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Title: Kanbans for a Non-Repetitive Manufacturing Operation

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KANBANS FOR A NON-REPETITIVE MANUFACTURING OPERATION

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Kanbans for a Non-Repetitive Manufacturing Operation

Abstract:

To maintain manufacturing competiveness, companies are looking to new manufacturing techniques to reduce cost and improve quality. One such method is the use of kanbans to limit the amount of work-in-process. Limiting the amount of work-in-process will increase a facilities throughput time, flexibility, and quality. This paper looks at how a kanban could be implemented in a personnel computer manufacturing facility, and the reasons and expectations for the implementation.

Introduction:

Circuit board assembly at many manufacturing facilities could typically be defined as a push type manufacturing system. The factory was divided up into workcenters and each workcenter was independently scheduled. Orders were released to the first manufacturing process and after the operation was completed, the workorder was pushed to the next process step. At each workcenter, the highest priority workorder was processed and again pushed to the next workcenter. Several product flow problems were continually occurring within the facility, including excessive product throughput times (an average five day product throughput time with an average product labor standard of 3 hours), a system which was unable to respond to forecast changes, and excessive in-process inventory (which many times required rework).

In an attempt to resolve some of the above issues, manufacturing decided to move toward implementing a just in time production system to reduce the amount of work in process, and to increase the product throughput times. While implementing JIT involves many aspects of the production process, one of the major tasks was to develop a system to make the board flow in the factory more efficient. The main method selected to accomplish this was the use of kanbans. This paper will focus specifically on developing a kanban system for the circuit board manufacturing facility with the focus specifically being to reduce the amount of work in-process, and to increase the product throughput times.

Factory Overview:

Figure 1 shows the PC production facility in which the kanban system will be applied. The factory consists of 11 workcenters: material prep, SMT primary, autoinsertion, SMT secondary, wave solder, robot assembly, final assembly, ATE, STBL, debug, and packaging. PC boards can enter the factory in three possible locations, depending of the type of components on the board. Possible routing schemes are also detailed in figure 1.

- o Location 1 is for boards containing primary side SMT components. Those boards go through the primary side SMT line then skip autoinsertion and go directly to the secondary side SMT line.

- o Location 2 is for boards which contain no primary side SMT components which are substituted for the older style leaded components. These boards enter at the autoinsertion workcenter.

- o Location 3 is prior to final assembly. It is used for previously built boards which require an engineering change.

The factory is considered a non-repetitive process since each product does not require the same assembly sequence. Of the four assembly processes (SMT primary, Autoinsertion, SMT secondary, and manual), there are four different assembly combinations used, depending on the product requirements. The product flow in figure 1 represents 90% of the possible factory routing schemes.

Kanban Overview:

Push vs Pull:

A push system can be characterized as a system where workorders at each process step are scheduled, meaning workorders are released to the factory floor based on the flow time it will take the order to reach the final workcenter. Production and inventory control is based on the forecasted value[1]. The workcenter performs the work in the order of schedule priority. The output is stored and consumed as required by the proceeding processes. The workcenter continues to process orders as they are received and push them through their workcenter. No consideration is given to the amount of upstream inventory.

