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The Implementation of TPM on Manufacturing Performance at FMCG Company

Sabjan S.N, Maheshwar Pratap

Abstract: ***The focus of this paper is to enlighten the commitments of Quality Maintenance Pillar of TPM in increasing the product quality in a FMCG industry involved in the manufacturing of HDPE bottles and coconut oil. QM pillar is a critical activity of the TPM approach which expects to delight the customer through zero defect manufacturing. TPM that is effectively implemented increases the production efficiency with an ultimate aim of achieving zero losses, zero breakdown and zero defects. The main aim of QM pillar is to eliminate the non- conformances in a methodical way and maintain the equipment for high quality products. Activities involved with QM pillar was able to decrease the customer complaints and regulatory complaints to zero. The targets put forward by the QM pillar was effectively achieved by the industry, the targets included maintaining the customer complaints at zero, reduce the in process defects by 50% and increase the production of Total value of goods worth 50 lakhs to one crore worth SKU.***

Index Terms: TPM, Quality Maintanance pillar

I. INTRODUCTION

In the present situation of rivalry, there is a great pressure on the manufacturers to diminish producing cost and give new and quality items in the market all the time. Thus, producers are putting extraordinary accentuation on quality improvement. Quality control was considered as a major capacity for accomplishing desired production targets in multi-stage manufacturing systems. Manufacturing companies were confronting the test of working their manufacturing processes and frameworks with a specific end goal to convey the required production rates of high quality products.

TPM is one such strategy which enables continuous and fast change of manufacturing processes by eliminating sixteen major losses. The objective of the TPM is to upgrade efficiency and quality along with increased employee and job satisfaction. It brings the improvement in the procedures by recognizing the best operating practices and methods and re-designing those programs and practices. The TPM implementation strategy in the organization wipes out the vast majority of the losses with the assistance of different techniques which assist the organizations with obtaining higher rate of performance i.e. higher overall equipment efficiency (OEE). TPM implementation reduces the equipment breakdowns alongside the upgrade in machine reliability, process quality and product's throughput. It plans to build the accessibility of existing equipment and subsequently reducing the need for further capital investment.

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***Correspondence Author(s)**
Sabjan S.N. Department of Business, Amrita School of Business Kollam India
Maheshwar Pratap, Department of Business, Amrita School of Business Kollam India

Both tangible and intangible advantages for equipment and employees were acquired after implementing TPM activities. TPM also reduces and controls the variation in a process framework, along with improvement in function and design of the equipment/process. TPM as a group activity action builds up the propensity for better communication among the different divisions in an organization and at all levels. This improved the team work spirit of the organization representatives and in this manner building up a healthy and effective workplace. Additionally, with the implementation of kaizens, the employees start to contribute completely at all levels so as to improve the effectiveness of the system.

II. STRUCTURE

The introduction is followed by the Literature Review which give details from the research papers that talks about the implementation of TPM. It is then followed by Methods and Methodology that talks about the data sources, type of research, and type of sampling. This is followed by Analysis that describes about the various techniques used to analyze the data. The next section talks about the results and the final section talks about the implications and limitations.

III. CASE STUDY

A case study presented in this paper features the successful implementation of QM pillar activities in a FMCG industry. Quality management is considered to be as a key factor in order to obtain competitive advantage. Among 8 pillars of TPM, Quality Maintenance (QM) is one of vital pillars of TPM which is pointed towards delighting customers by giving highest quality through defect free manufacturing. Focal point of QM pillar is on eliminating non-conformances in a methodical way. QM activities interface quality assurance and equipment control exercises keeping in mind the end goal to have defect free equipment. As each organization is confronting the issues identified with quality, for example, low production and high packing defects, huge customer complaints. Accordingly, a few technical and non-technical methodologies in quality management have been done to overcome such problems.

In Indian context, different activities were embraced by business people for strategic TPM implementation with the commitment of top level administration in an organization to accomplish manufacturing excellence.

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IV. TPM IN COMPANY, INDIA

Award for TPM excellence in December, 2008. Soon after getting this award, the company continued its TPM journey with a target to get "Award for Excellence in Consistent TPM Commitment. The company is one of India's leading consumer products companies operating in the beauty and health space since 1987. As of now present in 25 nations crosswise over developing markets of Asia and Africa, The Company has supported numerous brands in the classes of hair care, healthy skin, edible oils, health foods, male grooming, and fabric care. Graphing a yearly turnover of INR 59billion (Financial Year 2016 - 2017) crosswise over portfolio. Up to 1994, the plant capacity was low because of less market requirement. The steady development in market of beauty and wellness space took place between 1995 to1999 and exponential development occurred after 2000 onwards. . So, in order to meet the market requirement and delivering good quality products at low cost, the company initiated the implementation of TPM in early 2004. For this the organization built up TPM strategies, destinations, targets, hierarchical structure and additionally all essential techniques were set up with the goal that the set objectives ought to be particularly clear to everybody associated with TPM implementation. In June 2004, TPM is introduced through an enormous Kick-Off function. Company wide arrangement of all the eight pillars of TPM with their exercises, were begun from July, 2004. In March, 2008 the organization effectively executed TPM stage I and accomplished all the set targets. The plant got "Category-A" i.e. Award for TPM excellence in December, 2008. Not long after in the wake of getting this Award, the organization proceeded with its TPM venture with an objective to get "Award for Excellence in Consistent TPM Commitment."

