Operations Management I

Toyota Production System – Lean Production

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Toyota Production System – Lean Production

Overview
Implementation
Lessons

- Developer
- Basic Idea

- Overview
- Details
  - ✓ Production quantity control
  - ✓ Quality assurance

Hopp and Spearman, 2008, **Factory Physics**, McGraw Hill. **(Chapter 4)**

Krajewski and Ritzman, 2005, **Operations Management**, Prentice Hall. **(Chapter 11)**

Monden, Y., 1983, **Toyota Production System: Practical Approach to Production Management**, Norcross, GA: Industrial Engineering and Management Press.

Toyota Production System – Lean Production

- **Overview**

Developer

- Taiichi Ohno (1912 – 1990) at Toyota Motor Company
  - ✓ Motive: catch up with America

Increasing productivity
← Lowering costs
← Waste elimination
← Continuous improvement

← Strategic approach to manufacturing function

- Cost reduction
- Consistent quality

The essence of strategy is to achieve a long-term sustainable advantage over competitors in every business in which the firm participates.

- ✓ Corporate level
- ✓ Business level
- ✓ Functional Level

cf. automobile manufacturing

Press → Welding → Painting → Assembly

↑ Parts/Components

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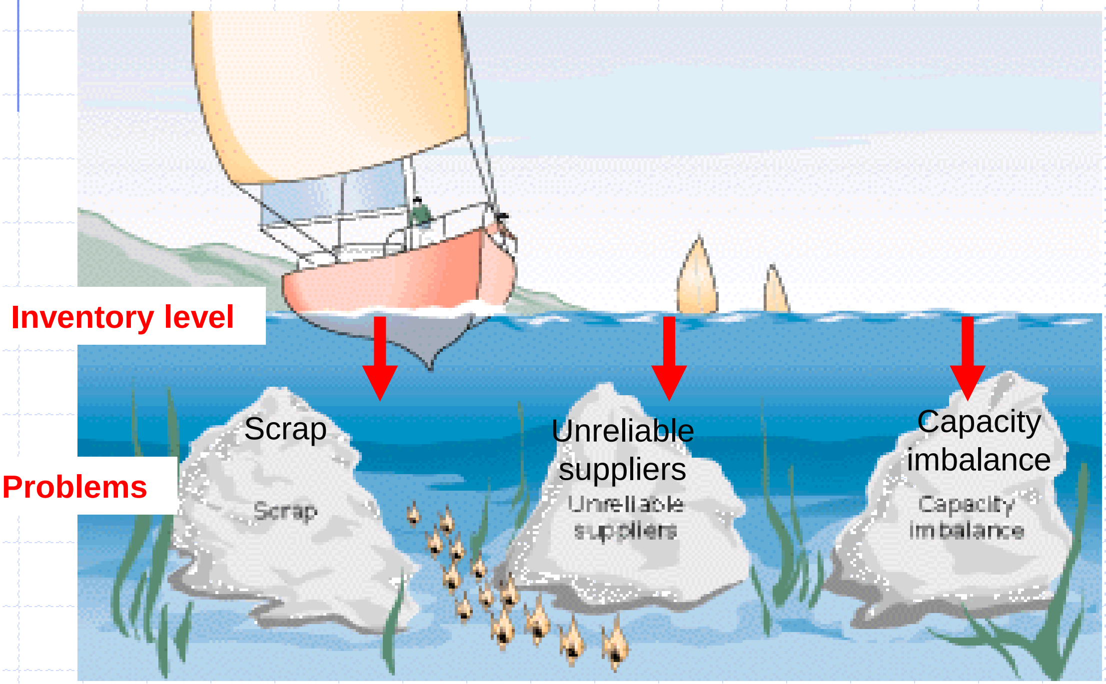
Overview

Basic Idea

- Continuous Improvement
  - ✓ Lowering inventory level ← - - - - - - • Lean production
    • Stockless production, etc.