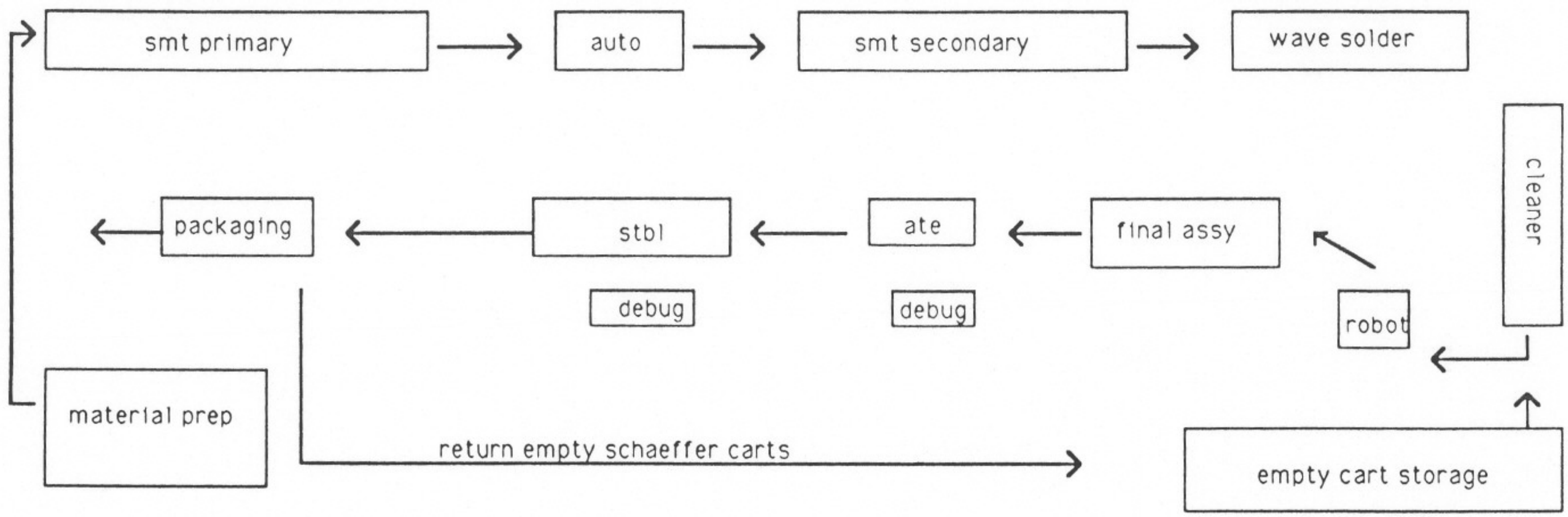
smt primary
auto
smt secondary
wave solder
cleaner
packaging
stbl
ate
final assy
debug
debug
robot
material prep
return empty schaeffer carts
empty cart storage

figure 1

The problems generally seen with the push system are:

- o A system which is unable to respond to changes in the production schedule, because of excessive inventory clogging up the factory[1]. To change the schedule, other products must be put aside and delayed. A push system encourages excessive safety stock to be produced to limit the effect of the changing schedule.

- o Push type manufacturing creates longer manufacturing lead times[1]. While manufacturing personnel will typically complain about the marketing forecast changing, one of the main problems is long manufacturing process cycles. The longer the cycle, the more likely the prioritized product list will change[2].

- o The push system provides an environment for hiding problems[3]. With the push system, the workcenters are always busy. Being busy could consist of building production or trying to solve a line problem which is preventing production from occurring. A supervisor or manager can not really tell the difference. With the push system, production continues while major problems are being resolved, so factory line problems are not highlighted.

Pull System

While the push system can best be described as a workorder processing system where the next workorder is determined by what is at the entrance to the workcenter, the pull system can best be described as a system where what's going on at the end of the workcenter controls what is processed next and when. The pull system does both the workorder scheduling and controls the amount of work in process in the facility. Additional workorders will only be processed at a rate equal to the rate at which they are consumed by the proceeding process[1]. Pull systems mean that material is drawn or sent for by the users of the material as needed[3]. The authorization to build additional workorders comes from the succeeding process. This means only the final assembly process needs to know the production schedule. They pull work from the proceeding processes, which causes a chain reaction of work in all proceeding processes[1]. The pull system eliminates the traditional shop floor scheduling task for every machine[1]. The pull system was best summed up by a foreman at General Motors who said: "You don't never make nothin' and send it no place. Somebody has to come get it."[3]

Work in process is controlled by limiting the amount of work between process steps. Since the authorization to build products can only come from the seceding process, and if additional product is not required downstream, no additional inventory will be build. Even if material is available to be assembled at the entrance of the workcenter, it will not be built. The authorization of what to build and when must come form the seceding workcenter.

The goals of the pull system are:

- To prevent excessive inventory from building up between processes to simplify the inventory tracking system[2].

- To prevent the fabrication of additional work orders without proper authorization[3].

