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Kitting Trolley for TCF Line

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Abstract- One of the key decisions for every assembly line is the decision about the materials feeding system which means the method of supplying materials to the operators. This decision affects all of the other activities performed as well as the performance of the assembly line. In the industry, kitting is practiced as a method of materials feeding among others such as continuous supply, batching and sequencing. Kitting is the name for the practice of feeding components and subassemblies to the assembly line in predetermined quantities that are placed together in specific containers.

Index Terms - Kitting, Assembly Line and Space requirement.

1. INTRODUCTION

In today's competitive world, an important concern for the manufacturing companies is to increase their customers satisfaction by constantly improving their delivery yet to keep quality at its best level. Meanwhile, they need to keep their costs and prices as low as possible to be able to compete with others but still increase their profitability. In the literature, numerous researchers mention that in order to achieve this, a company should have a very good control on its production systems and look for improvements wherever possible. Practices show that vision is as important as action to have the best control on the production system. One should have a strong vision and clear idea of its future goals to establish the most effective production system. Lean philosophies are seen as this revolutionary change in the mindset, which manufacturers in the search of perfection are thirsty of, with its effects to the actions as well as to the visions. Lean philosophies help companies not only to control their production but also help them to combine the improvements in operational and commercial aspects and manage them to find the way that provides long-term business success and the employee capability to continuously propel that company to further improvement.

In the industry, materials feeding decisions are really important since they enable a manufacturer to increase the control and affect the overall efficiency of its production system. Kitting is practiced as a method of materials feeding among others such as continuous supply, batching and sequencing. The practice of delivering components and subassemblies to the shop floor in predetermined quantities that are placed together in specific containers is generally known as kitting. Rather than delivering the required parts to an assembly station in component containers and in relatively large quantities, parts can be first pulled together in kit containers before they are delivered to the shop floor.

Kitting shows numerous benefits in all of five tracks if applied properly. Drawbacks of kitting are mostly caused by wrongly prepared kits, kitting too much or unnecessary parts. It is important to include all five of these aspects in business cases before the implementation of kitting, otherwise kitting activities are likely to cause further problems. The main reason for kitting in Swedish industry is the space requirements. Most companies are aware of other benefits such as quality and learning aspects but are not considering them as their most important reason to initiate kitting activities. Companies are also hesitant to initiate kitting since it is an expensive solution compared to other solutions. The biggest limitation of kitting seems as increased number of materials handling and the uncertainty about the level of kitting. Past experiences made companies more hesitant about kitting implementations. Kitting in a lean production system is possible as long as kits are secured so that they are 100% correct in the first place and there is no machine downtime caused by invalid kits. Additionally, waste should be continuously eliminated from kitting operations and workers should be trained well to get involved with the processes.

A template aimed at facilitating the evaluation of sequenced and kitted articles was created taking previously presented results from the analysis into consideration. The conclusion from this master thesis is that kitting is a more beneficial material feeding principle compared to sequencing via a 3PL. It is recommended that as many articles previously supplied with sequencing should be transformed into a kit flow as long as the article qualify to meet the different limitations which involves kitting considering actual load carrier for kitting, article characteristics and space requirements

Cultural differences are also observed in between the Japanese way and Swedish way of applying kitting activities. I Swedish context, lack of space is seen as the main motivation for applying kitting. However, in Japan and China it is more often used as a tool to improve quality, and even as a work instruction to improve learning. Picking is the activity of moving a product from the storage to packing and linked to an actual order. Picking time and accuracy are then very important process because they directly affect the lead time. Order picking activities define the method how to feed the assembly line and therefore they are very crucial for any assembly line. The main difference of order picking activities between different production systems are characterized by variables such as ordering frequency, acceptable delivery time and order structure. All of these variables have an effect on the overall efficiency of the assembly line. Kitting, when applied properly, has been observed to show numerous benefits for the assembly line. Since kitting involves the gathering of all parts together from the stock, and placing the "kit" to the assembly line, it involves a lot of possible sources of waste. From a lean philosophy point of view, this is worthwhile to think about to find out how the ways to lean kitting are possible.

2. BASIC PRINCIPLES

2.1. *Just-In-Time*

Just in Time production is one of the walls that built House of Lean and is based on a pull system. Pull means to produce only when there is a customer order. The opposite is push, and means producing even if there is no demand for it.

