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Two Dimensional Decision Matrix and Kanban System for Inventory & Cost Management

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Abstract: -In this VUCA (volatility, uncertainty, complexity and ambiguity) world, it is very difficult to predict or forecast the sales and inventory for the product. Manufacturing industry developments heavily depends on the strength of the supply chain. Inventory management is very vital activity in supply chain management as it fulfils the customer demand and also, helps the organization to keep inventory cost low and manage inventory on time. However, many organization struggles to manage inventories which increases the overhead costs and inventory cost to the organization. JIT and Kanban are the techniques which helps organizations to keep inventory minimal and at the same time avoid stock outs problems. This methods helps the companies to manage accounts efficiently. This paper presents the study and implementation of JIT and Kanban technique with the help of ABC and XYZ analysis. This study is also an example for SMEs which reveals how 2 dimensional decision matrix can help to reduce the inventory cost, avoid stock outs and manage inventories efficiently.

Keywords: Kanban, Just-In-Time, Lean, Inventory Management, ABC Analysis, XYZ Analysis

1. Introduction

One of the leading driving force after the pandemic COVID-19 is the delivering the business value and cost optimization. Various industry segments are looking for alternatives to reduce the cost of operation and overhead costs. Inventory management is very critical process for the manufacturing firm as it occupies the most strategic position in the firm in terms of working capital. Generally, one of the largest component of the current assets in any business enterprise is the inventories. Efficient control of the inventory is the serious problem in the sphere of the working capital [6]. If organization doesn't have control over the inventory, it has tendency to grow beyond the economic limits, may hold up fund and further increase the carrying cost and maintenance cost. Also, there is a challenge that if organization doesn't maintain the enough stocks of the inventory, it will create high probability of non-availability of the goods, stock outs and will generate deficit in the cash inflow on the account books [6]. Inventory control is an integral approach and is essential in determining the right amount of quantity of items, time, storing cost, without affecting the current and future production and distribution warehouse operations.

Various methods, tools and techniques are available to control and manage the inventory stocks effectively and efficiently. One of worldwide known method for the inventory control is Kanban. Kanban is a Japanese word, which means "Signboard" or "Billboard". Taiichi Ohno who was the Japanese Industrial engineer and businessman, has developed the Toyota Production System, which has inspired the Lean Manufacturing [5]. Kanban system emphasizes on the minimum or least level of inventory. The fundamental of utilizing the Kanban technique is to ensure that the right number of items are available at the right time. Kanban helps to resolve the logistic control issues. Kanban helps to create a smooth material flow with synchronized manufacturing process [2]. Just like Kanban, Just-In-Time (JIT) is another technique which ensures that right inventory is available at the right time and at right place. Continuously reducing the all forms of waste and finally eliminating it, is the primary goal of the JIT. Just-In-Time method emphasizes on the Zero Concept, which means, Zero waste, Zero wait time or Zero queue time, Zero inventories, Zero shutdowns or breakdowns, Zero defects and so on [5]. Kanban is new age development which plays important role in JIT production system. Kanban is nothing but a plastic card containing information related to

production of product at each stage of its path of completion.

1.1 Inventory Management Methods

Kanban is the methodology which helps to visualize the workflow of the production, and uses the queue theory to improve and control the inventory such that maximum production flow is attained without any disruption or stock-outs [10]. There are mainly two types of the Kanban systems, a) Push System and b) Pull system.

Push system: It is the most traditional and conventional system of production. In Push system, when job is completed at one station, it moves the item to next work station where it requires to perform some operations and process and finally it moves to the store. In Push system, job cards moves along with the job. Push system lacks the unpredictability of the production and hence sometime creates problem to adjust the unpredictable fluctuation of the demand [5]. Inventory planners keeps extra buffer stocks to adjust such fluctuation. Below figure 1 is the graphical representation of the flow of Push System.

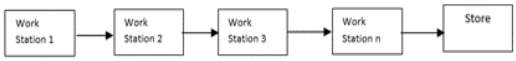

Figure 1. Push System

Pull System: In a pull systems, value addition to production happens at every workstation. In this system, at each workstation, the job is withdrawn from its succeeding workstation. So, Instead of being pushed by other work station, in pull system it job is being pulled by succeeding workstation. The production flow is controlled by the Kanban Card. In pull system can have single card Kanban or two card Kanban. When Kanban system operates with Single card, it is known as Production order Kanban (POK) [5]. Below figure 2 is the graphical representation of the flow of Pull system.