- To transfer the job of production control to the people on the shop floor and to promote immediate visibility of problems to the direct, hands-on people who can best tale immediate action to resolve[3].

Kanbans Role in the Pull System:

One of the important keys in implementing a pull type manufacturing system is the use of kanbans. Kanban is a term developed in Japan at the Toyota manufacturing facility, and is defined by them as an information system that controls the production of the necessary products in the necessary quantities at the necessary time in every process of the factory[1]. Simply stated, a kanban is a communication tool which says produce what you need just when you need it[2]. Kanbans are an authorization to do something, either move material to a workcenter or build additional inventory. Kanbans are typically used were demand is sufficiently constant and a production schedule is frozen for a certain period of time[1].

The advantages of kanbans are:

- o A simple and inexpensive method to control product movement through the factory. Product moves only when it is required by the seceding process. Scheduling is done at the final assembly stage only[1].

- o Provides a simple, visible, enforceable means to limit the inventory on the shop floor[3]. The number of kanbans on the shop floor equals the amount of work in process. Since every order must be contained to a kanban, the maximum work in-process allowed is set an known level. The amount of inventory in process also becomes visible. Since the filled kanbans are always stored at a required location, by just walking through the factory someone can determine the amount of inventory in the factory.

- o Exposes problems in manufacturing[4]. Since inventories are held to a low level, if a workcenter goes down, upstream processes will be forced to stop production as kanbans fill up. Kanbans will highlight processes which require management attention. Since the kanbans are visual items, they also allow production problems to be obvious to everyone.

- o Replaces more complex shop control and scheduling techniques[1]. No longer does every workcenter need to be scheduled. The final assembly schedule will force the required work into the required areas.

Their are several types of kanbans, the most common being the one or two card kanbans. No mater what type is used, the key point to remember is that the purpose of the kanban is to limit the amount of inventory stored between two process steps. Another type of kanban, the one being proposed for our facility, is the kanban square. The kanban square operation is shown in figure 2, and consists of marked locations on the floor where a certain amount of inventory is allowed to be stored[4]. In figure 2, there is one kanban square after a process and one prior to the next process. This allows only three kanban containers to move within one workcenter. After a workorder leaves workcenter 2, the empty kanban container will be returned to the kanban square prior to the workcenter. If the kanban prior to workcenter 2 is filled, that workorder will then be brought into the workcenter 2. Assuming workcenter 2 has the authorization to build (an empty kanban at the exit), work will begin on that workorder. If the kanban container post workcenter 1 is full, the two kanbans between workcenter 1 and 2 will be swapped. This will leave a empty kanban post workcenter 1, giving workcenter 1 authorization to build product. Workcenters can only build when an empty kanban exists. Without an empty kanban, the workcenter stops production and works on cleaning up the area, maintenance, or process improvement projects. The kanban square option was chosen because of the close proximity of the workcenters. With the distance between the workcenters being only 10 feet, a more elaborate card system is not required. The kanban squares are a good visual method of determining the inventory between workcenters and greatly simplify the operation procedures[2].

Operational rules of a kanban:

- o The subsequent process should withdrawal the necessary products from the proceeding process in the necessary quantities at the necessary point in time. Meaning, produce only when needed by a succeeding process. Production without authorization from the succeeding process is not allowed[1].

