What is a Kanban?

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Introduction

A key tool in lean manufacturing is the kanban. For one of the authors, James Chapados, learning about kanbans was helped by experiences with his mother.

My mother was many things, an Olympic caliber tennis player and remarkable all round athlete, a brilliant English and math teacher, witty, charming, fun, impulsive, and a loving, kind human being. But she was not what one would call a good cook. Indeed, it is hard to think of her as a cook at all. To avoid her cooking, both my sister and I learned to cook when very young. My sister and father usually took turns cooking dinner until I was old enough to become a part of the rotation. It was more self-defense than anything else. But my mother ran one heck of an efficient pantry. I never knew us to run out of any staple, be it flour, sugar, the ubiquitous "luncheon meat", eggs, crackers, milk, or catsup (she always spelled it catsup, not ketchup, I don't know why). At the same time, we never seemed to have a lot of stuff on the shelves.

My mother would put together a shopping list for my father to buy from on Saturday mornings. It always had on it what we needed in specific quantities – one box of oatmeal, two boxes of cornflakes, two dozen eggs, one can of asparagus, three cans of corn, etc. It was after she became ill with heart trouble and was in the hospital for an extended stay that my father took over the shopping list. We began to be short of butter or flour or eggs. After a couple of weeks of this I decided that it was time to ask my mother how she did what she did. By that time she was in the University Hospital 150 miles away, so I had to write for an explanation of her system. I couched it in terms of missing her and loving her and hoping she would get well and come home soon - and by the way, how did she know what and how much to put on the shopping list? She wrote back in a couple of days saying how much she missed us all and that she was doing her best to get better and to look in the towel drawer in the pantry for the answer.

I immediately went into the pantry, opened the drawer and found a notebook. Opening it, I found a record going back several years of our usage of all those basic needs. At the end was a chart. The first column listed each item and average use. The second column calculated the usage by the week or month. The third column calculated how much we needed to have on hand to last the week. The fourth column stated how much we should have on hand to last the week with a little extra - just in case. Other columns changed the quantities on some things, like milk, butter, etc. based upon the number of visitors we might have.

Her system was obvious, and later found it was just a bit more detailed than those used by most cooks. She would look on a shelf on Friday and see how many of each thing was left, which would then determine how many of that item she would write on the shopping list. When I looked inside the flour, sugar, and coffee canisters that were on the counter I saw that each had a line scratched into the inside which was my Mother's mark for when to order more.

Because of my mother, kanbans made immediate sense and, like when I was introduced to my mother's system, I marveled at how obvious and simple kanbans are. It is amazing how blind most of us are (including me) to seeing the obvious solution until it is pointed out to us.

My mother would have been a brilliant materials logistics manager, and she wouldn't have had to wait for the kanban concept to be reintroduced to American manufacturing by the Japanese.

What follows is a description of kanbans and their applications in manufacturing.

What Kanbans Are:

Kanban is Japanese for *sign* or *designated place*. It is used in manufacturing to mean a visual signal that tells when it is time to get or make more of something.

What Kanbans Do:

- Controls the amounts of raw material amounts and of material in Work In Process
- Smooths out flow, if sized properly
- Tells when and where there is a problem in the process
- Assures there is always just enough material on hand to make what is needed

Types Of Kanbans:

- **Raw Material Kanban –** tells suppliers when to send how much of a particular item to a particular place.
- **In-Process Kanban –** determines the amount of WIP (Work In Process) that can be kept between any two operations in a process
- **Finished Goods Kanban –** determines the amount of a product to be kept on hand at any given time. Removal of material from the Finished Goods Kanban acts as a signal for more of that product to be manufactured.

Types Of Kanban Signals:

- A calculated amount of material kept in a **designated space**, such as a **bin** or **between lines** on a workbench or on the floor
- A **card** that is used to tell the amount of material to be made or ordered
- The **markings on a bin** that determine when more material needs to be ordered or made
- Any other **clear visual signal** that indicates it is time to get more material

How Kanbans Work:

Material Resupply Kanban:

1. All of the parts used to manufacture a particular product are identified as well as the number used in each product.

2. Lead time is calculated, that is the amount of time it takes for the parts to be ordered and delivered.

3. The demand for the product over a specific length of time is then determined.

4. The number of parts used in the product is multiplied by the number of the products demanded over the length of time that it takes to order and receive the parts.

