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Tools for lean re-engineering

Production leveling

Kanban card control

Co funded by the Erasmus+ Programme of the European Union

Kanban Production Control Systems *the 5 rules*

1. The downstream process must only take from upstream the necessary parts in the required quantity and at the right time
2. The upstream process must produce the amount that is withdrawn downstream
3. Defective parts can't move downstream
4. The number of kanban must be the minimum
5. Kanban is the control tool to adjust to small fluctuations in demand

Two card kanban system

Pull signal system to control the production at each stage

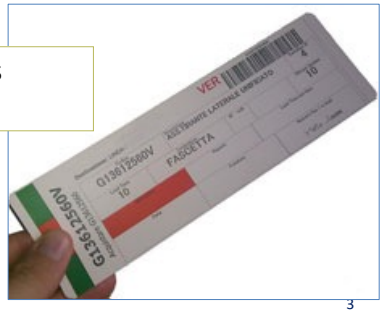
Withdrawal kanban

Specifies the quantity the process downstream must withdraw

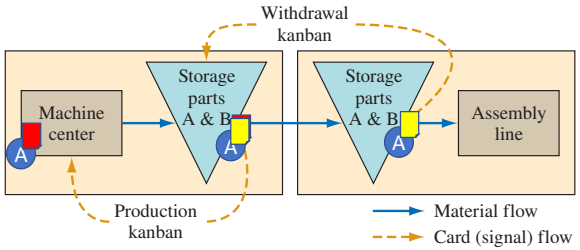
Production kanban

Specifies the quantityt the process upstream must produce

The kanban moves with the product (or container) and shows the information necessary for correct identification (name, code number, quantity, ...)



Two card kanban system



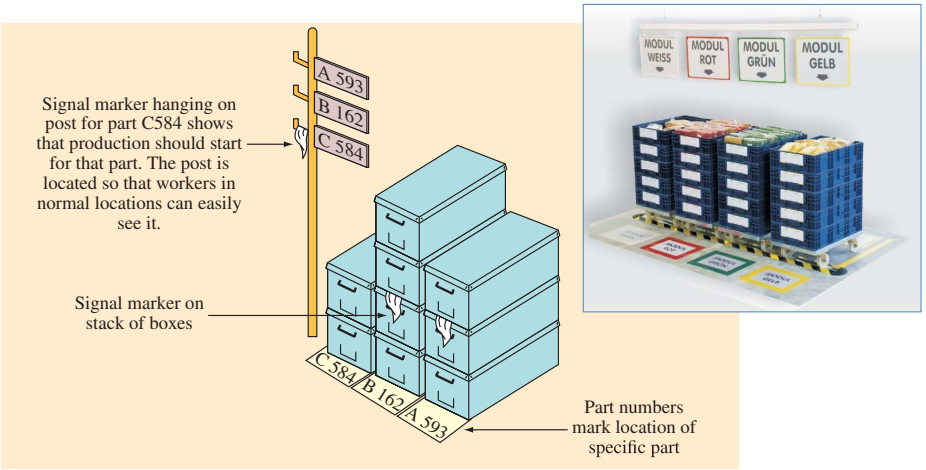
The machine center makes two parts, A and B, to feed an assembly line

- When the assembly line takes a lot of part A from the storage, a worker takes the **withdrawal kanban** from the container. The card is the replenishment signal to the machine center storage area
- In the machine center area, the worker finds a container of part A, removes the **production kanban**, and replaces it with the withdrawal kanban

  Placement of this card on the container authorizes the movement of the container to the assembly line
- The freed production kanban is placed on a rack by the machine center, which authorizes the production of another lot of material A

