Improvement in Material feeding system Through Introducing Kitting Concept in Lean Environment of MSME: A Review Study

[1]Jimesh M. Gajjar, [2]Prof. Hemant R. Thakkar
[1]Master of Industrial Engineering Research Scholar, [2]Associate Professor
[1]G.H.Patel College of Engineering & Technology, V.V.Nagar, Gujarat, India.
[1]jimaerospace05@gmail.com , [2]hemantthakkar@gcet.ac.in

Abstract—**This paper focus on the material feeding principle of kitting within in-plant material supply in mass customized assembly. With this principle, parts are delivered and presented to the assembly operations in pre-sorted kits, with each kit containing parts for one assembly object. Today many Industries are categorized by end customer demand for wide variety of products. Moreover, a large number of product variants has implications on the material flows with in the assembly plants. This require the small lot size delivery to support the production line. Since, continuous material feeding system resulted in increased inventory value, operator walk and search time, an attempt to increase production throughput is made. This research is done on the base of studying existing continuous supply material feeding system & its effect on production hindering volume growth. To eliminate certain waste, the alternative material feeding systems have been explored through literature. As per the author's point of view, lean kitting supply system resulted in reduction of line side storage space, inventory value, operator walk time, line side replenishment & overall lead time.**

***Key Words*—Material feeding, kitting, continuous supply, inventory value, lean environment, MSME**

I. Introduction

A growing number of product variants, which is reality for many assembling and manufacturing companies, often result in more part numbers. These part numbers need to be delivered to the assembly process. Delivering them in the traditional way with continuous supply and line side stores becomes a problem since the increasing number of parts demands an increase in line side storage space. An increase in line side storage space and part numbers creates longer operator walking and searching times at the assembly line. One way to decrease the line side storage space and operator walking and searching times is to deliver parts in kits. In manufacturing systems, 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". Theory explains a number of benefits and limitations with kitting, however most of the theory is found from research in parallelized assembly systems and assembly with small parts. It is therefore of great interest if these theories also apply to the situation at MSME, with assembly lines with high end product variation. Since most assembly plants are turning to the theories of Lean Production it is also of interest to see if kitting is applicable in Lean Environments.

Lean Production:

Lean Production is "A systemic approach for identifying and eliminating waste through continuous improvement by flowing the product at the pull of customer in pursuit of perfection". Today's industry has been experiencing a competitive environment and striving hard to find methods to reduce manufacturing cost, waste and improve quality. Lean production concepts are used by the industries to reduce work in progress inventories and also to reduce waste for competing in the global market. The ultimate goal is to speed up the process there by increasing productivity through a proper utilization of man and machine. Material feeding system also play a key role in influencing productivity, throughput time and cost of the product.

According to Krajewski et al. (2007) the essence of lean is to maximize the value added by each of a company's activities by paring unnecessary resources and delays from them. These unnecessary resources are also known as waste or Japanese term "Muda". Further Womack (2003) defines waste as "everything that exceeds a minimum of resources that are needed to add value to the product.

Womack (2003) identifies seven different types of waste:

- Overproduction, "producing more or faster than needed".
- Waiting, "keeping a worker idle".
- Transportation, "moving materials or products excessively".
- Over processing, "doing more than is required".
- Inventory, "excess raw material, work-in-process or finished goods".

- Defects, "repairing errors".
- Motion, "acting without adding value".

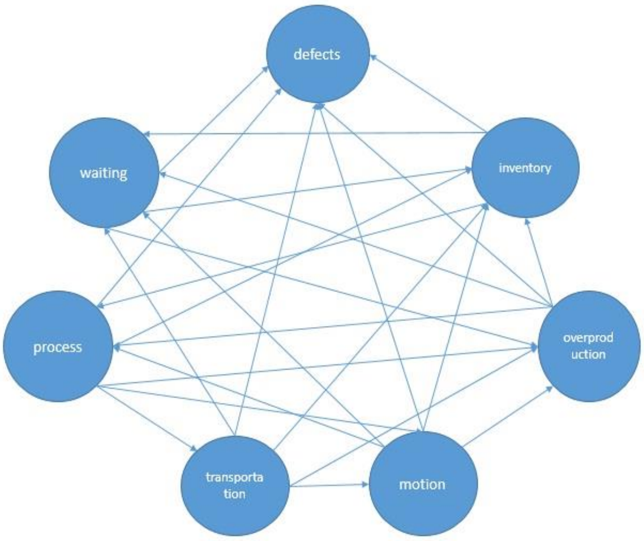

Fig-1 Interdependence of different types of wastes.

