Implementation of Kanban, a Lean tool, In Switchgear Manufacturing Industry – A Case Study

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Abstract

Kanban is a scheduling system for lean and just in time manufacturing industries or services firms. It is a very effective tool for running a production system as a whole, in this system problem areas are highlighted by measuring lead time and cycle time of the full process the other benefits of the Kanban system is to establish an upper limit to work in process inventory to avoid over capacity. The objective of this case study is to implement a standard Kanban System for a Electrical manufacturing MNC company. With this system, the firm implemented use of just in time to reduce the inventory cost stocked during the process. This case study also shows that the Kanban implementation is not only bounded to the company but to their vendor also, from where, some of the components are been assembled. A replenishment strategy was also developed, tested and improved at the company location. A complete instruction manual is also developed as a reference

Keywords
Value Steam Mapping, Kanban, Root Cause Analysis, Replenishment Strategy

1. Introduction

Lean manufacturing or simply 'lean' is a systematic method for waste reduction within a manufacturing system without affecting productivity. Lean also takes into consideration when waste created through unevenness in workloads and due to overburden. Lean thinking is now spread to every country in the world; leaders are also adapting these lean tools and principles beyond manufacturing, logistics and distribution, services, retail, maintenance etc.

Kanban, a technique for work and inventory release, is a major component of Just-in-Time (JIT) and Lean Manufacturing philosophy. Kanban was originally developed at Toyota in the1950's as a way to manage material flow on the assembly line. Over the last three decades, the Kanban process a highly efficient and effective factory production system has become a widely used tool in the manufacturing environment and global competition. Kanban stands for Kan- card, Ban- signal. The essence of the Kanban concept is that a supplier, the warehouse or the manufacturer should deliver components only when they are needed so that there is no excess inventory

2. Objective of the work

The company is involved into the business of switchgear manufacturing of which a particular project was under taken at the contactor assembly division, which is a component of switchgear only. The company

planned for new products and their assembly line with the help of lean manufacturing principles. The objective was to first understand the process with this understanding map the current value stream activities, and plan the achievable with the future state map as per the kaizen bust. The most prime objective the implementation of Kanban with proper plan , design and implementation.

3. Literature Review

According to Muriati Mukhtara and Riza Sulaimanb [1] Lean manufacturing or also known as lean production has been one of the most popular paradigms in waste elimination in the manufacturing and service industry. Thus, many firms have grabbed the benefits to practice lean manufacturing in order to enhance quality and productivity Also, according to R.Sundara, A.N.Balaji [2] Lean principles defines the value of the product/service as realized by the customer and then making the effective process flow with the customer pull and striving for perfection through continuous improvement to eliminate waste by sorting out Value Added activities (VA) and Non- Value Added activities (NVA). The sources for the NVA activity wastes are transportation, inventory, motion waiting, overproduction, over processing and defects. The NVA activity waste is vital barrier for VA activity. Elimination of these wastes is achieved through the successful implementation of lean elements. Various Survey demonstrate that most of the researcher focus on one or two major elements which having more effect on the process for finding out the existence of wastes and suggest their views on implementing these elements.Jafri Mohd Rohania, Seyed Mojib Zahraee [3] have considered a case study for colour manufacturing industry. They utilize one of the most significant lean manufacturing techniques called Value Stream Mapping (VSM) to improve the efficiency of production line . To achieve this goal, lean tools was implemented to construct VSM for identification and elimination of wastes by using team formation, product selection, conceptual design, and time-frame formulation through takt time calculation. Based on the future VSM, final results showed that by implementing some lean thinking techniques. In this case study production lead time and non-value added time is reduced. Rahani AR [4] mentioned in their case study at automotive industry that how things actually operated on the production floor through current state map. Then, a Future State Map is developed to design a lean process flow through the elimination of the root causes of waste and through process improvements. An Implementation Plan then outline details of the steps needed to support the lean objectives. Ahmad Naufal Bin Adnan and Ahmed Bin Jaffar [5] explained that uncertainties brought about by fluctuations in demand and customers' requirements have led many established companies to improve their manufacturing process by adopting the Kanban system. Implementation of the Kanban system resulted in reduction of inventory to minimum levels besides increasing flexibility of manufacturing. Successful implementation of the Kanban system furthermore reduces operational costs, consequently increases market competitiveness. They conclude that the Kanban system reduced lead time, minimized inventory on floor and optimized storage area. Raja Zuraidah RM Rasi and Suhana Mohamed [6] evaluate the study addresses the development of current state and proposes future state VSM using simulation with a focus on a manufacturing industry to investigate how dynamic VSM can be adapted in the discrete manufacturing environment.