- Environment as a control

	America	Japan
Setup Delivery Quality, etc.	Given (no change)	Control variable

Holistic, systems view of manufacturing

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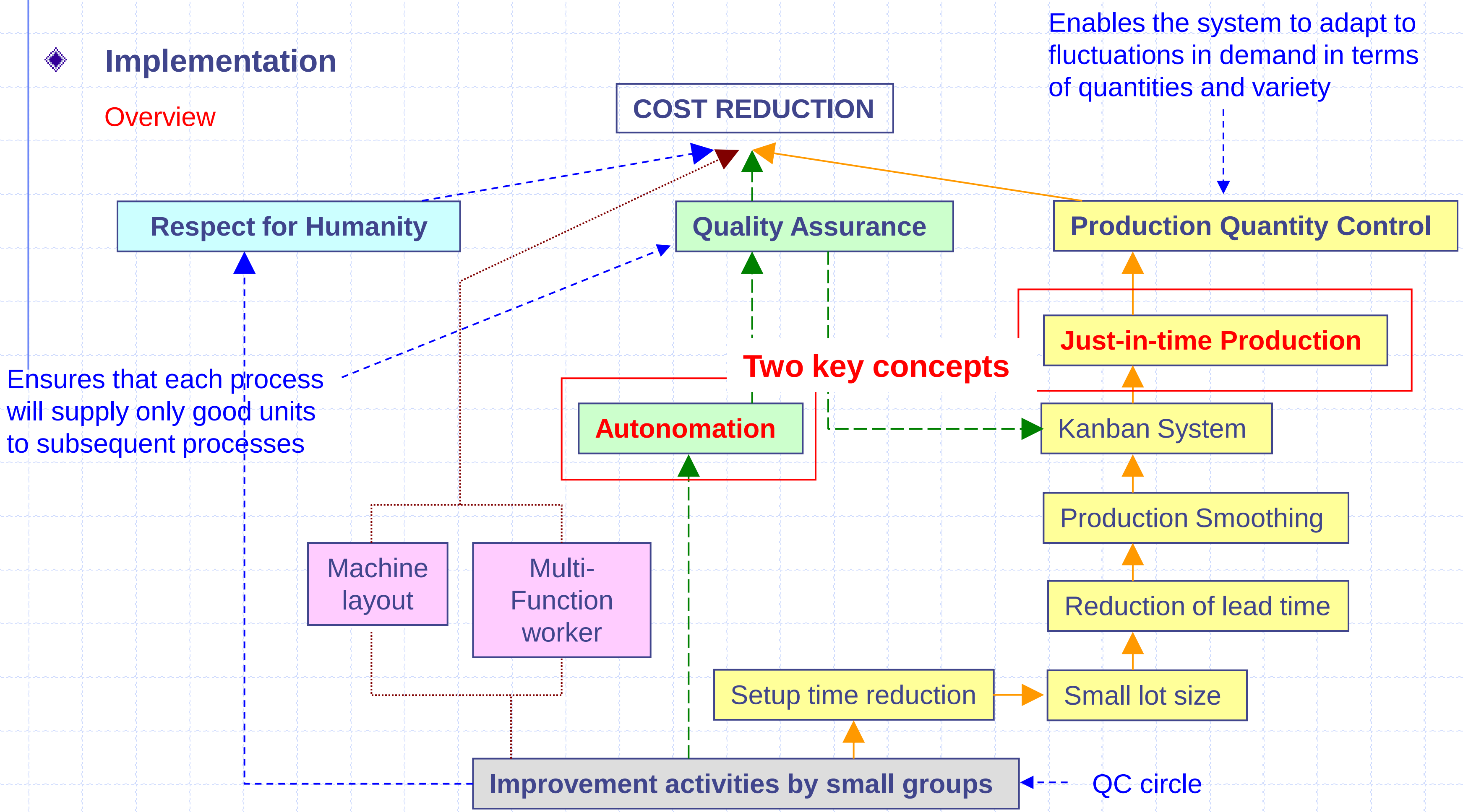
- **Implementation**

Overview



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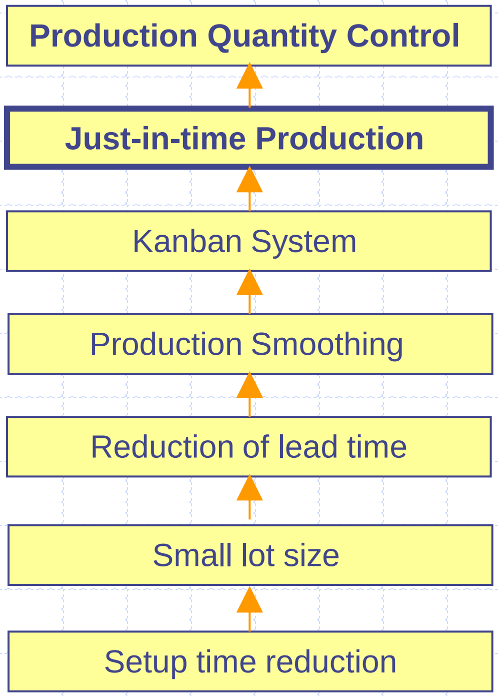

◈ Implementation

Production Quantity Control (1)

- Just-In-Time (JIT) Production

✓ Definition

Produce the necessary units in the necessary quantities at the necessary time

◄----- In the process of assembling the parts to build a product, the necessary kinds of subassemblies of the preceding processes should arrive at the production line at the time needed in the necessary quantities

JIT production

→ Eliminate unnecessary inventories in the factory
→ Diminish inventory carrying costs
→ Increase capital turnover

✓ Pull method of workflow

Each workstation acquires the required materials from upstream workstations precisely as needed (right time).

◄----- **Requires pull production control system (Kanban system)**

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Implementation

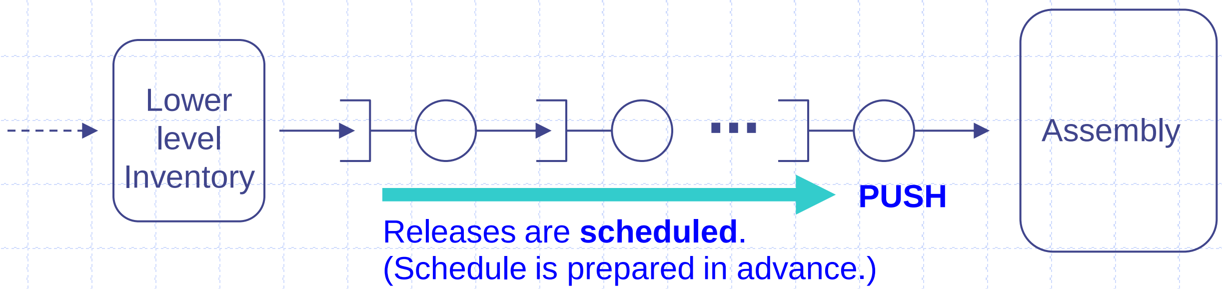
Production Quantity Control (2)

- Just-In-Time (JIT) Production

Push control systems	Pull control systems
Directly accommodates customer due dates	Directly respond to changes in the plant
Forced to respond to changes in the plant	Forced to accommodate customer due dates