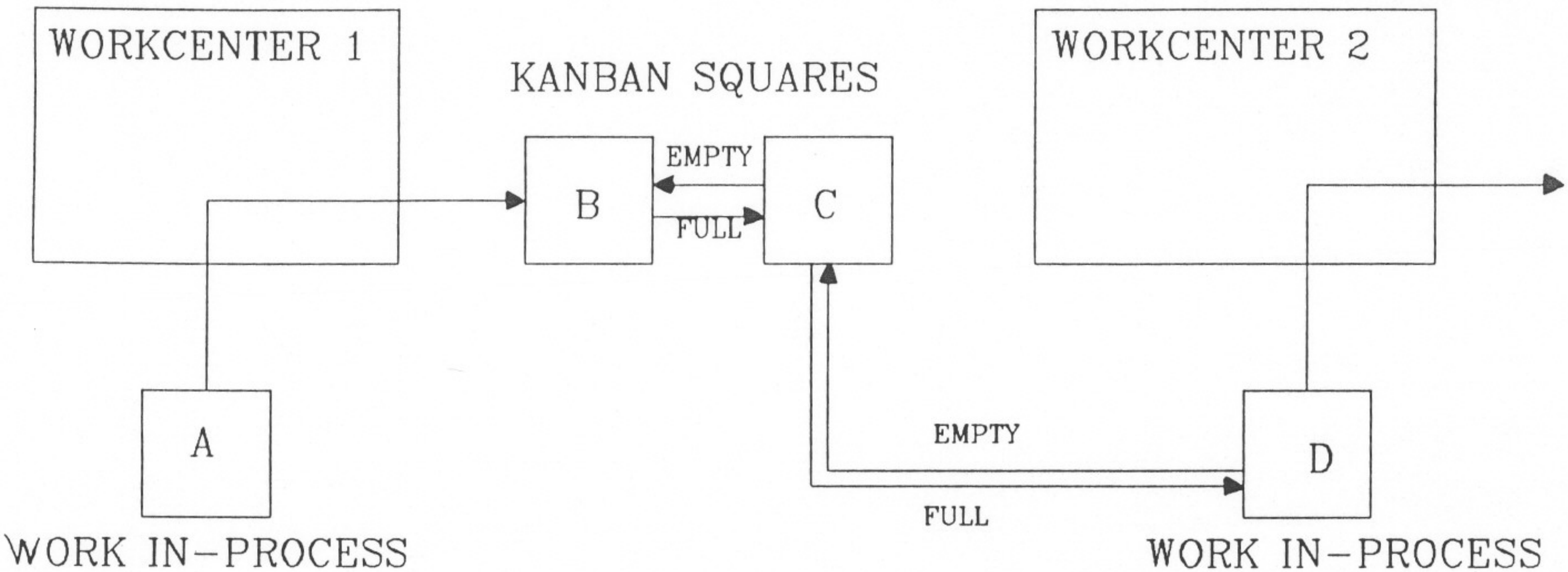
WORKCENTER 1
KANBAN SQUARES
WORKCENTER 2
EMPTY
B
C
FULL
A
EMPTY
D
FULL
WORK IN-PROCESS
WORK IN-PROCESS

FIGURE 2

- Everything has a place and is in place[4]. Kanbans allow for visual tracking of inventory. It also requires that all work in process be in the required location. When the preceding process comes to get work, it needs to be stored in the proper location. Kanbans force good housekeeping.

- Never pass a known defect[4]. Kanbans by design are supposed to highlight problems in the factory. By limiting the work in process and not allowing defects to be passed to the next process step, it forces problems to be solved immediately. No longer can they be hidden by excessive inventory. Problems must be corrected quickly with root cause fixes to prevent them from happening again.

- Continue to drive a reduction in the number of kanbans[4]. The lower the number to kanbans the faster the throughput time for the product, and the more efficient the process will run.

Determining the Size of a kanban:

The number of kanbans and the size of the kanbans sets the work in process upper limit[4]. The number and size of kanbans in the factory is determined by the product throughput time you want to maintain. The longer the throughput time that can be accepted, the greater number or size of the kanban. The equation for determining the total inventory which should be in process is[4]:

Total work in process = (throughput time X rate per day)
+ (safety time X rate per day)
+ (lot size)

For example, if a factory required:

2 days throughput time

500 boards per day

Safety stock of 0.25 days

Lot size of 100 boards

Using the kanban equation, the maximum total number of boards in process would equal 1225 boards (1000 + 125 + 100.) There are many kanban sizing equations available. Each equation is closely related in that they all use a production rate and safety factor as a variable. Each equation does have slight variations, and the one above was selected because it focused on sizing the kanban to obtain a certain throughput time. Also, this number is only a recommendation. At the Toyota manufacturing facility, the size of the kanban between two processes is determined by the supervisors. They determine the size based on some human judgement and past history[1]. They also are chartered with continually decreases the size of the kanban.

