
The JIT Revolution

Chapter 4

Just In Time (JIT)

*I tip my hat to the new constitution
Take a bow for the new revolution
Smile and grin at the change all around
Pick up my guitar and play
Just like yesterday
Then I get on my knees and pray
WE DON'T GET FOOLED AGAIN!*

–The Who

Origins of JIT

- Japanese firms, particularly Toyota, in 1970's and 1980's
- Taiichi Ohno and Shigeo Shingo
- Geographical and cultural roots
- Japanese objectives
 - “catch up with America” (within 3 years of 1945)
 - small lots of many models
- Japanese motivation
 - Japanese domestic production in 1949 – 25,622 trucks, 1,008 cars
 - American to Japanese productivity ratio – 9:1
 - Era of “slow growth” in 1970's

Toyota Production System

Pillars:

1. *just-in-time*, and
2. *automation*, or automation with a human touch

Practices:

- setup reduction (SMED)
- worker training
- supplier relations
- quality control
- Mistake-proofing (baka-yoke)
- many others

Supermarket Stimulus

- Customers get only what they need
- Stock replenished quickly
- But, who holds inventory?

Auto-Activated Loom Stimulus

- Automatically detect problems and shut down
- Mistake-proofing
- Automation with a human touch

Zero Inventories

Metaphorical Writing:

The Toyota production wrings water out of towels that are already dry.

There is nothing more important than planting “trees of will”.

– Shingo 1990

$5W = 1H$

– Ohno 1988

Platonic Ideal:

Zero Inventories connotes a level of perfection not ever attainable in a production process. However, the concept of a high level of excellence is important because it stimulates a quest for constant improvement through imaginative attention to both the overall task and to the minute details.

– Hall 1983

The Seven Zeros

- **Zero Defects:** To avoid delays due to defects. (Quality at the source)
- **Zero (Excess) Lot Size:** To avoid “waiting inventory” delays. (Usually stated as a *lot size of one.*)
- **Zero Setups:** To minimize setup delay and facilitate small lot sizes.
- **Zero Breakdowns:** To avoid stopping tightly coupled line.
- **Zero (Excess) Handling:** To promote flow of parts.
- **Zero Lead Time:** To ensure rapid replenishment of parts (very close to the core of the zero inventories objective).
- **Zero Surging:** Necessary in system without WIP buffers.

JIT Goals

“Ideals” Rather Than “Just Enough”

Place a cap on in-process inventory by using some type of pull scheduling system.

Level the production plan and provide a uniform product mix (run every model every day)

The concept is that gauging progress against absolute ideals provides an incentive and a true measure of success

The Environment as a Control

Constraints or Controls?

- machine setup times
- vendor deliveries
- quality levels (scrap, rework)
- production schedule (e.g. customer due dates)
- product designs

Impact: the manufacturing system can be made much easier to manage by improving the environment.

Environment As a Control

Rather than accept the environment as a given, JIT ideal requires that you proactively shape it.

- **Make manufacturing systems easier to manage**
- **Run smaller lots via setup reduction**
- **Due dates are negotiated rather than taken as a given (use reserve capacity as a strategy--finite loading of facilities)**

Environment As a Control

- **Reduce the number of suppliers so you can work more closely with them.**
- **Establish a means of achieving frequent deliveries of small quantities from suppliers with no increased transportation costs**
- **Build process knowledge and capability rather than try to inspect in quality**

Environment As A Control (Cont.)

Have engineers with a breadth of knowledge so that integrated product/process development occurs naturally.
-Japanese graduate engineer experience

Serious setup reduction as a strategy and tactic was initiated in Japan. US is still not great at it!

Major, major point

A systems approach to transforming the manufacturing environment is a necessity and constant attention to detail over an extended period of time are fundamental.

Implementing JIT

Production Smoothing:

- relatively constant volumes
- relatively constant product mix

Final Assembly Schedule:

- 10,000 per month (20 working days)
- 500 per day (2 shifts)
- 250 per shift (480 minutes)
- 1 unit every 1.92 minutes

Implementing JIT (cont.)

Production Sequence: Mix of 50% A, 25% B, 25% C in daily production of 500 units

$$0.5 \times 500 = 250 \text{ units of A}$$

$$0.25 \times 500 = 125 \text{ units of B}$$

$$0.25 \times 500 = 125 \text{ units of C}$$

A - B - A - C - A - B - A - C - A - B - A - C - A - B - A - C ...