5. The goal is to order parts at the point when the number of parts on hand reach the amount that will be used up during the time it takes to order and get the needed parts delivered. Usually, because of variability in lead time, the amount of reordered parts occurs is usually a bit more than the amount of parts needed to cover order lead time. Common signals used as kanbans include two bin resupply systems and card systems

Example:

In one company that manufactures actuators (devices to open and close valves) constantly found themselves being short on certain types of parts – notably gears and circuit boards. After examining their eight products, they determined they had a total of 165 parts from 30 suppliers. They calculated how long it took to order and get delivery for each part. They then calculated the total number of actuators they sold that used each part. Next, they multiplied the number of each part used in each actuator by the average number of parts demanded by customers for the length of each supplier's lead time for each part. Because they had as much as a 25% swing up or down from the average order during that time, and because they felt uncomfortable about their suppliers' abilities to meet lead time consistently, they decided to increase the amount of parts to have on hand as a reorder point by 50%. Parts were then bagged or placed into a styrofoam tray that had parts nests. So, whenever parts got to the calculated point, such as the last bag, or to the specific amount in the tray, parts would be reordered. Usage was reanalyzed every quarter for each part when parts were cycle counted.

Work In Process Kanban

A one piece flow, when products move one at a time from one process step to another, and where there are no kanbans at all is the ideal production. However, one piece flow demands a very well balanced manufacturing line, meaning that each process station uses approximately the same amount of time to do the necessary work.. Since that is often not possible, kanbans are used to help manage the flow.

1. First, the process times at each station are calculated.

2. Then, when one station has to take significantly more time to do its work than previous stations, kanbans are put in to keep material batching to a minimum. Usually, if a station takes twice as long as the station before, a kanban half again the size is put in place. This allows the person previous to the station where work has bunched up to help the person at the more work intensive station.

Example

One company machined connectors used on electronic cables in five steps. The first ste,p, cutting and roughing the part, took an average of two minutes. The second step, lathing the part took seven minutes. The third step, milling, took three minutes. The fourth step, deburring and polishing, took 3.5 minutes. The last step, final inspection, took three minutes. Work would collect in front of the lathe at a rate of more than three parts to one from cut and rough. Even when another lathe was bought, work would still build up. The solution was to put in a kanban of three parts in front of each lathe so that those kanbans were full, the cutting and roughing person help the lathe operators, or help in deburring until kanban space opened up. A kanban of one was placed in front of milling and another placed in front of final inspection.

Finished Goods Kanban

1. The demand for a particular product is tracked over time.

2. Based upon the demand, the safety stock is calculated, that is an amount of product to have on hand to satisfy most orders within a specific window of time (e.g. a day or a week).

3. Based upon the demand, it is then calculated how many of the product needs to be made per day. This is known as TAKT time (TAKT is German for rhythm).

4. Finished Goods Kanbans are set up in the shipping area with the amount of product that has been determined as required safety stock.

5. When orders are filled by pulling product from the Finished Goods Kanban, a signal, such as a bin or a card, is sent to the manufacturing floor. That signal tells production to complete the number of products needed to replenish the Finished Goods Kanban.. The amount of product needed is calculated using the TAKT time.

6. The assumption is that production has the capacity to make the necessary amount of the product in the required time to keep the Finished Goods Kanbans filled.

Example

A company that assembles a wide variety of temperature sensors battled increasing lead times and low on-time delivery performance in a context of business growing over 20% per year. The business manager responsible for the sensors identified 20 high running products that made up 80% of sensors produced in one manufacturing cell. Based on the forecasts and history, he identified the monthly demand for each one of the 20 sensors. To ensure on-time delivery to the customer, he decided to keep a two week safety stock for each product in the shipping area. Thus each product was assigned a Finished Goods Kanban sized to hold two weeks demand of sensors. The manufacturing manager determined how many of each sensor needed to be produced daily (the product's TAKT Time). By multiplying the number of sensors to be made by the process time to make one product by one person, and further dividing that by the number of people in the cell, he made sure that he had enough capacity to make the required number of products per day. He also determined that no less than 30 pieces of one product should be produced at a time in the cell. A set of cards containing instructions to produce 30 pieces of a given sensor totaling approximately the number needed to make a two week supply was attached to all the Finished Goods Kanbans. As shippers filled orders to be shipped by pulling sensors from the kanbans, they would also sent the cards to production as a signal to build replacement sensors for those just shipped.

