Improvement in Material Feeding by Introducing Kitting in the Assembly Line

Chinmay Kule, Shantanu B. Patil, and Sandeep Vaity

Abstract The concept of kitting is to ensure the supply of all complete sub-assemblies in the form of kits to the assembly station/line. The main purpose of this study was to analyze the business case and the possibility of the company to implement lean kit assembly concept. Inceptive part of the study was to understand the kitting concept completely and simultaneously study the current material feeding system, where improvement had to be incorporated. The study shows that kitting results in reduction of operator walk time, material search time and material fetch time. It also leads to better planning for material, manpower, and enhancement in productivity through appropriate work allocation. Although the benefits achieved from the implementation of kitting concepts are specific to the company's needs, results make it clear that kitting goes hand in hand with the lean manufacturing process.

Keywords Kit assembly · Centralized feeding · Analytic hierarchy process · Productivity

1 Introduction

ERP/MRP systems typically keep a record of the total quantity of a part type and not how that material is delivered. This inaccuracy and lack of granularity, combined with stockroom personnel mistakes, lead to problems that include: insufficient quantity of components, excess quantity of components, wrong components, incomplete kits, insufficient quantity of component packages (e.g., insufficient quantity of reels for split parts). Thereby, resulting in increased operator idle time, lead times and manpower.

Conventionally, kitting was started by the production control department based on the shop floor orders, as made by the plant's ERP/MRP system. Production control

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H. Vasudevan et al. (eds.), *Proceedings of International Conference on Intelligent Manufacturing and Automation*, Lecture Notes in Mechanical Engineering,
https://doi.org/10.1007/978-981-15-4485-9_42

had to initially confirm that adequate stock/quantity is available for each part number. Orders are placed for parts in case of any shortages. When executed properly, benefits of kitting include: maximized value added time of operators, easier operator training resulting in reduced training cost, maximized machine utilization—no line stoppage due to part shortages or searching for parts, reduced work in process (WIP), reduced lead times, reduced part damage due to excess handling.

This study of a manufacturing firm in Mumbai will discuss the problem with the current material feeding system in the methodology section. This section will also discuss the various parameters related to the kit formation to be considered before finalizing the kits. Further, the AHP process will be used as a medium to finalize the project parameters. Finally, the results and conclusion section will discuss the current findings and future scope of implementation.

2 Literature Review

The motive of lean is to eliminate unwanted resources and delays from each of the company's activities for maximizing the value added by them. Inventories can be classified into the following categories: (a) Raw material is an inventory that is used for the manufacturing of a product. (b) Work in process (WIP) is an inventory that is currently being used to complete a product. (c) Finished goods are goods where the process of raw material has been completed and those can be either sold to the customer or sent to another company as raw materials. Inventory went stored in excess not only results being wasteful but also hides other relating problems and their possible solutions [1, 2].

With reference to the movement, quantity, and storage of the material used, material feeding principles can be classified, namely into continuous supply and batch supply. In continuous supply, the material is supplied in units suitable enough for handling, which are replaced once empty. In batch supply, the material is sent in batches, either batch of required part numbers or a batch of these part numbers in specific quantities.

AHP is a quantitative methodology that determines the importance of a criterion concerning other multiple criteria by using paired comparison analysis. AHP assigns weights to every criterion according to their importance. AHP is an important decision-making tool in manufacturing industries and can be used to determine which factors are to be considered as the project parameters [3].

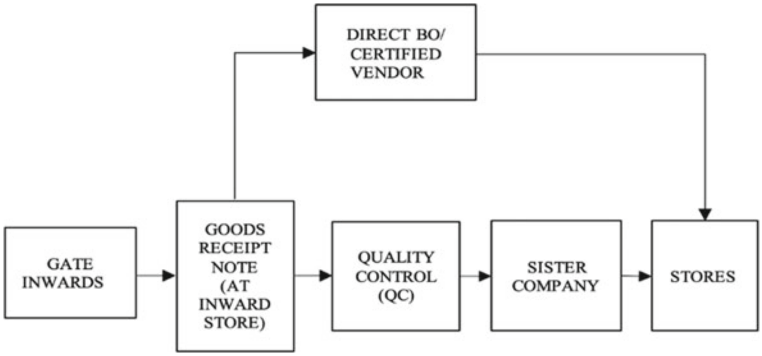

Fig. 1 Material flow in earlier method

3 Methodology

3.1 Earlier Method

Once the sales order is confirmed, a sales order bill of material (SOBOM) is generated in the SAP system. This bill of material (BOM) contains all the parts that are required for the assembly of the machine. The purchase department starts working toward the procurement of these parts. There are about 89 vendors who are supplying these parts. Figure 1 shows the process through which the material flows.

