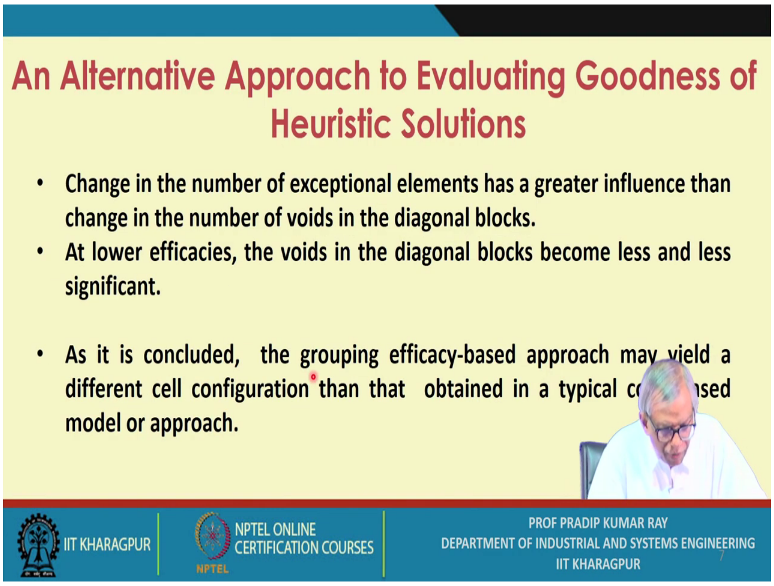

So, once again you go through and you will find that the which one is more preferable, whether this cost-based approach or this grouping efficacy-based approach.

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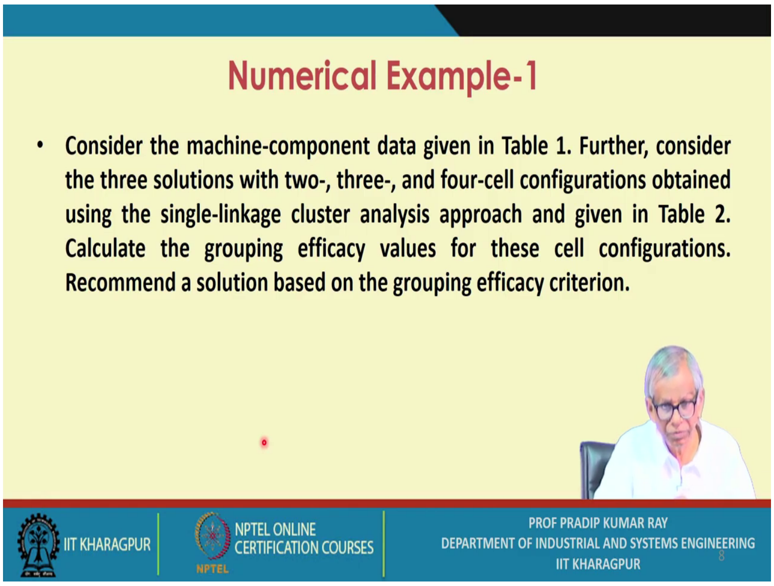

Related to this particular the say the determination of the grouping efficacy let us have this the numerical example. Consider the machine-component data given in Table 1. Further, consider the three solutions with two-, three-, and four-cell configurations obtained using the single-linkage cluster analysis approach and given in Table 2. Calculate the grouping efficacy values for these cell configurations. Recommend a solution based on the grouping efficacy criterion.

For two-cell configuration, three-cell configuration and four-cell configuration, you need to determine each grouping efficacy using the single-linkage cluster analysis.

Now, out of these three e we will select the cost-based approach that means, we will select that particular configuration which minimizes the cost. Here, you will select that particular configuration which maximizes the grouping efficacy that is the only difference. Calculate the grouping efficacy values for these cell configurations. Recommend a solution based on the grouping efficacy criterion.