4. METHODOLOGY OF WORK

The first step was to map each elements form the process of assembly line. This was done by constructing value stream map of the plant. As a result, a current state map was prepared. After its comprehensive study, a future state map was proposed coining out some Kaizen burst on the respective entities

4.1 Current State Map

The team had collected data about the modes of information flow amongst various departments in Supplier, industry, Vendor and customer. Current state map as is shown in the Fig. 1. Suppliers for these lines are metal shop and plastic shop secondary parts, etc. Lead times and modes of transportation were noted for the supply of material at assembly lines. Data boxes were prepared for each of the workstation consisting information about cycle time, setup time, uptime, shifts, working time.

In current state map, the cycle time was calculated by Maynard Operation Sequence Technique (MOST). The product variant having maximum demand in forecast that variant is taken for mapping, average quantity of inventory had taken from historical data. As the product was at the initial stage, so the actual variant wise requirement was not there, so there was no priority to any particular variant. We may see here that there was non-uniformity of variants and high in process inventory between the workstations. There is was not that much problem regarding with set up time, up and down time also. Inventory is high in in-process at stage station 4 near about 5 days. Total non-value added time was 13 days which was noticeable

4.2 Future State Map

The future state map as shown in Fig. 2 is the target to the addressed problem of having excess inventory at station4 (here each station represents the working process /assembly) , station1 and station3, which contributes around 69% of the total waste i.e. excess inventory. Discussion with the experts and the concerned managerial persons of each department included for identification of causes of waste and plan for future scenario after addressing those waste. For inventory optimization Kanban pull system is planned with supermarket to achieve just in time concept, non-value added time reduced up to 5.5 days