II. LITERATURE REVIEW

A. Material Feeding Systems:

Materials feeding mainly concern what principle to use for feeding the materials to a workstation or an assembly line. Johansson (1991) describe and analyses three different principles of feeding materials to an assembly station, namely continuously, batch Supply, and kitting. These are shown in Fig- 2, and categorized with regard to:

- Whether a selection of part numbers, or all part numbers, are displayed at the assembly station; and
- Whether the components are sorted by part numbers or assembly object.

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

Fig-2 Categorization of materials feeding principles

Continuous Supply

Johansson (1992) described that continuous supply refers to 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. There is no co-ordination of replacements for different part numbers. All part needed for producing every occurring product over a long period are available at the assembly station at every time. Refilling of parts at the assembly stations is often done by store men, either in station fix bins, or by some kind of two-bin system.

Batch Supply

Johansson (1991) described Batch Supply Systems as when material is supplied for a number of Specific assembly objects. The batch of materials can be a batch of necessary part numbers, or a batch of these part numbers in the requisite quantities. The first case differs from continuous supply in the sense that fewer part numbers have to be stored at the assembly station and that different part numbers are exposed at different points in time. The remaining material is returned to the store after completion of the batch of assemblies, unless it is to be is in the next batch. This job is eliminated in the latter case, but instead there is a need for counting the parts, which requires technical and administrative systems.

Sequential Supply

Johansson and Johansson (2006) stated that the explosion of product variants during the last decade in some case has made continuous supply impossible due to capital cost and lack of space at the assembly station. Further, if the product is assembled on a serial line where only a few components are assemble at each station, kitting is less advantageous. One way to solve this problem is to use sequential Supply. It means that the part numbers needed for a Specific number of assembly objects are displayed at the assembly station, sorted by Object.

Kitting

According to Johansson (1991) kitting means that the assembly is supplied with kits of components. The parts are sorted according to the assembly object; this differs from batch supply, where part number sorts parts. Kitting is further described in next paragraph.

B. Different authors view about kitting concept:

In manufacturing systems, 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". A more formal definition is described further down in the text.

According to Johansson and Johansson (1990) a kitting process is suitable for assembly systems with parallelized flow, product structures with many part numbers, need for quality assurance and high value components. Ding and Balakrishnan (1990) claims that kitting is most suitable for industries such as the electronics industry, which deals with small parts and performs assembly operations quite often, however they also say that JIT-systems dealing with larger parts also can benefit from kitting. They come to this conclusion after performing a case study at a US tractor plant that has successfully implemented a kitting process.

According to Bozer and McGinnis (1992) there are mainly two types of kitting operations: kit-to-customer and kit-to-manufacturing. The former meaning that you deliver your end product in a kit to your customer. The latter is concerned with pulling the required parts together in kit containers, which are subsequently delivered to the shop floor to support one or more assembly or manufacturing operations. This study is only considering the kit-to-manufacturing kitting operation, also commonly known as kit-to-assembly.

To understand a kitting process some definitions has to be made, Bozer and McGinnis (1992) make the following definitions:

- A component is defined as a fabricated or purchased part that cannot be subdivided into distinct constituent parts. In this thesis a component is also referred to as a part.
- A subassembly is defined as the aggregation of two or more components and/or other subassemblies through an assembly process.
- An end product is defined as the result of a series of assembly operations, which require no further processing in the current facility.
- A kit is defined as a specific collection of components and/or subassemblies that together (i.e. in the same container) support one or more assembly operations for a given product or "shop order".
- The number and types of components required for each kit type is given by the "kit structure".