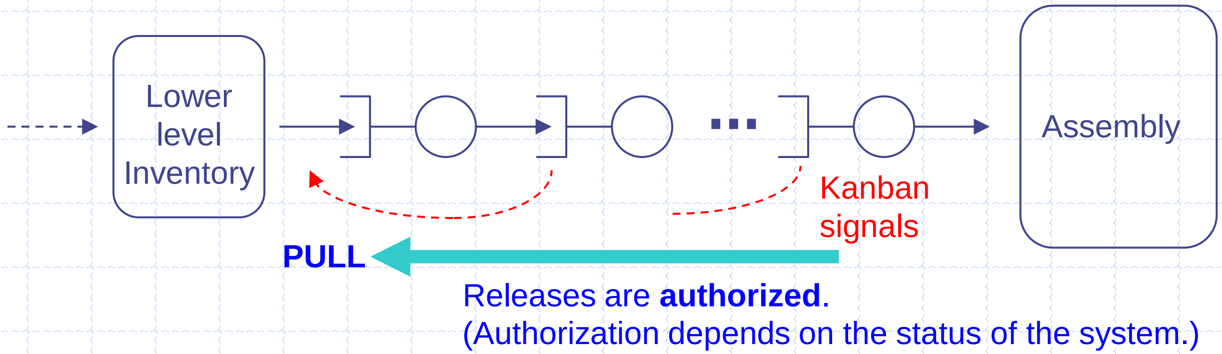
✓ Push method

e.g., MRP
Buffet



✓ Pull method (JIT)

e.g., JIT
five-star restaurant



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- Production Quantity Control
- Just-in-time Production
- **Kanban System**
- Production Smoothing
- Reduction of lead time
- Small lot size
- Setup time reduction

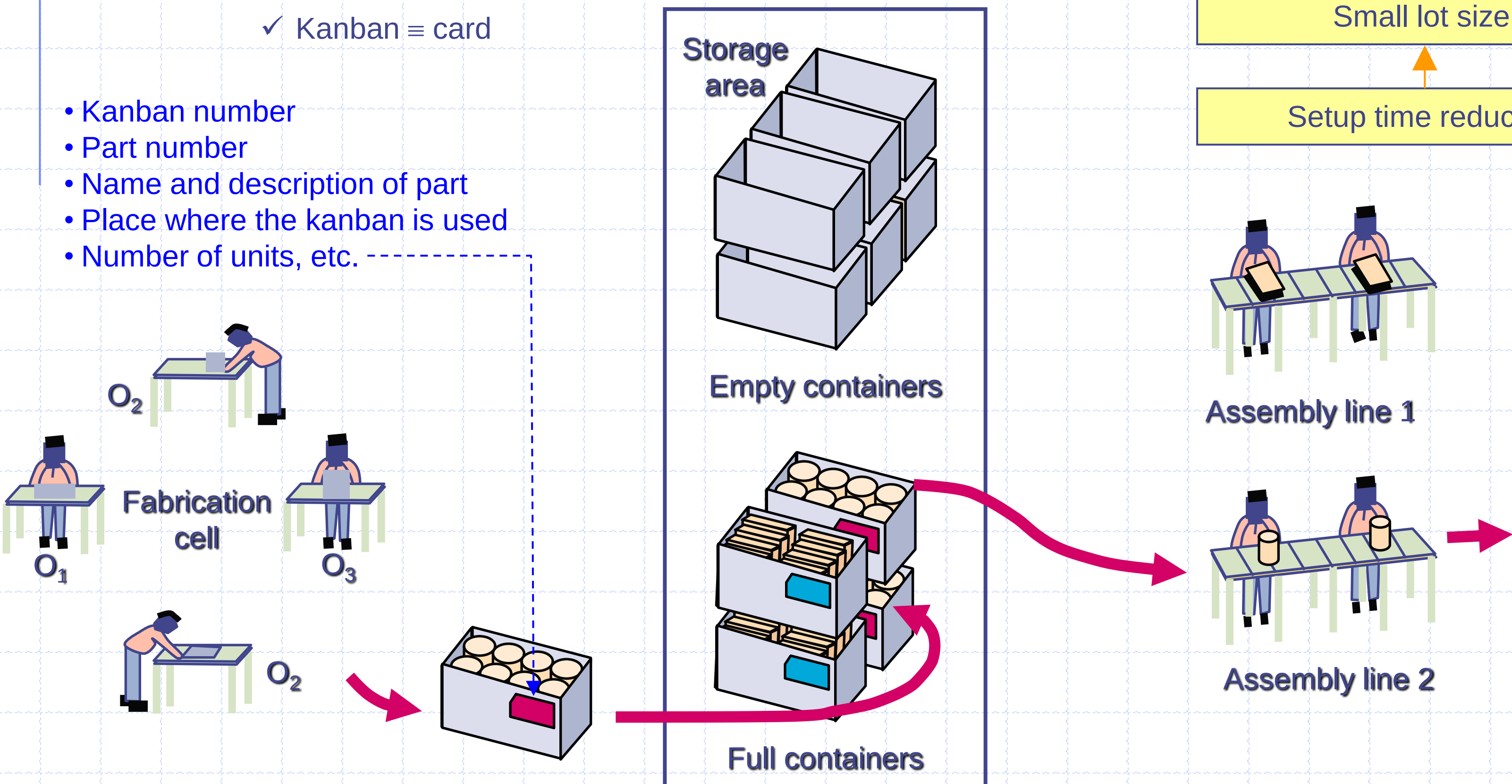
◈ **Implementation**

Production Quantity Control (3)

- Kanban System – Overview

✓ Kanban ≡ card

- Kanban number
- Part number
- Name and description of part
- Place where the kanban is used
- Number of units, etc.



