Chapter 5
Smoothed Production Helps Toyota Adapt to Demand Changes and Reduce Inventory

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5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- At Toyota, production smoothing is to diminish as much as possible the quantity variance in a production line.

- smoothing of the total production quantity

- smoothing of each model's production quantity

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- Smoothing of the total production quantity is to minimize the variance in total outputs between two sequential periods.

- mass production of Corolla as an example

- a monthly production schedule based on the demand forecast

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- The total amount in plan is divided by the number of operating days in the month.

- A daily production volume
- Maintain the daily production schedule for Corolla model as a whole.
- Do not consider the different models (consider only basic model).

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- The quantity of demand within a month is not constant.

- Demand for the early part of the month may be higher than the latter part of the month.

- A shorter period of a production plan could be better (e.g., a weekly plan).

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- A short period of a production plan cannot smooth the monthly production quantity.
- A preceding process prepares its production for the peak period.
- The period of short runs displays waste in the forms of workforce and inventories compared with a peak period.

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- Adapting to increased demand
  - temporary employees
  - early attendance and overtime

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

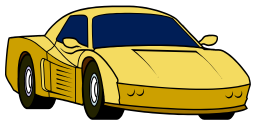
- Adapting to decreased demand
  - Transfer workers to other lines.
  - Decrease overtime.
  - Use a paid holiday.
  - Practice setup actions.

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- Adapting to decreased demand (continued)
  - Conduct maintenance and repair of machines.
  - Manufacture improved tools and instruments.
  - Conduct plant maintenance and upkeep.
  - Manufacture parts previously purchased from suppliers

5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- Suppose that a line produces one model for the whole day.


5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- During the long time of production for one model, the workers for the other model are idle.

- If every subassembly line completed its full production capacity of all types of stock every day with no stoppage, the quantity of parts would be large (over production in subassemblies).

5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

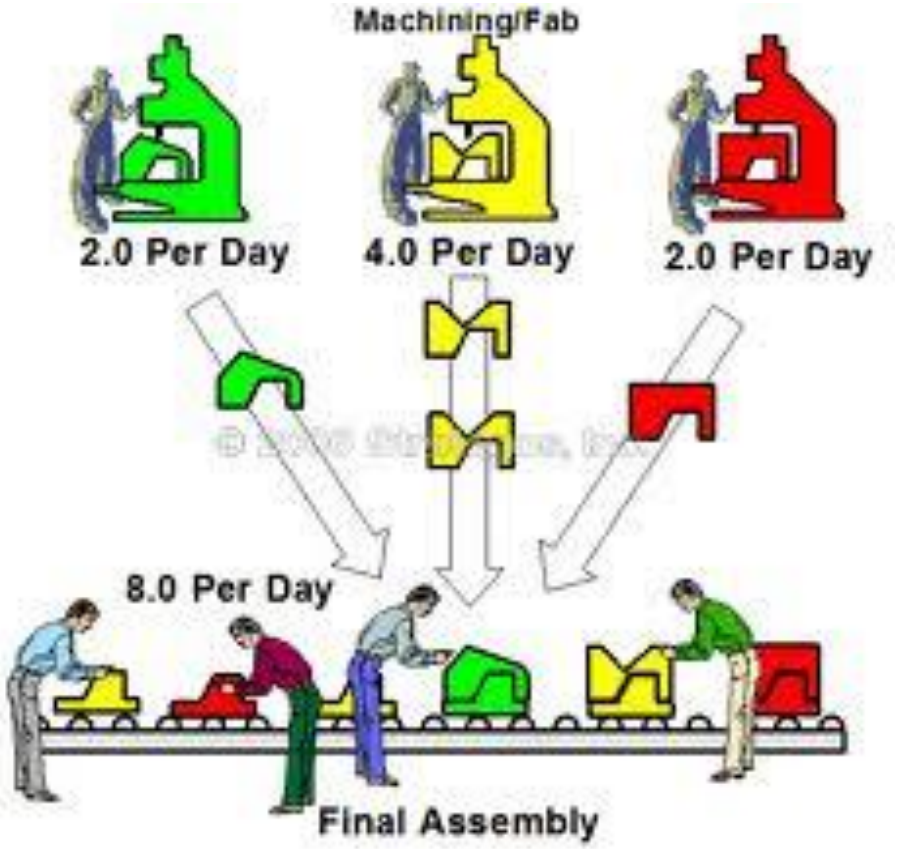
- Suppose that 16,800 Corollas must be produced in 20 operating days with two-shift operation per day.