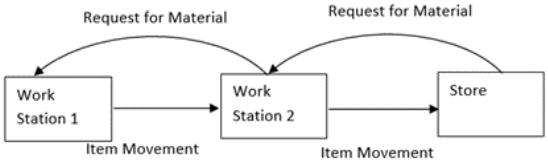

Figure 2. Pull System

In Kanban System, worker replenish the material or item when it is consumed. An empty bin or card or container will give an indication to worker that certain quantity of the item needs to be produced. Kanban System works on six simple rules [11].

1. Visualize
2. Limit work in progress
3. Manage Flow
4. Make Policies explicit
5. Implement Feedback loops
6. Improve collaboratively, evolve experimentally

ABC analysis is also one of the method which helps in improving the inventory management. In ABC analysis, all inventory are classified in to three groups A, B & C. The determining characteristic of the ABC analysis is the periodic turnover, it is determined as the product cost per unit and its consumption rate [4]. ABC analysis is fundamentally based on the Pareto Analysis, which says that 80% of the cost of inventory is because of the 20% of the total inventory [7]. Below list shows the advantages of ABC analysis:

It ensures strict and closer control over the inventories which has higher amount of investment

1. It helps to release the working capital, which otherwise would have been hold up
2. Reduction in carrying cost of the inventory
3. Allows to create sufficient buffer stocks for the items categorized as “C”
4. Enables the maintenance of high inventory turnover rate

2. Literature Review:

DivyaDevarajanhas analyzed the inventory of the Chemical firm using Fast Slow and Non-moving (FSN) and XYZ analysis to identify and discard unnecessary inventories and thereby create some cost saving. They have identified total 625 items of worth Rs. 22575608 which are non-moving items and requires very least controls. By eliminating this items chemical firm as able to make substantial amount of savings.

Zharalin Suryaputri has aimed to develop inventory policies based on the characteristic of the inventory of Medical firm. They have used integration of ABC and XYZ analysis to identify less important inventories. They have also emphasized on the re-order points of the inventories and suggested to make periodic inspection about the inventory management.

Asrat Mekonnen Gobachew, has demonstrated how implementation of Kanban system based on ABC/XYZ

analysis helps improving the inventory management. They have implemented Kanban based ABC/XYZ analysis in Ethiopian Pharmaceutical supply agency and showed that by this method, company has achieve 75% of cost saving on the inventory.

Ahmad Naufal has determined the optimum number of the Kanban required in Just in Time production. They have also analyzed the effect of the optimum numbers of the Kanban on the performance of manufacturing. They have gathered the information related to current situation, company database, floor space, and thereby they have developed mathematical model to calculate the optimum number of the Kanban quantity. They have concluded that the product lead time has reduced by 36% and floor spaces has improved by 81%.

Ahmad Naufal has implemented the Kanban system in local manufacturing firm at Malaysia which has high volume and medium variety products. They have implemented Pull system for the inventory management. Study reveals that by successful implementation of Kanban system, Author was able to achieve 40% reduction in lead time and Optimized finished good area by 4%. They have also improved the in-process and finished goods inventory by 23%.

Nor Azian Abdul Rahmanhas studied the multinational and small scale and medium scale companies who have already implement lean manufacturing systems in deploying Kanban systems. They have collected the data from the employees and management staff and analyzed it. They have found that for multinational and medium scale companies, Kanban system was effective and companies found various benefits whereas for small scale companies, it hinders the implementation of the Kanban systems as it lacks the support from the suppliers. They have concluded that for successful implementation of Kanban, Management commitment, Vendor participation, inventory management and quality management are essential parameters.

Marina Papalexi has implemented Kanban system in the Pharmaceutical supply chain agency. They have concluded that Kanban implementation has two major benefits 1) It provides the strategic benefits and improves the quality, 2) It provides the operational change and freedom to move from current push delivery logistic system to improved logistics strategy models.