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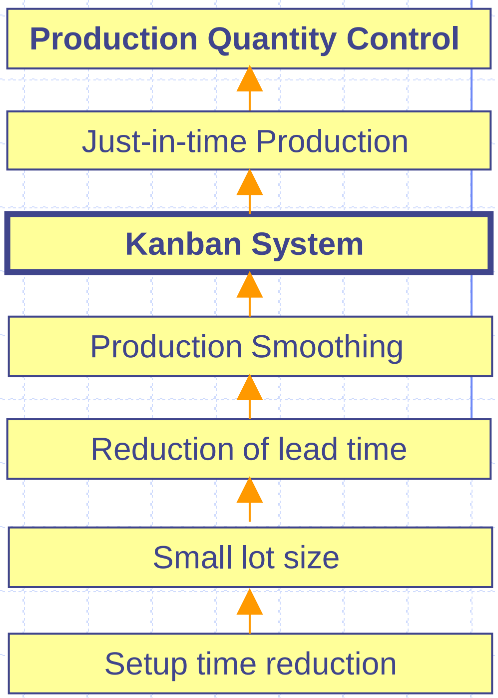

Implementation

Production Quantity Control (4)

- Kanban System – Overview
  - ✓ The information system to implement pull production control system (harmoniously control the production quantities in every process)

    ←----- **Requires production smoothing**
  - ✓ Types
    - ➢ One-Kanban System

      When workstations are close to one another
    - ➢ Two-Kanban System

      When workstations are spatially distributed
      - Move Kanban details the quantity which the subsequent process should withdraw ←----- Withdrawal Kanban
      - Production Kanban shows the quantity which preceding process must produce ←----- Production-ordering Kanban

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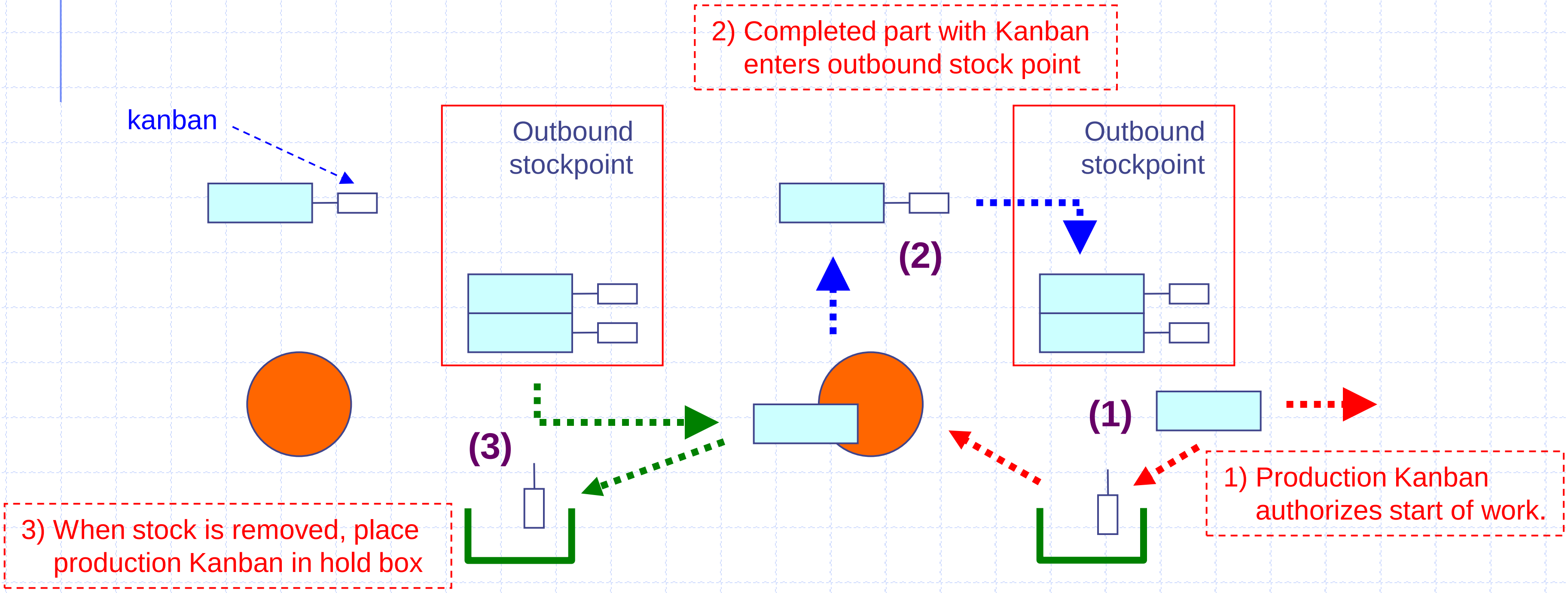
Implementation

Production Quantity Control (5)