1. Need of implementing Quality Maintenance pillar The Company was facing the following quality issues before implementing TPM:

a. High packing defects
b. Huge customer complaints
c. High product defects

These quality issues were because of high dependence on weather for product quality impacting deliverables. QM pillar initiatives were employed to overcome such issues. Quality Maintenance (QM) pillar is one of the most contributing pillars of TPM and its implementation approach in detail is discussed as a case study.

2. Aim of implementing QM pillar

a. Elimination of packing defects
b. Elimination of customer complaints
c. Elimination of product defects

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2. Aim of implementing QM pillar

a. Elimination of packing defects
b. Elimination of customer complaints
c. Elimination of product defects

V. LITERATURE REVIEW

TPM is a production driven improvement methodology that is designed to optimize equipment reliability and ensure efficient plant utilization by employee involvement and empowerment. TPM is developed by Japan Institute of Plant Maintenance. The main aim of TPM programme is to eliminate the six major equipment losses. Amik and Deshmukh [1] in 2006 stated that modern manufacturing requires that companies which want to be successful must practice effective and efficient maintenance. According Ollila and Malmipuro [2], to increase the performance of maintenance activity is to implement TPM. According to Toger M [3], in today's time based competition high equipment productivity in a manufacturing line is necessary in ensuring a competitive company. The concept of focused productive maintenance points out the importance of achieving profitability through equipment effectiveness. Ramayah [4] carried out a research with leading suppliers of various automotive components. TPM was implemented with a focus on autonomous maintenance and planned maintenance. Kathleen [5] through her research quantified the impact of total productive maintenance on manufacturing performance. Kathleen developed the relationship between Total Productive Maintenance and manufacturing performance through Structural Equation Modelling. She was able to identify that TPM has a positive and significant relationship with low cost, high levels of quality and strong delivery performance.

The relationship between TPM and Manufacturing performance can be explained by both direct and indirect relationships. The good hold preventive maintenance system alone is not necessary to eliminate the breakdowns but the organization should also follow a maintenance technique to achieve higher equipment performance. Gosavi (2006) [6] stated that the positive outcome of the implementation of TPM is the reduced occurrence of the unexpected machine breakdowns which ultimately result in enhancing the profit of the organization. Johansson and Nord (2006) [8] indicated that TPM improved the cost, delivery time, safety, productivity and morale of the employees. TPM can be considered as an asset for the organization. A growing body of literature indicates that the six elements of TPM are widely used in Indian manufacturing industry to target and measure improved company performance. Nakajima (1998) [9] stated that the function of TPM is to enhance equipment effectiveness and maximize equipment output. A number of organizations claimed improvements in equipment availability, reliability and reduction on maintenance costs when implementing TPM. The benefits of TPM are often quoted as increase in product quality, equipment availability and reduction in operating costs (Cholasuke, 2004) [10] Al- najjar (1996) [11] stated that through TPM. It is also possible to increase employee morale and job satisfaction by allowing the workers to be involved in every aspect. The success and benefit of TPM within the company are measured according to their requirements.Many companies have developed their own scale of measurement and indicators within the TPM framework. TPM principle evolved with the lean concepts to support the lean production system.

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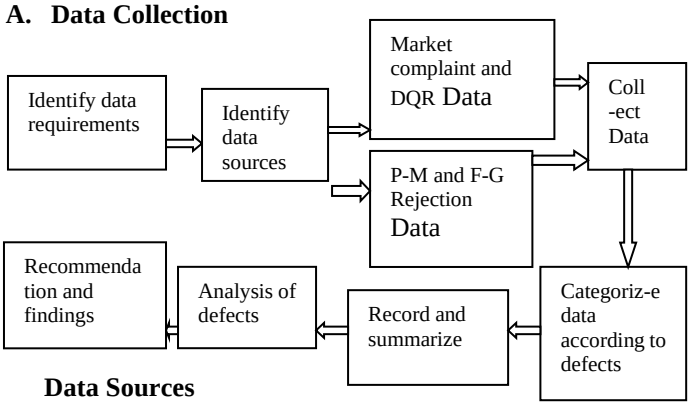
TPM has been established as an innovative approach to machine maintenance that is complementary to Total Quality Management, Just in Time, total employee involvement, continuous performance improvement etc. (Olillila and Maimipuro 1999)[12].

Lycke (2000)[13] points out that TPM is a highly structured approach and careful , thorough planning and preparations are keys to a successful companywide implementation of TPM.

The most significant elements of TPM implementation process is that it is a consistent and repeatable methodology for continuous improvement. TPM is a long term process. TPM is based on a " Zero-loss" concept viz Zero breakdown , accident and defects, to achieve high reliability, flexibility of equipment and reduce cost through minimizing wastage of manpower , raw materials, energy, consumables etc. TPM is expected to bing production and maintenance functions together by a combination of good working practices, team working and continuous improvement. TPM provides a method to achieve world class level of overall equipment effectiveness through people.

VI. METHODS AND METHODOLOGY

A. Data Collection



Data Sources

Primary Data: The data is collected from three departments such as defects, cause and effect.

Secondary data: The data collected such as market complaints, F-G rejection, and P-M data.

B. Type of Research

Exploratory Research: It will be defined as an attempt to connect ideas to understand cause and effect, meaning researchers want to explain what is going on.