Inherent Inflexibility of JIT

Sources of Inflexibility:

- Stable volume
- Stable mix
- Precise sequence
- Rapid (instant?) replenishment

Measures to Promote Flexibility:

- Capacity buffers
- Setup reduction
- Cross training
- Plant layout

Capacity Buffers

Problems:

- JIT is intrinsically rigid (volume, mix, sequence)
- No explicit link between production and customers
- How to deal with quota shortfalls

Buffer Capacity:

- Protection against quota shortfalls
- Regular flow allows matching against customer demands
- *Two shifting*: 4 – 8 – 4 – 8
- Contrast with WIP buffers found in MRP systems

Setup Reduction

Motivation: Small lot sequences not feasible with large setups.

Internal vs. External Setups:

- External – performed while machine is still running
- Internal – performed while machine is down

Approach:

1. Separate the internal setup from the external setup
2. Convert as much as possible of the internal setup to the external setup
3. Eliminate the adjustment process
4. Abolish the setup itself (e.g., uniform product design, combined production, parallel machines)

Cross Training

- **Adds flexibility to inherently inflexible system**
- **Allows capacity to float to smooth flow**
- **Reduces boredom**
- **Fosters appreciation for overall picture**
- **Increase potential for idea generation**

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Workforce Agility

Cross-Trained Workers:

- float where needed
- appreciate line-wide perspective
- provide more heads per problem area

Shared Tasks:

- can be done by adjacent stations
- reduces variability in tasks, and hence line stoppages/quality problems



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Plant Layout

- **Promote flow with little WIP**
- **Facilitate workers staffing multiple machines**
- **U-shaped cells**
 - Maximum visibility
 - Minimum walking
 - Flexible in number of workers
 - Facilitates monitoring of work entering and leaving cell
 - Workers can conveniently cooperate to smooth flow and address problems

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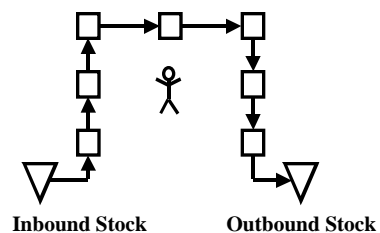
Layout for JIT

Cellular Layout:

- Proximity for flow control, material handling, floating labor, etc.
- May require duplication of machinery (decreased utilization?)
- logical cells?

Advanced Material Handling:

- Avoid large transfer batches
- Close coordination of physically separate operations



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Focused Factories

Pareto Analysis:

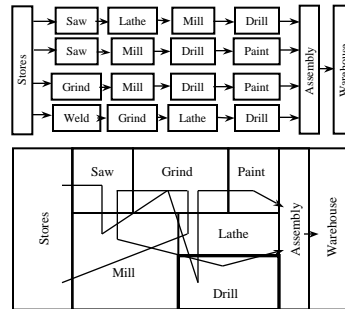
- Small percentage of sku's represent large percentage of volume
- Large percentage of sku's represent little volume but much complexity

Dedicated Lines:

- for families of high runners
- few setups
- little complexity

Job Shop Environment:

- for low runners
- many setups
- poorer performance, but only on smaller portion of business



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Total Quality Management

Origins: Americans (Shewhart, Deming, Juran, Feigenbaum)

Fertility of Japan:

- Japanese abhorrence for wasting scarce resources
- The Japanese innate resistance to specialists (including QA)

Integrity to JIT:

- JIT requires high quality to work
- JIT promotes high quality
 - identification of problems
 - facilitates rapid detection of problems
 - pressure to improve quality

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Total Quality Management (cont.)

Techniques:

- Process Control (SPC)
- Easy-to-See Quality
- Insistence on Compliance (**quality first, output second**)
- Line Stop
- Correcting One's Own Errors (no rework loops)
- 100 Percent Check (not statistical sampling)
- Continual Improvement
- Housekeeping (5 S's, Visual Control Systems)
- Small Lots
- Supplier Certification
- Total Preventive Maintenance (TPM, RCM)

Kanban

Definition: A “kanban” is a sign-board or card in Japanese and is the name of the flow control system developed by Toyota.

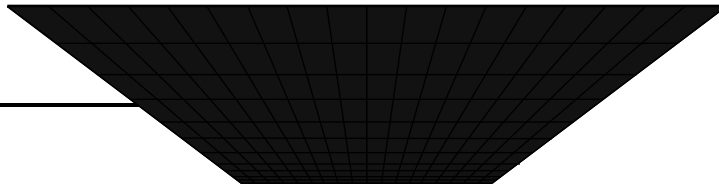
Role:

*Kanban is a tool for realizing just-in-time. For this tool to work fairly well, the production process must be managed to **flow** as much as possible. This is really the basic condition. Other important conditions are leveling production as much as possible and always working in accordance with standard work methods.*

