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IMPLEMENTATION OF KAIZEN AS A PRODUCTIVITY IMPROVEMENT TOOL IN SMALL MANUFACTURING COMPANY

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Abstract *-Thousands of small & medium scale industries are present in India. All are facing certain problems resulting in lack of productivity, greater lead time, processing time,stock out situations etc. The paper contains basis definition of Kaizen philosophy & a brief review of kaizen concept & its implementation. The purpose of this paper is to represent Kaizen, its related terms in a concrete way & its implementation in improving the overall effectiveness of small scale organization situated in India. This paper illustrate about kaizen implementation in small manufacturing industry & also focuses on the scenario of Indian manufacturing company while implementing Kaizen. The paper also reviews some of the papers which basically focuses on implementation of kaizen technique in small manufacturing companies. For detail justification a case study is conducted on the small manufacturing company who is dealing with manufacturing of PVC &HDPE pipes. The company is currently facing with the problem of increased lead time and stock out situation. In order to solve the faced problem we emphasize on two major alternatives & select Kaizen as a main productivity improvement tool. This implementation is focuses on reducing the lead time of sales order processing by mean of which the productivity of organization will be improved.*

I. Introduction

Kaizen is Japanese philosophy which means continuous improvement. 'Kai' mean Change & ' Zen' mean "Good" the whole purpose of which is betterment of work & improving the organization efficiency. The concept of Kaizen is so deeply ingrained in the minds of Japanese people that they often do not even realize that they are thinking Kaizen.[1] Japanese people uses the inborn instinct of being continuous change present in every human being & work for betterment by using existing resources available within the firm instead of spending lot much money on technologies. The kaizen implementation crucially includes the complete involvement of employees from worker to top level of management in the organization. Kaizen involve small but continuous improvement & this small change can improve the productivity in huge multiplication .in short Kaizen distinguish as the best method of performance improvement among all the techniques as it involve less implementation cost.

Similarly, Nowadays, organizations carry on seeking innovative ideas for improving their processes and retaining a competitive edge. Kaizen is a concept that focuses on improving a work area or an organization in incremental steps by eliminating waste. Kaizen can be applied to any area in need of improvement. Indeed, the overall concept of continuous improvement appears to be applicable to every area of industrial and logistics activity, from the production of basic materials such as steel, aluminum and timber to manufacturing industries as diverse as automotive, furniture, canning, food and drink (Leigh Pomlet, 1994). Many organizations have begun to incorporate the philosophy of kaizen through the use of kaizen methodology. Kaizen project typically focus on specific improvement goals like productivity improvement with small changes & improvement in the working area.

The objective is to focuson SME in India. In this paper we discuss the scenario of Indian SME& Their work toward the implementation of Japanese techniques Kaizen & 5S.The ultimate objective of Small medium manufacturing industries today is to increase productivity through system simplification, organizational potential and smallincremental improvements by using modern techniques. Most of the manufacturing industries are currently encountering a necessity to respond to rapidly changing customer needs, desires and tastes. For industries, to remain competitive in market, continuous improvement of manufacturing system processes has become necessary. Competition and continuously increasing standards of customer satisfaction has proven to be the endless driver of organizations performance improvement. But in small & medium manufacturing industries in India there is a need of small & continuous improvement with the huge patience in Top management people.

Manufacturing industries is the best place to implement the Kaizen project & evaluating its efficiency. This paper illustrate about kaizen implementation in small manufacturing industry who is dealing with manufacturing the PVC & HDPE pipes. The implementation is done in each possible segment of the company from raw material storage to

processing to dispatch section. The proposed Kaizen project would be able to increase the productivity. Reducing lead time.The implementation of Kaizen improve the productivity by 4.2%.The main concern of this project is to focus on lead time reduction & stock out situations which help to improve the productivity output. The kaizen tools used are 5S , kaizen sheet 5S sheet etc.

II. Scope of the study:

The paper involve the implementation of Kaizen in a pipe manufacturing company which is facing the problem of increased lead time & stock out situations in seasons. In short the paper evolves in manufacturing company which practice Kaizen & 5S methods in its production arena. The main concern of the study is to highlight the importance and impact of the Kaizen & 5S a continuous improvement project approach in manufacturing companies. The scope is narrowed to small manufacturing company in PVC,HDPE pipe manufacturing. The company is having two units & unit I among the two specially need the improvement. What would be the manufacturing sector's alternative way of increasing productivity or reducing waste rather than conventional method? This question is highlighted in the further discussion and literature surveys which have been done. Apart from that , case study was conducted through reference made from similar cases conducted in Indian small & medium manufacturing industries. A clearunderstanding of Kaizen & its application in manufacturing industry is the main concern why the study is performed.