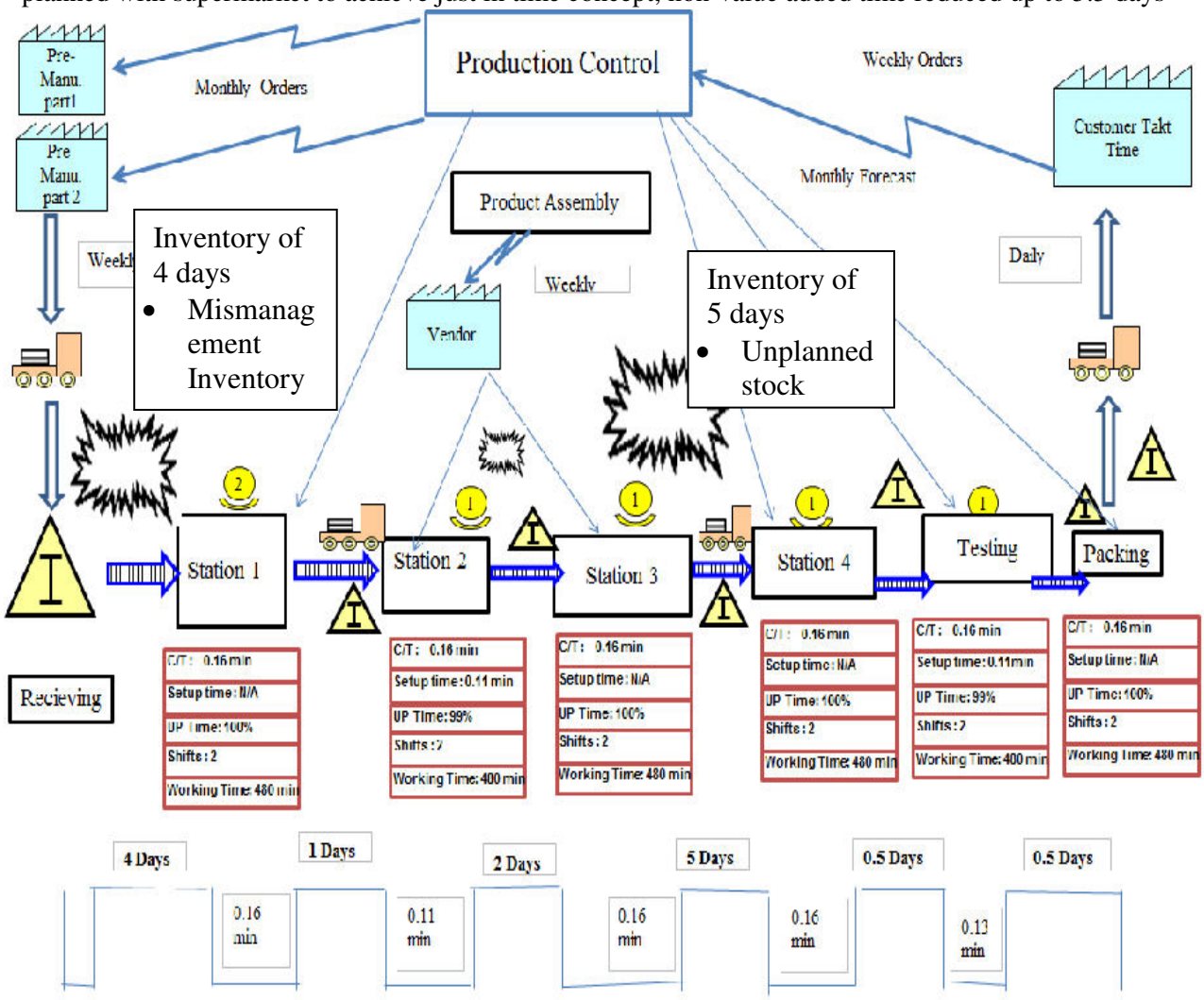

Figure No 1- Current State Map

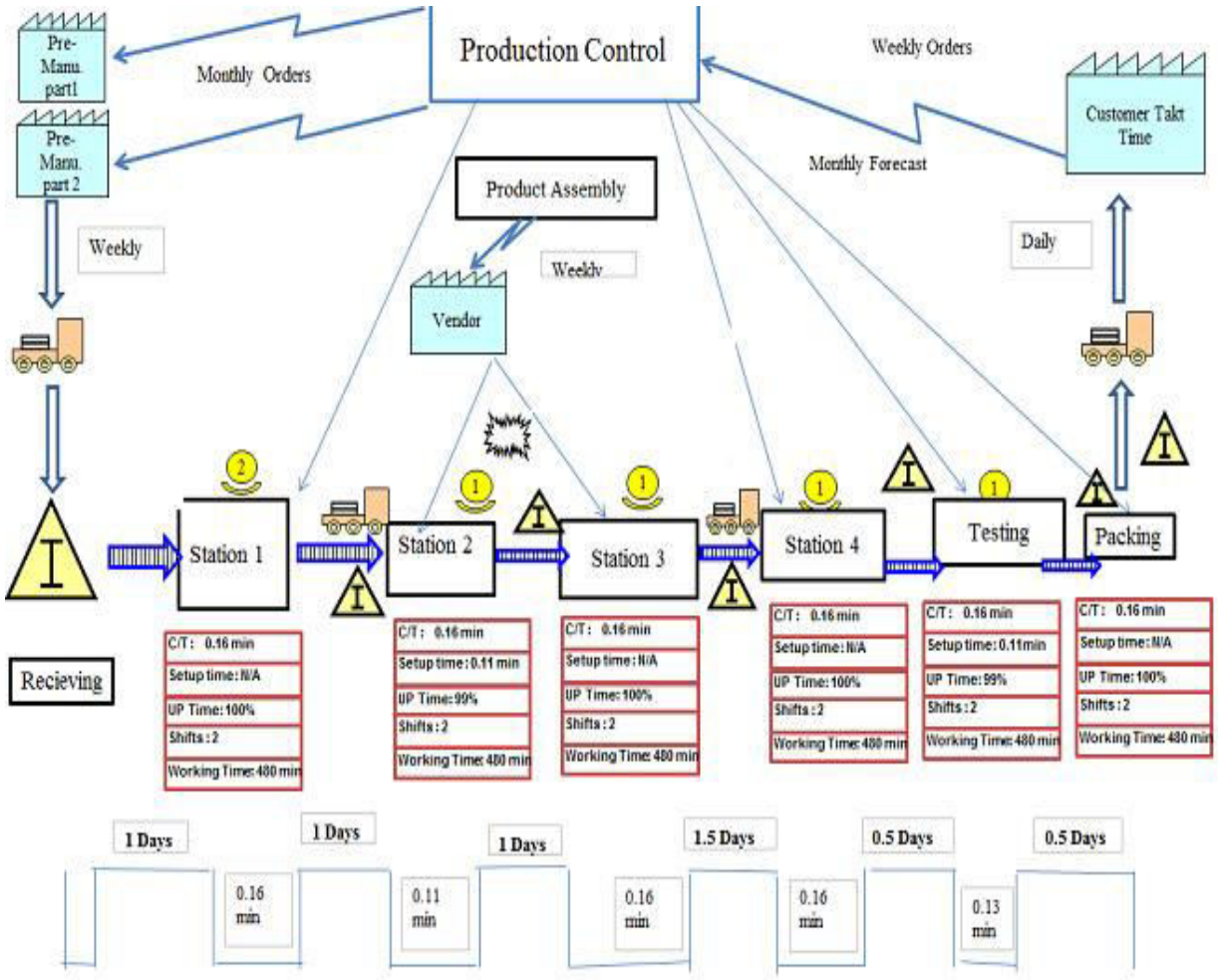

Figure No 2- Future State Map

4.3 Kaizen burst: Implementation of Kanban

From the current state map fig 1, non-value added time is about 13 days was identified because of improper inventory management. The reason being an 'overproduction' waste was found in current situation due to unplanned stock creation. It was required to optimize the work in process (W. I. P.) inventory, so pull system Kanban was planned. For implementation of pull system, the detail steps of Kanban system for this firm was applied as follows.

1) **Data Collection:** There are about 16 variants of product for this particular assembly line from X1 to X3 and X01 to X12. We estimate daily requirement of each product from the forecasted data. With the use of FSN (Fast, Slow and Non-moving product) analysis, FSN products were classified as A, B and C items and are shown in table I. From Fig. 3 all these A & B class items are consider for Kanban assignment which contributes near about 96 %, while C class items has very low demand so, these items will not be consider in Kanban exercise. X03 to X06.

2) **Design of Kanban system for assembly line***:* Fig.4 shows the actual flow of production and withdrawal Kanban card flow. Production Kanban card will get trigger from withdrawal Kanban card. A supermarket was design to avoid material shortage keeping in view of the access inventory storage at

