Automation in Production Systems and Management
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Flexible Manufacturing Systems - II
Lecture - 42
Operational Problems in FMS:
Tools and Techniques – 2, Numerical Examples

During this session, we will be taking up one numerical problem. In the last lecture session if you remember that we have the taken up one part selection and tool management problem.

We have formulated the problem and two approaches we have discussed; one is the Hwang's model and the other is Stecke and Kim extension of the Hwang's model.

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During this lecture session, with respect to this particular model, we will be taking up one numerical problem.

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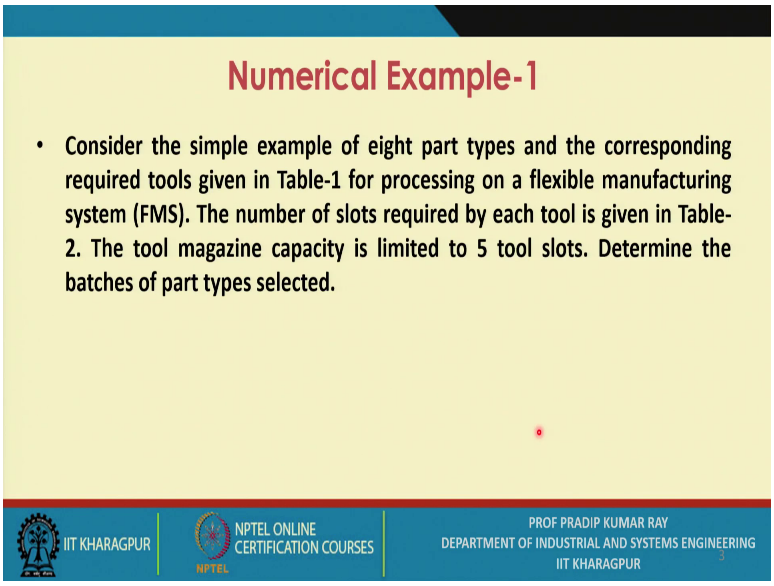

Consider the simple example of eight-part types and the corresponding required tools given in table-1 for processing on a flexible manufacturing system; that means, a set of parts given to you and against each part you refer to its process plan and you check the type of operations you need to carry out and immediately you identify the number and types of tools required.

For a given part say part 1 you may need one cutting tool or two cutting tools or maybe four cutting tools and the machine tool which you use in an FMS are all NC machining centres, not only one operation made available you can get multiple operations from the same machine.

You need to use NC technology. The number of slots required for each type is given in table 2, the number of the slots required to hold a particular cutting tool on a tool magazine and this tool magazine is installed at a particular NC machining centre within the FMS.

The tool magazine capacity is limited to 5 tool slots, the size of the tool magazine is very less.

Instead of using a batching approach suppose as you decrease the tool magazine capacity which particular approach you will follow whether you stick to the batching approach or you will move to flexible approach.

In order to the control and minimize the flow time \within FMS always you will opt for the flexible approach. If you want to process a group of parts as quickly as possible most efficiently, you need to adopt the flexible approach. Determine the batches of part types selected.

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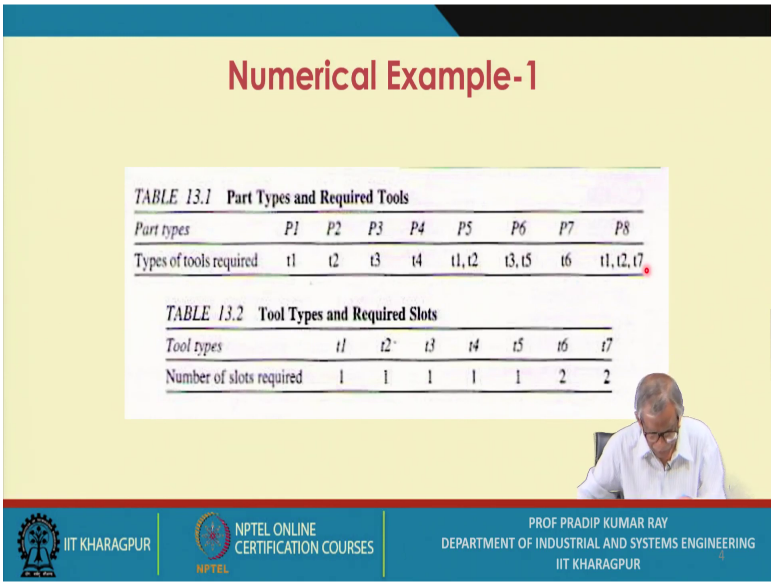

These are the data part types P1, P2, P3, P4, P5, P6, P7, P8. This information you get from the process plan. You just need one cutting tool of type t1, similarly for P2, t2, for P3, t3, for P4, t4, but for P5 you need two cutting tools.