JIT production follows four simple rules:

- Don't produce something unless the customer has ordered it
- Level demand so that work may proceed smoothly throughout the plant.
- Link all processes to customer demand through visual tools
- Maximize flexibility of people and machinery.

The components of a JIT system are:

2.2. *Kanban*

Is a system of visual tools that synchronize and provide instruction to suppliers and customers both internally and externally

2.3. *Production levelling*

The goal is to produce at the same pace every day so as to minimize the variation in the workload and supports quick adaptation to fluctuating demand.

2.4. *Jidoka*

The other wall which builds House of Lean is Jidoka. This term has been defined by Toyota as "automation with a human mind" and implies intelligent workers and machines identifying errors and taking quick counter measures.

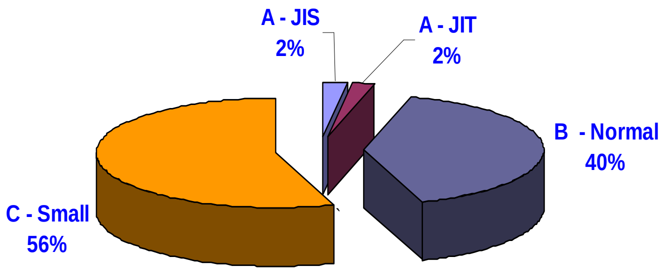

Fig.1. Classification of Materials on Assembly Lines

2.5. *Error proofing*

It states that high defect rates caused by the errors in production lead to frequent line stoppages, which make flow and pull, and therefore lean production impossible.

There ten different types of errors:

(1) Forgetfulness
(2) Errors due to misunderstanding
(3) Errors in identification
(4) Errors made by amateurs
(5) Wilful errors
(6) Inadvertent errors
(7) Errors due to slowness
(8) Errors due to lack of standards
(9) Surprise errors
(10) Intentional errors

Fast, flexible and the flow is the basis for lean in manufacturing. Companies who are able to combine them in the best way can enjoy huge productivity and quality gains simultaneously. Fast, flexible and flow is the vision which lean requires going for waste reduction and continuous improvement. It means breaking down the barriers between traditional departments. It also states that Fast is very important because speed is at the heart of lean as

"All we are doing is looking at the time line…from the moment the customer gives us an order to the point where we collect the cash. And we are reducing the time line by removing non value added waste"

In lean philosophy, the main focus is on economies of time, not on the economies of scale. Sufficient speed can be seen as an order qualifier but speed is increasingly an order winner.

Customers are often prepared to pay a premium for fast delivery. Besides, when producing fast becomes the goal it leads automatically to waste reduction, to improved layout, to reduction of over production, to closer working relationships, to better quality, to smaller batches, and to value stream thinking. Flexible is also very important for lean, because it holds key to answer market need as quick as possible and to gain competitive advantage. Today, Toyota by the use of lean philosophy has the flexibility advantage compared to its western competitors. By making subtle changes in the mix of vehicle models in the production schedule, Toyota can adjust its production output to meet rising or falling customer demand yet keep plants running at full capacity. In that sense, western companies are far less flexible and the consequences are idle plants, too much inventory or lost sales. Flow is also very important in lean. It means working steadily at the customer rate, not hurry up and wait as in batch and queue, or concentrating on the value adding seconds whilst ignoring non value adding hours. Going for flow means not only competitiveness through more satisfied customers but also greater productivity through reducing the wastes of waiting and inventory.

3. MATERIALS FEEDING SYSTEMS

One of the key decisions for every assembly line is the decision about the materials feeding system which means the method of supplying materials to the operators. This decision affects all of the other activities performed as well as the performance of the assembly line.
The three principles of materials feeding system for an assembly line which are batch supply, continuous supply and kitting. These principles are categorized with regard to two main variables .

- · Whether a selection or all of the part numbers are displayed at the assembly station
- Whether the components are sorted by part number or assembly object

3.1. *Continuous Supply*

It is define as continuous supply as the case where material is distributed to the assembly stations in units suitable for handling and where these units are replaced when they are empty. Bulk delivery of the materials is the usual way of materials feeding. Every different part number is supplied to the assembly line in an individual container. The most significant advantages of this way are that no pre processing of the parts are necessary and the continuous availability of stock at the assembly line. In the case that one part is missing or defected, assembly operator can easily pick another one from the container. However, there are some disadvantages too. If there are an excess number of parts to be assembled it means a lot of capital is tied up in stock, shop floor is becoming overcrowded by the parts, and the assembly operator has to move a lot to get the parts and loses time looking for the correct part numbers.