station 4, identified in kanban bust.

TABLE I DAILY REQUIREMENT OF PARTS PER VARIANT

Variant	Avg. Monthly Consumption	Daily Requirement on FY 18	Percent Requirement	Part category
X3	11041	480	29.8%	A Class
X2	6622	288	17.9%	
X1	4943	215	13.3%	
X10	3995	174	10.8%	
X2	2934	128	7.9%	
X07	2082	91	5.6%	B Class
X09	1162	51	3.1%	
X04	1064	46	2.9%	
X02	852	37	2.3%	
P12	745	32	2.0%	
X03	615	27	1.7%	C Class
X08	327	14	0.9%	
X11	277	12	0.7%	
X05	223	10	0.6%	
X06	182	8	0.5%	

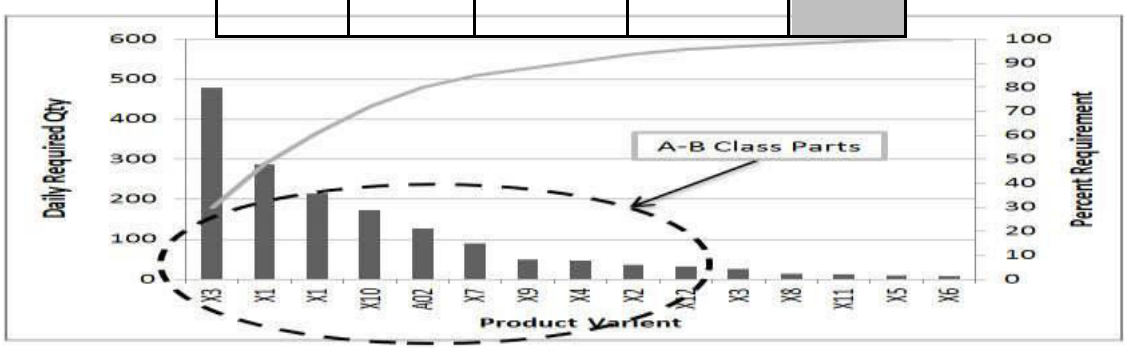

Fig.3 Product quantity analysis

The process of product is not done only in company factory, but some of the operations are done at the vendors end. For the Kanban information flow between vendor & company, E-mail communication medium is used. At each workstation there is supermarket for instant withdrawal of material.

At the vendor end, when operator withdraw Kanban card and put into the Kanban post, the spider will give that card to station 2 operator, it will be trigger to the station 3 operator to start the production. He will take station 4 bin from supermarket and put the card into the Kanban post. At the end of shift supervisor will withdraw all Kanban card and e-mail the Kanban card quantity to the Siemens supervisor.