III. Literature Review

Kaizen philosophy embraces three main principles proposed by Imai (1986) which areprocess orientation, improving and maintaining standard and people orientation. All principles are significant in order to implement the kaizen.

The brief ideas about the three basic principals are:

A. Process orientation

Imai stated that kaizen is process-oriented. Before results can be improved, processes must be improved, as opposed to result-orientation where outcomes are all that counts. Berger (1997) added to what Imai said that the principle has at least two practical consequences for the improvement process. First, management's main responsibility is to stimulate and support the effort of organizational members to improve processes. In order to be improved, a process must be understood in detail. Second, process orientation calls for evaluating criteria which can monitor and bring attention to theimprovement process itself, while at the same time acknowledging its outcome. And for process orientation the management should count the contribution of each and every employee who actively participate in continuous improvement. For effective participation the management should encourage the employee by giving some reward for contributing in betterment.

B. Improving and maintaining standard

Kaizen is distinctive in its focus on small improvements of work standards as a result of an ongoing effort. Furthermore, Imai (1986) said "There can be no improvement where there are no standards" which in essence denotes the relation between kaizen and maintaining standard procedures for all major operations (Standard Operating Procedures).

C. People orientation:

This principle basically referred to kaizen teian where the benefit gained from kaizen implementation can be seen on daily basis by all company employees. This principal simply focused on employee involvement in improvement process. In people orientation the suggestion of each & every employee from workers to the top management people is at least viewed & the suggestion which really contributing for improvement, actually implemented, which act as motivating factor for employee to participate in Kaizen activity.

Table 1 :Review of literatures in field of Kaizen implementation

Sr. no	Author	Type & Name of industry	Result
1	AbhijitChakraborty, Madhuri Bhattacharya	Front & rear axle manufacturing company	Production rate per hour increases & reduction of lead time
2	R.T. Salunkhe, G.S. Kamble, Prasad Malage	Irrigation pump manufacturing company	Productivity improvement with less processing time
3	D Rajenthirakumar&P R Thyla represent	Dead link &centre link manufacturing company	Productivity improve with solving a problem of tube bending assembly line
4	Zaidahmed Z. Khan, 2,Dr. Sanjay Kumar	Double Window sight flow indicator manufacturing	Manufacturing lead time will be reduced
5	PramodKumar,VineetPandey	Wire harness manufacturing company	Productivity improved along with reduction in production cost
6	Mr. Bhupendra Kumar Daiya	Cement manufacturing plant	Productivity improved with improved human

			engineering
7	Gundeep Singh, Dr. R.M. Belokar	Tractor manufacturing company	Productivity improved with reduction in production cycle time
8	PrateshJayaswal&Hemant Singh Rajput	Automobile maintenance part manufacturing company	Productivity will be improved with improved OEE
9	According to Nor AzlinBinti Ali	Machine spare part manufacturing company	Productivity will be improved with reduction in losses

Gap Analysis on Literature Reviews

1) Few papers have been published on manufacturing industries dealing with manufacturing of PVC,HDPE pipes.
2) The Papers generally not focused on the Employee empowerment which are the main resources of any organization.

IV. Methodology

The KAIZEN methodology has been used extensively for improving the organizational work in factories and actual methods used to manufacture products. The results obtained are real-time with implementation occurring within one week.With good & sincere practice by the employee in organization this simple concept improve the productivity of the organizationin huge way. Not only immediate improvements are seen in the process but it will also develop a list of the improvement opportunities that the staff can investigate and implement after the Kaizen. Kaizen will provide the company with immediate tangible results, motivation and ongoing continuous improvement within the company.

The adopted methodology contain Initial research on related field, Problem identification, Data gathering collected by interviews, Analysis of study of the previous records and observations, Generation of alternative solutions & final selection of best possible solutions,. Those relevant information have been taken into account and analyzed by inspecting the pitfalls of the existing system of the concerned SME.

The idea behind selection of Kaizen implementation process, after reviewing all the facts & consideration is the size & kind of industries in India which are generally small or medium scale & these industries need improvement without too much or negligible capital investment. The selected case company need improvement in productivity with less investment therefore we have selected Kaizen as an effective tool for implementation.