	Monthly Output	Output per Shift	Cycle Time
A	9,600 units	240 units	2' = 480/240
B	4,800 units	120 units	4' = 480/120
C	2,400 units	60 units	8' = 480/60
	16,800 units/months	420 units/shift	1.14' = 480 min/420 units

FIGURE 5.2
Smoothing of each model's production quantity and cycle time.

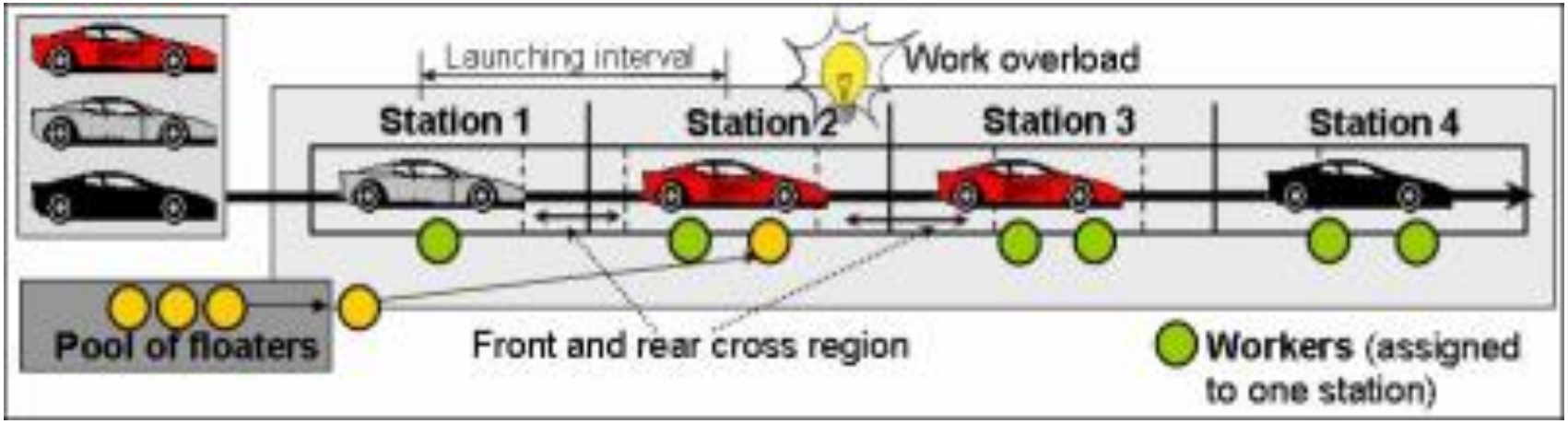
5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- Mixed-model assembly line (Ex.1)



5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- Mixed-model assembly line (Ex. 2)



5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- All product varieties can be produced according to the average cycle time of all varieties.

FIGURE 5.3
Sequence scheduling smoothed production.

5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- Lot production in which production occurs at the line's own peculiar speed.