3. Research Problem & Objective

The company where Kanban is implemented is leading machinery manufacturing company of plastic converting machinery. The company manufactures the machinery for side sealing; bottom sealing, T shirt, patch handle and zip lock bag-/pouch-making machines. The area considered for this study is assembly area and store area of the company. It was observed that company has large amount of inventories and occupies lot of store area as well as inventories becomes the bottle neck for the working capital as most of funds are hold-up in inventories. The company was in distress of inventory due to over stocking of the inventories. The management team were seeking the consulting service and help to improve the inventory management and reduce inventory cost by following the Kanban system. The main objective of this study is to improve the inventory management, reduce the inventory cost and improve the floor space area of the company.

4. Research Methodology

To ensure the effective and efficient implementation of inventory management, multiple discussion were planned with the management team and staff members of the company in research study. To begin with the Inventory management, Management team decided to complete the inventory management for SS-800 machine as it is the highest selling machine. After careful consideration and with the mutual agreement with management team of the company, it was decided to perform research study in four phases. Below are the four phases of the study.

Phase 1: Data collection to understand demand generation and existing inventory.

- Collect a data of machine sold to identify the frequency of machine sold
- Collect the Inventory stocks of the last seven months

Phase 2: Data Analysis

Data analysis was carried out using the Microsoft Excel software. Following Analysis were considered as the initial study.

- Analysis of machine sold to understand the frequency and demand of machine sold
- Analysis of month wise machine sold - SS-800 machine
- Analysis of the Inventory stock of last seven months
- Carry out cost of current inventory stocks

Phase 3: Selection of Inventory management technique

Various tools and techniques are available in Lean manufacturing system. However, after discussion with management team, following techniques were finalized for the inventory management.

- ABC Analysis: To understand what percentage or number of inventory contributes the most of cost of the inventory
- XYZ Analysis: To understand what percentage or number of inventory contributes to lesser lead time and so that it can be order just in time to make the fund available for working capital
- Create a two dimensional Integration of ABC-XYZ analysis to understand what percentage or number of inventory contributes the most of cost and has a least or medium lead time so that purchase order for those inventories can be placed in short period of time.
- Kanban System: To ensure that there is no stock out situation for the inventories and at the same time no over stocks of the inventories.

Phase 4: Implementation of ABC & XYZ techniques & Kanban

ABC Analysis: ABC Analysis is the technique which categories the inventory based on the total consumption in quantity and total consumption of value. In this method, products or items are grouped under the A, B, & C classification. The classification criteria for this study is as below:

A: Products/Item or inventory in this categories have highest value

B: Products/Item or inventory in this categories have medium value

C: Products/Item or inventory in this categories have least value

The fundamental of the ABC analysis method relies on the Pareto Principles:

A: 80% of total usage value is because of 10% of Inventory

B: 10% of total usage value is because of 35% of Inventory

C: 10% of total usage value is because of 55% of Inventory

Table 1: ABC Classification

Classification	% of total value	% of total inventory
A	80%	10%
B	10%	35%
C	10%	55%

XYZ Analysis: To classify the products/items or inventories in XYZ categories, material procurement lead time is considered as major factor.

X: Products/Item or inventory in this categories have high lead time

Y: Products/Item or inventory in this categories have medium lead time

Z: Products/Item or inventory in this categories have least lead time

Following criteria were decided to classify the inventories in XYZ categories.

Table 2: XYZ Classification

Classification	Lead time
X	Inventory procurement lead time is greater than 5 days
Y	Inventory procurement lead time is less than or equal to 5 days or greater than 2 days
Z	Inventory procurement lead time is less than or equal to 2 days

A Two dimensional matrix of ABC and XYZ analysis gives the broader view of inventory management and helps to address the inventory management problem in two aspects 1) Shorter lead time and high value inventories can be order later to make working capital available and 2) Higher lead time and high value inventories should be ordered first.

Below table shows the two dimensional matrix of ABC-XYZ analysis.

Table 3: Two dimensional matrix of ABC - XYZ

Classification	A	B	C
X	AX	BX	CX
Y	AY	BY	CY
Z	AZ	BZ	CZ

The nine categories of two dimensional matrix ABC-XYZ analysis are as below:

