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

Group Technology and Automation in Manufacturing
Lecture - 29
Numerical Examples on Part Family Formation

During that 6th week we are discussing in detail group technology and automation in manufacturing. In order to create or in order to develop an automated system in manufacturing or in a production system, you need to develop a specific the manufacturing system referred to as cellular manufacturing system.

In order to develop a cellular manufacturing system, you have to apply the GT principles. Under the group technology we try to define the similarity between two parts, or between two cutting tools.

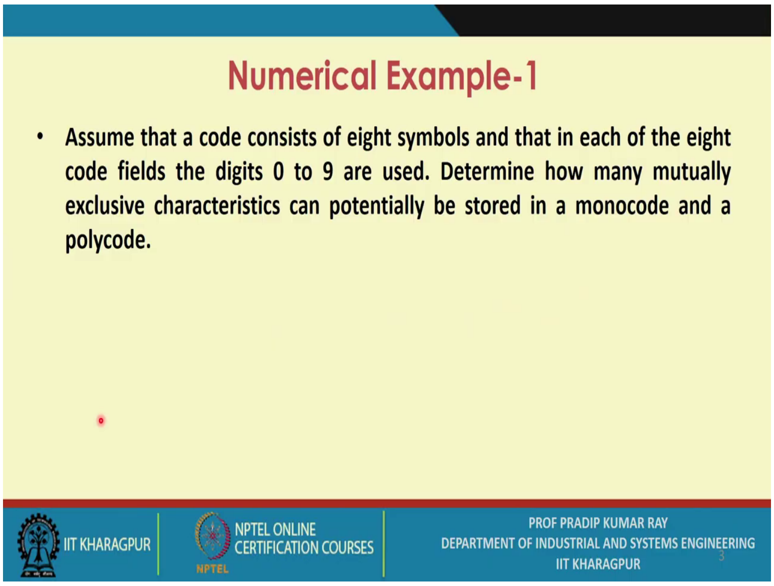
Based on the similarity the level of similarity you try to group a set of similar components. Instead of dealing with one individual item, you try to deal with a group of items together or in combinations.

(Refer Slide Time: 02:06)

The part family is formed and all the parts in a particular part family you try to produce. In order to form the part families, there could be different approaches like similarity coefficient-based approaches, production the flow analysis, rank order clustering, etc.

During this particular lecture session, we will be referring to a number numerical problems on part family formation.

(Refer Slide Time: 04:03)



We also must know the starting point is that a group of machines and the group of machines are engaged for processing a group of parts. When this information is known to you by using this part related process plans, you can immediately understand the similarity between two parts. You are referring to their process plans and accordingly you develop that machine component incidence matrix.

There could be many coding schemes like monocode, mixed coding, polycode and usually monocode is used to specify the design related information. The polycode you prefer to specify say the manufacturing related operations.

In many cases we propose a mixed code, a combination of monocode and polycode, and one example we have given that is called Opitz system classification and coding schemes.

Here is one simple problem. Assume that a code consists of eight symbols and that in each of the eight code fields the digits 0 to 9 are used. Determine how many mutually exclusive characteristics can potentially be stored in a monocode and a polycode.

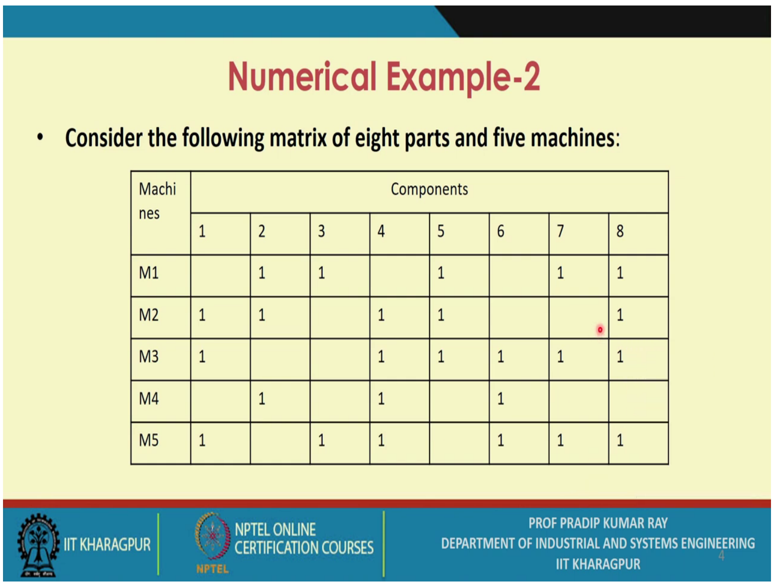
If you opt for a monocode, how many mutually exclusive characteristics you can consider, it is basically it is eight-digit code and in each of the eight code fields the digit 0 to 9 are used.