To determine the number of kanban containers, take the maximum number of boards to be in process and divide by the capacity or number of boards you want in the kanban container. If the container could hold 20 boards, then the total number of kanban containers would be 61 (drop 5 boards). This is generally considered a starting point for figuring out how many kanban containers are required.

Application:

Figure 3 shows the PC production facility again with the kanban squares added to the drawing. Each kanban cart holds up to 20 individual boards. If we assume the example shown above, the work in-process limit would be 1220 boards or 61 kanbans containers. The actual number of kanban containers between the workcenters was determined by the individual workcenters. The workcenters were responsible for setting the inventory level

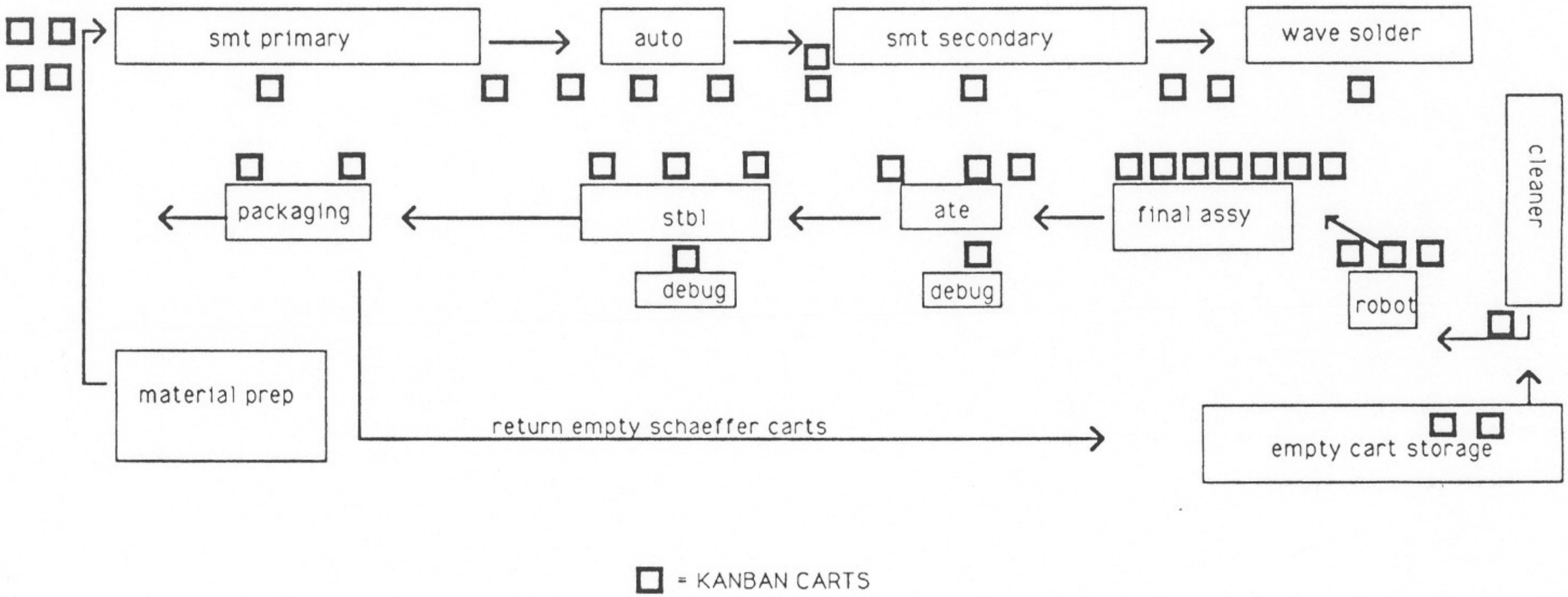

FIGURE 3 KANBAN LOCATIONS

based on not only the replenishment cycle of an average product, but also a safety factor based on the uptime of the process. The MRP system was also used to determine which processes were typically the factory bottlenecks. The SMT secondary side process is normally the bottleneck in the factory. Because of this, one additional kanban square was placed prior to the workcenter to add an additional safety against upstream variation. To maintain consistency, it was decided not to change the number of kanban containers between workcenters monthly, based on the factory bottleneck. To simplify the process, the bottleneck was determined based on the 6 month forecast, and the kanban square location was determined accordingly. When the workcenters input to the number of kanban squares were compiled, only 32 of the 61 kanban squares were allocated. After several reviews with the teams, only 6 additional kanbans were added. It was decided to pilot the system with only 38 kanbans and adjust the number as required.