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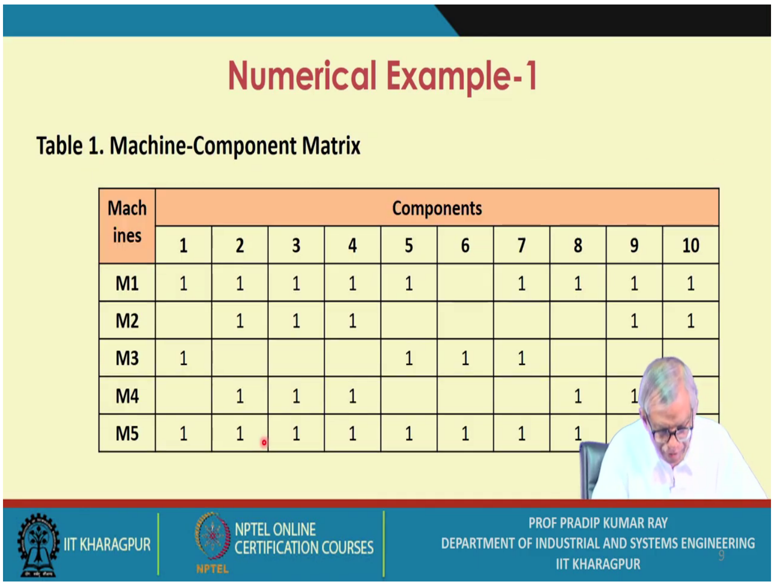

This is the machine component incidence matrix, these are the machines, and these are the components, there are 10 components, there are 5 machines and this is basically the allocation matrix. Which part is to be produced by using which machine?

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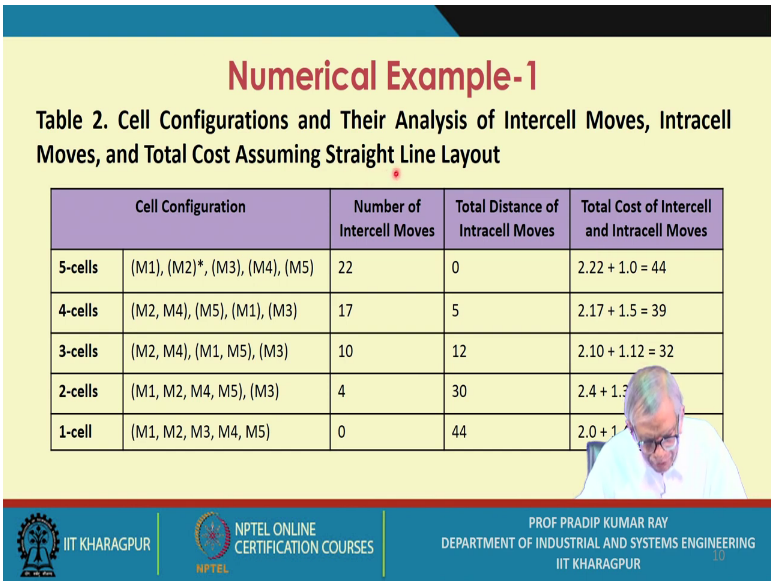

Now, you apply your particular algorithm, in this case say SLC algorithm and you find if it is a 5-cell configuration, these are the 5-cells. Similarly, if it is a 4-cell one, M2, M4 forming one cell and all other three machines are independent cell, 3 +1 = 4. Similarly, 3-cell configuration, 2-cell configuration, 1-cell configuration.

These values you get and here in one cell, the intercell will be 0. All these 5 machines are grouped as a one entity and the total distance of intercell moves will be 0 and the maximum will be when you have just 1-cell. The number of times you have to move from one cell to another will be maximum number of moves, if it is a 1-cell configuration.

The total cost for the intracell, total means all the machines are grouped into one entity. Here, it is the different entities you have. The total cost we have calculated, you find that when it is a 3-cell configuration; how do you calculate this because intercell moves on the total cost assuming straight line layout, that you have to assume.

You can change the layout; these values will be different. Here, we find that against this particular straight-line layout for all these configurations, the 3-cell configuration is the best one with the minimum cost.