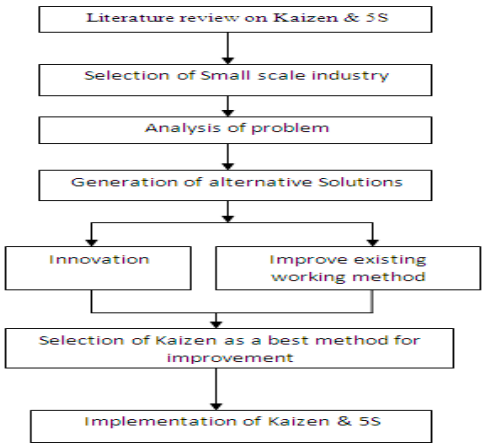

Fig. 1 Flow chart for research methodology

Implementation Process :

Company Background

The XYZ Company is located in Butibori, Nagpur, Maharashtra in India. The major product of the company is PVC & HDPE pipes used for water sprinkling & electric fitting purpose. This company is mainly focused on manufacturing as per customer's specification & requirement. The company currently has a capacity of about 150tonn per month (inclusive of all varieties), total annual sales volume is 5crores(in Indian rupees) and total employees are 12.The company is working in 2 shift & 24 hours. Out of 13 workers 7 workers are working in first shift & remaining on second shift.For implementation of technique we first need to identify that what the management people actually want and after identifying all the requirement the work will be started.So,we started our work in some prescribed manner.

Raw material used are:

HDPE RP
HDPE Granules
PVC Resin
Staric acid

Problem Statement:

As XYZ company is manufacturing variety of product, the company sometime facing difficulties in sales order processing specially in summer as there is large number of customer with verities of specifications for forthcoming seasons. The company is facing with processing these varieties of order and hence not able to satisfy on time delivery of order. The niche for improvement in the lagging condition is the management people who are interested in applying the philosophies as well as they are very much concern about the implementation of these ideas.

The project work basically focuses on improving the productivity of the XYZ company by using Kaizen as a problem solving approach, reducing the time losses in sales order processing which indirectly satisfy the target customer and introduces win-win

situation between customer & the company. Opportunities for productivity improvement through reduced time loss are critical to organizational survival and these efforts can be driven through kaizen initiative such as standard operating procedure or reflow the procedure of sales order processing which will be expose in this work.

But before actual implementation it is very necessary to study the standard operating procedure for completion of raw material into finished product.

The stepwise procedure for production is given below:

Step1: Raw material is weight in proper proportion as per the specification of desired pipe. This activity is manual followed by automatic transfer of this raw material by auger filler which directly send the mixture for heating & mixing in proper proportion. The complete activity takes about 10.46minutes.

Step 2: The mixture is then send to the hopper manually.

Step 3: The hopper transfer this raw material to the injection molding main machine chamber which consist of barrel & screw which heat & convert the raw material granules into hot plastic state. The size of the barrel can be change according to change in specification of product dimensions.

Step4: The molten plastic is then send to the die cavity by mean of nozzle at the same time the coolant is on to solidify the pipes. The seizers & automatic guide ways are provided for movement of pipe along the production line.

Step5: The finished pipe is then cut in the specified length. The company is currently using manual hand operated cutter.

Step6: This finish product is then taken away to the storage area manually where quality check visually.

For ease of understanding of the process we prepare a process flow diagram with the use of various symbols used in method study

Recognition of need:

Before starting the work we have discuss the requirement of the company in future & following are the need recognized from the manager of the company:

1. The top managerial personneed improvement in productivity.
2. The employees of the company need to be involved & concern about organization achievement.
3. Need of reduction in accidental hazards while cutting the required length pipe manually.
4. There should not be too much of capital investment in productivity improvement as the company is batch type & small scale

Fig.2 The process flow diagram for the manufacturing of pipe

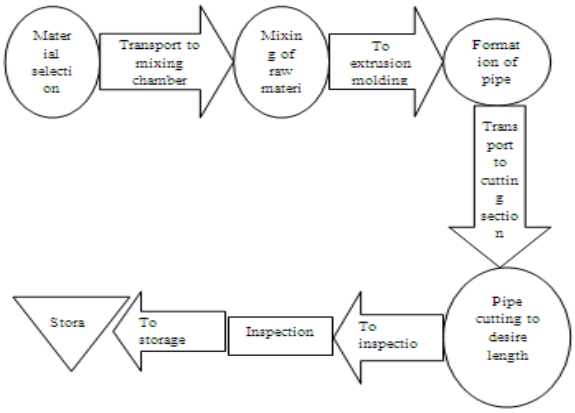

Table 2.Flowchart Symbol abbreviations

Sr.No	Symbol	Abbreviations
1		Operation
2		Inspection
3		Delay
4		Transportation

V. Objectives

An objective of this study is:

1. To improve the productivity of the organization by applying a Kaizen philosophy.
2. To reduce the sales order processing time& stock out situations.
3. Identify time losses at production area.
4. Identify opportunities for kaizen improvement using a problem solving approach.
5. Describe the effects of the improvement.