Same cycle is being followed between station 2 & 3 to Station 4. After 1st shift material will be delivered to the station 4 line and simultaneously at the time of return material will be provided to the station 2 machine. Every day 2 time delivery will be done. The detail requirement and calculation of Kanban cards as shown in the table II and III.

3) Kanban card design and calculations*:* All information at card must be clear and correct in order to help the user to send Kanban at affected production line. Quantity of Production and withdrawal card were based on variant and item number respectively. Fig. 4 shows an example of Kanban card used in this case study. Card includes all details like product type, item no. Card no for that particular variant, precedence and next work station is also give for detail information to the spider person for location identification.

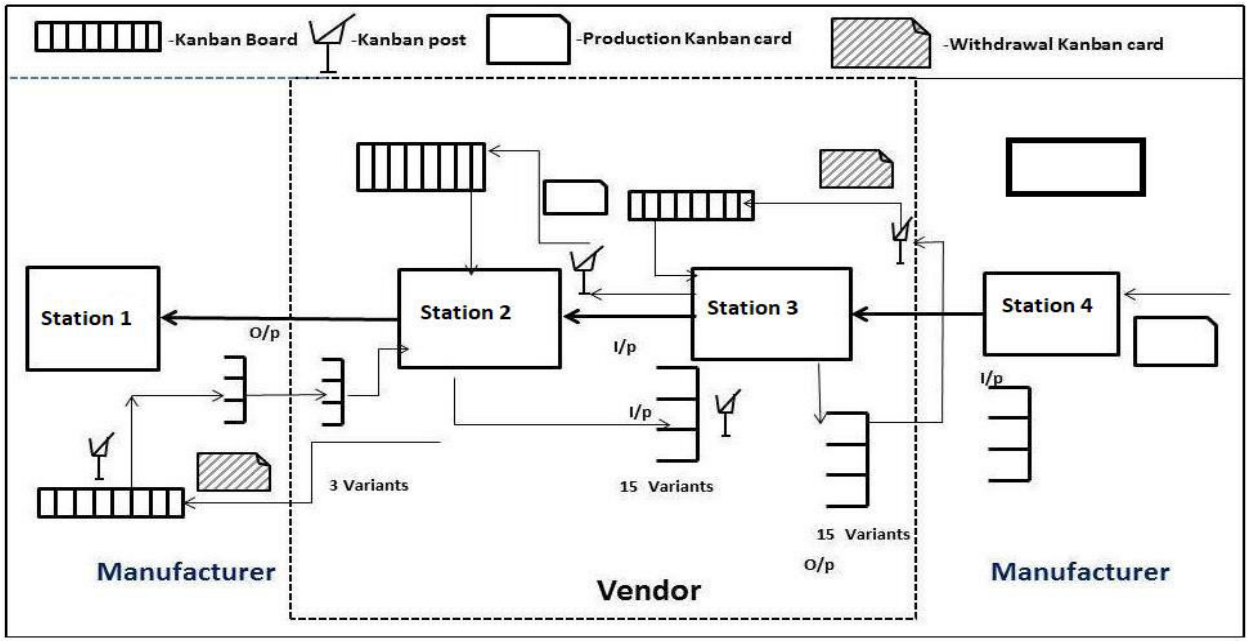

Fig.4. Production and withdrawal Kanban flow

Kanban Card		
Product type XYZ	Item No. XYZ000000001	
Card No. 2/48	Operation Seq. 1	Quantity 48
From Assembly module 1	Manufacturer Name	To Marking

Fig.5. Kanban Card information

The number of Kanban defines the performance of a pull system. If cards are few, there will have constant problems with interruptions and missed deliveries or idle workers and processes. If cards are too many, chances of waste space and money for inventory. There is choice between missed deliveries/idle workers or two more parts on the shop floor. Hence in Kanban calculations done by equation 1, it is customary to go for conservative side.

No. of Kanban card required = (Demand during lead time + safety stock) / container size… (Equation -1)

The detailed no. of cards required with respect to product variant is as follows in the table. Safety stock is required to avoid material shortage in conditions break down, holidays etc. from the storage bin

size and safety stock taken into the consideration Kanban cards are calculated are as follows in the Table IV. It includes total 15 variant i.e. X1 to X3 and X01 to X12. Safety stock of 0.5 days decided to keep in the supermarket provision between the work stations**.** So the daily requirement of material and safety stock gives the total inventory requirement as shown as below.