- Kanban System – Mechanism
  - ✓ One-kanban system



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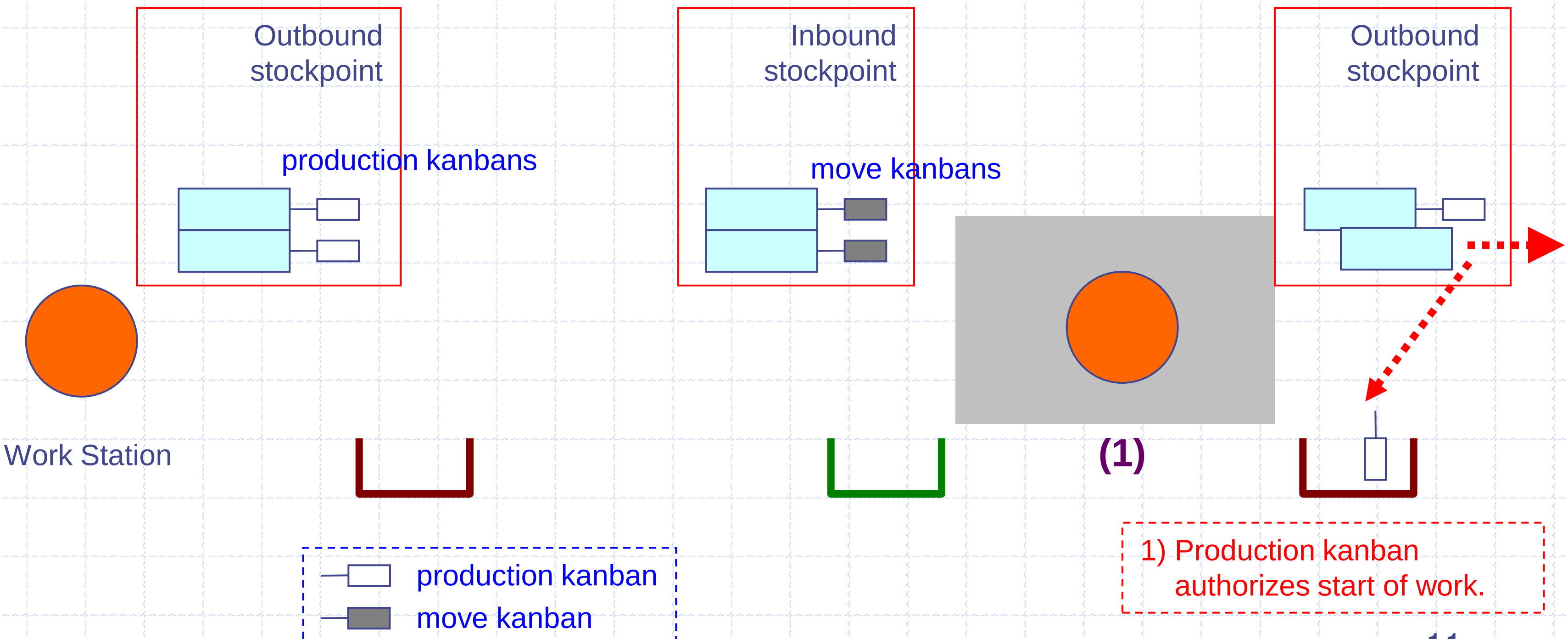
- **Implementation**

Production Quantity Control (6)

- Kanban System – Mechanism
  - ✓ Two-kanban system



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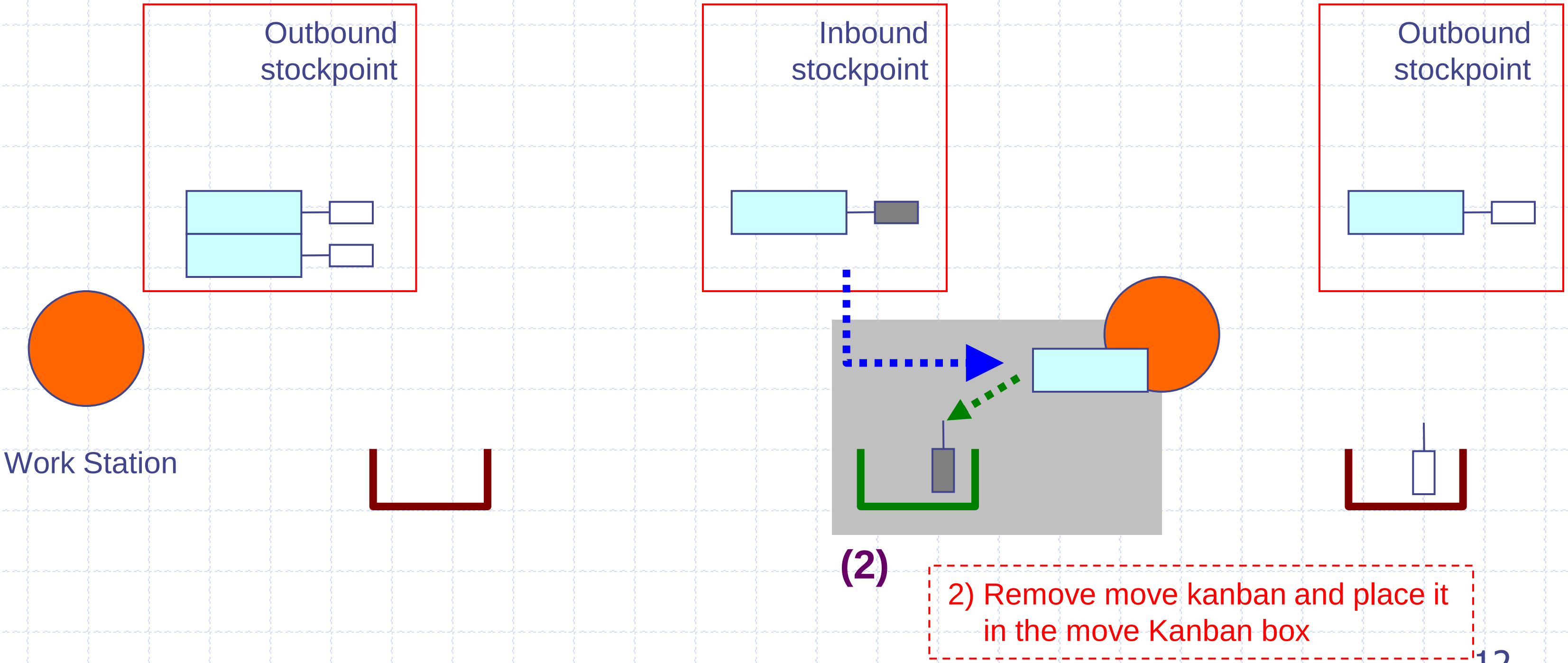
◈ Implementation

Production Quantity Control (7)