AX: Items or Inventories which has highest contribution in cost and has high lead time
AY: Items or Inventories which has highest contribution in cost and has medium lead time
AZ: Items or Inventories which has highest contribution in cost and has least lead time
BX: Items or Inventories which has medium contribution in cost and has high lead time
BY: Items or Inventories which has medium contribution in cost and has medium lead time
BZ: Items or Inventories which has medium contribution in cost and has least lead time
CX: Items or Inventories which has least contribution in cost and has high lead time
CY: Items or Inventories which has least contribution in cost and has medium lead time
CZ: Items or Inventories which has least contribution in cost and has least lead time
AY, BY, CY, AZ, BZ, & CZ have been considered as Just-in-Time inventories as it can be made available within a week time.
Last seven months stocks were taken to calculate the maximum number of inventories and stocks available for the particular items. To understand the Inventory cost, maximum number of the particular item ordered in the last seven month were counted.
Required Kanban quantity was calculated using following formula
K = D*LT*(1+SS)/C…… Formula (1)
Where,
D = Average daily demand/consumption of the item
LT = Lead time of the item in days
SS = Safety stock in days
C = Container capacity
K = Kanban size

5. Results & Discussion

In this study, it is tried to understand that how ABC analysis and XYZ analysis when integrated as a two dimensional matrix, helps to identify the inventories, which requires immediate attentions and other inventories which can be brought out Just in Time. Data analytics has also helped in creating the inventory policies for the company in study. Since the assembly lead time of the machine is 45 days, items which has lead time greater than 30 days, zero safety stock days has been considered for such items. For the items which has more than 15 days lead time, 3 days of safety stocks is to be considered, in order to achieve optimum Kanban numbers. In general, for all other items, safety stocks of 7 days is considered for the analysis and implementation. Also, Kanban system is used to optimize the inventory level. Implementation of Kanban has helped in reducing the inventory cost and maximize the floor space utilization.

From the data collected, it was observed that company under study has sold total 317 machines from the August 2021 to February 2023. On an average company under study is producing approximately 19 machines in a month. Below Figure 3 shows the graph of the machine sold by company from Aug-21 to Feb-2023. From the company's portfolio of the machines, SS-800 machine was the focus area for this study purpose. It was observed that company has sold total 63 machines from Oct-2021 to Feb-2023 with an average of approximately 4 machines per month. Below Figure 4 shows the graph of the SS-800 machine sold by company from Oct-21 to Feb-2023 and table 4 shows the inventory stocks for the SS-800 machine.

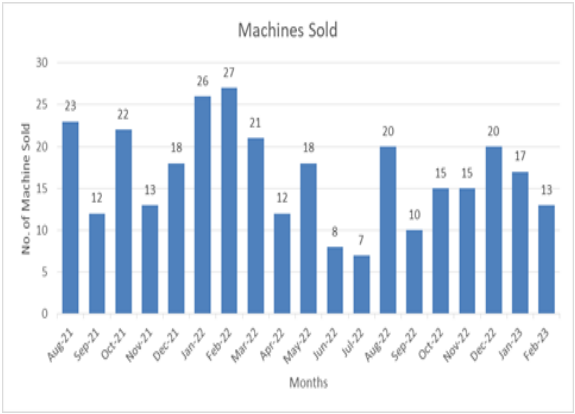

Figure 3. Machine Sold

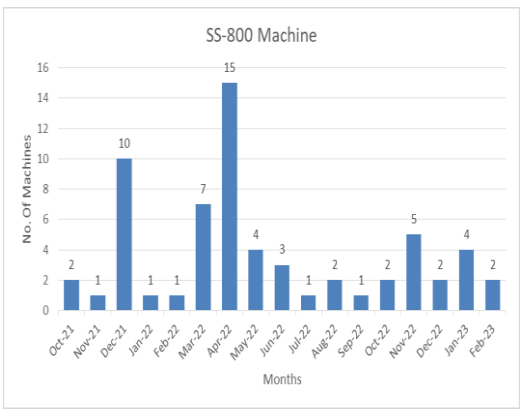

Figure 4. SS-800 Machine sold

Total cost of the inventory stock was calculated as Price per unit x Qty of Inventory stocks. For example, Inventory stock cost for Item #1 is INR 845 x 5 = INR 4225. Similarly Inventory cost of all 513 items calculated. The total Inventory stocks cost was found as INR 4,487,962.50.

For classifying the inventory in A, B and C categories, Pareto principle was followed and for classifying X, Y and Z, procurement lead time was considered. Below sample table 5 shows the sample calculation of the ABC analysis and XYZ analysis.

Below Figure 5. Show the graph of the ABC analysis. The X axis of the graph was plotted as Cumulative percentage of units of Inventory and Y axis was plotted as Cumulative percentage of the total inventory value. Table 6 & 7 shows the total value in INR and in % of total value and quantity of the inventory.