C. Benefits of kitting

The following benefits with kitting have been found in theory; most of the benefits have been recognized by several authors:

- Saves manufacturing or assembly space (Agervald, 1980; Bozer & McGinnis, 1992;medbo, 2003)
- Reduces assembly operators' walking and searching times. (Agervald, 1980; Johansson, 1991; Schwind, 1992)
- Kitting can reduce or make better control over WIP at the workstations by storing primary components and subassemblies at a central storage area. (Bozer & McGinnis, 1992; Ding & Balakrishnan, 1990; Ding 1992; Sellers & Nof, 1989)
- Since the majority of components and subassemblies are not staged at the workstations, it increases the flexibility of the workstation or assembly line; product changeover is accomplished with relative ease. (Bozer & McGinnis, 1992; Schwind.1992; Sellers & Nof, 1989) Offers better shop floor control by just handling the kit containers through the assembly system instead of every component container. (Bozer & McGinnis, 1992; Ding & Balakrishnan, 1990; Ding, 1992; Medbo, 2003)
- Reduces or facilitates material delivery to workstations by eliminating the need to supply individual component containers. (Bozer and McGinnis, 1992; Ding & Balakrishnan, 1990; Medbo, 2003)
- Provides better control and visibility for expensive or perishable components and subassemblies. (Bozer & McGinnis, 1992; Schwind, 1992).
- Offers potential in increasing product quality, due to the possibility to have quality checks earlier in the value chain and the possibility of reducing the frequency of wrong parts in the end product or missing parts in the end product. (Bozer & McGinnis, 1992; Schwind, 1992; Sellers & Nof, 1989)
- By reducing search time and designing the kits in a "pedagogic" way, kitting could ease assemble and ease education of new staff. (Agervald, 1980; Ding & Balakrishnan, 1990; Toyotas new material handling system shows TPS's flexibility)
- Facilities robotic handling at the workstations by presenting an opportunity to control the exact quantity, position and orientation of individual parts placed in the kit. (Bozer & McGinnis, 1992)
- In high variety production, kitting can help balancing the line by moving away setup time from the line. (Jiao et al., 2000)

D. Limitations of kitting

Many of the authors have acknowledged the risk of having a poor kitting process might turn the benefits into limitations. For example if the kits have a high rate of missing parts or wrong parts this may lead to reduction in product quality instead of an increase in product quality.
Except for what is stated above the following limitations with kitting have been found in theory:

- Making the kits (i.e. Kit assembly) consumes time and effort with little or no direct value added to the product. (Bozer & McGinnis, 1992)
- Is likely to increase storage (not line side) space requirements especially when kits are being prepared in advances. (Agervald, 1980; Bozer & McGinnis, 1992)
- Demands additional planning to assign on-hand parts to kit, especially when kits are prepared in advance. (Bozer & McGinnis, 1992)
- Temporary shortage of parts may force the user to kit short; doing so will reduce the overall efficiency of the operation (due to the double handling of kit containers and the additional storage space required by partially assembled kits). (Bozer & McGinnis, 1992)
- Defective parts that are inadvertently used in certain kits will lead to parts shortages at the workstations. Kits that contain defective parts must be “reassembled”. (Bozer & McGinnis, 1992)
- Components that may fail during (or as a result of) the assembly process will require special consideration or expectations (i.e. they may have to be excluded from the kits). One may be forced to provide either a spare piece with each kit or to store component containers at some workstations. (Bozer & McGinnis, 1992)
- If part shortages develop (due to defective parts or other reasons), 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. Also, it will almost always lead to double handling – first to remove the short part from existing kits and later to add the part to “cannibalized” kits when a new shipment is received. (Bozer & McGinnis, 1992)
- Picking parts is a monotonous working process; in the long run with a poorly designed picking process this might lead to injuries and unmotivated personnel. (Agervald, 1980; Christmansson et al., 2002)

Before introducing a kitting process one has to ask the questions: why do we want to kit? Is there a need for a kitting process? There is a possible need for a kitting process when the advantages written above exceed the limitations written above.

When there is a possible need for a kitting process, how to design the kitting process can be divided into four questions: where to kit? What to kit? Who kits it? How to kit?