In getting management to agree to implement the kanban system, one requirement given was to limit the downtime of the component assembly equipment (workcenters 2, 3, 4). This was done to appease a management concern for lost capacity. While the idea of the kanban was to prevent the build up of work in process, management also wanted to insurance that equipment would not go under utilized. Additional kanban squares were placed prior to SMT primary and certain sequence rules were developed to focus on maximizing the utilization of the assembly equipment.

The system developed would not be considered the classical pull system. Workorders are pulled from kitting based on a production committed delivery schedule. Based on that schedule, workorders are queued up prior to the SMT primary workcenter. Workorders are pulled from this queue and then actually pushed onto the floor based on the availability of an empty kanban square. The workorders move through the system as fast as possible with the pull system being used to control inventory. This is referred to as a generic kanban system[4], where each workcenter does not have each product in various stages on assembly, instead all products are considered the same.

One important aspect of implementing a kanban system, which has not yet been addressed, is limiting the setup time of the assembly processes. The component assembly workcenters (2, 3, and 4) have a setup time ranging from 0.5 hours to 2 hours. A program to aggressively reduce this time is currently ongoing. The long term success of the kanban system relies on quick setup times[2].

Rules for the kanban operation:

- There is only one entry into the factory pipeline which is from materials (kit pull) to SMT primary. This means that even product entry point 2 and 3 have been eliminated. This intentionally turns the factory into a repetitive process where kanbans can be used more effectively. Even though the product will not be worked on at SMT primary, it will still move through the workcenter. This was done to ensure that the delivery schedule of 2 days would always be met. If products were allowed to enter at different places, it would stop the upstream processes because of lack of an available kanban container, and increase the product throughput time. Currently, the plan is to have the product physically move through the non-required workcenters. As the implementation becomes accepted, this requirement most likely will be dropped and turned over to scheduling.

- If a workcenter has no workorders to process, the operators will move upstream to determine if they can help in moving the work along. If no available kanban square exists, the operator will move downstream to help remove the bottleneck.

- Only one workorder is allowed per cart. Workorder size is a maximum of 20. Large kit sizes of the same product are welcomed to reduce setup times, but need to be broken down into multiple workorders of 20 to allow for product flow.

- o Red cones will be used to identify empty kanbans.

- o The maximum number of kanbans in the factory will total 38. Everyone is responsible for continually trying to reduce the number of kanbans between workcenters.

- o For the assembly operation, boards will be transferred from a full container to an empty one. Thereafter, boards will remain is the same container.

- o On the assembly process, boards can move without the container being full. The pulling of individual boards in acceptable up to wave solder. From there, product movement will be in full container increments only.

- o Work can only be pulled ahead of another product on the line if it does not impact the flow of the product being "leap frogged," and work can begin immediately. For example, when the autoinsertion area is calling for work while the SMT primary side workcenter is setting up for a kit. If the kit can be processed before the SMT primary side line begins to produce product, then the kit can be processed. But, before they pull the autoinsertion kit in, the operators should see if there is anything they can do to help the SMT primary side operators to facilitate the setup.

- o Remember the focus is on moving the product as fast as possible, not local optimization of the workcenters.

Conclusions:

As the term "global economy" begins to effect more and more manufacturing facilities, companies are being forced to change from the typical manufacturing processes, to more efficient processes. Companies are now focusing on aggressively pursing methods which can continually decrease cost and eliminate waste. This paper looked at using a kanban system as one method for increasing the efficiency of a PC manufacturing facility. The goals of implementing the kanban system were to decrease the product production cycle from 5 days to 2 days, to allow the facility to respond better to forecasting changes, and decrease the work in process inventory. The system developed meets each one of these objectives and is just starting the implementation process.

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