Similarly, for P6 you need t3 and t5. These are basically coding of a particular cutting tool.

For the seventh part you need just one tool t6, for part 8 you need 3 types of tools t1, t2, t7.

For each tool you need certain number of slots so that you can hold them in the tool magazine appropriately.

This information you get from the next table and for each tool type you specify the number of slots required to hold that particular tool in the given tool magazine.

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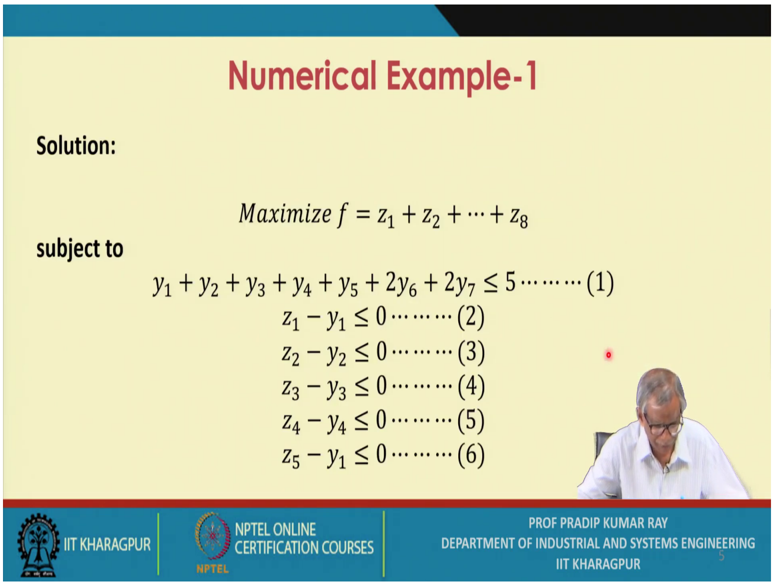

Solution:

$$Maximize\ f = z_1 + z_2 + \cdots + z_8$$

subject to

$$y_1 + y_2 + y_3 + y_4 + y_5 + 2y_6 + 2y_7 \leq 5 \cdots\cdots\cdots (1)$$
$$z_1 - y_1 \leq 0 \cdots\cdots\cdots (2)$$
$$z_2 - y_2 \leq 0 \cdots\cdots\cdots (3)$$
$$z_3 - y_3 \leq 0 \cdots\cdots\cdots (4)$$
$$z_4 - y_4 \leq 0 \cdots\cdots\cdots (5)$$
$$z_5 - y_1 \leq 0 \cdots\cdots\cdots (6)$$

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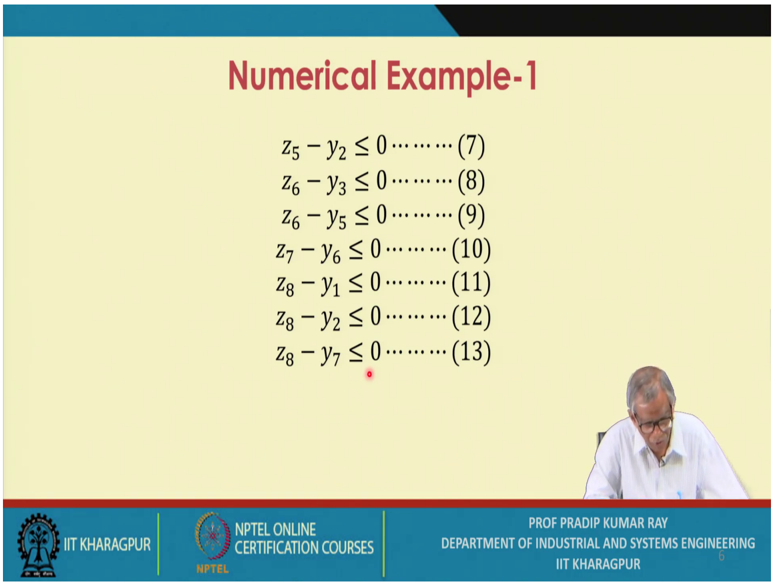

$$z_5 - y_2 \leq 0 \cdots\cdots\cdots (7)$$
$$z_6 - y_3 \leq 0 \cdots\cdots\cdots (8)$$
$$z_6 - y_5 \leq 0 \cdots\cdots\cdots (9)$$
$$z_7 - y_6 \leq 0 \cdots\cdots\cdots (10)$$
$$z_8 - y_1 \leq 0 \cdots\cdots\cdots (11)$$
$$z_8 - y_2 \leq 0 \cdots\cdots\cdots (12)$$
$$z_8 - y_7 \leq 0 \cdots\cdots\cdots (13)$$