It should be $10^8+10^7+10^6+10^5+10^4+10^3+10^2+10^1 = 111111110$, that is the maximum number of mutually exclusive characteristics you can include in a monocode.

If it is a polycode, the number will be 10*8 = 80. If you use a polycode usually manufacturing related characteristics or operations or the functions you can easily include.

It is very difficult to put the design information normally. It becomes easier for you to put the design formation in a hierarchical form. That is why the monocode is also referred to as the hierarchical code, this information in hierarchical form.

(Refer Slide Time: 09:04)

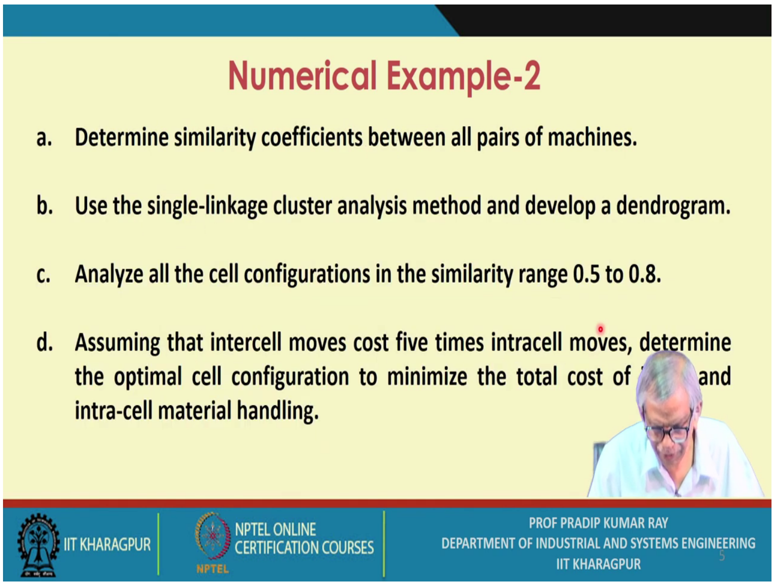


Considering the following matrix of eight parts and five machines. These are the components or the parts. There are eight parts. This is the incidence matrix and how many machines you have? M1, M2, M3, M4 and M5. In order to get component 1, you need machine 2 operation, machine 3 operation and machine 5 operation.

Similarly, if you want to manufacture part 6, you need three machines M3, M4 and M5. Now, with this combination how many clusters you will form? Each cluster will be referred to as a part family.

We will find that all these parts cannot be included in one or more say part families. There will be certain number of parts which you cannot include in a particular part family. Those parts are referred to as the exceptional parts and the machines which are processing the exceptional parts are referred to as the bottleneck machines.

(Refer Slide Time: 11:06)



In order to get these these part families, you have to use one particular technique. Here you need to determine similarity coefficients between all pairs of machines.

The similarity coefficient we have to define between two parts. Pairwise you have to consider 1-2, 1-3, 1-4, 1-5, 1-6, 1-7, 1-8. There are eight components. Similarity between these two pairs you have to define and the formula for defining as well as the measuring similarity coefficient.

Basically, there will be some common operations to be carried out in both the parts and there could be certain operations which you need to carry out only for the individual part and you have ratio. For each pair you can define the similarity coefficient. Use the single linkage cluster analysis.

No particular heuristics or algorithms or approach cannot get the best possible solution for all types of problems or different types of component machine or machine component incidents matrices.

