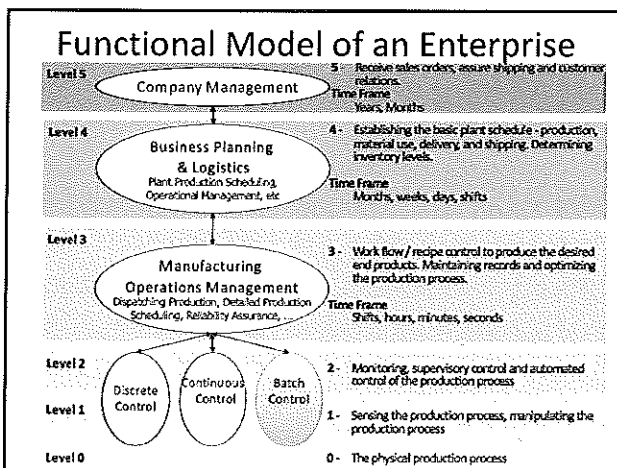


1

## Outline

- Batch Production Systems
- ISA 88 Batch Control Standard
  - Process Model
  - Physical Model
  - Procedural Model
  - Equipment Control Logic
  - Recipe
  - Recipe – Equipment Control Separation
  - Additional Items

2



3

## Batch Production Processes

General characteristics of batch production processes:

- Production of products in batches
- Discontinuous flow of materials.
- Production run determined by time/end point.
- Production goes through steps of operations.
- Fluid and dry processing.

4

## Example: Making cookies

Equipment needed to produce (process cell):

- Bowl
- Mixer
- Oven

Steps required to make the cookies (recipe):

1. Add flour, sugar and cocoa in a bowl
2. Mix and sift
3. Add butter,
4. Chop until well blended.
5. Roll very thin,
6. Sprinkle with granulated sugar,
7. Cut with cookie cutter,
8. Bake on a buttered sheet in a moderate oven.

Quantities of the ingredients (formula):

- 2 cups flour
- 1/4 cup cocoa
- 1/2 cup brown sugar
- 1/4 teaspoon salt
- 1/2 cup butter
- 1/2 teaspoon vanilla

5

## Industrial batch production

The products can most often also be done in a continuous way BUT ....

1. A higher degree of flexibility is beneficial

OR

2. Some of the production activities require an extended time to complete

=> Batch Production is sometimes the preferred production type.

6

### Industrial batch control

- Within the same process cell several products can be made.
- Within the same process cell several products can be made at the same time.
- Within the same process cell, the same product can be made using different equipment.

=> Batch control becomes more than just a control problem, it also becomes a system scheduling problem.

7

7

### Industrial Batch Production

Batch control includes:

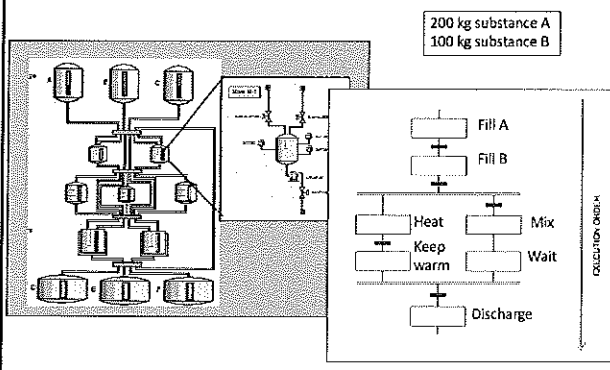
- Basic control (i.e. Classic continuous control)
- Logic control (i.e., start-stop)
- Procedural control (i.e. Sequencing)
- Coordination control (i.e. Allocation of equipment, propagating state changes)

=> Batch control therefore tends to be more complex than both continuous and discrete control

8

8

### Batch Control



9

### Outline

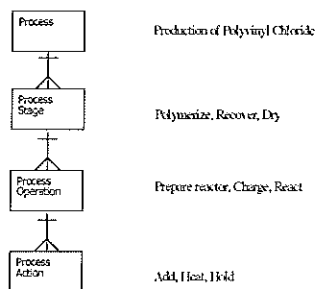
- Batch Production Systems
- ISA 88 Batch Control Standard
  1. Process Model
  2. Physical Model
  3. Procedural Model
  4. Equipment Control Logic
  5. Recipe
  6. Recipe – Equipment Control Separation
  7. Additional Items

10

10

### 1. Process Model

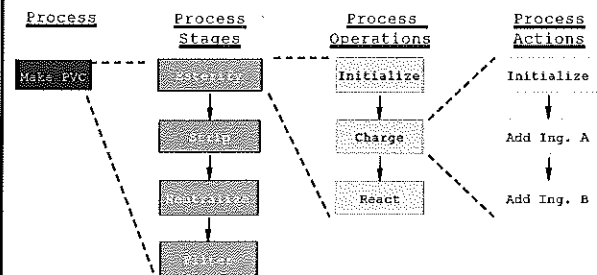
A process is a sequence of activities for the conversion, transportation or storage of material and energy.