Problem definition:

After analyzing the overall scenario of the company, the following are the problems which need to be focused.

1. The company is manufacturing varieties of pipes ranging from 400mm to 10000mm.There is much time involve in maintaining the stock of finish good.
2. The lead time for sales order is higher
3. Production cycle time is more than required.

Time calculation before Kaizen implementation:

Sr No	Time factor	Calculated time (In Hour)
1	Raw Material Preparation Time	3.5Hr
2	Machining Time	2.75Hr
3	Socket making time	1.25 Hr
4	Total Production Time(Material to time+RMPI+MI+SV")	3.33+3.34+2.75+1.25 = 7.92hr.
5	Lead Time(Total production time+transportation)	1 to 3.5 Days (depends on source destination destination)

As the company is working continuously with the closing on Wednesday. The next working day will require approximately 3.5hour for preparation and initial setting of the machine.

Similarly the company is utilizing about 90% of efficiency of the machine & 10% is lagging. So our main aim is to improve the machine utilization.

After analyzing the whole process flow & layout of the company some of the areas are found to be improved. These identified areas are discussed below;

X is demand per month
μ is the mean demand
σ is the standard deviation
Therefore μ = 25.5 Units/month
σ = 7units/month

$$X = \mu + Z \times \sigma$$
$$X = 25.5 + (Z \times 7)$$

2. Lead time follows the uniform distribution

LEAD TIME:$\{(3.5 - 1) \div (1 - 0)\} \times F(t) + 1$

3. DEMAND ABOVE AVERAGE
Demand above average will be calculated as:
(Demand/month-Average Demand)* Lead time

Note:*The data is collected during the questionnaire session with production manager for the analysis of some last month order processing & causes of backorders of the given production order.*

Estimation of stock out

Before starting the implementation process we are trying to estimate the possible stock out situations as there is a increased lead time.

A mathematical model is formulated by drawing the usual probability distribution pattern of demand & lead time. We take 10 samples for validation of this mathematical simulation table.

The Demand & lead time of particular product i.e. 75mm/4kg pipe is discussed below using Monte-Carlo simulation method.

The demand of PVC pipes of 75mm/4kg pipes for a company follows the normal distribution with a mean of 25.5 units/month and standard deviation of 7 units/month. The lead time is distributed uniformly from 1 t0 3.5 month. If the company is maintaining the safety stock of 7units,the estimated probability of stock out using Monte-Carlo simulation technique is shown in table below:

The lead time probability function & cumulative probability function is shown below

1. The demand pattern of the particular pipe specification follows Normal Distribution,which can be shown with:

DEMAND:

$$\mathbf{Z=(X-\mu)/\sigma}$$

Where

Z is normal deviation of demand (derived from normal distribution curve)

In order to analyze the stock out situation in the case company, we have prepared a case based simulation model for ten consequent orders to determine the probability of stock out situation being happened due to some flaws discussed in problem identification of this section.

Table 3.**Estimation of lead time & stock out situation before Kaizen implementation**

The first 12 demand collected from the companies production manager are

Sr. No	X (Demand per month)	X-μ	$(X-\mu)^2$
1	17.50	-7.975	63.60063
2	10.00	-15.475	239.4756
3	20.00	-5.475	29.97563
4	20.00	-5.475	29.97563
5	50.00	24.525	601.4756
6	53.20	27.725	768.6756

7	21.00	-4.475	20.02563
8	000	-25.475	648.9756
9	8.00	-17.475	305.3756
10	36.00	10.525	110.7756
11	30.00	4.525	20.47563
12	40.00	14.525	210.9756
Total	305.70		3049.783
Mean	μ = 30570/12 = 25.475	Standard deviation(σ)	$\sigma = \frac{\sqrt{3049.783}}{12}$ =15.94204