TABLE II
KANBAN CARD REQUIREMENT

Variant	Daily Demand	Safety stock 0.5 day	No. of Kanban card requirement				
			Station 1 to Station 2	Station 2 to Station3	Station 3 to Station 4	Station 4 to Station5	Total
X03	480	240	15	15	15	15	45
X01	288	144	9	9	9	9	27
X01	215	107	7	7	7	7	20
X10	174	87	5	5	5	5	16
X02	128	64	4	4	4	4	12
X07	91	45	3	3	3	3	8
X09	51	25	2	2	2	2	5
X04	46	23	1	1	1	1	4
X02	37	19	1	1	1	1	3
X12	32	16	1	1	1	1	3
Total							**144**

Hence, total 144 Kanban cards required i.e. equal to no. of storage bins required. From this design of Kanban pull system in process inventory can be reduced from 13 days to 5.5 days. By implementation of Kanban pull system total inventory level i.e. part of non-value added time reduced by 7.5 days as shown in Fig. 3.

4) Inventory Storage

After the bins requirement is finalized, inventory location for the same must be identified and designed in order to facilitate smooth functioning of the process. For slow moving items, a supermarket can be designed which allows First-In-First –Out (FIFO) to be implemented. Therefore an analysis was done about how many trolleys would be required

Table III.: Calculation for storage area requirement

Variants	Peak Demand	Per Bin Capacity.	No of cards required = No. of Bins (Demand/Bin Capacity)	No of Trolleys =No.of bins/10	Round Off
X03	3168	48	66	6.6	7
X01	1392	48	29	2.9	3
Y01	2016	48	42	4.2	5
Y10	720	48	15	1.5	2

X02	816	48	17	1.7	2
Y07	1824	48	38	3.8	4
Y09	672	48	14	1.4	2
Y04	768	48	16	1.6	2
X02	576	48	12	1.2	2
Y12	96	48	2	0.2	1
Y03	576	48	12	1.2	2
Y08	288	48	6	0.6	1
Y11	48	48	1	0.1	1
Y05	96	48	2	0.2	1
Y06	48	48	1	0.1	1
1	1440	48	30	3	3
6	1440	48	30	3	3
5	864	48	18	1.8	2
2	816	48	17	1.7	2
3	96	48	2	0.2	1
4	144	48	3	0.3	1
Module 1 cpl(AC)	6192	72	86	8.6	9
Module 2 Cpl(DC)	6912	72	96	9.6	10

Based on this information, we segregated the variants in to 2 categories, items with at least 5-7 bin requirement daily would be given a trolley whereas the items with up to only 4 bins would be handled via a 2 bin or 3 bin supermarket

5) Replenishment Strategy

Replenishment strategy indicates as to when and how the workstation will be replenished for its inputs. Thus we have to answer as to what items will be needed for production, how many would be needed. How soon they will be consumed and who will re-fill the inputs.

To answer these questions, we must first identify that at what rate one workstation consumes its inputs. Therefore based on the takt time, we identified the rate of consumption of the different workstations which is shown as follows (only one Workstation is shown below for clarity)

Table IV: Requirement of different components per workstation

AC								
Item	**Qty per bi**	**Quantity Needed**	**Bins per Track**	**Req per shift**	**Req per day (2 shif**	**Replenishment time per bin (in hours)**	**Replenishment time when track is completely**	**No of bins required after complete replenishment (2 shift)**

	n					**ts)**			**filled (in hours)**		
MODULE 1 Cpl	72	1	3	3.33	4	7	2.4	2	7.2	6.5	4
Module 2 Module Complete	48	1	3	5.00	5	10	1.6	1	4.8	4	7
Module 3	24	1	4	10.00	10	20	0.8	0.5	3.2	2.5	16
Module 4 Cpl	88	1	3	2.73	3	6	2.93	2.5	8.8	8	3
Module 5 Cpl	72	1	3	3.33	4	7	2.4	2	7.2	6.5	4
Accessories	100	1	3	2.40	3	5	3.33	3	10	4	2