- Kanban System – Mechanism
  - ✓ Two-kanban system



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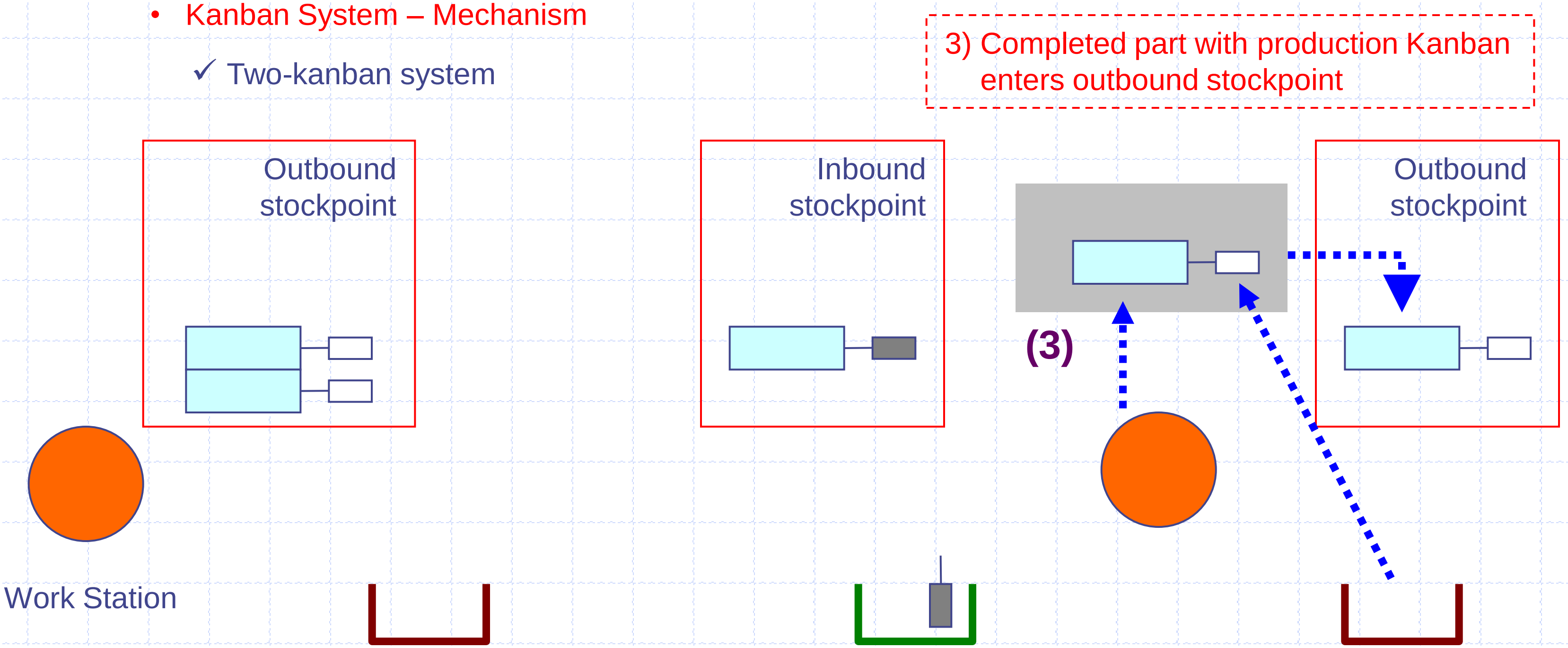
- **Implementation**

Production Quantity Control (8)

- Kanban System – Mechanism
  - ✓ Two-kanban system



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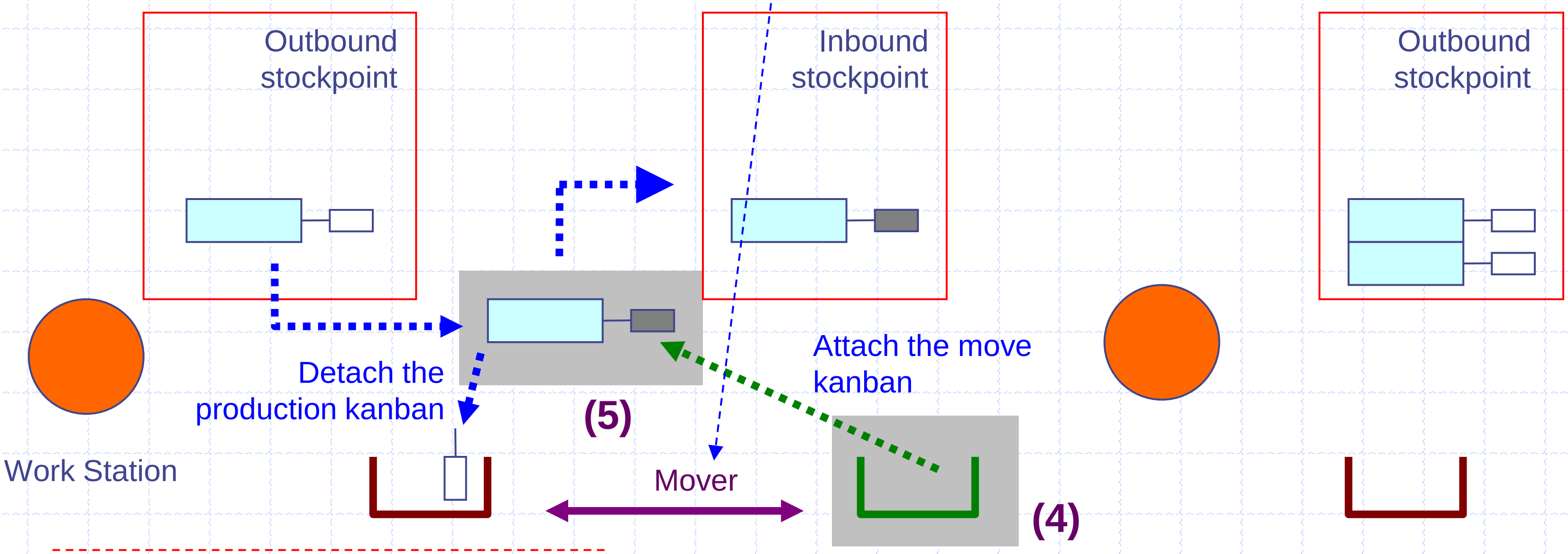
◈ Implementation

Production Quantity Control (9)

- Kanban System – Mechanism
  - ✓ Two-kanban system

Periodically, the mover checks the box containing move Kanbans and picks up them.