11

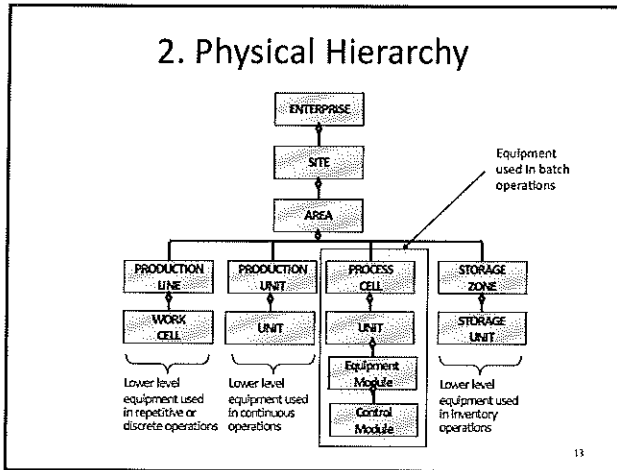
11

### 1. Process Model - Example

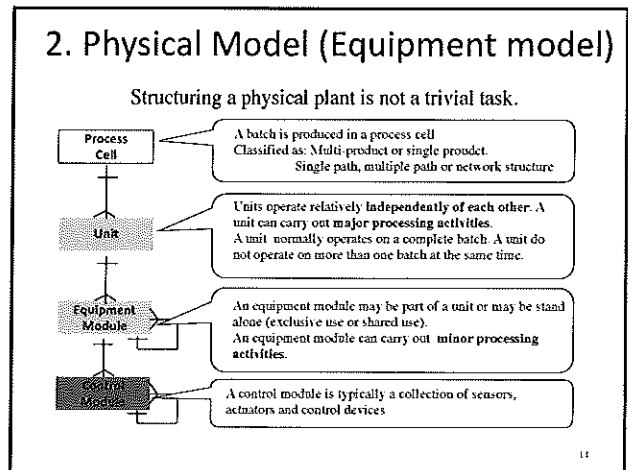


12

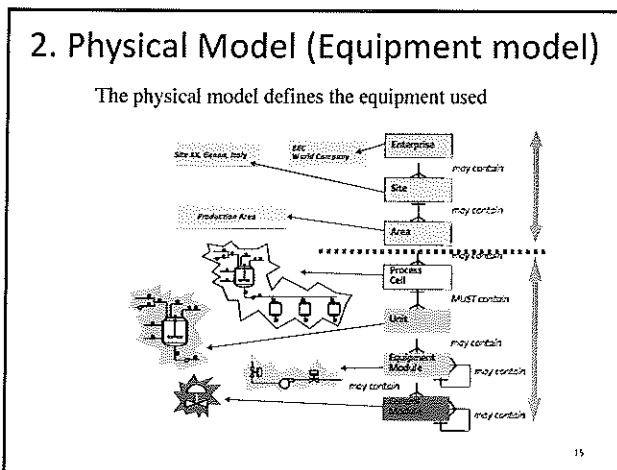
12



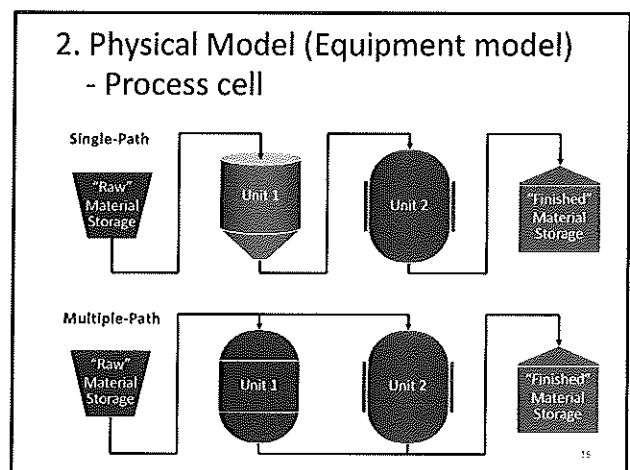
13



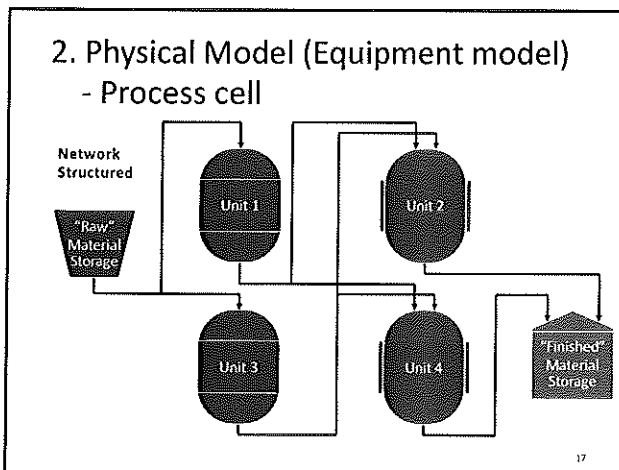
14



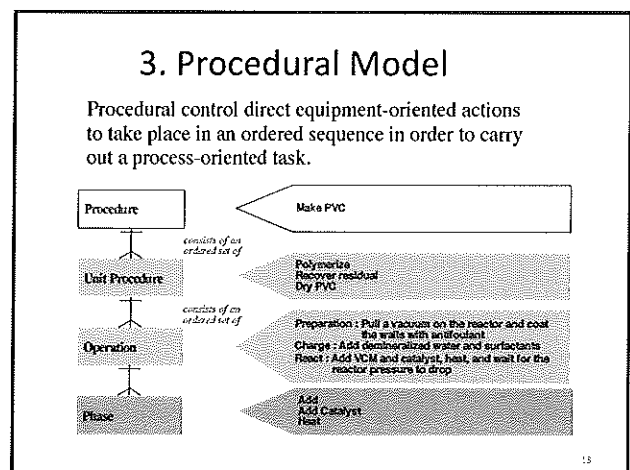
15



16



17



18

### 3. Procedural Model

Procedural control direct equipment-oriented actions to take place in an ordered sequence in order to carry out a process-oriented task.

```

graph TD
    Procedure -- "consists of an ordered set of" --> UnitProcedure[Unit Procedure]
    UnitProcedure -- "consists of an ordered set of" --> Operation[Operation]
    Operation -- "consists of an ordered set of" --> Phase[Phase]
            
```

The procedural part of the recipe is often described by graphical language, often SFC (Sequential Function Chart).

19