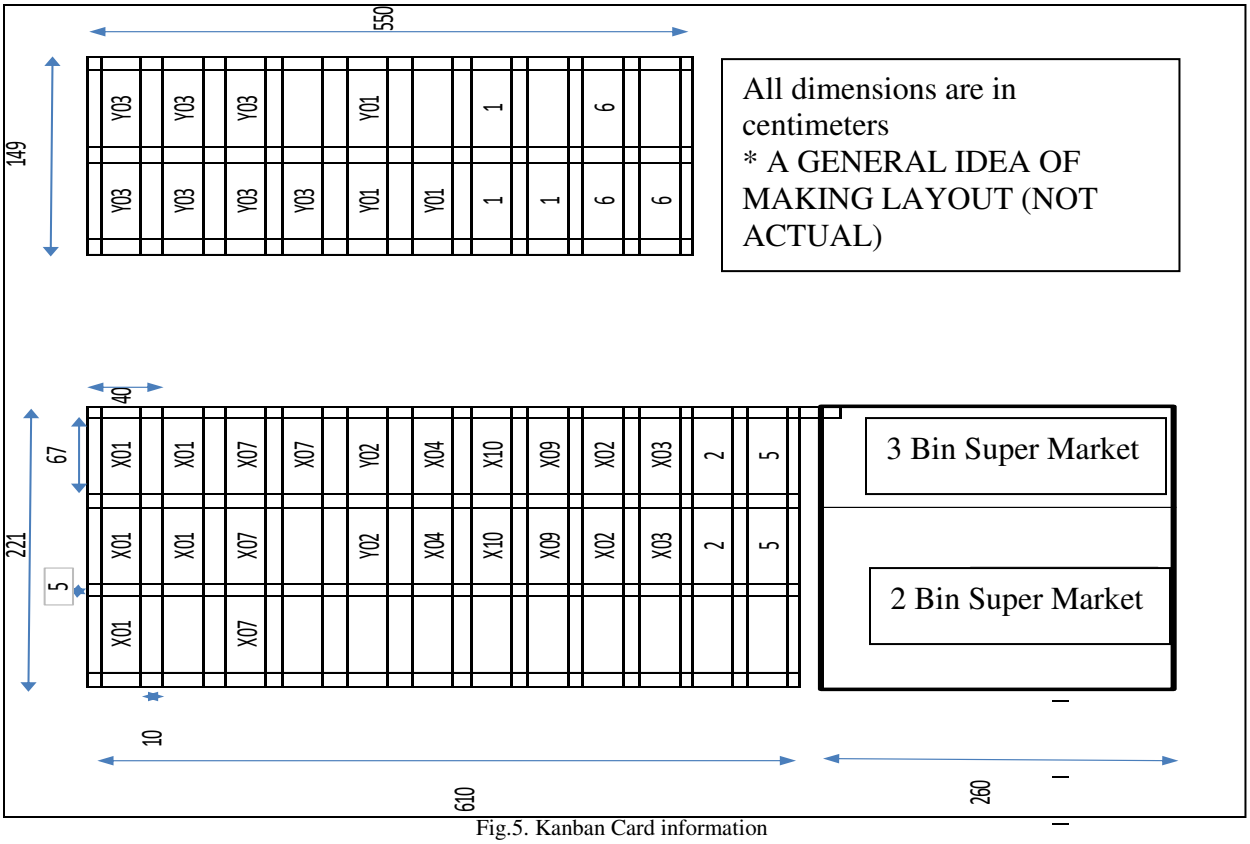

Fig.5. Kanban Card information

Based upon the production rate and bin quantity, the consumption time for one bin was calculated. Using the consumption time we were able to estimate the replenishment time, which if fails would lead to stop of production another consideration was the return bin track. Since there are multiple inputs with varying bin sizes that are used at a single workstation, return track could be a potential blockage and therefore must be addressed. Simulations were undertaken to fill the return track based upon the rate of consumption as determined earlier and the breakage point was identified after which the return track was completely filled and any subsequent bin empty bin would have no place to go.

Table V: Capacity analysis for the return track

	Module 1 Complete	Module 2	Module 3	Module 4	Module 5
6:00					
6:30			1		
7:00		1	2		
7:30			3		
8:00	BREAK	FAST	TIME		
8:30	1	2	4	1	1
9:00			5		
9:30		3	6		
10:00			7		
10:30	2	4	8		2
11:00	LUNCH		TIME		
11:30			9	2	
12:00		5	10		
12:30					
13:00	3	6			3
13:30					
14:00				3	
14:30					
15:00	4				4
15:30					

Empty tray capacity with output tray

In the above case, we identified that if the production was in full scale, the return track of a single workstation would be completely filled within 4.5 hours. Therefore, the track has to be cleared within this amount of time. Fortunately, this is a lot of time and therefore is not a bottleneck.