– Ohno 1988

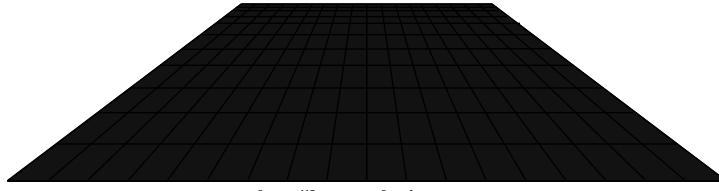
Push vs. Pull: Kanban is a “pull system”

- Push systems *schedule* releases
- Pull systems *authorize* releases



KANBAN is a Visual Signal

One of the Primary Tools of Lean Production



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Kanban as a Vehicle for Process Improvement

Kanban is a simple and visual system.

Kanban transfers ownership back to the shop floor.

With kanban, there is not one material plan but literally hundreds of individual material plans. Each kanban (part) has its own replenishment process.

Improvements come one part or one supplier at a time.

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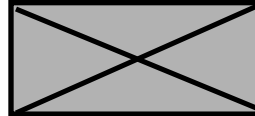
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KANBAN ~means Visual Signal

There are two basic types of Kanban Signals:

1. In-Process Kanban ~ a visual signal to pace the movement of products in a flow manufacturing process



2. Material Kanban ~ a visual signal to replenish materials consumed in a lean production process




KANBAN CARD ID: 0 "0"		Production Unit of Lot		PRINT DATE: 3/16/95
LOTSIZE NUMBER: 1 of 4	PART NO.: 12-00327-09	REF. DRAWING NO: dw1234		REVISION NO.: dr987
PART NAME: MODULE 69NT	KANBAN QUANTITY: 3	CONTAINER TYPE: BOX		
Supply Point: Supply B *Supply B*	Notes: NOTE 1			
USAGE POINT: USAGE C *USAGE C*				

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Material Kanban Types

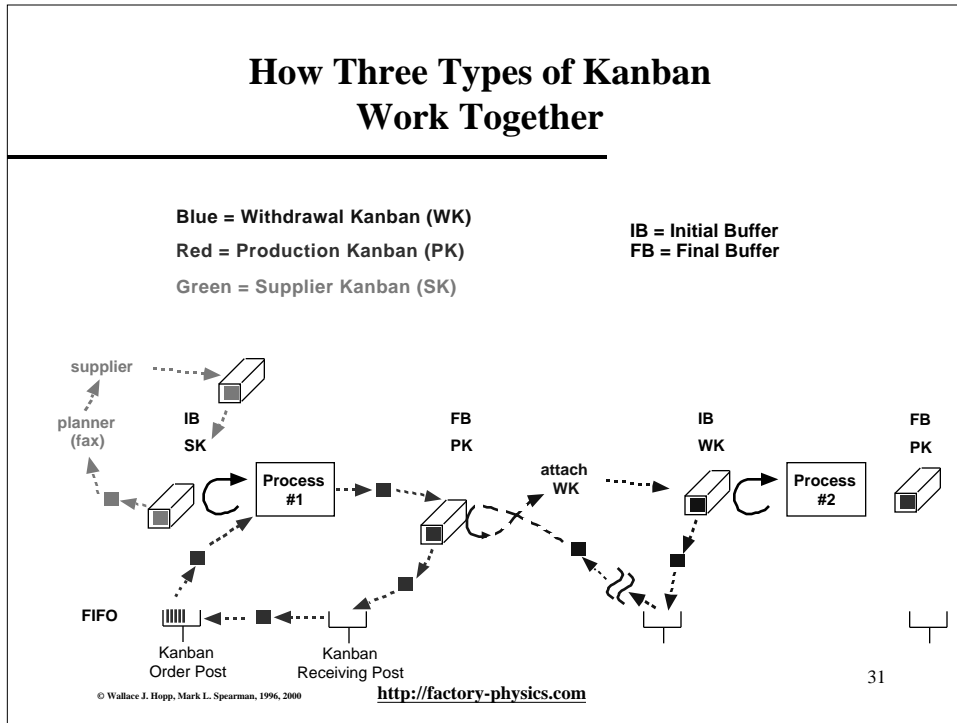
- ❖ Withdrawal Kanbans  blue
- ❖ Production Kanbans  red
- ❖ Supplier Kanbans  green

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How Three Types of Kanban Work Together



How Three Types of Kanban Work Together (Cont.)

When container in the initial buffer is opened or is empty, the withdrawal kanban is removed from the container (or container and card positioned in signaling location) and used to requisition material from final buffer of previous operation.