C. Type of Sampling

Acceptance sampling: Acceptance sampling uses statistical sampling to determine whether to accept or reject a production lot of material. It has been a common quality control technique used in industry. It is usually done as products leaves the factory, or in some cases even within the factory.

VII. SCOPE

Implementation of TPM activities will have a great way in the future. As this paper focus on the implementation of the quality maintenance pillar of TPM in the manufacturing the HDPE bottles, it was seen to have an increase in the product quality.

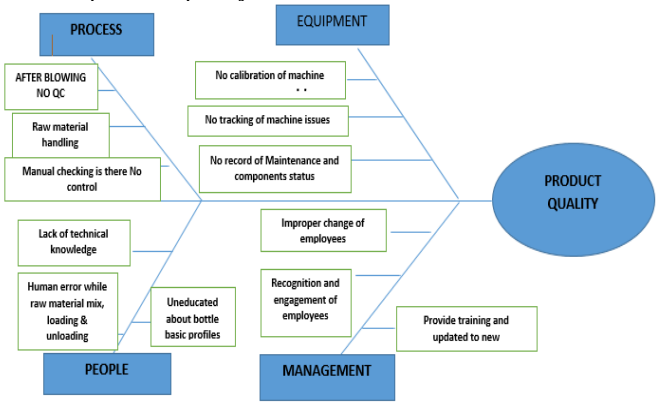
The future implications of implementing TPM is that the success rate of the product quality will be very high. The products can be manufactured with zero error and thereby no defects. It helps to manufacture the products with zero losses, zero defects and high quality. The equipment used for the high quality products can be maintained with the help of quality maintenance pillar of TPM. With the implementation of the QM pillar the customer and regulatory complaints can be brought down to zero. Thus the implementation of TPM helps to increase the profit of the firm.

Sl No	Methodology	
	Data Collected	*Objective*
1	Types of Quality Defect Data collected from Blowing, Filling and Printing Departments	Data collected was analyzed and defect quality matrixes were identified.
2	Online Inspection done every hour data was collected and analyzed	Major error was identified as, on time blowing, printing and filling error.
3	Finished Goods Rejection data was analyzed and found the error contributing mostly to on time delivery issue.	Various factors affecting the Finished goods was identified and Quality defect error was contributing majorly.
4	Market complaints data and Daily Quality Report showed the presence of defect due to various errors.	Understood the different defect reasons such as Blowing defects, Printing defects, Filling defects, Finished goods defects, Packing defects.
5	P-M Rejection data regarding the delay reasons	To understand the impact of different types of errors present in the department of blowing and filling.

VIII. ANALYSIS

A. Fish Bone Analysis

Fish bone analysis was performed to understand the cause and effect of product quality.



Fish bone analysis was done to understand the causes and effect of product quality. The main causes for the Product quality issues which were identified by fish bone analysis are:

Process: The process involves manual checking on every process is there no control, which creates chance for defect, that is when raw material come into the raw material storage area and the storage area of raw material is not hygienic also no cleaning will be doing there at frequent interval.

Raw material will be mixed as per mixing proportion FLIPTOP Standard Parameter-25KG HDPE, Master Batch: 1.175KG, Recycled Bottles: 20KG, Pellets: 2.5KG and also there have no blowing quality department it will lead to increase quality defects on other process.

Equipment: During Blowing process they are not doing any calibration on machine and operators doesn't track any machine errors happened in earlier stages and they are not kept any record or check sheet for maintenance.

People: When the HDPE bottles defects happen as a result of Lack of technical knowledge among the employees regarding the basic standard of a bottle profile. Also human error while raw material mixing, loading and unloading.

Management: The defect had happened due to the improper change management of labors in the company. Management lacks in recognizing its efficient employees. Also they are not providing any updates about the products and company requirements.

B. Failure Mode Effective Analysis

- First of all the process will be noted and -= the abnormalities were found.
- For each failure mode, identify all the consequences on the system, related systems, process, related processes, product, service, customer or regulations. These are potential effects of failure. What happens when this failure occurs?.
- Determine how serious each effect is. This is the severity rating, or S. Severity is usually rated on a scale from 1 to 10, where 1 is insignificant and 10 is catastrophic. If a failure mode has more than one effect, write on the FMEA table only the highest severity rating for that failure mode.
- For each cause, determine the occurrence rating, or O. This rating estimates the probability of failure occurring for that reason during the lifetime of your scope. Occurrence is usually rated on a scale from 1 to 10, where 1 is extremely unlikely and 10 is inevitable. On the FMEA table, list the occurrence rating for each cause.
- For each cause, identify current process controls. These are tests, procedures or mechanisms that you now have in place to keep failures from reaching the customer. These controls might prevent the cause from happening, reduce the likelihood that it will happen or detect failure after the cause has already happened but before the customer is affected.
- For each control, determine the detection rating, or D. This rating estimates how well the controls can detect either the cause or its failure mode after they have happened but before the customer is affected. Detection is usually rated on a scale from 1 to 10, where 1 means the control is absolutely certain to detect the problem and 10 means the control is certain not to detect the problem (or no control exists).
- Calculate the risk priority number, or RPN, which equals S × O × D. Also calculate Criticality by multiplying severity by occurrence, S × O. These numbers provide guidance for ranking potential failures in the order they should be addressed.
- Identify recommended actions. These actions may be design or process changes to lower severity or occurrence. They may be additional controls to improve detection. Also note who is responsible for the actions and target completion dates.
- As actions are completed, note results and the date on the FMEA form. Also, note new S, O or D ratings and new RPNs. During this analysis of process observed that the more defects are happening in Blowing of HDPE Bottles (RPN: 144) in machines of Blowing department Then the defects happened in printing area have high (RPN: 270) on the process of Screen Printing of 3 colours are Blue, Green, White. Also the process in which area of filling department the more defects are due to the process of capping, filling (RPN: 240&200).