Then, we allocated the responsibility of replenishment. Who will collect the various inputs, who will collect the empty bins and how frequently would it have to be taken in order to ensure that production goes smoothly with and there is no delay in production

Table VI: Responsibility, allocation and replenishment time strategy (Suggested)

No.	Where		When	Who	What	By what	How many	How to act
	From	To						
1	WS	Empty Component v station	every 1 hour	Spider	Empty module 3 bins	trolley	1 per WS (Total 12)	1. Pick up the empty component V bin 2. Remove the Kanban card 3. Drop the Kanban card in Kanban Post 4. Place the empty bin in Module 3 Warehouse
2	WS	M Shop	every 2 hours	Spider	Empty module	trolley	1 per WS (Total 12)	1. Pick up the empty Module

					2 bins			Complete bin 2. Remove the Kanban card 3. Drop the Kanban card in Kanban Post 4. Place the empty bin in Module 2 Warehouse
3	WS	Empty MODULE 1 area	every 2 hours	Spider	Empty Module 1 bins	trolley	1 per WS (Total 12)	1. Pick up the empty MODULE 1 bin 2. Place the empty bin in MODULE 1 Warehouse
4	WS	M Shop	every 3 hours	Spider	Empty Module 4 bins	trolley	1 per WS (Total 12)	1. Pick up the empty Module 4er bin 2. Place the empty bin in P Shop
5	WS	M Shop	every 3 hours	Spider	Empty 5 bins	trolley	1 per WS (Total 12)	1. Pick up the empty MODULE 1 bin 2. Place the empty bin in MODULE 1 Warehouse
6	WS	Empty Accessories area	every 3 hours	Spider	empty accessories tray	trolley	1 per AC WS (Total 4)	1. Pick up the empty Accessories tray 2. Place the empty tray in Warehouse
7	Module 3 Kanban Area	WS	once the inventory on track is consumed	Operator	Module 3 bins	trolley	till order requirement is satisfied	1. Pick up the coil bin from Module 3 Kanban Area 2. Replace the Kanban card with Withdrawal kanban card 3. Drop the Kanban card in Kanban Post 4. Place the coil bin in WS
8	Module Complete Kanban Area	WS	once the inventory on track is consumed	Operator	Module 2 bins	trolley	till order requirement is satisfied	1. Pick up the Module Complete bin from Module Complete Kanban area 2. Replace the

								Kanban card with Withdrawal kanban card 3. Drop the Kanban card in Kanban Post 4. Place the Module Complete bin in WS
9	MODULE 1 Storage Area	WS	before the starting of the shift and once in between	Warehouse person	Module 1 bins	trolley	till track is filled (total 3)	1. Pick up the empty MODULE 1 bin 2. Remove the Kanban card 3. Drop the Kanban card in Kanban Post 4. Place the empty bin in MODULE 1 Warehouse
10	M Shop	WS	before the starting of the shift and once in between	Spider	Module 4 bins	trolley	till track is filled (total 3)	1. Pick up the Module 4 bin 2. Place the bin on WS
11	M Shop	WS	before the starting of the shift and once in between	Spider	Module 5 bins	trolley	till track is filled (total 3)	1. Pick up the Module 5 bin 2. Place the bin on WS
12	Accessories storage area	WS	before the starting of the shift and once in between	Warehouse person	Accessories tray	trolley	till track is filled (total 3)	1. Pick up the empty MODULE 1 bin 2. Remove the Kanban card 3. Drop the Kanban card in Kanban Post 4. Place the empty bin in MODULE 1 Warehouse
13	WS	STATION 4 O/P	every 2 hours	Output Spider	Contactor	trolley	1 per WS (Total 12)	1. Pick up the Output bin 2. Place it in the Station 4 output area

CONCLUSION

According to the lean manufacturing principles particularly in this case study, the case study results have been evaluated using waste reduction metric parameter. Three waste metrics had been identified inventory, transportation (from vendor to company) and over production (un-planned stock). All these parameters were identified in the values stream mapping and were able to reduce with the help of kanban system.

FSN analysis for making the super market area (keeping in view of safety stock to reduce transportation cost from vendor to company) more over the replenishment strategy for the spider to replenish materials at each station to reduce the motion of the spider. The result can be verified in the future state map i.e. reducing the inventory storage (both inventory level and over production) from 13 days to 5.5 day which means reduction of around 58% in non-value added activities.

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