Table 4. Sample Inventory Stocks for SS-800 machine

Sr. No.	Drawing No.	Drawing Name	Price Per Unit INR	Quantity Per Machine	Inventory stocks
1	FSS-1200-04	FOLDER FRAME SLIDING BAR	845	1	5
2	FSS-1200-05	RH STUD	145	1	5
3	FSS-1200-19	MOVINE FRAME	12750	1	5
4	FSS-1200-20	FIX FRAME	12500	1	5
5	FSS-1200-25	VERTICAL FRAME NEW	5000	1	5
6	FSS-1200-26	TRIANGLE SIDE FRAME ASSLY	6000	1	5
7	FSS-1200-36	FRAME SLIDE BAR	2200	2	10
8	FSS-1200-49	ROLLER MNTG ANGLE	345	1	5
9	FSS-1200-50	ROLLER MNTG ANGLE 2	340	1	5
10	FSS-1200A-027	FREE ROLLER ASM	3300	1	5
11	FSS-1200A-029	FREE ROLLER ASM	3000	2	10
12	FSS-1200A-031	FREE ROLLER ASM	2200	6	30
13	FSS-1200A-086	FREE ROLLER ASM	1800	1	5
14	FSS-700-035	FREE ROLLER MNTG BLOCK	636	2	10
15	FSS-1500-13	FREE ROLLER MNTG ANGLE	380	2	10
16	FSS-1500-34	LH STUD	130	1	5
17	FSS-1500-36	HANDLE	195	1	5
18	FSS-1500-37	ROD END PIN	90	1	5
19	FSS-1500-38	FREE ROLLER MNTG BKT 1	150	1	5
20	FSS-1500-39	FREE ROLLER MNTG BKT 2	150	1	5
21	FSS-1500-42	MOVING FRAME STUD	800	1	5
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513	SS-800-01-027	ANGLE FOR GUARD 2	85	2	10

Table 5. Sample ABC and XYZ Classification of inventories

Sr. No.	Drawing No.	Drawing Name	Price Per Unit INR	Quantity	Procurement Lead time Days	Cumm. QTY	Cumm. QTY %	Total Price INR	Cumm. Price INR	Cumm. Price %	CLASS ABC	CLASS XYZ
1	HF-JP5034	SERVO MOTOR	52050	1	45	1	0.03%	52050	52050	5.8%	A	X
2	MR-J3-500B4-S234	SERVO DRIVE	36450	1	45	2	0.07%	36450	88500	9.9%	A	X
3	VFD007EL21A	DELTA MAKE AC DRIVE 1 HP	11000	3	45	5	0.17%	33000	121500	13.5%	A	X
4	SS-800-0412	UPPER PRESSING UNIT MNTG FLAT	2765	8	5	13	0.44%	22120	143620	16.0%	A	Y
5	UW-1200-01-003	PNEMATIC AIR SHAFT	21613	1	3	14	0.47%	21613	165233	18.4%	A	Y
6	FX5-40SSC-S	SSC NET MODULE	21400	1	45	15	0.51%	21400	186633	20.8%	A	X
7	STATIC ELECTRODE600	ELECTRODE	6000	3	45	18	0.61%	18000	204633	22.8%	A	X
8	STATIC ELECTRODE800	ELECTRODE	6000	3	45	21	0.71%	18000	222633	24.8%	A	X
9	STATIC ELECTRODE1000	ELECTRODE	6000	3	45	24	0.81%	18000	240633	26.8%	A	X
10	POB 050,2.15A ,DC24V	HELISTAR MAKE BRAKE	17000	1	45	25	0.85%	17000	257633	28.7%	A	X
11	PRE SEALER UNIT	NAVINBHAI SUPPLY	15500	1	10	26	0.88%	15500	273133	30.5%	A	X
12	FSS-1200A-031	FREE ROLLER ASM	2200	6	21	32	1.09%	13200	286333	31.9%	A	X
13	FSS-1200-19	MOVI NE FRAME	12750	1	15	33	1.12%	12750	299083	33.3%	A	X