Raw Material Kanban Methods

Is: A calculation that determines the optimal amount of raw material goods to be placed in a buffer (Kanban)

Does: Allows for inventory control of raw parts while assuring the raw material is available on demand

How:

General Rules:

1) Determine actual production lead time to produce parts.

2) Analyze average demand over lead time of supplier for parts.

3) Identify peak demand and frequency of demand spikes beyond average.

4) Present data to supplier and get agreement from the customer to utilize Kanbans.

5) Determine quantities of raw parts needed to be in Kanbans.

6) Negotiate safety stock amounts with supplier. Make an agreement with the supplier as to who owns any raw material in kanbans. Make sure that any finished goods in kanbans are properly costed and that margins reflect absorption of those costs burdened by your company.

7) Determine container to be used as for material. Determine if container should be used as signal for making parts (empty container arrives and needs to be filled) or some other kanban signal should be used, such as: kanban cards, faxban, etc.

8) Supplier agrees to kanban rules. First option: the supplier ships raw parts using established lead time + shipping time window for delivery and parts with front end loading of parts into kanbans. Kanbans are filled when arrived in established time window. Second option: set up a "two bin resupply process, where one kanban is full at the supplier waiting for you to order and that kanban is shipped immediately. The second kanban is filled during lead time and is ready when you order the next shipment.

Raw Material With Stable Pull:

Method 1:

- Determine time frequency (e.g. every week) and agreed upon amount of raw parts to be shipped
- Determine Takt time for period between agreed upon shipments. (number of parts to be shipped / time between shipments)
- Kanban size then equals standard order size.

Tt = Takt Time
nP = Average number of Parts shipped
tS = Average time between Shipments

$$K = Tt = \frac{tS}{nP}$$

Example:

An electrical panel manufacturer uses 1200 weekly of one type of panel box. The purchasing manager as negotiated a daily shipment of panel boxes.

The calculated daily Takt time would be:

$$\frac{1200}{5} = 240 \text{ A Day}$$

The daily Finished Goods Kanban size would be 240.

Make sure that the supplier's existing resources can meet demand within time frequency. In resources are too low to meet demand increase resources

Method 2:

When a customer is unwilling to utilize a pull system with kanbans, then one can set up one's own internal kanban system. The formula for that would be:

Where
K = Kanban size
DL = Average Demand during Lead time
SS = Safety Stock
CS = Container Size

$$K = \frac{DL + SS}{CS}$$

Example:

An industrial seal manufacturer uses consistently 2500 rubber rings a week. The supplier's lead time for manufacturing the connectors is 3 weeks. In order to assure that there will always be parts available the the seal manufacturer has asked that a 3 week safety stock be on hand. The manufacturer also wants rings shipped in re-useable containers of 500. In this example:

$$\frac{(2500 \text{ X } 3) + (2500 \text{ x } 3)}{500} = \frac{14000}{500} = 28 \text{ containers}$$

A general Kanban rule is to always round up to determine Kanban size or the number of containers that will make up the Kanban.

Variable Demand Raw Material:

- Determine time frequency for shipments and agreed upon normal size (might or might be greater than average size order) order to be shipped
- Determine highest level of demand for order and frequency demand is greater than agreed upon normal size.
- Determine Takt time for meeting that highest level of demand using standard lead time.

Tt = Takt time
nP = Number of Raw Parts that can be made in determined shipping window time
SLt = Standard Lead time

$$Tt = \frac{nP}{(SLt)}$$

Determine if the supplier can meet the Takt time using existing resources. If not, determine amount of lead time needed to be able to meet highest level of demand.

Agree to provide notification in lead time window prior to lead time in order for the supplier to meet highest level of demand. If the supplier agrees, keep Kanban size at normal pull level and deal with additional demand by additional pull signals from shipping.

If you cannot provide prior lead time notification determine how much additional material would be needed to meet highest level of demand. Determine how much material can be built in production window between pull signal from you the supplier ship date. Subtract the amount that can be built from total quantity needed and use that as kanban size. Make the difference as safety stock. Make an agreement with the supplier as to who will own safety stock.

Kanban size = Amount possible to make during production lead time
Safety Stock = Highest Demand – Amount made during order to ship lead time.