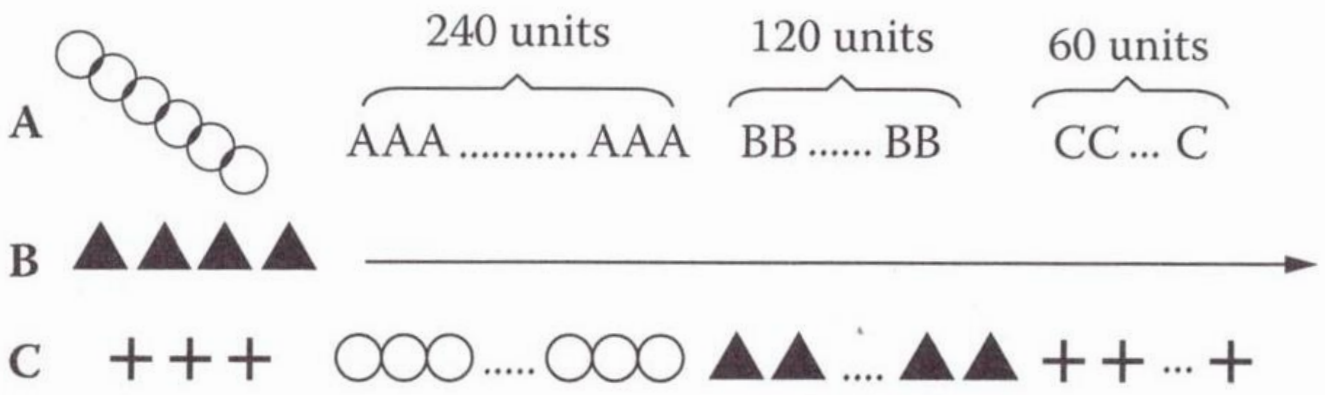


FIGURE 5.4
Lot (batch) production.

5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- Suppose the man hours need for A, B, and C on the same line are 70,50, and 60 minutes.=>The line would not stop.

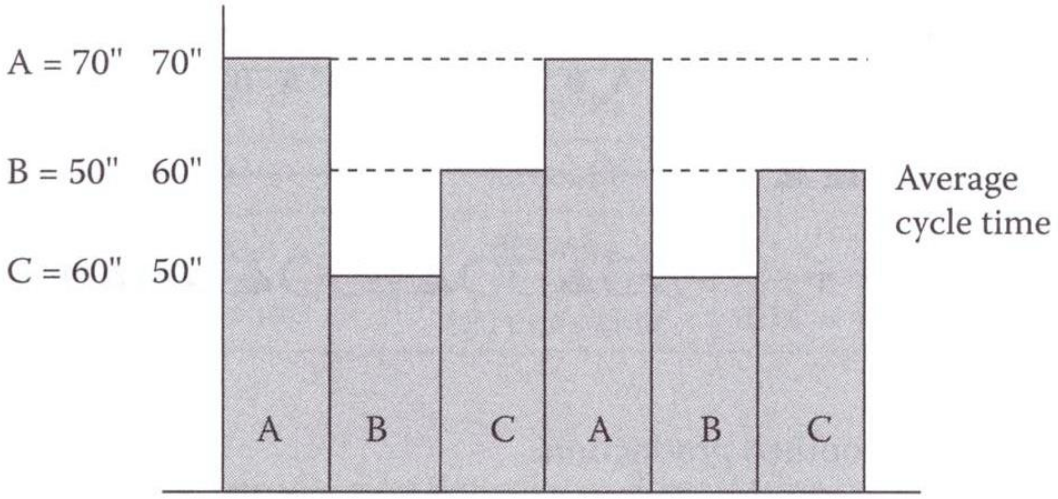


FIGURE 5.5
Sequence schedule that enables assembly within the average cycle time.

5.2 SMOOTHING EACH MODEL'S PRODUCTION QUANTITY

- Suppose the man hours need for A, B, and C on the same line are 70, 50, and 60 minutes.