Sr. No	Lead time in month		Demand/month			Demand above average	Stock out? (demand >10units)
	Random. No (from table) (1)	Lead time 2.5*f(t)=1 (2)	Random. No (from Table) (3)	Normal deviation (Z) (4)	X=μ+z*σ (demand) (5)	(demand/month -Avg. demand)* lead time [(5)-μ]*(2)	
1	0.7571	2.892	0.6644	0.425	32.2495	19.5969	YES
2	0.8703	3.17575	0.8005	0.842	38.896	42.623	YES
3	0.8069	3.01725	0.4382	-0.155	23.0043	-7.4547	NO
4	0.6081	2.520	0.9041	1.305	46.2767	52.425	YES
5	0.9861	3.46525	0.7937	0.82	38.5458	45.29	YES
6	0.2785	1.696	0.4981	-0.02	25.1562	-0.540	NO
7	0.5194	2.2985	0.1986	-0.843	12.03758	-30.885	NO
8	0.0475	1.1187	0.5066	0.015	25.7141	0.267	NO
9	0.8474	3.12	0.0565	-1.58	0.2898	-78.54	NO
10	0.8763	3.19075	0.7600	0.767	37.70098	39.01	YES

While studying the identified problems are :

1. Improper Utilization of stored space for finished product.
2. Improper Utilization of stored space for raw material.
3. Improper arrangement of supporting tools for production.
4. Improper arrangement of raw material in store.
5. Improper arrangement of finish good.

The problematic identified areas are shown in following figures:

Fig3. Improper stock of Finish good

Fig4. Improper arrangement of raw material

Fig.5 Poor working area

Fig.6 Improper arrangement of supporting tools

Implementation

The implementation process involve following areas

1. Countermeasure for poor working area and improper stock maintenance
2. Countermeasure for safety stock determination
3. Calculation of safety stock

Before starting kaizen process we had focused on Why -Why analysis in the identified problem areas.As Kaizen is a continuous as well as slow process, the estimated duration for implementation would be 4.5 month.

In order to find that the selected process is successfully implemented & the desired target is achieved or not, a pre-process & post-process lead time estimation analysis will be done.

VI. Scope

This study will thoroughly focus on reducing time losses while at the same timereducing the lead time of sales order processing in XYZ company andindirectly improve customer satisfaction. This condition will create a win-win situationbetween company and customers.

5 'S' System

Establish and maintain a clean, neat and tidy workplace Translation of 5 Japanese S's, what is 5S and why do we want to do it? 5S represents 5 disciplines for maintaining a visual workplace (visual controls and information systems). These are foundational to Kaizen (continuous improvement) and a manufacturing strategy based "Lean Manufacturing" (waste removing) concepts[16].

5S is one of the activities that will help ensure our company's survival. Fig. Sort / Arrangement (SEIRI) (Eliminate unnecessary items) Through the suitable sorting it can be identified the materials, tools, equipment and necessary information for realization the tasks. Sorting eliminates the waste material (raw materials and materials), nonconforming products, and damaged tools. It helps to maintain the clean workplace and improves the efficiency of searching and receiving things, shortens the time of running the operation. The 1S rules proceedings.

A) On the first stage one should answer to so-called Control Questions: - Are unnecessary things causing the mess in the workplace? - Are unnecessary remainders of materials thrown anywhere in the workplace? - Do tools or remainders of materials to production lie on the floor (in the workplace)? - Are all necessary things sorted, classified, described and possess the own place? - Are all measuring tools properly classified and kept? On the basis of the answer to the above questions it is possible the estimation of the workplace in terms of the 1S rule so littering the workplace. If on any question answer is yes, it should execute sorting of things, which are in the workplace.

B) On the second stage one should execute the review of all things which are in the workplace and group them according to the definite system. According to carried out sorting it should execute the elimination from the workplace the things, which were found „unnecessary".

C) To permanent usage the 1S rule is so-called the Programmed of the Red Label. It means giving the red label to things, which operator will recognize as uselesswithin his workplace. This label will make possible not only the elimination of the given thing, but through its own formula will make possible the liquidation of the reasons of appearing on the workplace this given thing.

Set in Order / Neatness (SEITON) (Efficient and effective storage method) Especially important is visualization of the workplace (eg. painting the floor helps to identify the places of storage of each material or transport ways, drawing out the shapes of tools makes possible the quick putting aside them on the constant places, colored labels permit to identify the material, spare parts or documents etc.). Implementing the 2S rule It should execute the segregation of things and mark the places of their storing. Used things should always be divided on these, which should be: - In close access (1st degree sphere), - Accessible (2nd degree sphere), - In the range of hand (3rd degree sphere). To the estimation of the workplace in terms of the 2S rule that is setting in order things serve the following Control Questions: - Is position (location) of the main passages and places of storing clearly marked? - Are tools segregated on these to regular uses and on specialist tools? -Are all transport palettes storage on the proper heights? - Is anything kept in the area of devices against the fire? - Has the floor any irregularity, cracks or causes other difficulties for the operators movement? Things used occasionally and seldom should be on the workplace but outside the direct using sphere. Their distance and location from the place of work should depend on the frequency of using these materials or tools. Places of storage should be marked in the manner making possible their quick identification. It can be used colored lines, signs or tool boards.