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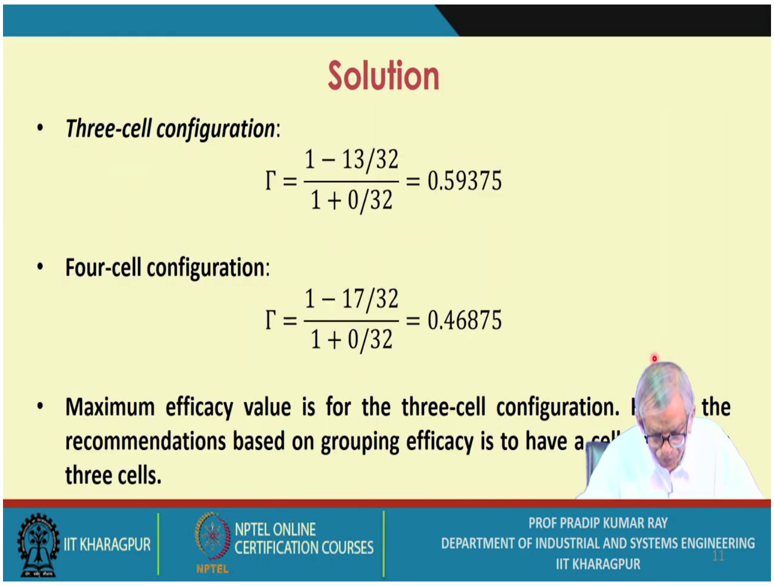

For Three-cell configuration:

$$\Gamma = \frac{1 - 13/32}{1 + 0/32} = 0.593$$

For Four-cell configuration:

$$\Gamma = \frac{1 - 17/32}{1 + 0/32} = 0.468$$

The highest efficacy value is for the three-cell configuration. Therefore, the recommendations based on grouping efficacy is to have a cell design with three cells.

Hence, the recommendations based on grouping efficacy is to have a cell design with three-cells.

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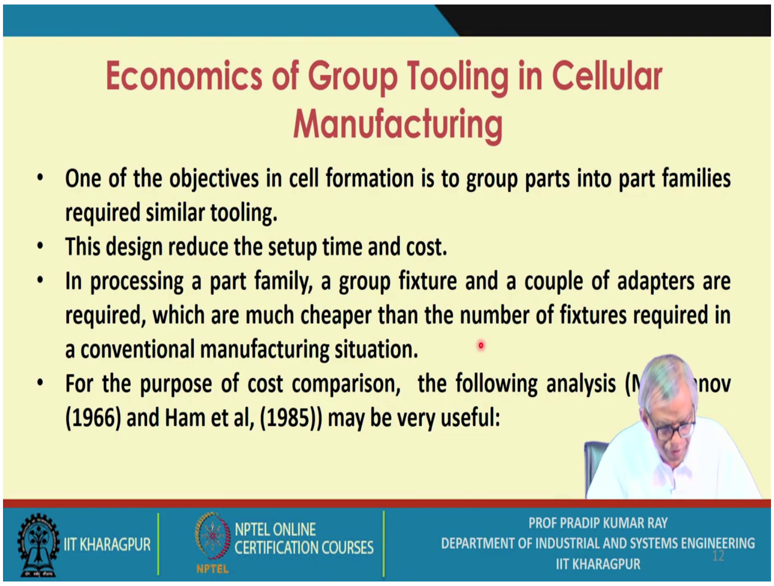

Now, the next important aspect we are going to discuss related to cellular manufacturing is referred to as the group tooling.

In processing a part family, a group fixture and a couple of adapters are required, which are much cheaper than the number of fixtures required in a conventional manufacturing situation. For the purpose of cost comparison, we present the following analysis from Mitrofanov (1966) and Ham et al, (1985):

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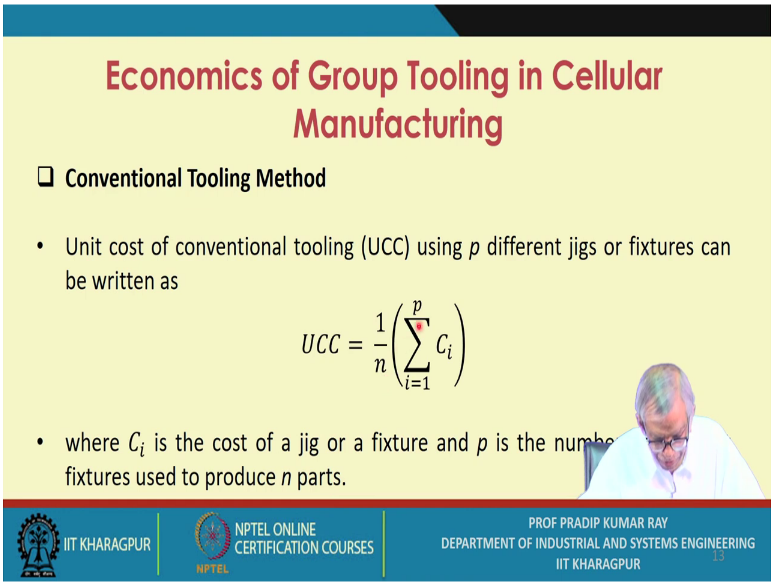