Example:

In one company that makes office furniture, one specialty office chair had an extremely variable demand because of cost and radical design. The chair fabric is specially made for the manufacturer by a supplier. Lead time for making the material is 6 weeks. Average material used is 1400 yards a month. However, because of the variability in orders the amount varies from 600 to 2500 yards a month (This level of demand occurred twice during the last year). The Kanban size agreed upon was 2500 yards because the customer decided that if an order occurred that used up all of the material the probability of another large order immediately following was very small. This Kanban size would allow the supplier to just about refill the Kanban before other demands were made. The chair manufacturer agreed notify the fabric company three months before hand if the chairs would be discontinued and to cover the cost of any material left in the Kanban.

Raw Material With Intermittent Time Demand:

If orders are more frequent than 8 times a year, Use either of the above processes based upon steady or intermittent quantity demand. If orders are less frequent, establish work as a CONWIP System rather than a Pull System.

In Process Kanban Sizing Formula

Is: A calculation that determines the optimal size of a production process queue (Kanban).

Does: Allow for production process control using Kanbans.

How:

General Rules:

1) Select the process or sub-process to implement Kanban process control.

2) Determine Kanban locations. Kanban locations are determined by evaluating the rhythm of the process or sub-processes and determining where controlled queues are needed. Rhythm can be calculated by determining the longest cycle time (in minutes) of all operations in the process or sub-process. The overall rhythm should be balanced against that longest operation. Kanbans can be used to achieve balance in a process.

3) Determine the Kanban size. This is done using by using an average customer demand (usually monthly) divided by the number of operation minutes during that same period times the process rhythm (time).

Formula: $$K = p/u * T$$

Where

K = Kanban size (in units)
p = Units shipped per month
u = Number of monthly production minutes available
T = Process rhythm (time)

Example:

A sprocket manufacturer provides a heavy equipment operator with 2000 double 8 inch sprockets with 48 Teeth. The monthly production time available for this product is: 15,600 minutes (2 shifts 6.5 at hours a day productivity). This product is manufactured in a manufacturing cell. The manufacturing process steps are:

PROCESS STEP	OPERATION	CYCLE TIME
1.	Saw	2.75 minutes
2.	Lathe	4.55 minutes
3.	Hob	6.25 minutes
4.	Deburr	1.5 minutes
5.	Drill & Tap	2.5 minutes

Operation 1 Saw Kanban: No In Process Kanban needed as first operation in the process

Operation 2 Lathe Kanban: Covers times in operation 2.

K = 2000/15600 X 4.55 = .58 or 1 unit for the Kanban*

(*All fractions are rounded up)

Operation 3 Hob Kanban: Covers times in operation 3.

K= 2000/15600 X 6.25 = .80 or 1 unit

Operation 4 Deburr Kanban: **C**overs times in operation 4.

K= 2000/15600 X 1.5 = .19 or possibly one unit, although a kanban is probably not necessary for this operation.

Operaton 5 Drill & Tap Kanban: Covers times in operation 5.

K= 2000/15600 X 2.5 = .32 or possibly one unit, although a kanban is probably not necessary for this operation

Notes

The above example was used to demonstrate the calculations. In reality, Kanban sizes should be determined based on a statistical analysis of the customer pull rates, or ship rates.

Driving Linearity in scheduling helps reduce Kanban sizes. Linearity is measured by calculating the monthly schedule into a daily rate. You then measure actual builds against the daily rate. The absolute deviation from the daily rate becomes your measure of Linearity.

Kanbans can be sized to drive improvements. In cases where more process visibility and improvement is needed, reducing the Kanban size will drive further activity. This should always be done based on a statistical analysis, and reducing upper limits.

Finished Goods Kanban Methods

Is: A calculation that determines the optimal amount of finished goods to be placed in a buffer (Kanban)

Does: Allows for inventory control of finished goods while assuring the customer receives material on demand

How:

General Rules:

1) Determine actual production lead time to produce parts

2) Analyze average demand over lead time of customer for parts

3) Identify peak demand and frequency of demand spikes beyond average

4) Present data to customer and get agreement from the customer to utilize Kanbans.

5) Negotiate safety stock amounts with customer. Get agreement from customer to purchase any material in finished goods kanbans. If not make sure that any finished goods in kanbans are properly costed and that margins reflect absorption of those costs.