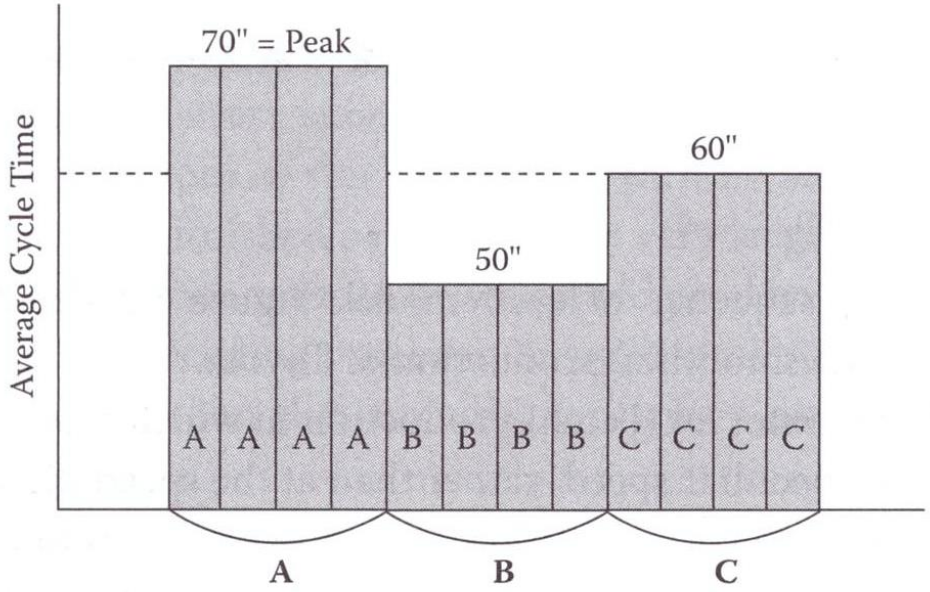


FIGURE 5.6
Sequence schedule that causes line stoppage.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

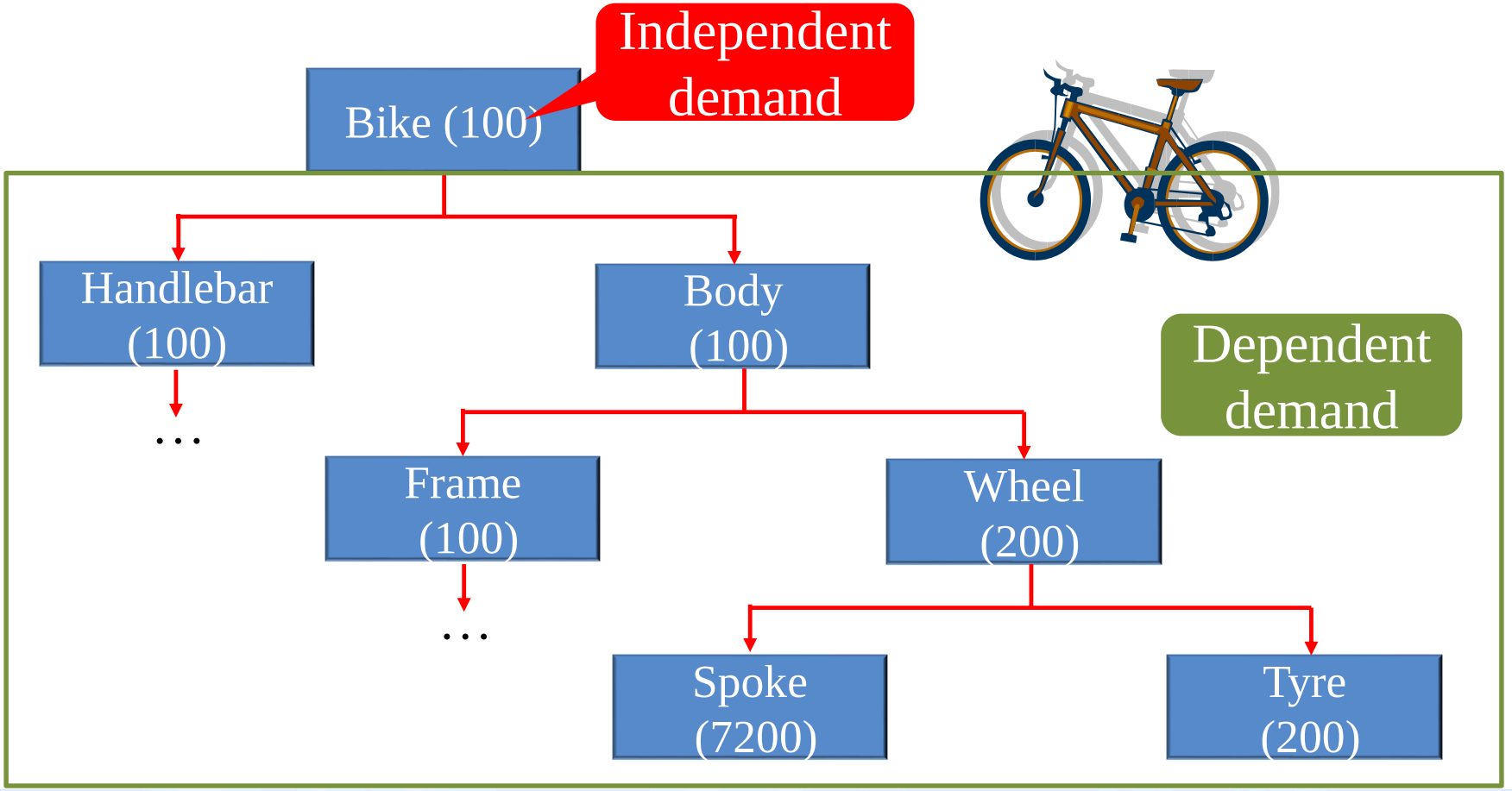
- Material requirement planning (MRP) is a system with bill of material (BOM).