E. Where to kit?

According to Brynzer and Johansson (1995) the choice of a kitting process design at a high level involves decisions regarding the work organization and the geographical location of the kitting process. They also say that if kitting on the factory site the kitting process can either be located in a central picking store or in decentralized areas close to the assembly stations, the so-called materials markets (also called satellites). Two examples of how this principle can look like are shown in figures 3 & 4.

In the article “Is third party logistics in your future” (2000) it is explained that kitting also can be done off the factory site, either by third party logistics suppliers or by suppliers supplying more than one part going into the same product. Since this study is aiming at analyzing the effects of a kitting process, the authors believe that investigating third party kitting more extensively will not contribute to solving the purpose and goals of this thesis. With the time limitations given to this project it is also assumed by the authors that there will be no time to investigate third party kitting further.

Having a central picking store means that one can benefit from economies of scale making many different kits in the same area, however there might be a lack in communication due to the geographical location of the kitting area. Having a central picking store also provides the possibility of integrating the kitting area with the main stores, reducing unnecessary materials handling.

The benefits of having decentralized kitting areas close to the assembly line is mainly communication, however there might not be space for such areas and it might be labor intensive due to the difficulty of balancing the workload of making kits.

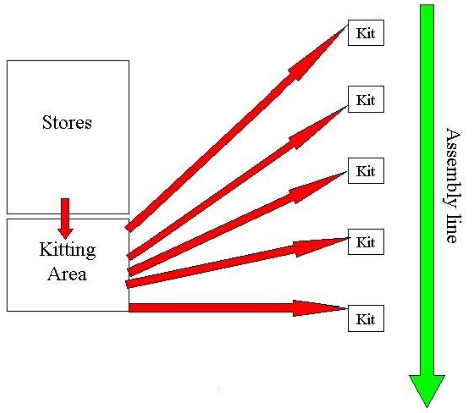

Fig-3 Kitting with centralized picking stores.

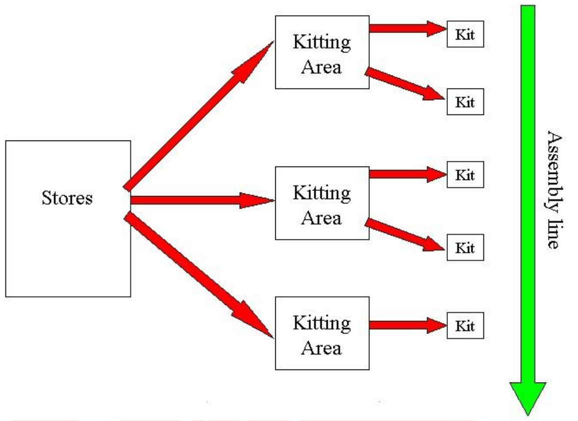

Fig-4 Kitting in decentralized areas.

F. What to kit?

Regardless of the type a kit typically does not contain all the parts required to assemble one unit of the end product. This is sometimes due to the product complexity or product size. Also, certain components such as fasteners, washers, etc. are almost never included in kits; instead such parts are bulk delivered to the shop floor in component containers (Bozer & McGinnis, 1992)

Ding (1992), investing kitting in a tractor plant, says that considerations of kitting in a pull system are part sizes, lot sizes and kit sizes. Under the part size consideration, Ding claims there are kittable parts and non-kittable parts due to size restrication; non-kittable parts should be pulled separately when needed. According to Schwind (1992) expensive or high value parts are suitable for kitting since one can have higher damage control and parts can be individually accounted for in some systems.

Bozer and McGinnis (1992) have observed two types of kits: stationary kits and travelling kits, shown in figures 5 and 6 respectively. A stationary kit is delivered to a workstation and remains there until it is depleted. The product to be assembled moves from one workstation to another independent of the stationary kits. A travelling kit is handled along with the product and supports several workstations before it is depleted. There are two types of travelling kits. The first type is a single container where the kit and the product travel in the same container as the product is assembled. With the second type, the product travels in one container (or fixture) while the kit follows the product in parallel in another container. The two travel together from one workstation to another.