TABLE I

	Effective Analysis					
	Blowing	***Risk Priority No***	***Printing***	***Risk Priority No***	***Filling***	***Risk Priority No***
1	Raw material mixing	128	Elevator to hopper	224	Unscrambler bottle feeder	6
2					Automatic ARM (Bottle feeder to conveyor)	64
3	Loading on hopper	112	Hopper to Unscrambler	280	Preheating	180
4	Plasticizing	80	IJP Process	200	printing	270
5	Mould opening and Closing	48	Filling(Main Drive)	200	Screen printing (Blue)	240
6	Blowing	144	Cap Heating	200	Dryer	180
7	Deflashing	64	Cap Dispensing	200	Screen Printing(Green)	270
8	Online Inspection		Capping	240	Dryer	180
9					Screen Printing White	270
10					Dryer and Inspection	160

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TABLE II:

Sl No	Quality Defect Matrix for Blowing		
	Process	***Correlation Analysis***	***Defect***
1	Raw Material Mixing	Process which is related to problem	Pinhole,Blowhole,Blackspot,Flowline,Opacity Bottle, Color shade bottle
2	Loading on Hopper	Process which is related to problem	Blow hole, Bottom hole, Opacity Bottle, color shade
3	Plasticizing	Process which is related to problem	Pin Hole, Blow hole, Bottom hole ,Parison shift, Flow line
4	Mould Opening and closing	Process which is related to problem	Improper cutting/Deflashing
5	Blowing	Process which is related to problem	Pinhole,Blowhole,Blackspot,Flowline,Opacity Bottle, color shade bottle, Airline spot, Extra material inside or outside, Bottom Hole, Parison shift ,Improper cutting
6	Cutting	Process which is related to problem	Blowhole, Extra material inside/outside, Improper cutting
7	Online Inspection	Process Inspection	Pinhole,Blowhole,Blackspot,Flowline,Opacity Bottle, color shade bottle, Airline spot, Extra material inside or outside, Bottom Hole, Parison shift ,Improper cutting

TABLE IV

Sl No	Quality Defect Matrix for Printing		
	Process	***Correlation Analysis***	***Defect***
1	Unscrambler to bottle feeder Pre Heating	Process which is related to problem	Missing Text, Blue patch, Legal problem ,print smudge, print peel , without green or blue or white , shrinkage
2	Printing	Process where predicted to occur	Missing Text, Blue patch, Legal problem ,Ink spot ,print smudge, print peel , print shift, without green or blue or white, shrinkage
3	Dryer	Process which is related to problem	Missing Text, Blue patch, Legal problem ,Ink spot ,print smudge, print peel , print shift, without green or blue or white, shrinkage
4	Online inspection	Process inspection	Missing Text, Blue patch, Legal problem ,Ink spot ,print smudge, print peel , print shift, without green or blue or white, shrinkage

TABLE III

Sl No	Quality Defect Matrix for Filling		
	Process	***Correlation Analysis***	***Defect***
1	Elevator to hopper	Process which is related to problem	Bottle Denting
2	Hopper to Unscrambler	Process which is related to problem	Bottle Denting
3	IJP process	Process which is related to problem	Ink Jet Printer issue
4	Filling	Process which is related to problem	Leakage, Oil smear ,Bottle Denting, Underweight
5	Cap heating	Process which is related to problem	Leakage, Untightened cap, Crackened caps
6	Cap dispensing	Process which is related to problem	Untightened caps, Crackened caps, Tamper proof Damage
7	Capping	Process which is related to problem	Leakage, Oil smear ,Untightened caps ,Crackened caps ,Tamper proof damage, Bottle Denting

C. Production Input Analysis

During each process the QA process matrix identified as being closely associated with defect production, clarify the relationships with the production inputs.
(Equipment, Material, Method)

TABLE V

Sl No	Analysis in Blowing Department			
	Defects	***Equipment***	***Material***	***Method(People)***
1	1.Parison shift	YES	YES	YES
2	2.Improper Deflashing	YES	NO	YES
3	3.Flow line	YES	YES	NO
4	4.Opacity Bottle	YES	YES	YES
5	5.Black spot	YES	YES	YES
6	6.Pinhole	NO	NO	YES
7	7.Blowhole	NO	NO	YES
8	8.Airline gap/Airspot	YES	NO	YES
9	9.Extra material inside neck	YES	NO	NO
10	10.Extra material outside neck	YES	NO	NO
11	11.Colorshade Bottles	NO	NO	YES
12	12.Nonhomogeneous mixing of color	NO	NO	YES

13	13.Bottom hole	NO	NO	YES
	14.Weak spot	NO	NO	YES

During this process in Blowing Department identified as being closely associated with defect production, clarify the relationship with the production inputs Method and Equipment are the major cause for producing defects in blowing department.