- **Independent demand**: demand for items that are considered end items that go directly to a customer, and for which demand is not related to inventory decisions for any other item

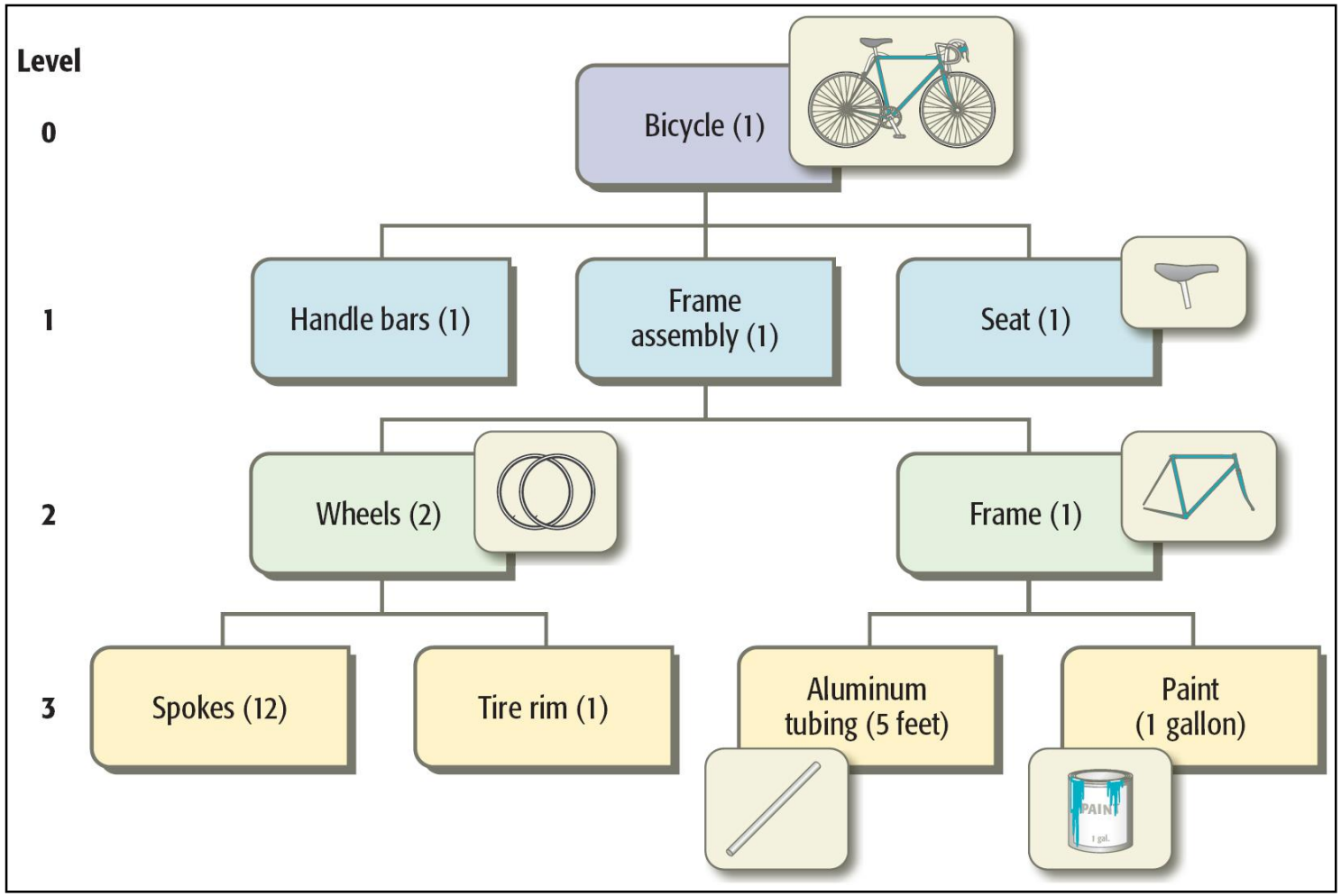
- **Dependent demand**: demand for items that are used to make another item or are considered to be parts of another item