### 3. Procedural Model

Procedural Element Relationship

20

### 3. Procedural Model

Equipment Entity/Procedural Element Mapping

Process Cell	Procedure		
Unit	Unit Procedure	Operation	Phase
Equipment Module			Phase
Control Module			

21

### Outline

- Batch Production Systems
- ISA 88 Batch Control Standard
  1. Process Model
  2. Physical Model
  3. Procedural Model
  4. Equipment Control Logic
  5. Recipe
  6. Recipe – Equipment Control Separation
  7. Additional Items

22

### 4. Equipment Control Logic

The functionality (control logic) of the equipment is implemented in the PLCs

Equipment Control Logic

```

graph TD
    EP[Equipment Procedure] --> EUP[Equipment Unit Procedure]
    EUP --> EO[Equipment Operation]
    EO --> EPH[Equipment Phase]
            
```

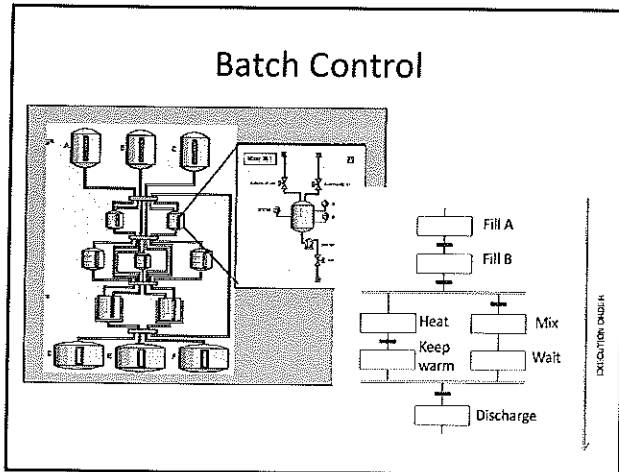
*Note:*  
Not all levels in this hierarchy have to be implemented.