The withdrawal kanban is placed on the container pulled from the final buffer (production kanban taken off container to trigger production, placed on receiving post) of previous process and taken to initial buffer of next process.

The production kanban is placed in the receiving post (FIFO) and acts to schedule production.

The supplier kanban acts just like a withdrawal kanban, except that the upstream process is an external supplier.

Kanban Calculations

$$\begin{aligned} \text{Number of Kanbans} &= \frac{\bar{D} \times (1 + SF) \times KCT}{\text{Kanban Size}} \left[\begin{array}{l} \text{Signal =} \\ \text{Full Container} \\ \text{Opened} \end{array} \right] \\ &= \frac{\bar{D} \times (1 + SF) \times KCT}{\text{Kanban Size}} + 1 \left[\begin{array}{l} \text{Signal =} \\ \text{Container} \\ \text{Empty} \end{array} \right] \end{aligned}$$

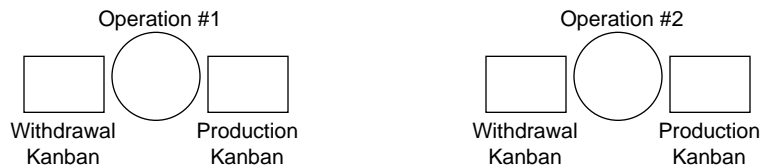
\bar{D} = Average Demand
 SF = Safety Factor
 KCT = Kanban Cycle Time (time for material to be replenished once a signal has been received)

Signal could be: empty container
 container opened
 full container taken away

Number of kanbans = number of cards (not necessarily full containers) required for system to work

If the number of kanbans = 2, then: Kanban Size = $\frac{\bar{D} \times (1 + SF) \times KCT}{2}$

Interaction Between Production Kanban and Withdrawal Kanban



Production Rate = 1 unit / 5 seconds
 = 0.2 units / second
 Kanban Size = 6 units

Production Rate = 1 unit / 10 seconds
 = 0.1 units / second
 Kanban Size = 6 units
 Let Safety Factor = 10%
 Kanban Cycle Time = 30 seconds

Interaction Between Production Kanban and Withdrawal Kanban

Withdrawal kanban - signal when container is opened

$$\begin{aligned} \text{Number of Kanbans} &= \frac{\bar{D} (1+SF) KCT}{\text{Kanban Size}} \\ &= \underline{\hspace{2cm}} \end{aligned}$$

Withdrawal kanban - signal when container is empty

$$\begin{aligned} \text{Number of Kanbans} &= \underline{\hspace{2cm}} \\ &= \underline{\hspace{2cm}} \end{aligned}$$

Withdrawal kanban - signal when container is empty & KCT = 120 seconds

$$\begin{aligned} \text{Number of Kanbans} &= \underline{\hspace{2cm}} \\ &= \underline{\hspace{2cm}} \end{aligned}$$

Interaction Between Production Kanban and Withdrawal Kanban

Production Kanban

Production Rate = 0.20 units / second

Demand Rate = 0.10 units / second

(a) Waiting time to work into schedule

Time (sec.)	% Total
60	40
70	30
80	30

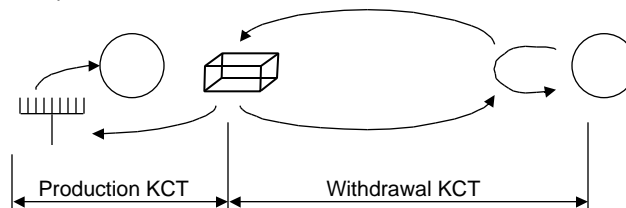
Average Time = ?

(b) Run Time = ?

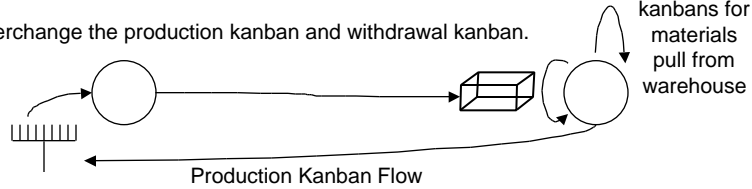
$$\begin{aligned} \text{Number of Kanbans} &= \frac{\bar{D} (1+SF) KCT}{\text{Kanban Size}} \\ &= \underline{\hspace{2cm}} \end{aligned}$$

How else can I make the pull system work?

Interchange the production kanban and withdrawal kanban.



Do not interchange the production kanban and withdrawal kanban.



Likely greater variability in KCT!
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The Lessons of JIT

- The production environment itself is a control
- Operational details matter strategically
- Controlling WIP is important
- Speed and flexibility are important assets
- Quality can come first
- Continual improvement is a condition for survival

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