TABLE VI

Sl No	*Analysis in Printing Department*			
	Defect	***Machine***	***Man***	***Material***
1	1. Missing Text	YES	YES	NO
2	2. Blue Patch	YES	YES	NO
3	3.Ink spots	YES	YES	NO
4	4. Legal Problems	YES	YES	YES
5	5. Print Smudge	NO	YES	NO
6	6. Print peel	YES	YES	NO
7	7. Print shift	YES	NO	NO
8	8. Without Blue colour	YES	NO	NO
9	9. Without Green colour	YES	NO	NO
10	10. Blue patch	YES	YES	NO

During this process in Printing Department identified as being closely associated with defect production, clarify the relationship with the production inputs Method and Equipment are the major cause for producing defects in blowing department.

TABLE VII

Sl No	Analysis in Filling Department			
	Defects	***Machine***	***Material***	***Method***
1	Leakage	YES	YES	YES
2	Oil smear	YES	NO	NO
3	Untightened/Improper cap fitment	YES	NO	YES
4	Cracked/Brokened caps/plug/hinge	YES	NO	YES
5	Tamper proof Damage	YES	NO	YES
6	Bottle Denting	YES	NO	YES
7	Underweight	YES	NO	YES
8	cap crack	NO	NO	YES
9	Ink jet printer	NO	NO	YES

During this process in Filling Department identified as being closely associated with defect production, clarify the relationship with the production inputs Method and Equipment are the major cause for producing defects in printing department.

D. Problem Chart Analysis

TABLE VIII

	Problem Chart Analysis in Blowing		
Sl No	***Sub Process***	***Defect***	***Initial Condition/Problem***
1	RAW MATERIAL MIXING	Pinhole	Raw material must be stored in a closed tank based on standard parameter. Mixing proportions are changed if mixing is done in open dirty area.
2	RAW MATERIAL MIXING	Blowhole	Auto dosing machines are used to mix materials which didn't check the proportions every hour. Hdpe, master batch and recycled grinding plastics and pellets are closed in auto dosing machine.
3	RAW MATERIAL MIXING	Black spot	Improper mixing of materials contains dust. Recycling of defected bottles contains foreign materials and dust particles.
4	RAW MATERIAL MIXING	Flow line	Material mixing issue and operator unknown condition.
5	RAW MATERIAL MIXING	Opacity bottles	Master batch content low and issue of mixing raw material.
6	RAW MATERIAL MIXING	color shade bottles	Master batch content low and excess usage of grinding bottle.
7	LOADING ON HOPPER	Blow hole	Mixing proportion of raw material and master batch will be calibrated at frequent interval
8	LOADING ON HOPPER	Pin hole	If the storage area is not as per the standard it is considered as dirty area.
9	LOADING ON HOPPER	Opacity bottles	Master batch as loading via automation.
10	LOADING ON HOPPER	color shade bottles	If master batch is loading via automation, it is not possible to know the exact amount of grinding material containing pm bottles.
11	PLASTICIZING	Pinhole	If any one of them will not work and frequent checking is not conducted.
12	PLASTICIZING	Blowhole	Machine melted with inside carbon content and foreign materials melted with polymers.
13	PLASTICIZING	Flow line	Failure of heater and improper working of spindle screw motor.
14	MOULD OPENING & CLOSING	Improper cutting hole	If left side and right side parameters are not correctly set then it is not possible to cut the bottom side and the spring damage thus induce bottom deflation.
15	MOULD OPENING & CLOSING	Improper deflashing	Hot wire cutter supply sometimes cut off and sharpness get lowered.
16	MOULD OPENING & CLOSING	Pinhole	If all utility, blow pin, free blow and air pressure are not declared at standard parameter including parison with small impurities.
17	MOULD OPENING & CLOSING	Blow hole	If all utility, blow pin, free blow and air pressure are not declared at standard parameter including parison with large impurities.
18	MOULD OPENING & CLOSING	Airline/ air spot	If all utility, blow pin, free blow and air pressure are declared at standard parameter and blowing pin is not cooled thus it gets damaged.
19	MOULD OPENING & CLOSING	Extra material inside neck	If all utility ,blow pin ,free blow and air pressure are declared at standard parameter and blowing pin is not cooled and hot wire cutter sharpness issue

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20	MOULD OPENING & CLOSING	Extra material outside neck	If all utility ,blow pin ,free blow and air pressure are declared at standard parameter and sometimes excess heat or foreign material may induce parison shift
21	MOULD OPENING & CLOSING	Black spot	If all utility ,blow pin ,free blow and air pressure are declared at standard parameter and excess impurities in parison may show black spot
22	MOULD OPENING & CLOSING	Parison shift	If all utility ,blow pin ,free blow and air pressure are declared at standard parameter and sometimes excess heat, cup and presetting or worn out issue
23	MOULD OPENING & CLOSING	Weak spot	If all utility ,blow pin ,free blow and air pressure are declared at standard parameter and impurities are seen on that blowing
24	CUTTING	Improper deflashing	If air circulation is not correct then the knife will not rotate and thus the knife sharpness cannot be checked.
25	CUTTING		Air pressure and Mould bottom plate will not be checked