Shine / Cleanliness (SEISO) (Thoroughly clean the workplace) Regular cleaning permits to identify and to eliminate sources of disorder and to maintain the clean workplaces. During cleaning it

is checked the cleanness of machine, workplace and floor, tightness of equipment, cleanness of lines, pipes, sources of light, current data, legibility and comprehensibility of delivered information etc. Indispensable is also taking care of and maintenance the personal tidiness of the operator.

Implementing the 3S rule

The first step of realization the 3S rule is renovation the workplace. It is assumed that „the first cleaning" forces the exact checking of usage two of the previous rules. The usage of the 3S rule relies on everyday keeping in faultless cleanness the workplace. It is executed by the operator of the given workplace. To the estimation of the workplace in terms of the 3S rule, that is cleaning the workplace, serve the following Control Questions: - Are the oil's stains, dust or remains of metal found around the position, machine, on the floor? - Is machine clean? - Are lines, pipes etc. clean, will they demand repairing? - Are pipe outlets of oils not clogged by some dirt? - Are sources of light clean?-Are the workplace is clean. Are the storage areas are clean

Standardize / Order (SEIKETSU) (Order and control to be established for) Worked out and implemented standards in the form of procedures and instructions permit to keep the order on the workplaces. Standards should be very communicative, clear and easy to understand. Regarding this during preparation and improving, it should be involved all participants of the process on the given workplace, it means direct workers. The group knows the best specificity of its own activities, and process of elaboration and after that, usage gives them possibility of understanding the essence and each aspect of the operation. In the aim of assuring all the easy access, obligatory standards should be found in constant and visible places. It is assumed that standards should not be implemented only in the typical operational processes e.g. production, movement maintenance, storing, but also in the administrative processes, for example: book-keeping, customer service, human resources management, or secretariat service.

Sustain / Discipline (SHITSUKE) (Sustain new status quo,,everything in its place) Implementing the idea of the 5S will demand from workers the compact self-discipline connected with implementing and obeying the rules of regularity in cleaning and sorting. It leads to increasing the consciousness of staff, and decreasing the number of non-conforming products and processes, improvements in the internal communication, and through this to improvement in the human relations. It is also important to understand the need of executing the routine inspections of usage the 5S rule. This inspection is executed by helping of so-called Check List and created on its basis the radar graph of the 5S, which serves to estimation of the workplace. The inspection of realization of the 5S rule is executed once a month by chosen team implementing the 5S rule – the control team

Preparation of Kaizen sheet

Implementation Of5s Techniques

Sort all unneeded tools, parts and supplies are removed from the area. The company layout is fixed according to process but the company does not consist of a systematic arrangement for various material handling and storage.

Fig. 7 Set in Order A place for everything and everything is in its place.

Fig.8Shine The area is cleaned as the work is performed

Fig.9 Standardize Cleaning and identification methods are consistently applied. Daily improvement process followed by using machine process chart & production plan board Before 5S

After 5S

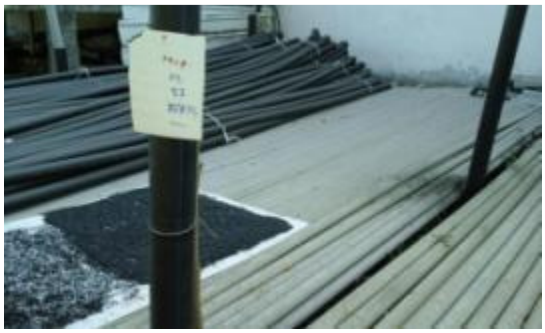

Fig. 10 Production information chart for worker

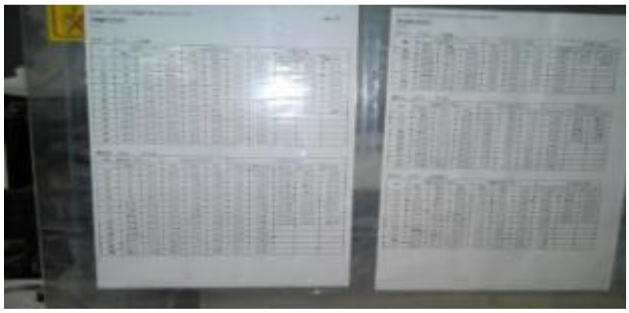

Fig.11 Sustain 5S is a habit and is continually improved the company culture

Safety stock determination]

As discussed earlier the company is following any scientific method for maintaining a safety stock and this is also a main reason for stock out situation. For solving this problem it is very necessary to find the amount of stock the company should maintain for effective service level.