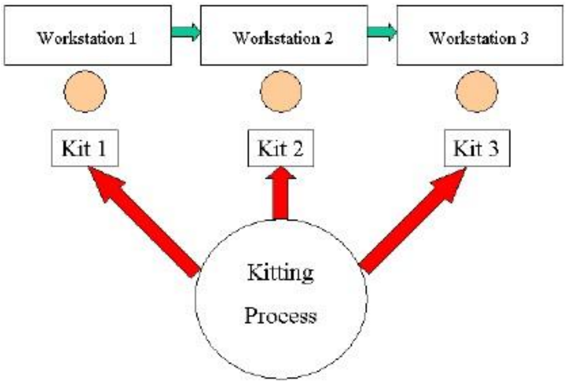

Fig- 5 Stationary kits.

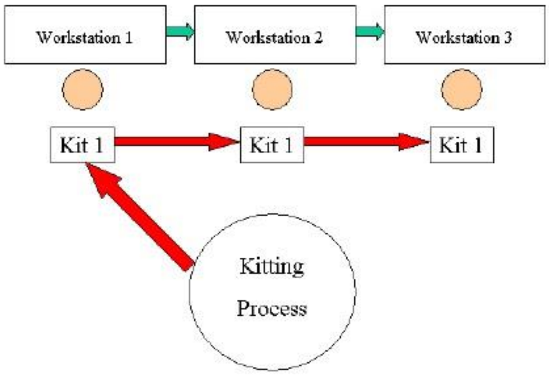

Fig-6 Travelling kits.

G. Who kits it?

Who physically produces the kits is firstly divided into man or machine, e.g. employee or robot. This research will not consider robotic picking and kitting since the authors believe that the variation and size of the parts at Industry makes it unfeasible.

According to Brynzer and Johansson (1995) making the kits can either be done by the assemblers themselves or by a specific category of operators, called pickers. In some cases assemblers produce kits for other assemblers, most often belonging to the same team on the assembly line. They also acknowledge two benefits of integrating the kitting process in the assemblers work. First, there is the idea of obtaining higher picking accuracy when the operator is responsible for the whole job. Second, integration and job enlargement will enhance the overall productivity by reducing balancing problems and giving better possibilities regarding job designs that promote ergonomics and the quality of working life.

The article "Toyotas New Material-Handling System Shows TPS's Flexibility" acknowledges the benefits of having certain pickers as: Assembly operators now focus nearly 100% of their time on the value-added work of installing parts because they no longer have to perform the nonvalue-adding task of walking a few steps to retrieve parts from flow racks. This system also eliminates reaching, stretching and searching for parts by assembly operators.

H. How to kit?

How to kit can be divided into three questions: How do we get the right parts in the right kit? How do we get the right kit to the right workstation? How do we design the kits to be as easy as possible to kit and as easy as possible to assemble parts from?

Bozer and McGinnis (1992) define "kit assembly" as an operation where all the components and/or subassemblies required for a particular kit type are physically placed in the appropriate kit container. They also come to the conclusion that kit assembly conceptually is an order picking operation.

According to Brynzer and Johansson (1995) one way of classifying order picking systems is whether the picker is travelling to the picking locations (picker-to-part) or whether the materials are brought to the picker (Part-to-picker). Picker-to-part systems are the most commonly used in the industry. Part-to-picker systems are even described by Christmansson et al. (2002) as a principally new way of materials kitting.

Bozer and McGinnis (1992) have observed that in most cases, since several component and/or subassembly containers must be retrieved to assemble a kit, it is fairly common to assemble several kits of the same type simultaneously. That is, once a component or subassembly container is brought to kit assembly area, one may pick enough pieces from that container to assemble several kits of a given type. After the required parts are retrieved, the component or subassembly container is returned to storage (provided the container is not empty). The number of kits (of the same type) that are assembled simultaneously as described above is by Bozer and McGinnis defined as the “Kit batch size”.

This research reflect on the above statements is that kitting in batches only makes sense when there is no or little variation in part numbers going into the kits, e.g., parts that can vary between kits cannot be picked in batches, unless there happens to be more than one kit in a row containing the same variation of parts. Meaning you could plan your production sequence to be able to make kits in batches even with variation in part numbers.