3.2. *Batch Supply*

In batch supply systems the material is supplied for a number of specific assembly objects. The batch of materials can be a batch of the necessary part numbers or a batch of these parts numbers in the requisite quantities.

3.3. *Sequential Supply*

It is define as sequential supply as the supply method that part numbers needed for a specific number of assembly objects are displayed at the assembly stations, sorted by object. The main motivation for sequential supply is the fact that if the product is assembled on a serial line where only a few components are assembled at each station, kitting is less advantageous since it will require a lot of extra materials handling to prepare different kits for each station. The sequencing process can be located within or outside the assembly plant which means that the materials feeding principle can differ between the assembly station and the supply chain. This is also true for the other materials feeding principles.

3.4. *Kitting Systems*

The practice of feeding components and subassemblies to the assembly line in predetermined quantities that are placed together in specific containers is known as *kitting* in the industry. For discussion purposes, a kit may be generally viewed as a container which holds a specific assortment of parts that are used in one or more assembly operations in the plant. In kits, all items are presented in a logical order so they can be removed from the container as quickly as possible without damage. It is important to keep it simple and the kit itself is structured or laid out in a predetermined and effective way. The type of components and subassemblies required for each kit type is given by the kit structure. Kit assembly is an operation where all the components and/or subassemblies that are required for a particular kit type are physically placed in the appropriate kit container. Conceptually, kit assembly is an order picking operation. Kit assembly is commonly considered as a non-productive work

	Selection of part numbers	All part numbers
Sorted by part number	BATCH	CONTINUOUS
Sorted by assembly object	KITTING	

Fig.2.Classification of Material Feeding System

Fig. 3. Model of Kitting Trolley full with Material

However, some researcher's states the assortment of components could itself be viewed as value adding since it improves prerequisites for the assembling operator. Kit assembly can be performed by pickers or by the assemblers themselves. Further, the picking can either be performed in a central storage or decentralised areas located close to the assembly area, so called materials markets. Two types of kits were observed by which stationary kits and travelling kits are. A stationary kit is delivered to a workstation and it remains there until it is depleted. The product which is assembled moves from one station to another. A travelling kit is handled along with the product and it supports several workstations before it is depleted. There are also two types of travelling kits. In the first type, the kit and the product travels in the same container as product is assembled. In the second type, the product travels in one container and the kit follows it in parallel in a separate container. A kit typically does not contain all the parts required to assemble one unit of the end product due to the complexity or product size. Besides, certain components such as fasteners, washers are almost never included in kits, instead bulk delivered to the shop floor.

Kitting can be performed in-house or by the supplier at lower hourly cost. However, the lead time will increase due to the transport from the supplier to the production line. Since the kits are often supplied in the correct sequence of the production schedule, this will complicate the job of supplying operator. Besides, the distribution of kitting activities over several suppliers sometimes leads to suboptimal installations and largely manual operations