If it is a conventional tooling method, The unit cost of conventional tooling (UCC) using p different jigs or fixtures can be written as

$$UCC = \frac{1}{n}\left(\sum_{i=1}^{p} C_i\right)$$

where C_i is the cost of a jig or a fixture and p is the number of different fixtures used to produce n parts.

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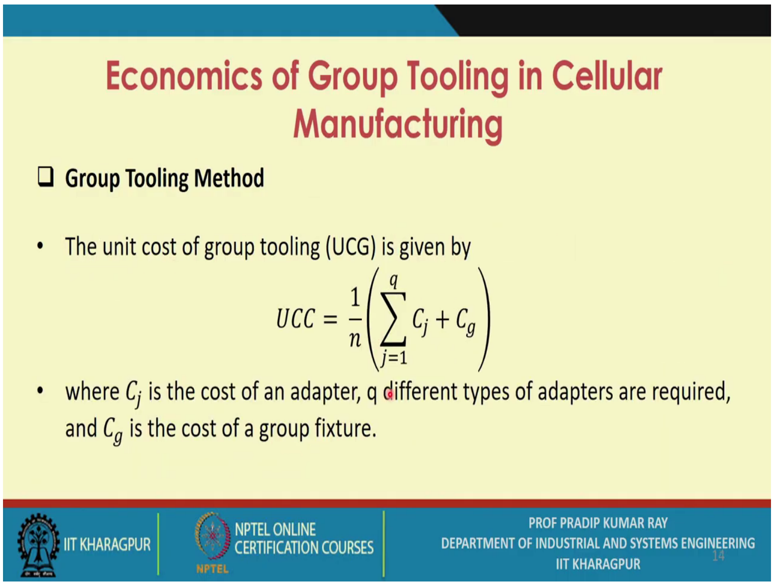

If you use the group tooling method so, The unit cost of group tooling (UCG) is given by

$$UCC = \frac{1}{n}\left(\sum_{j=1}^{q} C_j + C_g\right)$$

where C_j is the cost of an adapter, q different types of adapters are required, and C_g is the cost of a group fixture.

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Normally, cost of an adapter is much less than that of a fixture in conventional tooling. That is why the adapter-based system s becoming cost effective. It is therefore obvious from these relations that group tooling would become more economical with an increase in the number of parts in the family.

Before you opt for FMS, make sure that CMS is implemented and when you implement CMS, the group tooling you adopt, you have to use different kinds of adapters.

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Cellular manufacturing systems have certain characteristics that make the production planning problems different from those in traditional production systems.

For example:

1 Use of group tooling considerably reduces setup time.

2 Machines are more flexible in performing various operations.

3 Low demands and large variety of parts.

4 Fewer machines than part types

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These characteristics alter the nature of production planning problems in GT-cellular manufacturing systems and permit us to take advantage of similarities of setups and operations by integrating GT concepts with material requirements planning (MRP). In an MRP-based system, optimal lot sizes are determined for various parts required for products. However, similarities among the parts requiring similar setups and operations are not exploited.

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The grouping of the parts for loading and scheduling based on similar setups and operations will reduce setup time. On the other hand, the time-phased requirement planning aspect is not considered in GT. That is, all the parts in a group are assumed to be available at the beginning of the period. Integration of GT and MRP will lead to a better production planning and control system.

There will be some critical problems you might face in creating or in developing an appropriate production, planning and control system for CMS. There are certain good conditions you may have when you adopt MRP based system.

So, why do not you use both the GT and MRP based system so that you will have the maximum control or you get the best possible performance of your production planning and control systems in an FMS as well as in CMS.