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- Bill of material (BOM).



5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP



5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

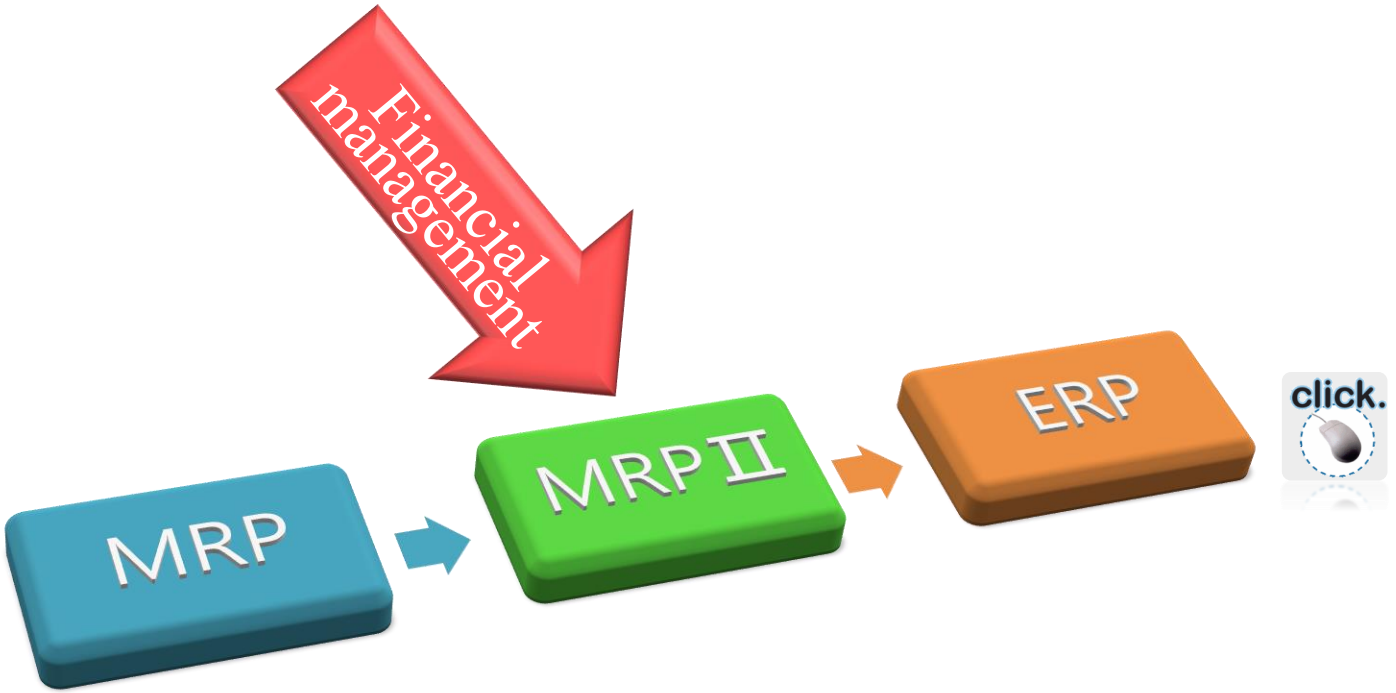
- MRP utilizes two basic principles:

  - Requirements for dependent demand items are derived from the production schedule for their parents (the items that are assembled from component parts).