23

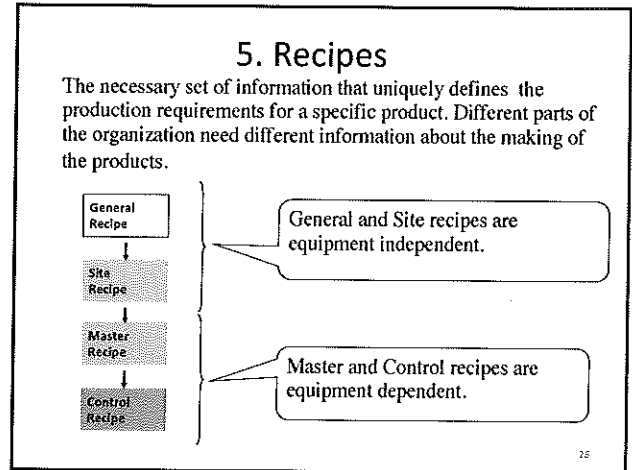
### 5. Recipes

- The recipe tells the batch control system how to make product
- A recipe usually exists for each intermediate or finished product that is to be produced
- Recipes provide a way to describe products and how they are produced

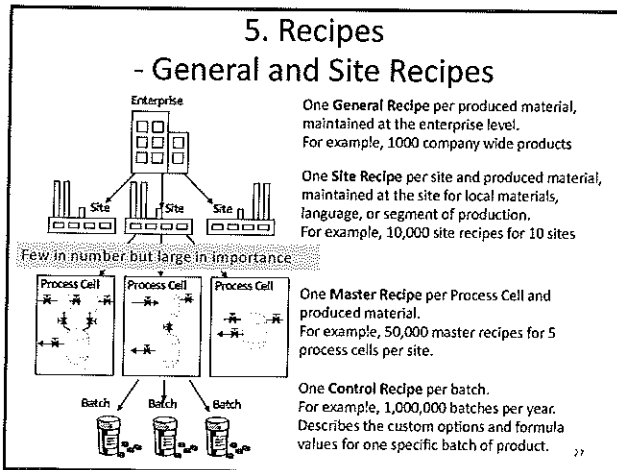
24



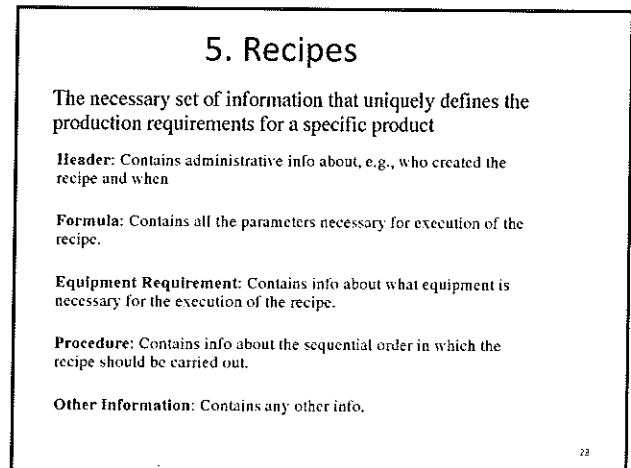
25



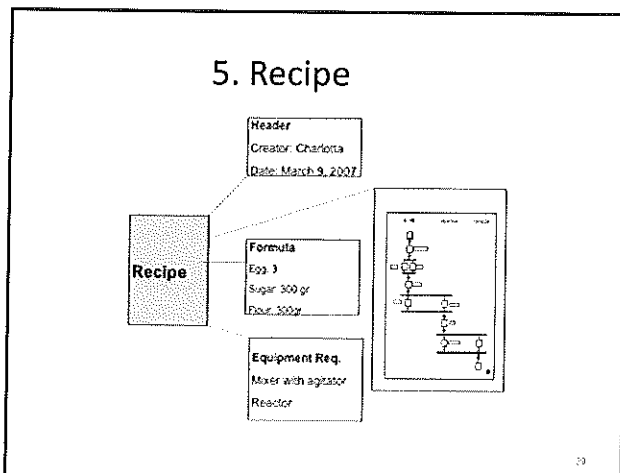
26



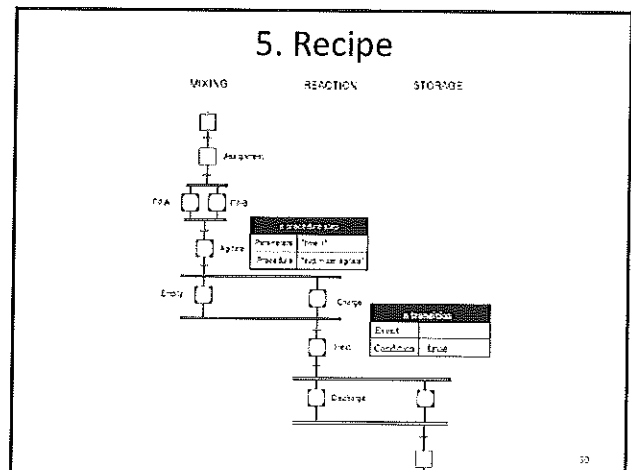
27



28



29



30

### 6. Recipes – Equipment control separation

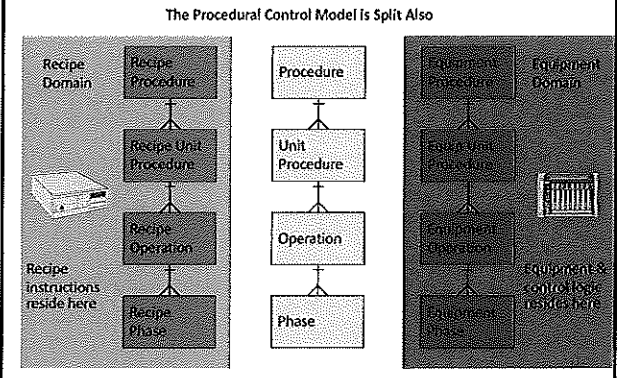
The recipe that describes how the batch is to be made *is separate from* the equipment and control that is actually used to make the batch

- Makes control more flexible
- Makes multiproduct plants easier to control