6) Determine container to be used as for material. Determine if container should be used as signal for making parts (empty container arrives and needs to be filled) or some other kanban signal should be used, such as: kanban cards, faxban, etc.

7) Customer agrees to kanban rules. First, Customer orders shipment using established lead time + shipping time for delivery and parts are built and shipped to customer when filled. Or, alternately, set up a "two bin resupply process, where one kanban is full waiting for customer order to ship and that kanban is shipped immediately. Second kanban is filled during lead time and have ready for when customer orders a shipment.

Product With Stable Pull:

Method 1:

- Determine time frequency (e.g. every week) and agreed upon size of order to be shipped:
- Determine Takt time for period between agreed upon shipments. (number of parts to be shipped / time between shipments)
- Kanban size then equals standard order size.

Tt = Takt Time
nP = Average number of Parts shipped
tS = Average time between Shipments

$$K = Tt = \frac{tS}{nP}$$

Example:

A circuit board manufacturer gets weekly orders for 600 of one type of specialty circuit board with quantities to b e shipped daily to the customer, a valve actuator company.

The calculated daily Takt time would be: $\frac{600}{5} = 120$ **A Day**

The daily Finished Goods Kanban size would be 120.

Make sure that existing resources can meet demand within time frequency. In resources are too low to meet demand increase resources

Method 2:

When a customer is unwilling to utilize a pull system with kanbans, then one can set up one's own internal kanban system. The formula for that would be:
Where

K = Kanban size
DL = Average Demand during Lead time
SS = Safety Stock
CS = Container Size

$$K = \frac{DL + SS}{CS}$$

Example:

A power cable connector manufacturer has a customer that a fairly constant 125 connectors a week. Lead time for manufacturing the connectors is 2 &1/2 weeks. In order to assure that there will always be parts available the customer has asked that a 2 week safety stock be on hand. The customer also wants material shipped in re-useable containers of 75. In this example:

$$\frac{(125 \times 2.5) + (125 \times 2)}{75} = \frac{565}{75} = \textbf{8 containers}$$

(rounded up from 7.53)

A general Kanban rule is to always round up to determine Kanban size or the number of containers that will make up the Kanban.

Product With Variable Order Size:

- Determine time frequency for shipments and agreed upon normal size (might or might be greater than average size order) order to be shipped
- Determine highest level of demand for order and frequency demand is greater than agreed upon normal size.
- Determine Takt time for meeting that highest level of demand using standard lead time.

Tt = Takt time
nP = Number of Parts that can be made in determined shipping window time
SLt = Standard Lead time

$$Tt = \frac{nP}{(SLt)}$$

Deterimine if Takt time can be reached using existing resources. If not, determine amount of lead time needed to be able to meet highest level of demand.

Have customer agree to provide notification in window prior to lead time in order to meet highest level of demand. If customer agrees, keep Kanban size at normal pull level and deal with additional demand by additional pull signals from shipping.

If customer cannot provide prior lead time notification determine how much additional material would be needed to meet highest level of demand. Determine how much material can be built in production window between pull signal from customer and ship date. Subtract the amount that can be built from total quantity needed and use that as kanban size. Make the difference as safety stock. Get agreement from customer that they will purchase all safety stock.

Kanban size = Amount possible to make during production lead time
Safety Stock = Highest Demand – Amount made during order to ship lead time.

Example:

In one company that makes rakes used in waste water treatment plants, one user of a particular rake had extremely variable demand because rakes were used as replacements during routine maintenance and also for emergency repairs. Routine maintenance resulted in an average 200 rakes a month, plus or minus 50. Emergency repairs had increased order numbers up to 650.
Lead time to make 250 rakes was 2 weeks. Orders were usually monthly. The average Kanban size agreed upon was 650 because the customer decided that if an emergency occurred that used up all of the rakes they wouldn't be doing any routine maintenance for at least a month after, allowing the company to rebuild

most of the Kanban stock. The customer agreed notify the company three months before hand if the rakes would be discontinued and to cover the cost of any material left in the Kanban.

Product With Intermittent Time Pull:

If orders are more frequent than 8 times a year, use either of the above processes based upon steady or intermittent quantity demand. If orders are less frequent, establish work as a CONWIP System rather than a Pull System.