Material received from self-certified vendors is directly transferred from inward store to the warehouse, skipping QC. The mentioned path of material movement is traced in SAP and at every step, and it is posted to the next location in SAP along with the physical transfer. 718 components are required to complete the assembly of the machine. The production manager has a closing deadline, so he instructs to assemble the said machine with available 400 out of 718 components required. Besides, the rest of the machines which were kept aside for the priority of this order also add up to WIP inventory. A few weeks later on arrival of the missing parts the production manager shortcuts few procedures on the waiting machine and sends it for dispatch. Therefore, to improve this process, a study is being conducted which will only analyze the current material feeding system and compare how kit assembly will help the organization eliminate the problems with the current system.

3.2 Method by Using Kitting System

The method of implementing kitting system involves considering the type of kitting, depending upon the assembly and the current manufacturing scenario of the organization. It suits to manufacturing having a parallel flow of sub-assemblies and assemblies consisting of many high valued sub-assemblies [4, 5]. According to Johansson [6], the type of assembly decides the way parts will be sent in different kits to the assembly line. Based on the current manufacturing scenario, kit-to-manufacturing, where different kits are delivered to the shop floor for the assembly of more components, was incorporated [7]. Considering the number of parts required for the machine assembly, sending one part per kit was not a feasible option; therefore, kit-to-manufacturing was the most suitable option. Once the type of kitting was decided, additional factors such as where to kit, kit design and how to kit were to be considered.

3.2.1 Selection of Kitting Area

A centralized material feeding system [8], which involves filling the kits in a particularly assigned area (first floor in this case) and then distributing the kits throughout the assembly line, was implemented. The only way from the stores to the assembly line was through the first-floor elevator being one reason. Another reason was to avoid an increase in the line storage space. In addition to the centralized material feeding system, different color codes were assigned to bins of the different machines to easily identify them in the particularly assigned kitting area. For example, gray color bins for model 1, green color bins for model 2, and blue color bins for model 3, as shown in Fig. 2.

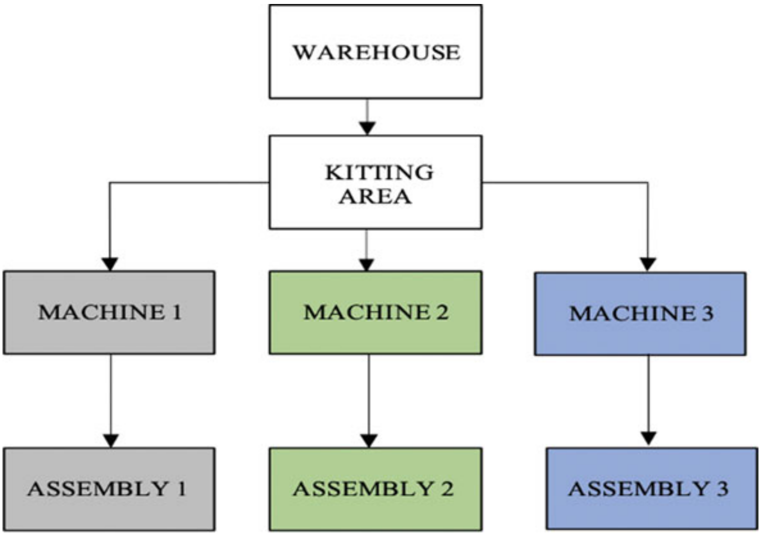

Fig. 2 Centralized material feeding system with the assignment of color codes for easy identification of stationary type bins (kits) of different machines in the kitting area

Fig. 3 Left: kit containing separate racks for parts as well as drawings and right: Poka-yoke implemented in the kit to avoid the mistakes while filling of the kits

3.2.2 Design of Kits

The kit may contain all the items required to complete the assembly, may it be drawings, tools or parts relating to that assembly as shown in Fig. 3. Sometimes due to product complexity, assembly parts might include small parts such as nuts, bolts, washers, which might make the installation of the kit a troublesome process. Since these parts were standardized, it was decided to exclude these items from kits, and make them available in separate racks available on shop floor. The purchase of these items was been done as a bulk consumable, and the value of some of these parts was considered to be uneconomical for them to be handled separately for each machine [9].

3.2.3 How to Kit?

The kits were being manually assembled by plant associates assigned to the stores' department. A material requisition (MR) provided by the production team was used by associates from the stores' department to fill kits. A picker to part method, where associate brings the part into the kit (Fig. 4), was used for material withdrawal and kit formation [8] since a system-generated picklist of parts along with the bin numbers was used by the store associates. In addition to the picker to part method, the kitting area was divided into separate kitting zones [8], according to different models of machines available (Fig. 4).