Safety stock is determined by assuming the probabilistic distribution of demand during the lead time the distribution may be assumed as normal distribution or Poisson distribution based on the previous record. As per the data collected during the questionnaire session with the production manager the last order in the previous year the demand is normal in random manner. Therefore, we assume the normal probability distribution for the demand.

To find out the safety stock level, we draw the usual demand pattern of last twelve month demand and calculate the **mean and standard deviation of the demand** during the lead time which is calculated as **25.475 & 15.94** respectively.

Note: *values of mean and standard deviation are calculated in earlier part of this chapter.*

If R is the rate a consumption demand),L is the lead time, then
Consumption rate during the lead time = RL
If s is the safety stock , and Q is the re-order quantity, then
Maximum stock level, Q+S
Minimum stock level, S=s
Production Point = Safety stock + consumption during lead time
= safety stock + mean lead time consumption

Now consider normal distribution of lead time consumption

As shown in figure the area under the normal curve give probability of demand of order point or less during the lead time. If the production point of the customer is the stock level available at the point of order comes , then this area will indicate fraction of order periods without stock out. Thus, area under the normal curve for x=Production point give the service level.

Normal variate , $z=\frac{x-\mu}{\sigma}$

From normal distribution table, for area under normal curve we can find the value of z correspond to the area equal to the service level expressed in decimal fraction, Then,

Safety stock = z×σ

Calculation of safety stock:

In this first we have to find the probability of stock out when the company is maintaining the minimum stock of 18 units i.e 1800 pipes (one specific item).mean demand is 25.475 and std. deviation is 15.94.the probability that the demand comes more than 18 unit is calculated as

X=18 in terms of z is
Z= (18-25.475)/15.95=-0.46895 (approximately -0.47)
P(x>18) = P (Z>-0.46895)
=Area right to z=-0.47
= (area between z=0 to z=0.47) + 0.5000
= 0.1808+0.5000
= 0.6808

i.e 68.08% of probability of stock out when the company is maintaining a safety stock of 18 units. Then what should be the safety stock?

For the usual demand pattern drawn from the observation and production manager the mean and standard deviation was found to be 25.475 and 15.94 respectively. The policy of the management is to have 95% of the service level.

For approximately 95% of the service level (approximately 0.9495 and 9405)The values of area for z= 1.64 and z=1.65 which can be calculated as :

Approximate values from table are
A = 0.9405 and A= 9505 which are taken from z= 1.64 and z= 1.65
By interpolation actual value of z will be

$Z= 1.64 + [\frac{0.9500-0.9405}{0.9505-0.9405} * (1.65-1.64)]=1.68475$

μ = 25.475 and σ = 15.94

Therefore , **Safety stock =z *σ**
= 1.64875 * 15.94
=26.28 approximately (26.3 units)

Therefore the company should maintain a safety stock of 26.28 units for 95% of the service level

Validation after implementation process

After successful implementation of any technique it is necessary to find our the result of implementation. As the purpose behind implementation of Kaizen and 5S technique is to reduce the lead time similarly estimate the lead time and stock out situation before and after implementation.

In earlier part of work the first and foremost objective i.e estimation of probability of stock out before implementation was completed which shows the probability of 50% stock out. to reduce this probability we have practice the Kaizen and 5S technique in the case company. In this part of work our objective is to again formulate a simulation model after the determination of safety stock which is calculated to be 26.3 units (probably) for 95 % of the service level as discussed by the management personal.

We have developed a simulation model for estimation of stock out for same demand pattern in future with lead time 25.475 and standard deviation of 15.94.but the difference is earlier the company is maintaining a safety stock of 18 unit without any scientific method for inventory control which is now change to 26.3 unit(by calculation).

Time difference calculation (Before and after implementation)

1. Raw material preparation time
   Before implementation = 0.54 hour
   After implementation = 0.495 hour
   Difference = (0.54- 0.495) = 0.045
   Approximately time reduction of 3 min

2. Actual machining time or processing time
   Before implementation (95 % of efficiency of machine) = 2.70 hour
   After implementation (99 % of efficiency of machine) = 2.38 hour
   Difference= (2.70-2.38) = 0.32 hour
   i.e before implementation 37 pipes will be manufactured in one hour and after implementation the figure will be improved to 42 pipes in one hour.