Brynzer and Johansson (1995) states that in some sense batching also causes a more complex picking, including the design of the picking information, which can have a negative effect on the picking accuracy. A preliminary conclusion from their case studies is that the higher picking efficiency, resulting from these batching policies, is in many cases offset by an increased amount of sorting and administration.

When designing the kitting area it can either be one big area or you can divide it into zones. If you have one big area you pick the whole picking order in one picking tour, this is shown in figure-7.
According to Brynzer and Johansson (1995) zone picking divides the storehouse into different picking zones and an order is divided between these zones. Brynzer (1995) explains two types of zone picking: Progressive zoning is processing each order or kit by one zone at a time, when the order or kit has gone through all the zones it is finished, this is shown in figure-8. Synchronized zoning is when all the zones are working on the same order or kit at the same time, the parts from each zone is then brought together into the order or kit, this is shown in figure-9.
According to Brynzer (1995) the picking information design has been shown to be an important factor concerning picking accuracy, picking productivity and how the picking work is perceived. Brynzer and Johansson (1995) have during their case studies observed five main ways to design the information system, in which the picker receives and understands the information regarding which parts to pick for each order.

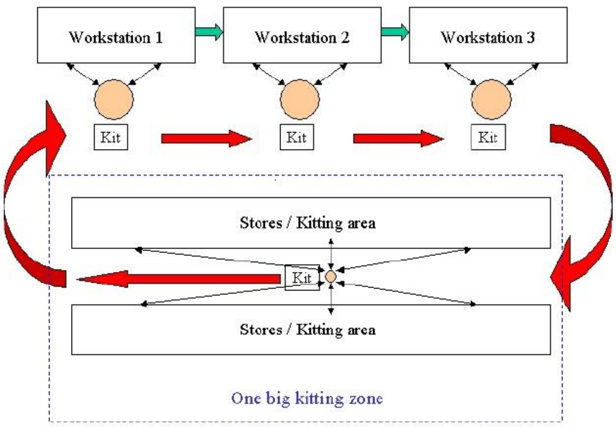

Fig-7 Kitting in one big area in combination with travelling kits

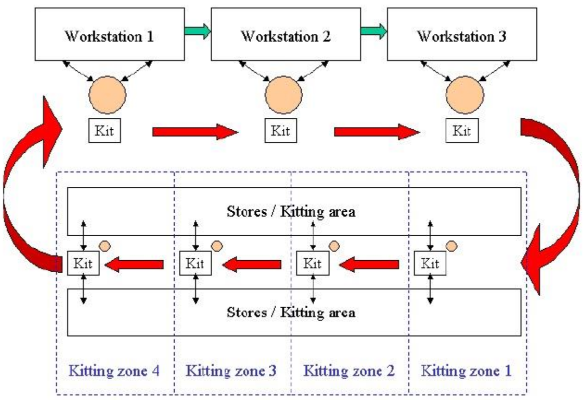

Fig-8 Zone picking alternative 1 in combination with travelling kits.

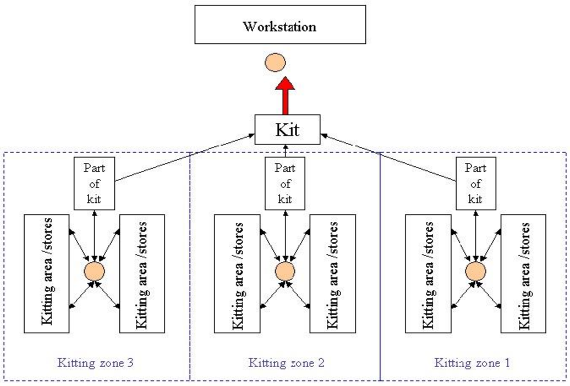

Fig-9 Zone picking alternative 2.