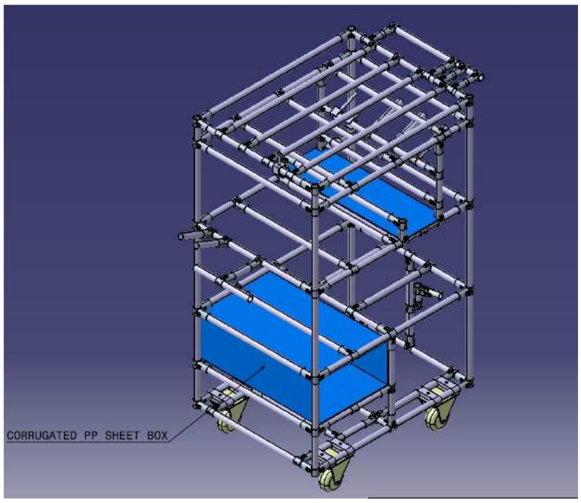

Fig. 4. 3D Model of Kitting Trolley

4. REASONS FOR KITTING

In the search for more efficient and flexible production systems together with the possibility of better work conditions, highly parallelized assembly systems with long cycle times have been developed. Generally, product lines require more and more part numbers due to a growing diversity of variants. One disadvantage with these parallel and long cycle time systems is their complicated materials feeding. Therefore, kitting systems have been considered and developed. The reasons to use kitting still look somewhat not well understood and controversial in the literature. It state that proponents of kitting point out that it gives the user better control of WIP, and helps reduce floor space. On the other hand, opponents' claim that the man-hours consumed in the picking process is non-productive labour and that kitting is used primarily to conceal poor manufacturing operations management. In parallel assembly systems, more part numbers must be exposed at every work station compared to serial assembly. This leads to a lack of space when continuous supply is used. Moreover, the number of storing areas for a part number will be increased since every part number is supplied to several parallel stations instead of one station. In this situation, with the use of continuous supply administrative problems occur. Besides, problems about flexibility occur which result in large amount of tied-up capital in the storage and in the production system.

- When a large number of variant components demand a large floor area in the assembly system.
- For minimising the risk of assembling the wrong component

From a product flow point of view, parallel flow and long cycle time assembly systems might look confusing to the engineers who wants to smoothen the flow of products and components within a plant, since the product flow in this type of plant does not mirror the actual assembly work. Since the operators constantly move around the products and alternate between the products and subassembly stations, the work pattern only mirrors the assembly work but not the product flow. Therefore, an important reason for kitting is the product description aspect. A basic principle is that the materials kit should function as a structured puzzle which is an assembly instruction enabling the operators to monitor their work. By this way the operators 'assembly work is supported. The theory about parallel flow and long cycle time assembly systems has been focused mostly on efficiency and organisational aspects. Arguments underlined are that increased job enlargement, through long cycle time assembly work, combined with parallel product flows, enables job enrichment and autonomous workgroups. However, merits in the form of flexibility are also becoming more and more important due to shorter product life cycles, increased product variation and shorter lead times.

5. MAJOR BENEFITS OF KITTING

In the literature, numerous advantages for the usage kitting are mentioned. Many of them are repeated by more than one researcher. For the purposes of this research, it was found beneficial to group them under previously mentioned five tracks. Here, it is worthwhile to mention some benefits can be thought for more than one tracks, for example the elimination of searching time can be thought as a benefit both from a materials handling point of view and also from a learning point of view since it will cancel some of the required training for the order picker. These benefits all together can be seen as a table in the appendix section.

5.1. *Benefits to solve space problems*

(1) Saving space in the work stations, if the materials were supplied in materials containers, i.e. tote pans, with numerous identical components in the same container, this would have resulted in an enormous plant.
(2) Savings in manufacturing space and a better organized shop floor.
(3) Inventory costs could be reduced due to integrated storage and assembly.

5.2. *Benefits to solve quality problems*

(1) Parts could be damaged lying idle in open packages.
(2) Safer use of components that are similar in appearance.
(3) Components can be presented in sequential or assembly order in special packages that ensure correct assembly.
(4) Kitting ensures that the latest bill of material is used.
(5) High value components can be secured in kitting package.
(6) Early identification of low quality components.
(7) There will be less damage in the transportation process.

5.3. *Benefits on materials handling*

(1) Reduced material handling, instead of sending single parts, a collection of parts will be sent to the assembly line.
(2) The elimination of searching time. Order pickers do not need to search for the required parts, since all parts are in single kit therefore increased productivity.
(3) Better control over WIP, the parts of existing kits provide immediate information regarding the WIP level, since each kit consists of a predetermined quantity of parts.
(4) It could be ensured that all components are available prior to scheduling work.
(5) Better control of material flow.
(6) When kits are standardized, this offers an opportunity to implement robotic handling.

5.4. *Benefits on flexibility*

(1) The assembly areas could become more flexible and free from leftover components.
(2) If traditional materials feeding through line stocking is utilised in parallel flow assembly, control of the number of components to store, replenishment, and the numerous design change orders will be complicated to administer and handle.
(3) Improved control over and better visibility of the flow of components on the shop floor. As a consequence part availability will also better besides product changeover can be easily accomplished.
(4) Less work-in-process at the work stations, and consequently shorter lead times.

5.5. *Benefits on learning*:

(1) Kits are easier to learn for assembly workers which leads easier training lower learning curves and also reduces the training cost.
(2) Using the materials as work instruction.
(3) Complex products can be overviewed and be understood.
(4) It would be easy to notice if a component is missing, given that the kit package is properly designed.