3. Socket making time
   Before implementation = 75min i.e 1.25 hour for one unit
   After implementation = 69 min i.e 1.15 hour for one unit
   Difference = (1.25-1.15) =0.1 hour
   Therefore total production time after implementation total production time = (machine warm up time+ raw material preparation time+ actual machine time+ socket making time)
   = (3.29 hour + 0.495 +2.38+1.15)
   = 7.315
4. Dispatch time (searching time for finished goods)
   Before implementation = 25 minutes i.e 0.417hour (for dispatching a particular time from store to vehicle)

After implementation = 17 minutes i.e 0.28 hour (as the stock is maintained according to specification)
Difference = (0.417-0.28)=0.137 hour

Now,
Lead time after implementation will be
Lead time = (total production time + dispatch time+ transportation time)
= 7.315+0.28+0.28 hour + (1 to 3.0days)
= 0.3047+0.01167+ (1 to 3.0)
Lead time now will bw approximately 1 day to 3.4 days
As lead time follow uniform distribution, new lead time after implementation will be
lead time =(3.3-1)/(1-0)=2.4

Sr.No	Lead time in month		Demand/month			Demand above average	Stock out? (demand >26.3 units)
	Random. No (from table) (1)	Lead time 2.3*f(t)=1 (2)	Random No (from Table) (3)	Normal deviation(Z) (4)	X=μ+z*σ (demand) (5)	(demand/ month-Avg. demand)*lead time [(5)-μ]*(2)	
1	0.7571	2.74133	0.6644	0.425	32.2495	18.57114009	NO
2	0.8703	3.00169	0.8005	0.842	38.896	40.2871223	YES
3	0.8069	2.85587	0.4382	-0.155	23.0043	-7.055998009	NO
4	0.6081	2.39863	0.9041	1.305	46.2767	49.89558167	YES
5	0.9861	3.26803	0.7937	0.82	38.5458	42.71576652	YES
6	0.2785	1.64055	0.4981	-0.02	25.1562	-0.52300734	NO
7	0.5194	2.19462	0.1986	-0.843	12.03758	-29.490003068	NO
8	0.0475	1.10925	0.5066	0.015	25.7141	0.265221675	NO
9	0.8474	2.94902	0.0565	-1.58	0.2898	-74.2716585	NO
10	0.8763	3.01549	0.7600	0.767	37.70098	36.86732043	YES

Before implementation:
Machine is producing 37 pipes in 60 min
Machine time for 1 piece will be = 1.62minutes
Actual machine time (before implementation) = available time per shift of 8 hour/ time per pipe.
= 8*60 / 1.62
= 296.29 pipes (actual output)

After implementation:(the time for each pipe will be an ideal time or standard time per piece)
Ideally the machine now producing 42 pipes in 60 minutes
Standard time for one pipe will be = 1.428 min
Ideal machine time (after implementation) = available time per shift of 8 hour / time per pipe.
= 8 * 60 / 1.428
= 336.134 pipes
Machine productivity = (actual output / ideal output) * 100

= productivity per shift will be 88.12 %

VII. Result & discussion:

After discussing with the production manager and the middle level management team during questionnaire thewhole layout including the working conditions and otherfactors was analyzed and after going through the entire problem faced by the company Kaizen and 5Stechnique is being successfully implemented in the case company.

Similarly the successive difference occurs before and after implementation is shown in tablebelow :

Sr.no	Factor	Before Kaizen implementation	After Kaizen implementation	Difference
1	Total production time	7.82 hour (for 1 unit i.e 100 pipes)	7.315 hour	Reduction of production time by 0.50 hour
2	Lead time	1 to 3.5 day	1 to 3.3 days	Reduction of lead time by 0.2 day
3	Safety stock	20 units (without any technical assumption)	26.3 units calculated value	NA
4	Probability of stock out	50 % of the time stock out situation	40% probability of stock out	Probability of stock out will be reduce by 10 %
5	productivity	296.29 pipes (actual output)	336.134 pipes	Machine Productivity will be 88.12 %

Conclusion

From all the literature reviews we come to the conclusion that the Kaizen practices can also be effectively used in small manufacturing industry as a productivity improvement tool. Successful implementation of Kaizen and 5S process There will also a future scope of study & research work

on Implementation of Kaizen as a part of computer aided manufacturing.

Future Scope

In future we suppose to develop the real time simulation model for the analysis & estimation of stock out situation for improvement of productivity in computerized manufacturing era.

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