- Simplifies recipe and equipment control validation
- Enhances ability to reuse software

Recipe Domain      Equipment and Control Domain

31

### 6. Recipes – Equipment control separation



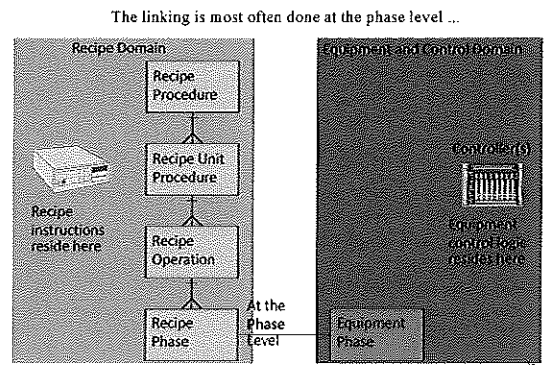
32

### 6. Recipes – Equipment control separation

- In order for the execution to take place, there must be a link between the recipe domain and the equipment and control domain.
- The recipe directs the equipment control logic
  - To run
  - In the proper order
  - In the proper unit
  - With the proper formula values

33

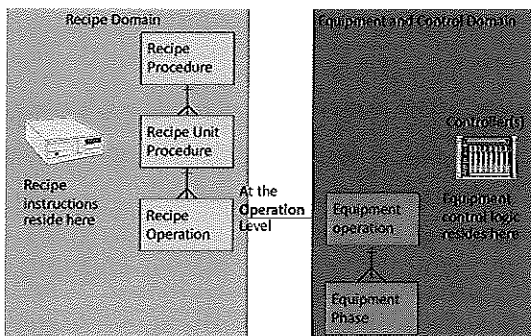
### 6. Recipes – Equipment control separation



34

### 6. Recipes – Equipment control separation

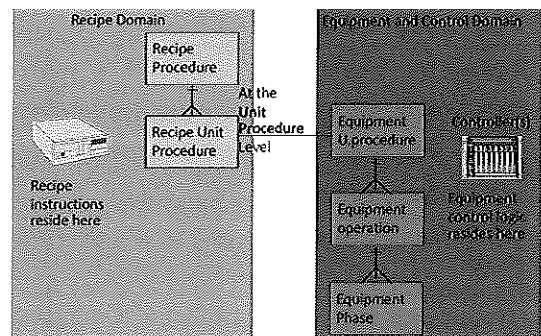
...but it can also be done at the operation level ...