The physical design of the kit container is of great importance when designing a kitting process. Brynzer (1995) means that the kits have to be functional in the picking process as well as in the assembly process. Medbo (2003) comes to the conclusion that assembly work is definitely supported by the way kits are configured. He means that configuring the parts in the kit container according to the order they are to be assembled can substantially decrease assembly cycle times. Brynzer (1995) also acknowledges the importance of designing the kit container so that the picker knows where specific parts go and can easily detect if any parts are missing. This can for example be done by specific pigeonholes or colored maps. A drawback with these kit containers is their inflexibility since they need changing when parts are changed and they might not be suitable for kits in high product variation assembly. These kit containers also demand customized design and manufacturing which can be costly.

II. EFFECTS OF CURRENT MATERIAL FEEDING SYSTEM

From the collected data to analyze the current continuous material feeding system in assembly line of Inspiron industry. Parts, inventory and volume plan information became the primary data for the analysis. Figure 10 shows the effects of current material feeding system.

Fig-10 Effects of current material feeding system

Part Shortages: The biggest issue with which assembly had been getting affected was getting right part at right time in Point of Use (POU). This has got many reasons inbuilt with the feeding system and led to poor material planning due to lack of visibility, supplier delays, poor response time when replenishing line side and poor inventory control. Many times part shortages were known when the part was required for assembly.

Poor Kanban Quantity: Line side storage is poorly balanced. Some parts had one week worth of inventory at line side. This poorly balanced inventory level leads to excessive storing which according to Lean theory is called as waste.

Decanting (Re-packaging) of Parts: Suppliers were not delivering parts in right kanban quantities and in right packaging that fits line side stores. This was the reason why parts had to be replaced after receiving. This not only involves time but also involves cost for this additional operation. This additional handling may cause quality defects.

Big Line side Stores: Since company is following continuous supply system, all parts were stored at line side and even some parts were used less frequently. This was a main problem having more parts at line side which was consuming more space. This results in time consuming operations for operators to walk and search for parts required for assembly. This was against the theory of 5S violating Lean rules. This was directly affecting end product throughput time.

Unstandardized Work: Since parts picking is a laborious job for the operators, they started collecting parts in batches required for one shift and this affected the standard work which in turn affected end product quality.

III. Scope of the Work

By implementation of Bozer & Mc Ginnis model for kitting at MSME. The following outputs can be possible to come out as result: Lineside replenishments per day, storage replenishments per day, line side storage, assembly operator walking time per day, kitting time per day, physical part handling per day, line side inventory value, kitting space.

The scope of the work is to analyze and recommend reliable material feeding system, which helps to reduce line side storage space by 70%, line side replenishment by 20%, line side inventory value by 50% and operator walking time by 75%. The paper also brings out methods to improve warehouse process that supports new material feeding system. Further the feasibility of the process has been validated before implementation.

Summary of Key learning points about kitting operations from professional:

Henrik Brynzer (Volvo Cars Torslanda)	• An efficient picking information system to support picking is very vital • Kitting operations should be located as close as possible to production line • It is very critical to secure the kits are 100% correctly assembled and efficiently performed. • Too much material handling is an important limitation for kitting • Sensitive parts with quality issues should not be included in kits. • Kitting should not be the first solution for a company
Peter Friberg (Volvo Cars Skövde)	• Kitting is never the first solution because it is more expensive than other solutions. • Everything should not be kitted. There is a break-even point somewhere. • Fixed kitting personnel is necessary otherwise the errors increase. • Parts like nuts & bolts should not be included in kitting • Good training and the support of an electronic system are vital
Sebastian Numler, (Johnson Controls Arendal)	• Main reason for kitting is the problems about space. • It is important to use boxes specially designed for kitting. • A large picking area and electronic support are important for good kitting • Kitting activities will be increasingly used in the future.
Lars Medbo, (Chalmers University of Technology Göteborg)	• Kitting can be used to solve problems of space, quality, flexibility, materials handling and learning • Kitting is a tool that helps workers to learn and assemble correctly • There are big differences how kitting is reconized in Swedish and Japenese industry. • Kitting is not fully understood in Sweden with all its aspects such as quality, flexibility and cognitive aspects, it is more often considered to solve space problem. • Kitting brings huge reductions in non-value adding time of the assembly workers. • It is very important to follow up the kits are 100% correctly assembled.