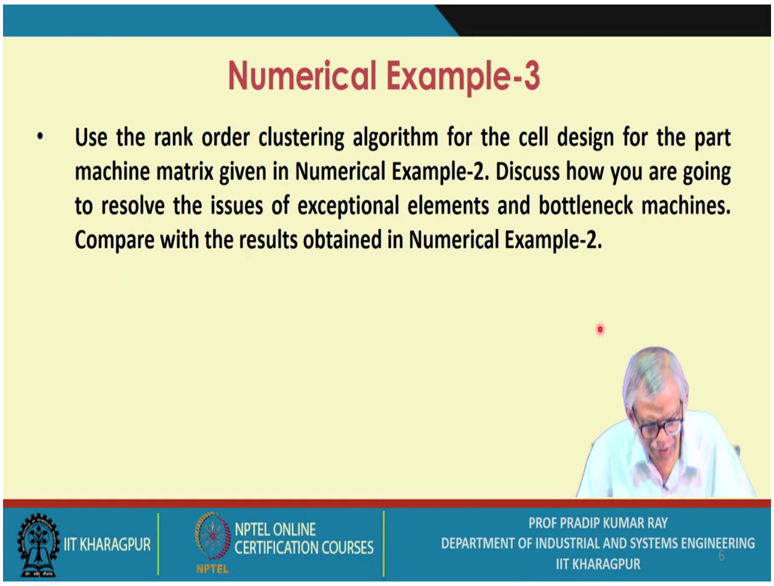
You develop a dendrogram. Analyze all the cell configurations. How many cells you may have? You can have a just a 1 cell consisting of all the 5 machines, you can have the 2 cells. So, in one cell you have just one machine and in the second cell you have remaining 4.

Similarly, it would be a 3-cell configuration or 2 cell configuration or 1 cell configuration or 5 cell configurations. Analyze all the cell configurations in the similarity range of 0.5 to 0.8.

We will find how to determine a particular cell configuration with respect to a particular range of similarity coefficients. There you stop; you cannot reduce the value of the cell say similarity coefficient less than 0.5, that rule you have to follow.

Assuming that intercell moves cost five times between the machine cells determine the optimal cell configuration to minimize the total cost of inter and intracell material handling. This cost estimates will be given and you just follow that particular procedure and you get the solutions.

(Refer Slide Time: 16:22)



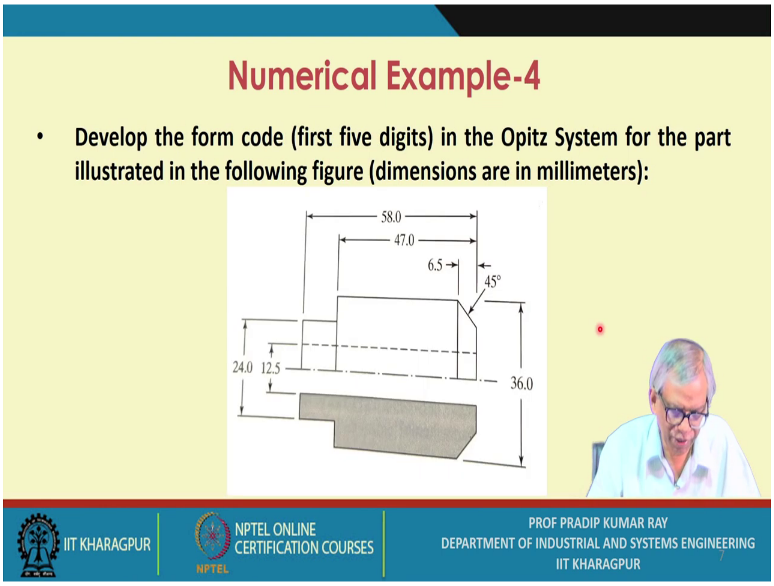
In the third example, you have to use the rank order clustering algorithm ROC algorithm. The details already we have come to know for the cell design for the part machine matrix given numerical example 2. The same problem where there are 8 parts and the 5 machines and the same incidence matrix you consider.

But here you try to apply the ROC algorithm, that means, there will be the binary weight and then considering all these binary weights, against each row, first you calculate the decimal weight, and then you go for permuting the rows and the columns. First you start with the row and then you go to over the column.

You arrange them in descending orders and ultimately when you find that incidence matrix does not change between two successive iterations, we stop there, that is the stopping rule.

Then you look at the arrangements of the parts with respect to the machines and you try to identify the minimum number of clusters of machines with the parts. But, in all likelihood, you will find that all the parts you cannot include in part families, some parts will be outside of the part families. Compare with the results obtained in numerical example 2.

(Refer Slide Time: 18:44)



With respect to the given problem or the machine component incidence matrix, you will come to know that which particular approach is most suitable. So, you apply both the approaches and you just verify that for which approach you get a better solution and once you say it is a better solution, you need to justify it.

When you apply the ROC algorithm, the material handling cost is to be determined.

Many a time, against a particular solution, you try to get an estimate of the total material handling cost and as well as intercell movement of parts between the machine cells for the cost estimate. You need to consider movements of parts.