The operator gets the materials indicated by the Kanbans from their respective outbound stock points, replace their production Kanbans with move Kanbans, and move them to the appropriate inbound stock points



5) When stock is removed, place production Kanban in hold box

4) Move Kanban authorizes pickup of parts (by a mover)

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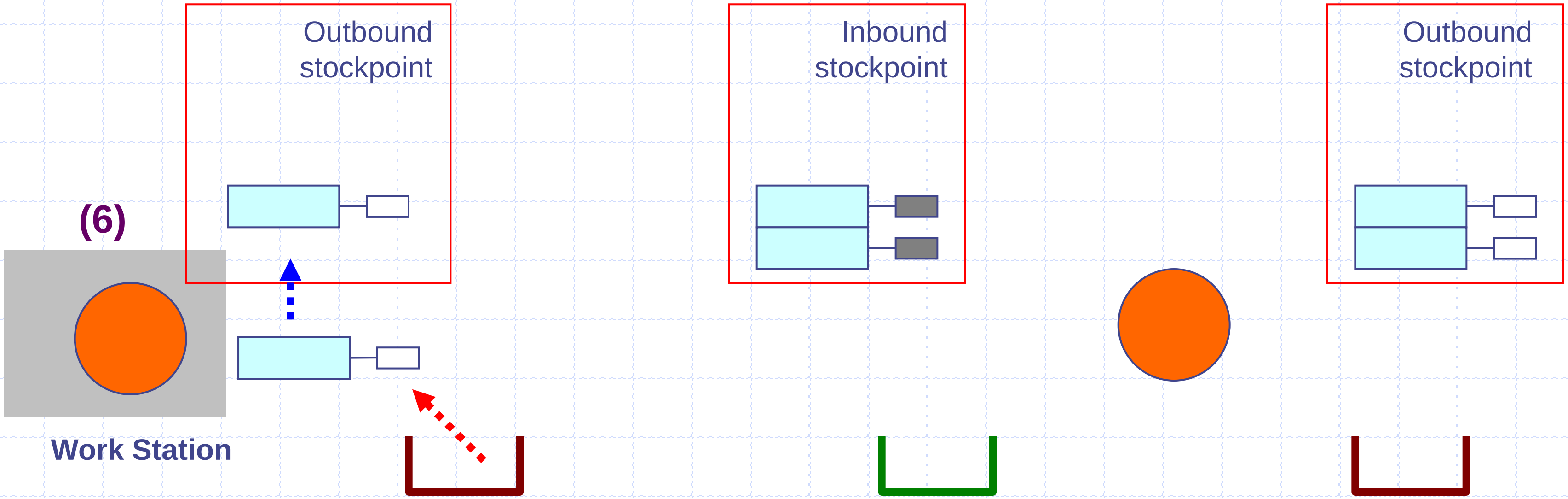
- **Implementation**

Production Quantity Control (10)

- Kanban System – Mechanism
  - ✓ Two-kanban system



6) When the processing is finished, the part is moved to outbound stock with a production kanban

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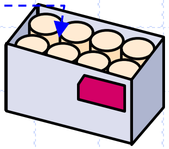
- **Implementation**

Production Quantity Control (11)

- Kanban System – Main Decisions

✓ Number of units to be held by each container

Lot sizing (← inventory control)



✓ Number of containers (Kanbans) flowing back and forth between supplier and user

$$k = \frac{\boxed{d \cdot (w + p) \cdot (1 + a)}}{c}$$

Average demand during lead time + Safety stock

number of parts in a container

- Average demand during lead time = d × (w + p)
  - d expected daily part demand (units/day)
  - w average waiting time during the production process + material handling time for containers (fractions of a day)
  - p average processing time per container (fractions of a day)
- Safety stock = d × (w + p) × a
  - a policy variable for safety stock

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Production Quantity Control
↑
Just-in-time Production
↑
Kanban System
↑
Production Smoothing
↑
Reduction of lead time
↑
Small lot size
↑
Setup time reduction

Implementation

Production Quantity Control (12)

- Production Smoothing

Production planning to minimize the fluctuation of production in the final assembly line (uniform workstation loads)

← minimizes the variation in the withdrawn quantity of each part produced at each workstation, thereby allowing workstations to produce each part at constant speed or at a fixed quantity per hour

↑

Corrective actions are required for deviations (capacity buffer)

Production smoothing ← Reduction of lead time ← Small lot size ← Setup time reduction

Production smoothing ↑ Zero surging

Reduction of lead time ↑ In a perfect JIT, a downstream workstation requests parts and they are provided immediately (zero lead time)

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- **Implementation**

Production Quantity Control (13)

- Production Smoothing

✓ Procedure

1) Smoothing aggregate production requirements (master production schedule)

e.g., 10,000 units / month and 20 working days/month

→ 500 (= 10,000 / 20) units / day
→ Two-shifts (capacity buffer) → 250 units / shift
→ 1.92 min / unit

2) Sequencing final assembly

e.g., 10,000 units (Product A 50% , Product B 25% , and Product C 25%)

Daily production (500 units)

- Product A: 250 units
- Product B: 125 units
- Product C: 125 units

-----► sequence: A B A C A B A C ….