TABLE IX

Sl No	Problem Chart Analysis in Printing		
	Sub Process	***Defect***	***Actual Condition/Problem***
1	UNSCRAMB-LER BOTTLE FEEDING	No defect	If blowing bottles are not loaded continuously it will affect the printing process or scramble block issues
2	AUTOMATIC BOTTLE FEEDING	Bottom denting	If arm fails to take the bottle continuously it will affect the stroke and production which weakens the bottle thus it bends
3	PREHEATING	Irregular printing (all defects)	Lack of checking the flame color and LPG gas ,pneumatic pressure
4	SCREEN PRINTING BLUE	Missing text	If printing gig pin, squeegee cylinder, air valve timing, cloth matter, rubber brush. Two brush, color mixing at its standard otherwise it will create defects
5		Blue patch	Blue patch issue up to sensor valve issue and seal cut will lead to pressure
6		Legal problem	Lack of checking the standard parameter, must check the mouth locking pressure, squeegee pressure, color mixing
7		Print smudge	Operator issue in color mixing and squeegee process setting
8		Print shift	Stroke bearing problem and gig pin and cloth matter spring
9		Without blue	Sometimes these issues raise like cloth matter spring broken down ,gig pin
10		Print peel	Sometimes the rotation of mouth and air pressure will affect
11	DRYER	Missing text, blue patch, ink spots, legal problem, print smudge, print peel, print shift, without blue or green or white, blue patch	Sometimes the heating temperature will change and sometimes it must be off
12	SCREEN PRINTING GREEN	Legal problem	Not checking the standard parameter, must check the mouth locking pressure, squeegee pressure, color mixing
13		Print smudge	Operator issue in color mixing and squeegee process setting
14		Print peel	Sometimes the rotation of mouth and air pressure it will affect
15		Print shift	Stroke bearing problem and gig pin and cloth matter spring
16		Without blue or green	Sometimes these issues raise like cloth matter spring broken down ,gig pin
17	DRYER	Missing text, blue patch, ink spots, legal problem, print smudge, print peel, print shift, without blue or green or white, blue patch	Sometimes the heating temperature will change and sometimes it must be off
18	SCREEN PRINTING WHITE	Missing text	If printing gig pin, squeegee cylinder, air valve timing, cloth matter, rubber brush. Two brush, color mixing at its standard otherwise it will create defects
19		Ink spot	Squeegee rubber replace in brush , dryer off
20		Legal problem	Lack of checking standard parameters, must check the mouth locking pressure ,squeegee pressure, color mixing
21		Print smudge	Operator issue in color mixing and squeegee process setting.
22		Print shift	Stroke bearing problem and gig pin and cloth matter spring.
23		Print peel	Sometimes the rotation of mouth and air pressure will affect.

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24		Without green or blue or white	Sometimes these issues raise like cloth matter spring broken down, gig pin.
25	DRYER	Missing text, blue patch, ink spot, legal problem, print smudge, print peel, print shift, without blue or green or white, blue patch	Sometimes the heating temp will change and sometimes it will be off.

TABLE X

Sl No	Problem Chart Analysis in Filling		
	Sub Process	***Defect***	***Actual Condition/Problem***
1	CAP HEATING	Leakage	sometimes they are not heated as per standard
2		Untightened/ Improper cap fitment	Caps get untightened when heating methods are not done properly and also pressure of shafts are not adjusted as per SKU
3		Cracked/ Brocken caps	Irregular heating of caps retards the formation of lines and thus caps are moved into the dispenser and are heated which leads to cracking of caps
4		Untightened/ Improper cap fitment	sometimes the caps are not heated or lines are stopping frequently ,it may reduce the heat from caps
5		Cracked/Broken caps	cap from cap heater to cap dispenser as loaded per interval based on filling line speed
6		Tamper proof Damage	At the time of rotation the tamper may get broken
7	CAPPING OF BOTTLES (PRESSURE SHAFT)	Leakage	When operator fails to take care of cap pressure as per SKU
8		Oil smear	During capping sometimes the cap may get broken and gear loose in cap and stroke timing may lead to oil smear
9		Untightened/ Improper cap fitment	Change in cap pressure or heater temperature
10		Tamper proof Damage	Rotation of cap dispenser may damage the caps
11		Bottle Denting	when pressure of cap get increased it dents the bottle

E. Root cause Analysis

TABLE XI

Sl No	Root cause Analysis in Blowing		
	Parameters Involved	***Process Failure***	***Recommended Actions***
1	RAW MATERIAL	Improper mixing proportions changes opacity of bottles and affects color shade of bottles	Auto dosing machine proportion must be noted every hour and also it is found that printed bottle particle in grinding storage tank. Avoid these man made errors HDPE and palletized material must be in pure condition and end products in different storage area Raw material storage area and mixing area must be kept clean, standard mixing proportion should be followed while mixing, Check standard parameters and materials. keep raw materials
2	LOADING ON HOPPER	Error in proportion leads to change in bottle profile and its color	Accuracy of mixing proportions, Accelerate master batch automation. Introduce air filter while in taking air to avoid foreign particles. Use simple sized magnetic blade in the hopper and use two or more magnetic blades.
3	PLASTICIZING	If the polymer is heated excessively or if it is not melted then the heater, spindle and thermo coil will not work properly.	Temperature zone and spindle should be checked daily and record them every 4 hours. Heater, Thermo coil and spindle rotation should be checked once in a week. Provide Machine health card, Mould health card and check sheets near every machines and must be updated by the operator on an hourly basis
4	MOULD OPENING AND CLOSING	If left and right side parameters are not declared correctly it will lead to improper cutting of bottom side and bottom deflation through the spring damage	Opening and closing of Mould, system delay and Mould temperatures must be checked every day .Provide machine card near every machines to note down any problem if encountered, also provide Mould health card near every machine, and check the sharpness of neck hot wire cutter.