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130	SS-800-0024	PICK OFF CAM SHAFT	1422	1	4	285	9.67%	1422	716158	79.8%	A	Y
131	UW-500-01-021	STUD MTG PIECE 2	700	2	3	287	9.74%	1400	717558	80.0%	A	Y
132	UW-500-01-023	FREE ROLLER MNTG BKT	700	2	3	289	9.80%	1400	718958	80.2%	B	Y
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512	LCT-350-0062	PRESSURE SPRING	14	1	14	2947	99.97%	14	896975.5	99.9%	C	X
513	SS-800-0637	DANCING CAM SPRING	12	1	2	2948	100.00%	12	896987.5	100.0%	C	Z

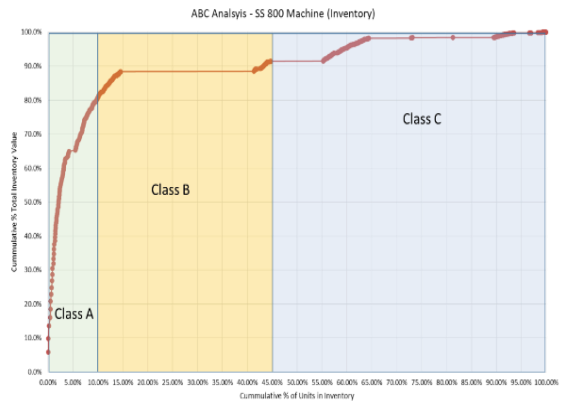

Figure 5. ABC analysis of SS- 800 machine

From the above graph and table 6 and 7, it is evident that 80% of machine cost built by 9.74% of the total items of the machine. Similarly for 33.48% of total items of machine contributes to the 9.99% of the total cost of machine and 56.78% of total items of machine contributes to the 10.02% of the total cost of machine.

Table 6. ABC Classification Summary

Class	Sum of Total Price INR	Sum of QTY
A	717558	287
B	89571	987
C	89858.5	1674
Grand Total	**896987.5**	**2948**

Table 7. ABC Classification in %

Class	Sum of Total Price %	Sum of QTY %
A	80.00%	9.74%
B	9.99%	33.48%
C	10.02%	56.78%
Grand Total	**100.00%**	**100.00%**

Also, while collecting the data for SS-800 machine, procurement lead time for each inventory was noted. Which has helped in classifying the inventory in X, Y and Z categories. Below table 8 & 9 provides the details of X, Y and Z categories with respect to total price and quantity.

From the table 8 and 9, it is observed 544 items which is 18.45% of total items, contributes to INR 605152 which is 67.46% of the total cost has lead time greater than 5 days. Also, it can be observed from the table 8 & 9 that 81.55% of items of machine has lead time as 5 days or less than 5 days. It also indicates that INR 291835.5 of the machine cost can be made available for working capital as these items will be procured Just in Time before the 5 days of the final assembly of machine.

Table 8. XYZ Classification in INR & QTY

Class	Sum of Total Price INR	Sum of QTY
X	605152	544
Y	254755.5	2303
Z	37080	101
Grand Total	**896987.5**	**2948**

Table 9. XYZ Classification in % & QTY %

Class	Sum of Total Price %	Sum of QTY %
X	67.46%	18.45%
Y	28.40%	78.12%
Z	4.13%	3.43%
Grand Total	**100.00%**	**100.00%**

When ABC analysis is integrated with XYZ analysis it has delivered below results. Table 10 to 13 shows the Total value and total quantity of the inventory in ABC –XYZ format.

Table 10. Total cost in INR of the machine ABC – XYZ matrix

Class	A	B	C	Grand Total
X	553202	29366	22584	605152
Y	148536	49601	56618.5	254755.5
Z	15820	10604	10656	37080
Grand Total	**717558**	**89571**	**89858.5**	**896987.5**

Table 11. Total cost as % of the machine cost ABC – XYZ matrix

Class	A	B	C	Grand Total
X	61.67%	3.27%	2.52%	67.46%
Y	16.56%	5.53%	6.31%	28.40%
Z	1.76%	1.18%	1.19%	4.13%
Grand Total	**80.00%**	**9.99%**	**10.02%**	**100.00%**

Table 12. Total quantity of the machine inventory ABC – XYZ matrix

Class	A	B	C	Grand Total
X	135	61	348	544
Y	140	908	1255	2303
Z	12	18	71	101
Grand Total	**287**	**987**	**1674**	**2948**