3.2.4 Network Analysis

In addition to the formation of kits considering several factors, network analysis, which involves understanding and segregating the various processes involved in the machine assembly as online and offline processes, was performed, as it would employ additional time-saving and cost-saving. Offline processes can be carried out

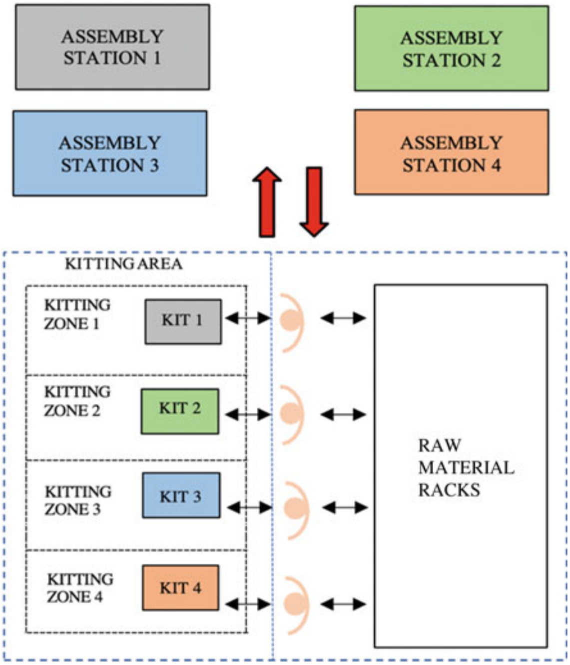

Fig. 4 Stationary kits from different zones in the kitting area

simultaneously with the ongoing assembly process. Online processes are processes that are to be followed in order of the assembly process.

3.2.5 Analytic Hierarchy Process (AHP)

This section will cover the formulation of the AHP matrix using the rankings provided by the various managers. A hierarchy was tabulated consisting of the main criteria and sub-criteria. The main criteria consisted of assembly side inventory, binning time, assembly time/space, part handling, idle time, required kitting space, and assembly side replenishments/day. The sub-criteria were considered at an advance level of decision making. A senior manager from every department was involved in the AHP meeting. Each criterion was discussed, and the ranks provided were incorporated (Table 1) into a relationship matrix using Saaty's scale for the AHP matrix. The rating given to each criterion was based on the scale with 1 (high) to 9 (low). For example, while comparing assembly side inventory and binning time, managers felt binning time was more important, therefore provided a higher rating ($1/2 = 0.5$). While rating the various criteria, factors such as current requirements, future goals, alignment with manufacturing goals were considered. After the pairwise comparison of every criterion, the normalized weights were obtained using the AHP software and were tabulated in MS Excel. Table 2 exhibits the outcome of the analysis, i.e., idle time, part handling, and assembly time/space are three criteria that are notably very

Table 1 Relationship matrix showing a comparison of the main criteria

Main criteria	Assembly side inventory	Binning time	Assembly time/space	Part handling	Idle time	Required kitting space	Assembly side replenishments/day
Assembly side inventory	1	2	0.5	0.33	0.2	3	4
Binning time	0.5	1	0.5	0.25	0.142	0.5	2
Assembly time/space	2	2	1	0.333	0.2	4	5
Part handling	3	4	3	1	0.333	3	5
Idle time	5	7	5	3	1	5	7
Required kitting space	0.333	2	0.25	0.333	0.2	1	3
Assembly side replenishments/day	0.25	0.5	0.2	0.2	0.142	0.333	1

Table 2 Results of AHP

Criterion	Normalized weights
Idle time	0.413
Part handling	0.212
Assembly time/space	0.133
Assembly side inventory	0.098
Required kitting space	0.064
Binning time	0.05
Assembly side replenishments/day	0.031

important. Therefore, idle time will be considered as the project parameter and the data collection will be based on this project parameter.

4 Results of Kit Implementation

The implementation of the kit assembly was quite successful and it nearly achieved all previously stated goals. In addition to achieving goals, it also brought a few other assemblies related discrepancies in the picture. Table 3 and Fig. 5 provide a statistical comparison between before and after assembly times of various processes. The cells that are highlighted in Table 3 indicate the reduction in the assembly time of that particular operation after implementing the kit for that assembly. Despite the measures taken, certain psychological and technical factors were overlooked and certainly caused hurdles during the implementation stage. The psychological challenges included: noticing the operator idle, the production manager used to force the stores' department to send the kits. There were times when even the technicians tried to send incomplete kits to the assembly station to show goodwill to their reporting line managers. Few of the technical factors include: due to itching missing on the majority of parts a lot of time was wasted in material rechecking. As the lead time consisted of production time as well as waiting time, where the waiting time was largely only due to components unavailability. This gave the illusion that the operation will take more time, and lead to the faulty conclusion that earlier start made will help to achieve the deadline for dispatching machine.