6. MAJOR DRAWBACKS OF KITTING

It is crucial to mention the drawbacks of kitting concept to be able to give an unbiased representation. The major drawbacks which were mentioned in the literature are as follows:

(1) Preparing the kits requires some time and effort which is a non value adding activity (waste) · Kitting is likely to increase

in storage space requirement, especially when kits are prepared in advance. · When different kits contain common parts, an assignment of available parts to kits needs to be done.
(2) Temporary shortage of parts will decrease the overall efficiency of kitting.
(3) Spare parts might be needed at the assembly line in the case that a part in the kit is wrong or defected; otherwise the production will be disrupted.
(4) Components that may even fail during the assembly process will require special consideration or exceptions.
(5) If parts shortages develop, some kits may get cannibalized. That is, short parts may be removed from some of the existing kits. This may further complicate the shortage and it may lead to problems in parts accountability.
(6) An increased number of handling occasions increases the probability of damaging the components, therefore not all components are suitable for kitting.

The rules how to use the complete kit are threefold:

(1) Do not start assembly unless the kit is complete. Assign one person as the gater to be in charge of the complete kit and gater's tasks are defined as follows:

- ·Making sure that only the jobs that need to be produced according to the schedule will be released.
- Auditing the batch sizes and ensuring that only small lots that conform with the demand will be released.
- Monitoring the buffers on the floor. Once the buffers are full, he should not release more WIP to the floor.
- Making sure that only complete kits are released.

(2) If the process / assembly or subassembly time exceeds 50% of total lead time, the levels of assembly should be redefined.
(3) All entities needed to complete the process are included in the kit. The fact that working with a complete kit is being significantly important indicates there should be some problems working with an incomplete kit.

7. ANALYSIS AND CONCLUSION

Kitting as a method of materials supply to the assembly line is generally observed as a good solution for the industry whenever there are problems about space, quality, materials handling, flexibility and learning due to high number of variants. However, it is also a demanding and expensive solution. Companies prefer considering it as their last solution due its high amount of cost. In the industry, kitting is used in combination with other materials supply methods such as line stocking, batching and sequencing. Experiences show that kitting everything is not a good idea. There is a breakeven point where kitting is at its best and after that point more problems occur due to increasing complexity. Furthermore, some certain parts should not be ever included in the kits. These are small parts like nuts and bolts, washers and also certain sensitive parts with quality issues.

7.1. *Space*

As supported by all researches and professionals from the industry, kitting is used as a very useful solution when there is high number of variants demand a large area around the Assembly line. Space problems seem the only and most important reason for applying kitting. All interviewed professionals were agreeing on showing space issues as their main reason. Furthermore, as in the case of Volvo Cars, although they had a past failure caused by too much kitting, today kitting is still a hot topic for them. The reason is simply the space concerns.

7.2. Quality

In the literature almost all researchers mention benefits of kitting from a quality point of view. Main benefits for quality are the reduction in the number of wrong pickings and wrong assembly by safer use of parts that are similar in appearance. Although, it doesn't seem as the most important reason for applying kitting from the Swedish industry point of view, they all are aware of the quality benefits. Still, no quality issue was shown by them as the main motivation for kitting.

7.3. Materials Handling

As previously mentioned, there are a number of benefits of kitting in materials handling area such as the elimination of searching time, better control over WIP, better parts availability, standardization of the work. These are commonly accepted by most researchers however there are different and contradictive ideas when it comes to the amount of materials handling after applying kitting. Conceptually, kitting is an order picking operation itself. The figure proves that travelling, extracting and searching time for the parts in order picking constitutes an average of 80% of the whole working time. Kitting, as a method of bringing the picking location to the picker, helps to decrease all of these non-value adding times significantly.

8. FUTURE SCOPE

- Quantifying kitting with all of its five aspects since there is a lack of modules to quantify all aspects and use them in business cases.
- Kitting of larger parts since the literature is mostly on small and medium sized parts.
- Elimination of waste from kitting activities since it s a never ending process.
- Kanban system will achieve these benefits most only when the demand from Customer is relatively

constant. However the demand from customer is not stable, varying time to time. Study on how to translate the unstable demand from customer to relative constant work flow are necessary.

- More study should be focusing on failure mechanism of machines and cross training of operators

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