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5	BLOWING	Inflating blowing pressure (2-4), Free blow (2-3) may be over pressure or less pressure may produce broken bottles	Check all the utilities like Air pressure and Blow pin cooling every day and update in check sheet. If any problem is encountered by the operator, make sure that it is recorded in maintenance sheet and use check sheet for routine checkup.
6	DEFLASHING	If proper air circulation is not their then the knife will not rotate and if the sharpness of knife ,air pressure and Mould bottom plate are not checked	Operator must check the air pressure, circulation and sharpness of the blade daily. Make sure that bottom plate sharpness is in standard parameter. Keep machine maintenance card and defect should be noted in it.

TABLE XII

Sl No	Root cause Analysis in Printing		
	Parameters Involved	***Process Failure***	***Recommended Actions***
1	UNSCRAMBLER BOTTLE FEEDER	If blowing bottles are not loaded continuously it will affect the printing process or scramble block issues	Set any alarm for clearing the issue of bottle shortage or blockage
2	AUTOMATIC BOTTLE FEEDER	Blowing bottles may get bend if the arm fails to take the bottle continuously as it affect the stroke and production	Set an alarm if the bottle gets blocked somewhere at the starting of the conveyor or automatically remove the bottle from starting if it is found that the bottle is denting
3	PREHEATING	Flame may not be in blue color , LPG gas issue ,pneumatic pressure issue	Maintain a standard parameter for gas flame and color .Use check sheet to note down issues related to flame, LPG and pneumatic pressure. Set components conditions status sheet for every components and check that area at frequent interval
4	PRINTING	If printing Gig pin, squeegee cylinder, air valve timing, cloth matter, rubber brush, Two brush, Color mixing are not checked issues may occur	Maintain check sheets for gig pin, SQUEEGE cylinder pressure, mouth locking pressure, color mixing and color quality level. Maintain components conditions status sheet for every components. Operator must have to check at definite time interval.
5	SCREEN PRINTING(BLUE)	IF printing Gig pin, cloth matter, heating problem, Squeegee cylinder, Air valve timing, cloth matter, rubber brush. Two brush, Color mixing are not checked issues may occur	Must implement high pixel camera for checking blue printing. Maintain check sheets for gig pin, SQUEEGE cylinder pressure, Mouth locking pressure, screen setting, color mixing and color quality level Maintain components conditions status sheet for every components. Operator must have to check at definite time interval
6	DRYER	If Blue IR lamp dryer is off it may create defects	Maintain check sheet for dryer machine standard condition and in summertime time dryer must be in off state, otherwise the bottle will get heated excessively
7	SCREEN PRINTING(GREEN)	IF printing Gig pin, cloth matter, heating problem, Squeegee cylinder, Air valve timing, cloth matter, rubber brush. Two brush, Color mixing are not checked issues may occur	Maintain check sheets for gig pin, SQUEEGE cylinder pressure, mouth locking pressure, color mixing and color quality level. Maintain components conditions status sheet for every components. Operator must have to check at definite time interval.
8	DRYER	If green lamp will not work it will create defects	Maintain check sheet for dryer machine standard condition and in summertime time dryer may be in off state, otherwise the bottle will get heated excessively
9	SCREEN PRINTING(WHITE)	If printing Gig pin, cloth matter, heating problem, Squeegee cylinder, Air valve timing, cloth matter, rubber brush. Two brush, Color mixing are not checked issues may occur	Maintain check sheets for gig pin, SQUEEGE cylinder pressure, mouth locking pressure, color mixing and color quality level. Maintain components conditions status sheet for every components. Operator must have to check at definite time interval.

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10	DRYER	If white lamp is l cut off it will create defects	Must implement a check sheet for dryer machine standard condition and in summertime time dryer will be in off condition otherwise the bottle will get heated excessively

TABLE XIII

Sl No	Root cause Analysis in Filling		
	Parameters Involved	***Process Failure***	***Recommended Actions***
1	ELEVATOR TO HOPPER	When elevator fails to take bottle from the bottle feeder it damages the bottle and also the rotor in the hopper may also damages the bottle	Maintain check sheet machine components. Operators must kept the maintenance status sheet and machine components sheet for bottle feeder, elevator and hopper bottle rotor and operator must notice the bottle line from bottle feeder to hopper
2	HOPPER TO UNSCRAMBLER	Sometimes the conveyor to belt drive bottle may get damaged through the line (weal bottle may be damage)	Operator must check the hopper to Unscramble conveyor and confirm the line without any blockages. Note the machine component status sheet. Not that bottle may get weak by the defect of blowing process
3	IJP PROCESS	Issues arises when jet and sensor are not aligned or mismatched , ink validity issues, over speed of conveyor and also when jet is not cleaned at frequent interval .	Operator must keep maintenance status sheet and machine component status sheet of jet, sensor, ink validity and jet cleaning and also notice the sensor alignment
4	FILLING (MAIN DRIVE)	In filling process defects are found in blowhole, pinhole, and Airline and parting line. Bottle gets dent due to issues in blowing and printing .Issues are found when gear setting and volume adjuster bolt are improperly done and also when impurities are present in cylinder hose and valve. When operator fails to check conveyor lines of Unscrambler and elevator to hopper line ,defects arises	For filling process the IJP bottles are directly fed to main drive. The operators must check the standard parameters like Stroke timing, volume adjuster bolt, checkout, cylinder hose impurities and piston rad. Keep the status of components near machine and operator must check the stroke timing, blowing defects, underweight and bottle denting and must report to respective departments.
5	CAP HEATING	Issues arises when heater fails to heat the cap or if there is any problem within the heater and cap won't get heat as per the standard.	Operator must maintain check sheet for cap heater and must note the temperature in inspection sheet and also check the cap heating machine at regular intervals.
6	CAP DISPENSING	Sometimes the caps are not heated properly or when lines are disappearing frequently it may lead to reduce the heat from caps. Caps are fed to cap dispenser from cap heater as loaded per interval based on filling line speed. Tamper may get broken at the time of rotation	Operator must alter the dispenser as per the size of cap with tamper size. Operator must adjust the speed of conveyor and must control supply of caps
7	CAPPING	Issues occur when operator fails to adjust cap pressure as per SKU. During capping, cap may get broken or sometimes gear loose in cap affects the oil smear. Stroke timing may lead to oil smear cap pressure and cap heater temperature sometimes changes. When conveyor stops frequently it will reduce cap heat and thus the cap gets broken.	Operator must maintain check sheet status for equipment, capping pressure shaft, cap heater and dispenser. Only load capping dispenser as per the requirement of filling speed of conveyor and stroke timing. Operator must notice about the dispenser flow of cap in flexible temperature, cap heater and avoid tamper damage