To avoid the occurrence of the challenges faced during the implementation stage again in the future, certain rules were set:

(a) Only complete kits must be sent to the assembly station.
(b) Only one person should be responsible for releasing kits, monitoring materials being filled in kits in the kitting area and monitoring buffers on the shop floor.
(c) Each production engineer will be responsible as a person in charge for the handover of kits of the machine model allocated to him from the warehouse to the assembly line.

Table 3 Results of implementing kitting in assembly

Process	Current assembly time	Kit assembly time	Percentage saving in time (%)
Index, Z-cam and Geneva assembly	8	**6**	**25**
Main shaft assembly	12	**9**	**25**
Mount drive assembly	22	**20**	**9**
Turret ring assembly	6	**3**	**50**
Control panel assembly	2	2	0
Junction box assembly	2	**1**	**50**
Top cover mounting	4	**3**	**25**
Capsule reservoir assembly	2	**1**	**50**
Vacuum valve assembly	3	**2**	**33**
Closing plate assembly	1	1	0
Tamping assembly mounting	12	**10**	**17**
Loader assembly mounting	6	6	0
Sub assembly mounting	10	**6**	**40**
PMM assembly	8	**3**	**62.5**
Second QC	1	1	0
Pendant box mounting	2	**1**	**50**
Powder unit mounting	4	**1**	**75**
Machine wiring	8	**6**	**25**
Capsule/powder trials and QA check sheet	6	6	0
Electrical test chart and machine power on testing	1	1	0
Final QC	4	4	0
F A T	8	8	0
Dispatch	8	8	0

The bold numbers in the “kit assembly time” column indicate the reduction in the assembly time of that particular operation after implementing the kit for that assembly. The bold numbers in the “percentage saving in time” column indicate the percentage of time saved for that particular assembly operation

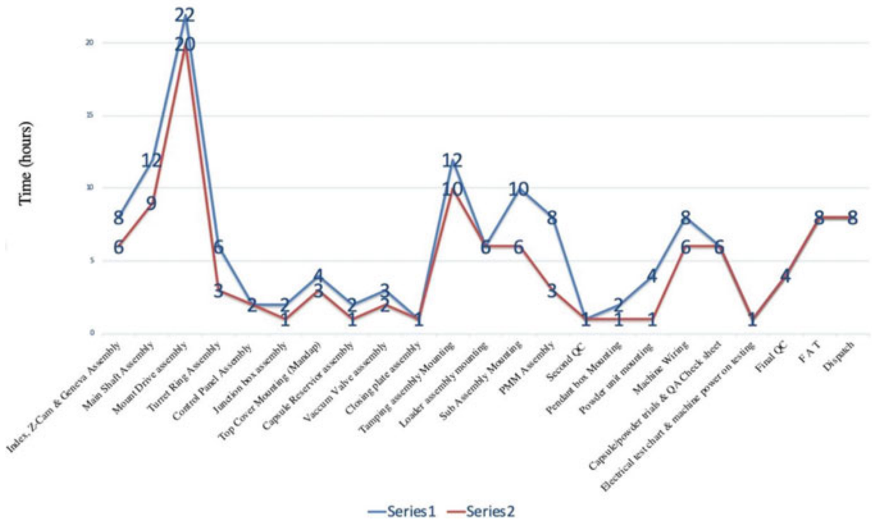

Fig. 5 Series 1: depicts the assembly timings of the current process, and series 2: depicts the assembly timings after implementing kitting

(d) Machines are subject to improvements based on feedback given by the service team or customers for delivering better performance and efficiency. Hence, machines improve with time, changing their parts sometimes if needed too. Hence, there may be a possibility that the kits will also have to be redefined accordingly. This completely depends on the circumstances at that particular time. Thus, the definition of a complete kit should be changed accordingly as a good rule to work smartly [10].

5 Conclusion

The implementation of the kit concept had a positive impact, in terms of functioning and cost involved at several departments in the organization. In terms of functioning, the purchase department, as well as assembly supervisor, knew which parts will be required when and therefore could prioritize the follow up. Shortage lists were also generated kit wise, thus making the process substantially convenient. The concerned person in the purchase department exactly knew as to which part was required when and also had records of lead time for every part. Subsequently, it becomes easier to ensure that each part arrives in the company before it was required on the machine for assembly, therefore, avoiding any delays/stoppages on the assembly line. In terms of cost, as the number of parts handled at a time were less, a lot of time, space and energy was saved. Stocking of parts on the shop floor which are not required immediately was avoided, thereby improving the shop aesthetics and reducing assembly side

WIP inventory. Prioritization of material procurement would avoid delay in assembly, thus helping the production team to adhere to deadlines and commit to lower lead times. Control points that usually occurred at the end of any process, in the case of kit assembly occurred at the end of every individual kit assembled, leading to corrective actions to be taken at the early stages.

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