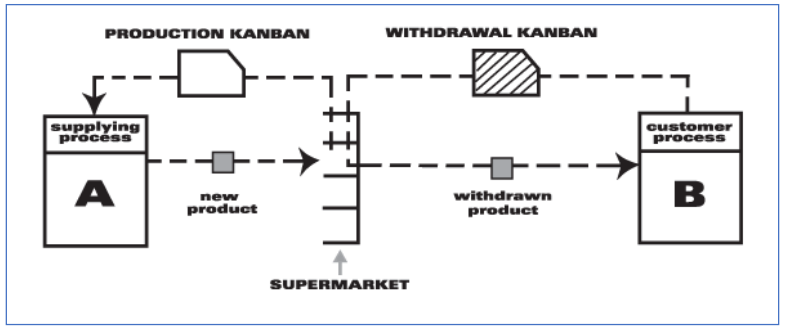
  The cards on the rack visually show upcoming work for the machine center

Outbound Stockpoint (supermarket) with Warning Signal Marker (prod. kanban)



Fonte: Chase et al., 2018 - Chap. 14

Supermarket



Number of Kanban cards

- The **kanban cards** represent the **number of containers** of material that flow back and forth between the supplier and the user areas
- Each container represents the **minimum production lot size** to be supplied
- The number of containers directly controls the amount of **WIP inventory** in the system
- Container size should be **standard and «small»** (generally <10% of the average daily demand)

Number of Kanban cards

$$k = \frac{\textit{Expected demand during lead time + Safety stock}}{\textit{Size of the container}} = \frac{D\,L\,(1+S)}{C}$$

k Number of kanban cards

D Average number of units demanded per period [u/time]

L Lead time to replenish an order (expressed in the same units as demand *D*) [time]

S Safety stock (expressed as % of demand *D* during the lead time *L*)

C Standard Container size [unit]

Note:

Generally the safety stock is < 10% of *D* during *L*

Example

- Use of kanban to pull material through its manufacturing cells from the assembly cell
  - Demand = 8 [u/h]
  - Safety stock = 10% of the expected demand
- Multi-purpose fabrication cell
  - Production and transportation batch = 10 [u]
  - Change Over Time = 0 [s]
  - Production lead Time = 4 [h]
  - Transportation time = 0 [s]
- The number of the kanban to manage the replenishment cycle

$$k = \frac{D \cdot L \cdot (1+S)}{C} = \frac{8 \cdot 4 \cdot (1+0{,}1)}{10} = 3{,}52 \Rightarrow k = 4$$

Closed Loop – Kanban circuit

Number of kanban cards

K = RE + LO + WI + SA1 + SA2

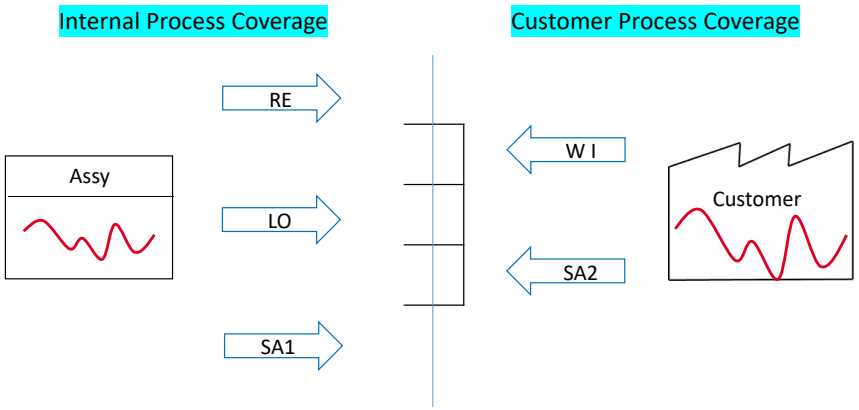
RE → **Re**plenishment Time coverage (*Customer demand according to customer takt-time within replenishment time for 1 Kanban*)

LO → **Lo**t Size coverage (*Lot size building*)