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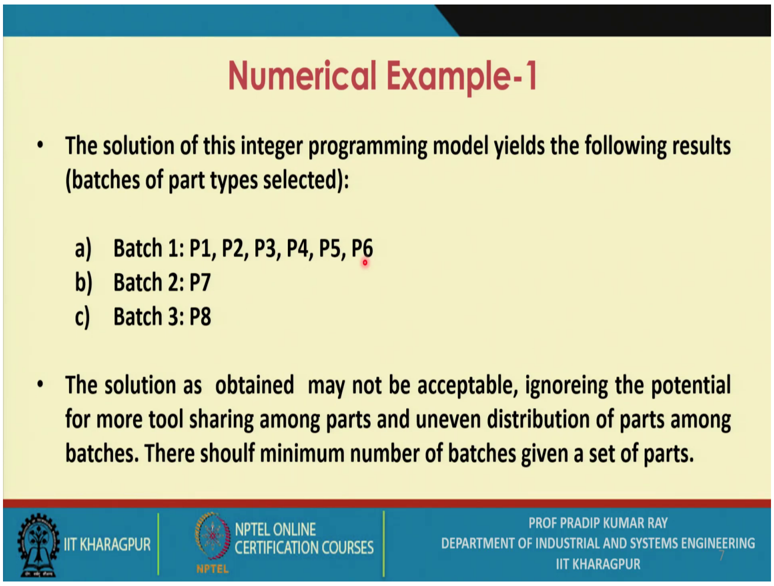

Now, you try to get the solution.

The solution of this integer programming model yields the following results.

The solution of this integer programming model yields the following batches of part types selected:

a) Batch 1: P1, P2, P3, P4, P5, P6

b) Batch 2: P7

c) Batch 3: P8

Now, looking at the solution you ask yourself whether this is a good solution or not. The solution as obtained may not be acceptable to you.

Normally, the best possible the solution if you have, you will find that more or less all the parts are evenly distributed. Suppose there are 30 parts. There could be one solution you get like say more or less 1 form 2 batches; let it be flexible approach or let it be batching approach.

If you find that in one group or one batch you have around 15 parts and in second batch you have around 15; it could be first group 16; next group is 14 or it could be the 17, but if you find that in one group you have just 25 units or 25 parts and the next batch you have formed with 5.

This is referred to the uneven distribution- this is not acceptable or if it is evenly distributed, suppose the sample size is 30. You get a solution: 3 batches and more or less in each batch you have 10 part type.

Ignoring the potential for more tool sharing among parts and uneven distribution of parts is it possible for you to use this tool in different batches?

There should be minimum number of batches for a given set of parts.

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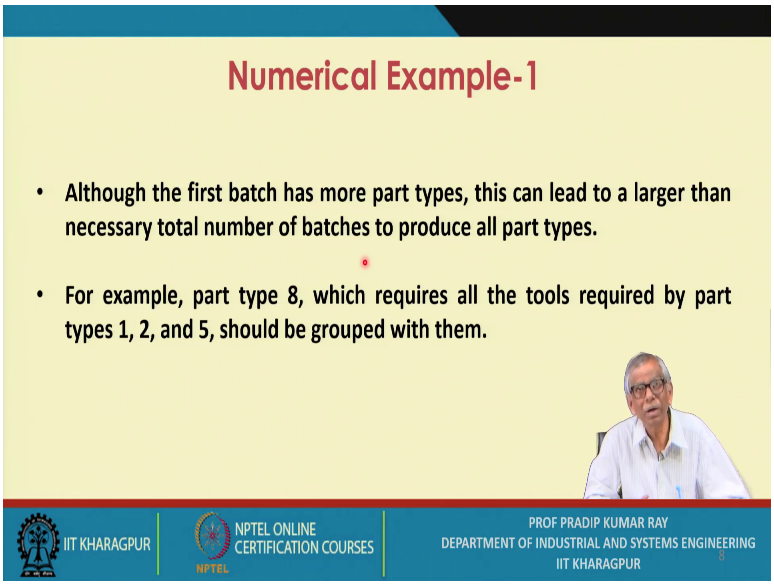

Although the first batch has more part types this can lead to a larger than necessary total number of batches to produce all part types. Now the key question is-suppose you deal with the smaller number of the batches then what is the main advantage? Suppose you have to deal with a greater number of batches what is the main disadvantage?

If equal size of lots or batches are formed, then it is a good solution and you have the minimum number of batches. For example, part type 8 requires all the tools required by part types 1, 2 and 5 and should be grouped within them.

Multiple subgroups you need to form and this multiple subgroups you form in such a way that the tool sharing is possible.