IV. Conclusion

The main reason for kitting was observed as space requirements in industry. 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. In Japanese context, aspects like quality and learning are the key reasons to initiate kitting activities. Space is not their first priority. 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 was observed to show numerous benefits in all of five tracks (space, quality, material handling, flexibility,Learning) 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.

According to the analysis, kitting operations can go along with lean philosophies 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.

V. FUTURE RESEARCH

I think further research of kitting in the following areas would be beneficial:

- 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.

Since most of the literature found in the area of kitting to manufacturing is aimed at either production in parallelized assembly systems or production with small parts (mainly electronics) we think further investigations should be done in industries with larger parts. Especially since these industries by nature should have a space issue line side, and explained earlier one of the greatest advantages of kitting is reducing lineside storage space.

Testing the model of Bozer & McGinnis in similar production environments would also be of interest to verify, criticize or finding needs of improvement of the model. Investigating existing kitting processes and compare it to the model would also be a way to do this. Investigating industry practice would also be of great interest since this research has not performed any benchmarking except for written sources.

REFERENCES

[1] Art Smalley, (1997). *Toyota's New Material handling Systems Shows TPS's Flexibility*, http://www.leaninstitute.nl/publications/1106/ToyotaNewMaterialHandlingSystem.pdf, Retrieved on June 2012.

[2] Bozer Y.A., Mc. Ginnis L.F., *Kitting versus line stocking: A conceptual framework and a descriptive model*, International Journal of Production Economics, Vol. 28, Issue 1, pp. 1-19, 1992.

[3] Brynzer H., *Evaluation of kitting systems – Implications for kitting systems design*, Department of Transportation and Logistics, Chalmers University of Technology, 1995.

[4] Brynzer H., Johansson M.I., *Design and performance of kitting and order picking systems*, International Journal of Production Economics, Vol. 4, Issue 1, pp. 115-125, 1995.

[5] Christmansson M., Medbo L., Hansson G.A., Ohlsson K., *A case study of a principally new way of material kitting-an evaluation of time consumption and physical workload*, International Journal of Industrial Ergonomics, Vol. 30, pp. 49-65, 2002.

[6] Ding F.Y., Balakrishnan P., *Kitting in Just-In-Time production*, Production and Inventory Management Journal, Vol. 31, Issue 4, pp. 25-28, 1990.

[7] Ding F.Y., *Kitting in JIT production: A kitting project at tractor plant*,Industrial Engineering, Vol. 24, Issue 9, pp. 42-43, 1992.

[8] Ford Henry, (2007), *In Encyclopedia Britannica*, Website:http://search.eb.com. proxy.lib.ltu.se/eb/article-22464, Retrieved on July 2012.

[9] Johansson B., Johansson M.I., *High automated kitting system for small parts – A case study from the Uddevalla plant*, Automotive Technology and Automation, Vienna, pp. 75-78, 1990.

[10] Johansson M.I., *Kitting systems for small parts in manual assembly systems: Production Research Approaching the 21st Century*, pp. 25-30, Taylor & Francis, 1991.

[11] Lee H., & Yang J. An AHP decision model for facility location selection. Facilities 15(9/10), pp. 241-254, 1997.

[12] An evaluation of kitting system in lean production by M.Alper Corakci, Thesis from University of Boras.

[13] Medbo L., *Assembly work execution and materials kit functionality in parallel flow assembly systems*. International Journal of Industrial Ergonomics, Vol. 31, pp, 263-281, 2003.

[14] Kitting in High Variation Assembly line, A case study at Caterpillar BCP-E, Master's Thesis of Lulea University of Technology, by Oskar Carlssson & Bjorn Hensvold.

[15] Schwind G.F., *How* storage systems keep kits moving, *Material Handling Engineering*, Vol. 47, Issue 12, pp. 43-45, 1992.

[16] Improvement of material feeding system for an excavator assembly line through lean principle, Raghvendra Ramappa, K.M. Sharath kumar, Ashoka. K. Nairy, M.S.Ramaiah School of Advance studies, Bangalore.