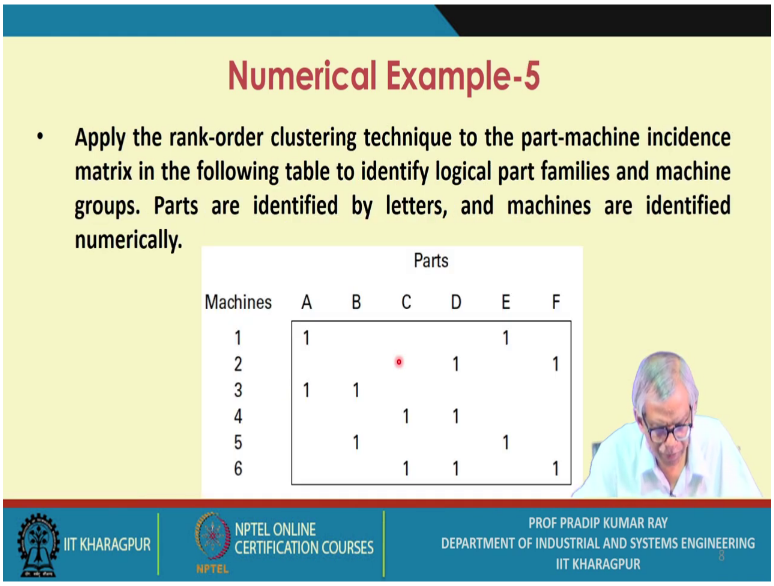
The fourth example is-develop the form code (first five digits) in the Opitz System for the part illustrated in the following figure (dimensions are in millimeters):

The first the five digits are referring to the form code and this code you use to specify the design related characteristics for the part illustrated in the following figures.

When you get this particular shape, what kind of the operations you require that also you should specify. Here the designed features you have to specify, and remember that when these design features are known to you, you have to write down the code or part program.

Once you look at this particular drawing you will find what are the geometric elements you need to consider.

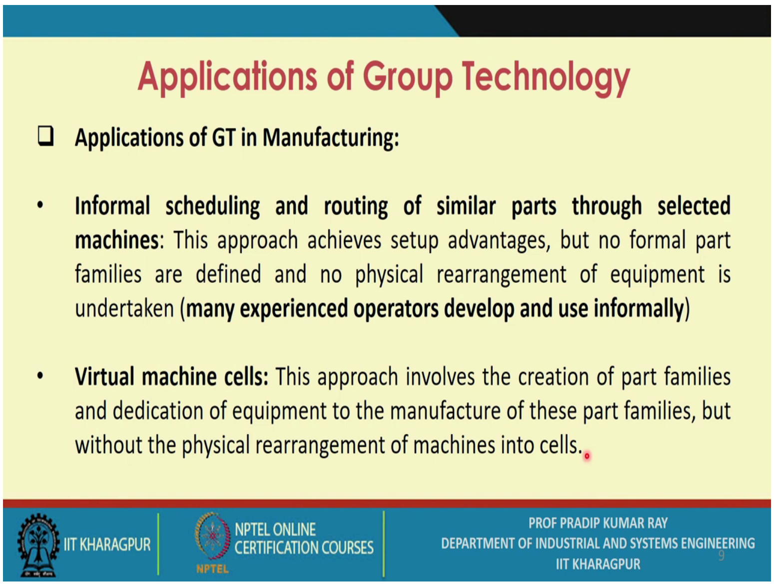
(Refer Slide Time: 22:00)



Machines	A	B	C	D	E	F
1	1				1	
2				1		1
3	1	1				
4			1	1		
5		1			1	
6			1	1		1

Apply the rank-order clustering technique to the part-machine incidence matrix in the following table to identify logical part families and machine groups. Parts are identified by letters, and machines are identified numerically.

(Refer Slide Time: 22:57)



Group technology principles you can use in various ways. In a typical manufacturing system, you will find that operators will be on a particular machine tool may be producing or may be processing different type of parts in shapes and sizes, and over the years he is gaining experience.

You will find that knowingly or unknowingly he is forming the group of parts and the groupwise process and while he or she forms the group, there is a similarity principle he or she applies. Informally you develop your own part families.

Using the common senses and by defining the similarities naturally he tries to make a group. This is basically referred to as informal scheduling and routing of similar parts through selected machines. Suppose if you find that part 1 is similar to the part 2. For part 1 you have one root, and for part 2 maybe you have another root, but there is little difference between these two roots. In all likelihood you will find that roots also will be different because their process plans are different.