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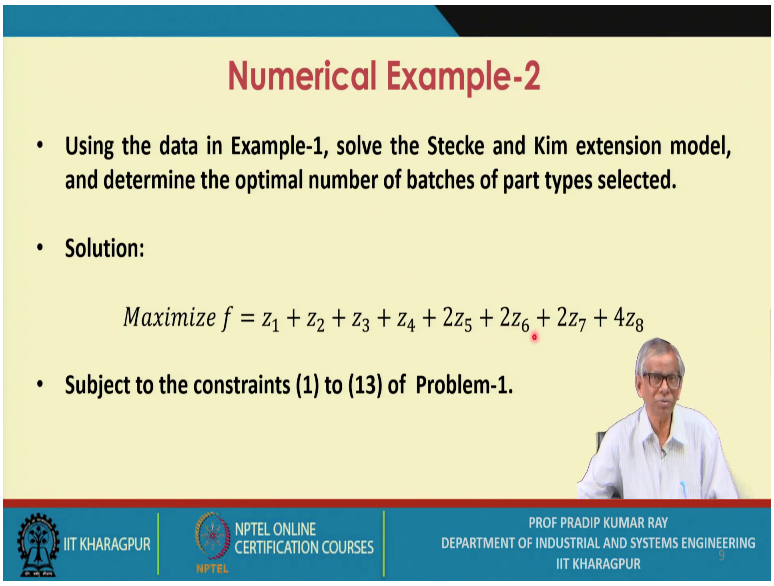

Using the data in example 1, can you not use that the Stecke and Kim extension model? The objective function must consider the number of tool slots required to hold each tool for processing one or more parts.

$$Maximize\ f = z_1 + z_2 + z_3 + z_4 + 2z_5 + 2z_6 + 2z_7 + 4z_8$$

Subject to the constraints (1) to (13) of the previous problem

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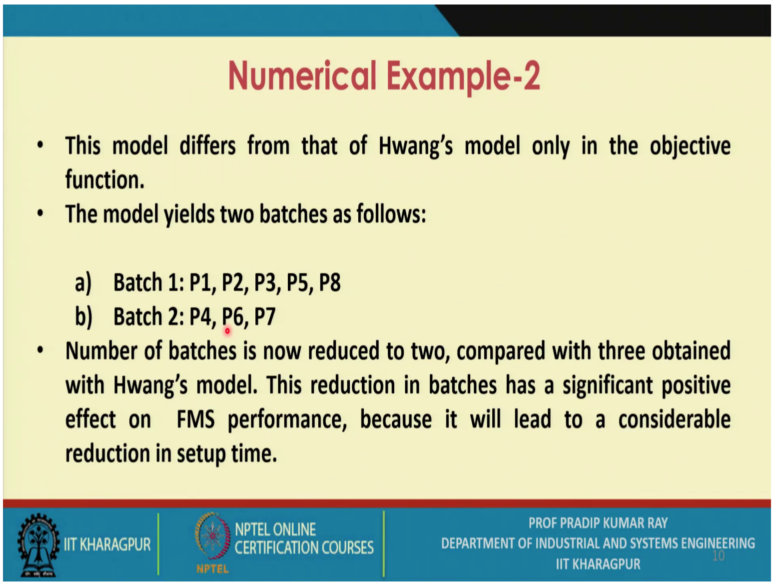

The solution will be better if there will be even distribution of parts among the batches.

This model differs from that of Hwang's model only in the objective function.

The model yields two batches as follows:

a) Batch 1: P1, P2, P3, P5, P8

b) Batch 2: P4, P6, P7

The number of batches is now reduced to two, compared with three obtained with Hwang's model. This reduction in batches has a tremendous influence on the performance of an FMS, because it will lead to a considerable reduction in setup time.

Before I close the session let me highlight a very important issue that is part selection problem is related to overall tool management problem. Essentially the kinds of operations required and the types of cutting tools you require, that is the second stage.

In the third stage you link this a particular type of cutting tool with the number of slots in the tool magazine; that means, you are defining the characteristics of a particular cutting tool with respect to the characteristic of the tool magazine.

When we talk about the tool management system, we refer to the tool holding devices; in this case is the tool magazine. Now, how do you utilize the tool magazine fully? Utilize the tool magazine capacity fully whether it is 30 or say 60 or 120 and that is installed in your machining centre within FMS.

There are certain critical problems you need to deal with. With respect to the utilization of the tool magazine, how many different ways you may use your tool magazine?

First one is bulk exchange policy. One lot or one batch is formed, batch of parts, corresponding to the tools you select and the batch size you select in terms of how many tools you can accommodate in a tool magazine of certain capacity. When the capacity is full, what is the size of the batch and how many different part types you can include in the batch?

You start processing it and then the batch is completed. Batch processing is overprocessing of the entire batch, all the parts in the batch are over and a full magazine now has become an empty magazine. So, this process repeats. This is your starting point and as you start working with this particular method, later you feel like changing the procedures and you try to make it as flexible as possible.

Those details we will be discussing in subsequent lecture sessions and for each tool management policy, there could be different types of numerical problems. So, those problems we also will be dealing with in subsequent lecture sessions on FMS.