Table 13. Total quantity as % of inventory the machine ABC – XYZ matrix

Class	A	B	C	Grand Total
X	4.58%	2.07%	11.80%	18.45%
Y	4.75%	30.80%	42.57%	78.12%
Z	0.41%	0.61%	2.41%	3.43%
Grand Total	**9.74%**	**33.48%**	**56.78%**	**100.00%**

From the table 10 to 13 it can be observed AY, BY, CY, AZ, BZ, and CZ contributes to 81.55% of the total inventory which constitute INR 291835.5 of the machine cost. These inventories has the lead time less than or equal to 5 days which indicates that INR 291835.5 can be made available for working capital. Also, From the Two dimensional matrix of ABC-XYZ, it can be observed that AX, BX and CX cumulatively 18.45% of the total inventory contributes INR 605152 of the total cost the machine.

After calculating the existing stock, and ABC-XYZ analysis, Kanban system was implemented. Below figure 6 shows the Kanban board and figure 7 shows the Kanban Card. Kanban board helped to keep a track of inventories. It triggered a signal to place an

order for the items to fill or provided information of about the material/item consumption. Kanban card gives the indication of how many items needs to repurchased or refill. Both Kanban Card and Kanban board has helped to avoid inventory stock-out problem.

Figure 6. Kanban Board

Figure 7. Kanban Card

Table 14 shows the calculation of the Kanban quantity using the formula 1 mentioned above section. Daily consumption has been calculated based on the last seven months average consumption.

Based on the Kanban quantity, the total inventory cost for machine has been calculated as INR 2,818,786.00. It has been observed that with the help of Kanban quantity, company was able to save INR 1,669,176.50 as the inventory cost. Below table shows the Change in inventory quantity and change in inventory cost after the Kanban Implementation.

Table 15. Impact of Kanban Implementation

	Inventory Quantity	**Inventory Quantity in %**	**Inventory Stock Cost in INR**	**Inventory cost in %**
Befor e Kanban	5005	100%	4,487,962.50	100%
After Kanban	2099	58.06%	2,818,786.00	37.2%

Below figure 8. Shows the improvement in the Inventory cost.

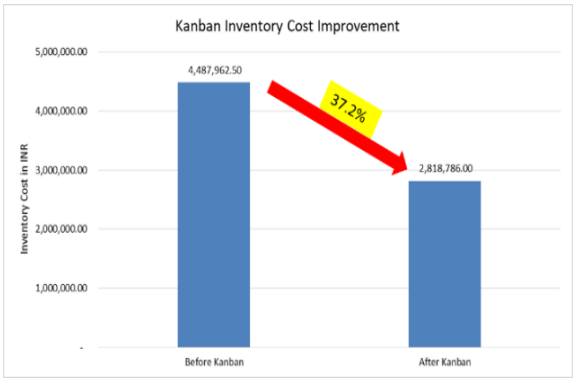

Figure 8. Inventory cost improvement Kanban System

Below figure 9. Shows the improvement in the Inventory quantity.

Figure 9. Inventory quantity improvement Kanban System

Table 14. Sample Kanban quantity calculation

Sr. No.	Drawing No.	Drawing Name	Daily Consumption (D)	Procurement Lead time Days (LT)	Consumption (PLT) (Days)	Safety Time (SS) Days	Safety Stock (SS1)	Container Capacity (C)	ROL = D*LT(1+SS)/C	Kanban Qty
1	FSS-1200-04	FOLDER FRAME SLIDING BAR	0.10	8	0.76	7.00	0.67	3	2.03	3.00
2	FSS-1200-05	RH STUD	0.10	3	0.29	7.00	0.67	10	0.23	1.00
3	FSS-1200-19	MOVINE FRAME	0.10	15	1.43	7.00	0.67	3	3.81	4.00
4	FSS-1200-20	FIX FRAME	0.10	15	1.43	7.00	0.67	3	3.81	4.00
5	FSS-1200-25	VERTICAL FRAME NEW	0.10	10	0.95	7.00	0.67	3	2.54	3.00
6	FSS-1200-26	TRIANGLE SIDE FRAME ASSLY	0.10	10	0.95	7.00	0.67	3	2.54	3.00
7	FSS-1200-36	FRAME SLIDE BAR	0.19	7	1.33	7.00	1.33	3	3.56	4.00
8	FSS-1200-49	ROLLER MNTG ANGLE	0.10	7	0.67	7.00	0.67	3	1.78	2.00
9	FSS-1200-50	ROLLER MNTG ANGLE 2	0.10	7	0.67	7.00	0.67	3	1.78	2.00
10	FSS-1200A-027	FREE ROLLER ASM	0.10	10	0.95	7.00	0.67	3	2.54	3.00
11	FSS-1200A-029	FREE ROLLER ASM	0.19	10	1.90	7.00	1.33	3	5.08	6.00
12	FSS-1200A-031	FREE ROLLER ASM	0.57	21	12.00	7.00	4.00	18	5.33	6.00
13	FSS-1200A-086	FREE ROLLER ASM	0.10	10	0.95	7.00	0.67	3	2.54	3.00