Informal scheduling and routing of similar parts through selected machines. This approach achieves setup advantages, but no formal part families are defined and no physical rearrangement of equipment is undertaken.

Virtual machine cells. This approach involves the creation of part families and dedication of equipment to the manufacture of these part families, but without the physical rearrangement of machines into cells.

(Refer Slide Time: 28:41)

Next is the formal the machine cells. This is the conventional GT approach in which a group of dissimilar machines are physically relocated into a cell that is dedicated to the production of one or a limited set of part families. The machines in a formal machine cell are located in close proximity to one another in order to minimize part handling, throughput time, and work-in-process.

You say that yes this is a particular dedicated manufacturing system exclusively for producing the parts in one part family or may be in certain cases for few part families. It is totally dedicated machine cell. For one or a limited set of part families, the machines in a formal machine cell are located in close physical proximity to one another in order to minimize part handling.

Because manual material handling is involved, the movements of parts throughout throughput time and work in process. Like when you go for the cell design one important the aspect to be consider that is the flow time of a part enters a cell and it comes out of the cell. So, all the processes operations are carried out. This flow time should be as minimum as possible.

Other GT applications in manufacturing include process planning, family tooling, and numerical control (NC) part programs.

(Refer Slide Time: 31:57)

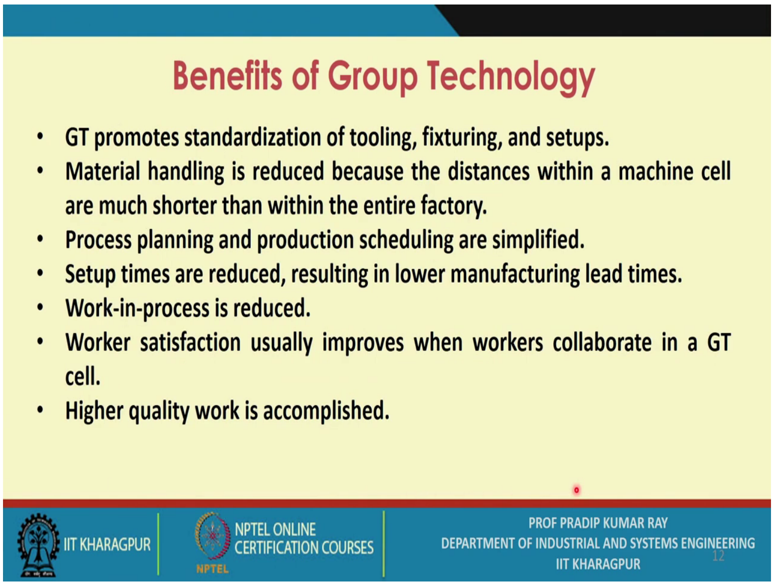
The application of group technology in product design is principally for design retrieval systems that reduce part proliferation.

Other design applications of group technology involve simplification and standardization of design parameters such as tolerances, inside radii on corners, chamfer sizes on outside edges, hole sizes, and thread sizes.

There is also a benefit in reducing the amount of data and information that the company must handle. Fewer part designs, design attributes, tools, fasteners, and so on mean fewer and simpler design documents, process plans, and other data records. You have to simplify the design and one way you can simplify that is reducing the number of parts. Reducing number of parts and this particular aspect is coming under design for assembly and design for standardization. When you go for standardization, when you go for simplification, in all likelihood you will find that on similarity basis you can define very easily a number of part families.

The number of part families will be less and within a particular family you will find that similarity between the parts or among the parts within a particular part family could be at a very high level.

(Refer Slide Time: 34:27)



When you start using the GT principles, you will be going for simplification of the assembly design.

Let me highlight some of the benefits of the group technology like GT promotes standardization of tooling, fixturing and setups, it is a total systems approach. Material handling is reduced. Process planning and production scheduling are simplified because the constantly you have been using the GT principles.

It is not that just once you apply the GT principles and then sales are formed, part families are formed, always there will be a scope for improvement. Setup times are reduced resulting in lower manufacturing lead times. Work in process is reduced. Worker satisfaction usually improves when workers collaborate in a GT cell.

Normally the machine cell that a group of persons will be working will come to know how these parts are related to one another. So, higher quality work is accomplished.

(Refer Slide Time: 35:50)