35

### 6. Recipes – Equipment control separation

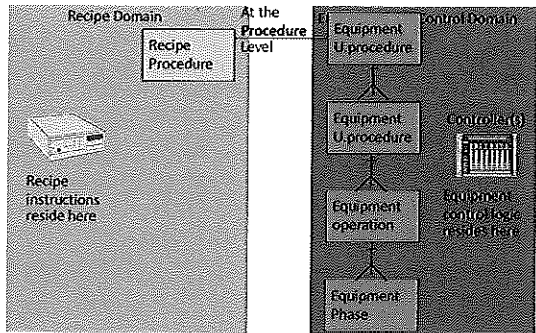
... or at the unit procedure level ...



36

### 6. Recipes – Equipment control separation

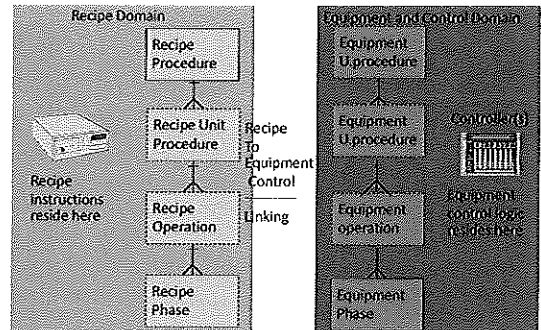
... or at the procedure level.



37

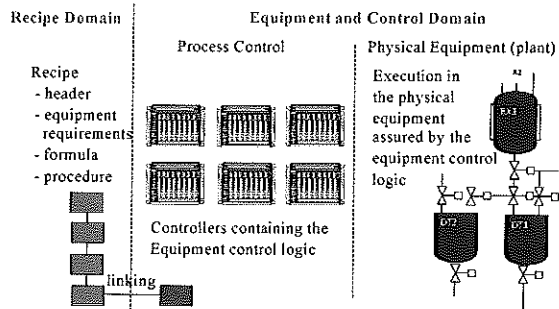
### 6. Recipes – Equipment control separation

One or more hierarchical levels are allowed to be left out



38

### What is defined in ISA 88?



39

### Outline

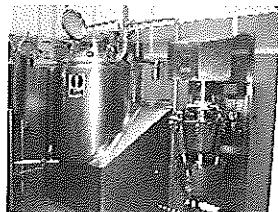
- Batch Production Systems
- ISA 88 Batch Control Standard
  1. Process Model
  2. Physical Model
  3. Procedural Model
  4. Equipment Control Logic
  5. Recipe
  6. Recipe – Equipment Control Separation
  7. Additional Items

40

### Batch Production Processes

General characteristics of batch production processes:

- Production of products in batches
- Discontinuous flow of materials.
- Production run determined by time/end point.
- Production goes through steps of operations.
- Fluid and dry processing.



41

### Example: Making cookies

Equipment needed to produce (process cell):

- Bowl
- Mixer
- Oven




Steps required to make the cookies (recipe):

1. Add flour, sugar and cocoa in a bowl
2. Mix and sift
3. Add butter,
4. Chop until well blended.
5. Roll very thin,
6. Sprinkle with granulated sugar,
7. Sut with cooky cutter,
8. Bake on a buttered sheet in a moderate oven.

Quantities of the ingredients (formula):

- 2 cups flour
- 1/4 cup cocoa
- 1/2 cup brown sugar
- 1/4 teaspoon salt
- 1/2 cup butter
- 1/2 teaspoon vanilla


42



Charlotta Johansson  
Dean Campus Helsingborg  
Professor Dept. of Automatic Control  
Chair ISO/TC184/SC5 - Industrial Interoperability  
Faculty of Engineering (LTH), Lund University, Sweden  
Box 118, 22100 Lund, Visiting address: John Ericssons väg 3  
Mobile: +46 706 408769, Email: charlotta.johansson@th.lu.se

43

43


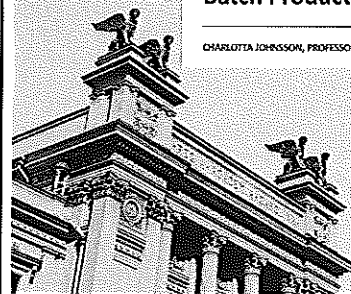


LUNDS  
UNIVERSITY

# Batch Production Systems

THANK YOU!

CHARLOTTA JOHANSSON, PROFESSOR IN AUTOMATIC CONTROL, LUND UNIVERSITY



44

44