14	FSS-700-035	FREE ROLLER MNTG BLOCK	0.19	5	0.95	7.00	1.33	3	2.54	3.00
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170	EPC-1200-008	JOINT PIPE 1	0.19	12	2.29	7.00	1.33	4	4.57	5.00
171	EPC-1200-009	BASE PLATE	0.10	12	1.14	7.00	0.67	2	4.57	5.00
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513	SS-800-01-027	ANGLE FOR GUARD 2	0.19	3	0.57	7.00	1.33	2	2.29	3.00

6. Conclusion

The study reveals that the ABC analysis is helpful in determining what percentage of the total inventory governs the cost the machine or product. However, when ABC analysis is integrated as two dimensional matrix with XYZ, it helps to understand the complex problem of inventories with regards to lead time, quantity and cost of the inventories. From the study and two dimensional ABC-XYZ matrix, it is observed that 81.55% of the total inventory, worth of INR 291835.5 can be procured just in time before the assembly of machine. This amount can be relaxed for the other operations of company and same amount can be made available as working capital. Thus, it is evident from the study that ABC-XYZ not only helps the company in study to reduce the inventory cost but also helps to manage the inventory with more ease. Not only that since 81.55% of inventory will be brought in with concept of Just-in-Time, Storage area/floor space will also be made available for the finished goods or any other additional material or for other productive work of the company. AX, BX, and CX component of two dimensional matrix requires special attention, and order for those inventories needs to place with caution in order to avoid any breakdown in the assembly line. Kanban size calculation also revealed that company can save 37.2% of the total inventory cost without any stock out issues and it also reveals that the total inventory quantity has reduced from 5005 to 2099 units, which is 58.06% savings in quantity and floor space per unit of inventory. Few inventory policies or advisories were suggested to the company in study, like, Items which has high cost value and high lead time of greater than 30 days, no inventories should be kept in store area for such items. It must be ordered only on need basis. Also, for the items with lead time of more than 15 days, but less than 20 days, at least 3 days safety stock should be kept in order to avoid any stock out issues and for items whose lead time is 5 days or less, procurement of such items should be Just –in – Time.

7. Implications

This research article includes the implementation of two dimension decision matrix ABC-XYZ and Kanban system to improve the inventory cost and inventory management for plastic converting machinery industry in India. This study specifically focuses on the plastic converting machinery industry in Gujarat, India. In this study, the authors have considered two dimensions for the study: (1) nature of the business/industry, i.e. plastic converting machinery industry and (2) location of the industry, i.e. Gujarat, India, which reflects the current status of Asian market. This paper is also a reference for the plastic converting machinery industry for improving the inventory management by implementing Kanban and ABC-XYZ analysis.

For inventory management, main parameters considered was the cost, quantity and lead time of items. Developing e-Kanban system with RFID tags can be considered as future work. The authors have reviewed various research articles in which other researchers have used one or more already established for inventory management. As per the authors' best knowledge, no research work for the said purpose has been carried out at these two dimensions of industry and location.

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9. Data Availability Statement

The data for this project are highly confidential as it has information related to company in study's product cost and other proprietary details, but may be obtained with Data Use Agreements with the Chandubhai S Patel Institute of Technology Charotar University of Science and Technology (CHARUSAT) Changa. Researchers interested in access to the data may contact Dr. Gajanan S Patange at gajananpatange.me@charusat.ac.in, also see https://www.charusat.ac.in/cspit/#id_contact. It can take some months to negotiate data use agreements and gain access to the data. The author will assist with any reasonable replication attempts for two years following publication

10. Conflict of Interest

The authors declare that there is no conflict of interest regarding the publication of this article.

11. Notes on Contributors

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