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Implementation

Production Quantity Control (14)

- Setup Reduction

  ✓ Smooth production cannot be done without reducing setup times. (environment as a control)

  ◂- - - - setup cost ↑ → lot size ↑
  setup cost ↓ → lot size ↓

  A B A C A B A C ….

  Large setup time → Smooth production does not work.

  e.g. die change of pressing

  3 hours in 1945 - - - -▸ 3 minutes in 1971 (single-digit setup)

  ✓ Classification

  ➢ Internal setup

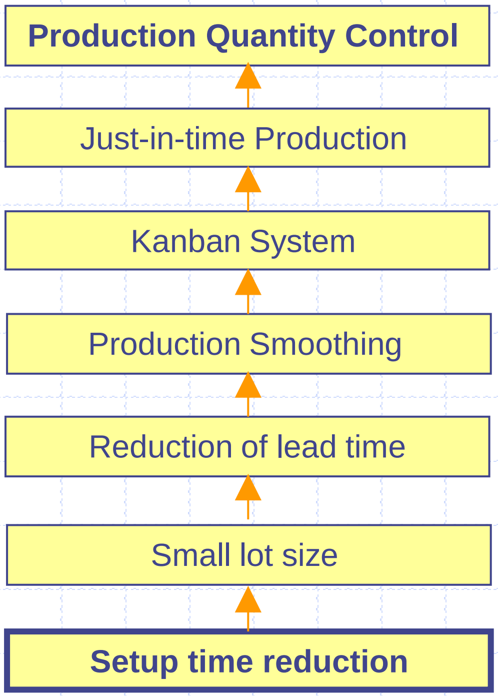
  Tasks that take place when the machine is stopped (disruptive to the production process)

  e.g., press: removing a die

  ➢ External setup

  Tasks that can be completed while the machine is still running

  e.g., press: collecting the necessary tools to remove a die



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- **Implementation**

  Production Quantity Control (15)

  - Setup Reduction
    - ✓ Basic concepts for setup reduction
      - ➢ Separate the internal setup from the external setup

        Specify which tasks should be done with the machine stopped
      - ➢ Convert as much as possible the internal setup to the external setup

        e.g., a die can be preheated before installing it
      - ➢ Eliminate the adjustment process

        e.g., jigs, fixtures, sensor to eliminate adjustment
      - ➢ Abolish the setup itself

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Implementation

Quality Assurance (1)

- Autonomation

  Machines that are both automated and foolproofed

  One worker can operate many machines.

  Workers automatically detect problems . (Supports Just-in-Time by never allowing defective units from a preceding process to flow into and disrupt a subsequent process)
  e.g., andon (line stop)

- Preventive Maintenance

  Reduce the frequency and duration of machine down time (maintenance during capacity buffer)

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- **Implementation**

Quality Assurance (2)

- Total Quality Management

JIT requires a high level of quality to function.
(The line stops if there are quality problems due to JIT production.)

✓ Seven principles

- Process control ←------ Make sure that production processes operate properly
- Easy-to-see quality ←------ Put quality on display (e.g., display board, gauge, etc.)
- Insistence on compliance ←------ If a part in the line is defective, it is not accepted. (quality first and output second)
- Line stop
- Correcting one's own errors ←------ Workers' responsibility for quality (autonomation)
- 100 % check in principle (sometimes, sampling)
- Continual improvement

←------ Zero defects

Every part should be made correctly in the first time
With defects, the production process will be disrupted. (due to no excess inventory)

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- **Implementation**

Others – Cross-Training and Plant Layout (1)

- Cross-Training
  - ✓ Multifunctional workers ←------ flexible workforce
    - Keep multiple skills sharp
    - Reduce boredom and fatigue on the part of the workers
    - Foster an appreciation for the overall picture on the part of everyone
    - Increase the potential for new idea generation
  - ✓ Worker rotation system

    Workers are rotated through the various jobs in the shop.

    ←------ Once a sufficient number of workers are cross-trained, rotations on a daily basis begins.

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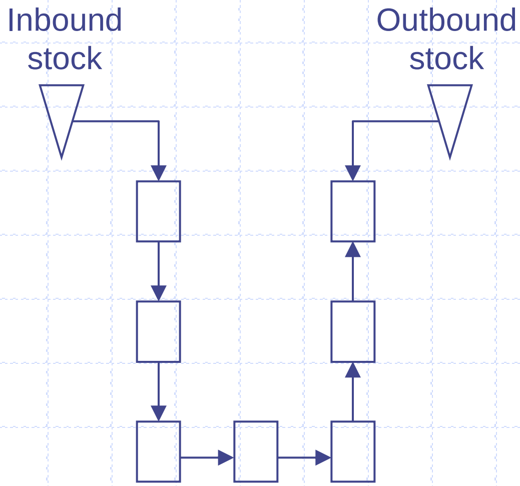
Implementation

Others – Cross-Training and Plant Layout (2)

- Plant layout
  - ✓ U-Shape Manufacturing Cell ← - - - - - - Group Technology (GT)
    - ➢ One worker can see and attend all the machines with a minimum of walking.
    - ➢ Flexible in the number of workers they can accommodate (allowing adjustments to respond to changes in production requirements)
    - ➢ Facilitating just-in-time flow (a single worker can monitor work entering and leaving the cell to ensure that it remains constant)



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- **Lessons**
  - ✓ The production environment itself is a control.

    e.g., reducing setups, leveling production schedule, etc.
  - ✓ Operational details matter strategically.
  - ✓ Controlling WIP is important.

    e.g., low WIP → short cycle times → high quality levels
  - ✓ Flexibility is an asset.

    e.g., short setup times, capacity cushion, work cross-training, cellular plant layout , etc.
  - ✓ Quality can come first.

    ➡ Continual improvement is a condition for survival.