  - The production order is sent based on the lead time.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- Material requirement planning (MRP) is a system with bill of material (BOM).



5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- For MRP, a *time bucket* is a specifically allotted period of time in which a certain quantity of units must be produced.

  - A typical MRP time bucket will entail at least a week.

- For the kanban system, the time bucket can be seen in one day.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- MRP necessitates the *time phasing* concept.

  - Making up an inter-bucket schedule that dispatches parts to a product by using lead time data

- The kanban system does not essentially require this time-phasing concept.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- The delivery cycle must often be considered in determining the number of kanbans based on the lead time of the production process.

- In the case of short production runs, smoothing of production is difficult and MRP may be more appropriate.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- An overall production schedule is very important for MRP (master schedule in MRP). 

- In the kanban system, the overall schedule does not strictly target production, but merely sets up a loose framework that prepares the plant-wide arrangement of materials and workers at each process.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- For MRP, a review must be made at the end of every planned production interval to compare the planned production with actual performance.
  - Revise the master schedule
- The kanban system does not require such comparisons.
  - Only the final assembly line needs to be notified of any changes in sequence for the plant's production.

5.4 SUMMARY

Subgoal *a*:

- to minimize variance in the usage of parts and/or materials constituting the final products

  - called *parts usage smoothing*

  - the most important goal

5.4 SUMMARY

Subgoal *b*:

- to prevent that a certain product requiring a longer assembly time is continuously introduced to the assembly line

- Products with varied assembly times must be introduced with even variance into the line

- This is called *product work-load smoothing*.

5.4 SUMMARY

Subgoal *c*:

- to produce daily as many units of product as can be sold on average day in the month in question

- Each product must be produced in accordance with its takt time (cycle time).

- This is called *product sales-rate smoothing*.

5.4 SUMMARY

Subgoal *d*:

- to prevent products requiring a longer assembly time to flow in succession
  - The parts assembly line that directly links to the final product assembly line also makes a variety of parts.
  - These parts must in turn flow smoothly.
  - This is called *parts work-load smoothing* (=*product work-load smoothing*).

5.4 SUMMARY

- A positive correlation exists between subgoals (*a*) and (*c*), which has been verified by the simulation experiment of Aigbedo and Monden (1996).

- Conflict often occurs between subgoals (*a*) and (*b*).

=>need coordination

Aigbedo, H. and Monden, Y. 1996. A simulation analysis for two level sequence-scheduling for Just-In-Time (JIT) mixed model assembly lines, *International Journal of Production Research*, 35(9):2543-2564.

5.4 SUMMARY

- To achieve any of the four goals, the central problem is how to determine the

sequence schedule of the mixed model assembly line

5.4 SUMMARY

- To achieve the four goals simultaneously, we need some method of multi-goal sequence scheduling.

- *Goal Chasing Method* that makes a composite objective function for goals (*a*) and (*b*) (Chapter 20).

- *Goal Coordination Method* that utilizes an artificial intelligence (AI) approach together with the goal chasing method (Chapters 20 and 21).

5.1 SMOOTHING OF THE TOTAL PRODUCTION QUANTITY

- Minimize idle time in regard to manpower, equipment, and work-in-process (WIP).
- Reduce inventory.
- It is the cornerstone of the TPS.

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- Enterprise Resources Planning (ERP)

5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- Systems Applications and Products in Data Processing (SAP)
- The company and product use the same name, SAP.
- The company plans to increase the revenue to €20 billion in 2015.

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5.3 COMPARISON OF THE KANBAN SYSTEM WITH MRP

- An example of master schedule

Master Schedule for a Family of Bicycles

	February				March			
	Feb. 1	Feb. 8	Feb. 15	Feb. 22	Mar. 1	Mar. 8	Mar. 15	Mar. 22
Aggregate production plan for bicycle family	600				500			
Mountain bike	200		100			80		80
Road bike		50		100	100		100	
Tandem bike		75		75		70		70