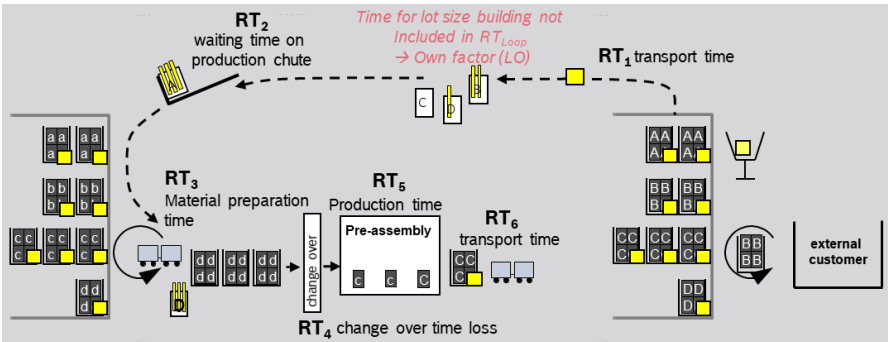
WI → **W**ithdrawal Peak coverage (*Known customer demand fluctuations*)

SAi → **SA**fety Time Coverage
1. (*Unknown fluctuations of internal process*)
2. (*Unknown fluctuations of the customer process*)

Closed Loop – Kanban circuit



Replenishment Time coverage



RT1: time between withdrawal from the supermarket and arrival of Kanban on the production chute *(without lot size building!)*
RT2: waiting time on production chute
RT3: material preparation time (Milkrun)
RT4: change over time loss
RT5: production time for 1 Kanban
RT6: transport time in the supermarket

Replenishment Time coverage

$$RE = RT_{loop} / (TT \times NPK) \text{ [\# kanban]}$$

RT_{loop} = Replenishment time = *Rt1 + Rt2 + Rt3 + Rt4 + Rt5 + Rt6* [s]
NPK = Number of parts per Kanban [u/kanban]
TT = Takt Time = (*POT*/*PR*) [s/u]

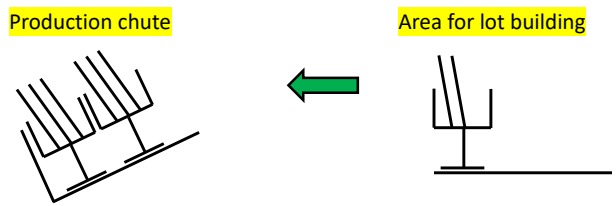
POT (Planned Operation Time) = Production time excluding planned breaks
PR = Period Requirement (production)

$$RE = RT_{loop}\ PR / (POT \times NPK) \text{ [\# kanban]}$$

Lot Size coverage

$$LO = (LS/NPK) - 1 \text{ [\# kanban]}$$

LS = Lot Size [u]
NPK = Number of parts per Kanban [u/kanban]



Withdrawal Peak coverage

$$WI = Kspot\ tot - RE - LO \text{ [\#kanban]}$$

Kspot tot = Kspot1 + Kspot2 + Kspot3

Kanbans in the **PROCESS** (***Kspot1***)	Total Number of kanbans required for the planned set-up (***Kspot tot***)	Kanbans covering **Replenishment time** (***RE***)
Kanbans in the **SUPERMARKET** (***Kspot2***)		Kanbans covering **Lot Size Formation** (***LO***)
Kanbans in the **OVERFLOW** (***Kspot3***)		Kanbans covering **Planned customer withdrawal peaks** (***WI***)

Safety Time Coverage

$SA_{1\ SUPERMARKET}$ → To cover negative fluctuation

- If production deliver less than planned, to protect the customer, we must include safety stocks in the supermarket

$SA_{1\ OVERFLOW}$ → To cover positive fluctuation

- Number of cards to be provided to the production when it performs better than average OEE
- OEE was the basis to define the number of cards available daily (the aim is to support positive performance to the process)

Summary

- What Lean Re-engineering is
- The role of decoupling in Pull Systems
- How the Pacemaker controls the production
- Levelling the production mix and volume
- How to calculate the number of Kanban in a closed loop