Quantitative analysis was conducted and results were obtained to identify the effect of these factors on timely delivery.

F. Percentage Analysis

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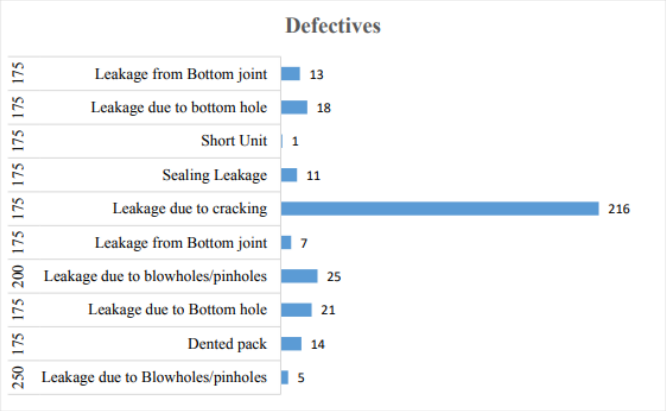

The percentage analysis helps to observe that the Defect mainly occurred to the leakage due to cracking in filling department. The Leakage due to crack is because of mainly blowing or printing root cause issues. Also found 216 Bottles are defects occurred happened due to Leakage of bottles due to cracking this cracking was happened due to various problems occurred in various departments and other defects are found and evaluated by the analysis and analyse which find the defect is more or minimum in each department and know how much product are rejected due to these reasons.

1. Blowing Department
2. Printing Department
3. Filling Department

IX. RESULTS

Provide possible suggestions to improve the product quality of the company by reducing the adverse impact of various defect quality indexes in the overall satisfaction of customers. Implementing Machine and components daily Health status sheet, maintenance sheet and defect arrested record in 3 departments must be recorded and placed near the machine are already to introduce so implementation of the process won't require much
cost but can ensure those resources are fully utilized and easily found the problems in machine can take precaution early can reduce the no of human resource needed to complete the production.
Raw material error amounts to 50% of the defect reason and can be successfully reduced by implementation of calibrating machines and introduce hygiene mixing area and closed storage tank , implement check sheet for proportion and manual settings in systems. Addition of machine care of MCBM required for the blowing and its machine components can improve the quality of individual bottle among the production .Also introduced Blowing Quality department in plant will reduced the error of 80% error to reduce up to 25%. Also introduced a defect sheet and maintenances sheet for every operator in charge of 3 department on daily basis must be recorded it will reduced the machine breakdown and rejection of product.

TABLE XIV

Sl No	Results	
	Defects	*Current And Future*
1	Blowing related	Current product defect error amounts to 85% which can be brought down to less than 5% as the Machine error and human error can be nullified and also provide online power support can increase up to 7.5 lakhs more than current production.
2	Printing related	Current product rejection up to 80% reduced to 5% because of after introducing blowing quality check and implementation of status sheet and operator maintenances sheet respectively which can be completely resolved.
3	Filling related	After the analysis and found the critical area and implement check sheets and maintenance sheet also the quality check will be more effective than previous structure will be current rejection reduced up to less than 5%.
4	Packing related	Currently ensuring the packing and loading also carton taping and buckling and dispatching handling must be notified and more care.

TABLE XV

Sl No	Results	
	Department	***Results***
1	Blowing error can reduce from 80% to 40%	Total Value of Goods 43,155,94 INR worth SKU and Total quantity of material saved-16718KG
2	Printing defect can be reduce from 50% to 25%	Total Value of goods 14242864.5INR worth SKU
3	Filling defect can be reduce from 90% to 45%	Total Value of goods 373605INR worth SKU Salvage oil saved-824.055 KG Scrap oil saved- 306.34 KG
4	Initiative of On process power backup	Can produce 28800PPM/DAY and 57 AKH words SKU.

TABLE XVI

Sl No	Recommendations	
	Defects Areas	***Recommendations***
1	Blowing related	• Implementation of machine maintenance, operators defects arresting, standard method, material quality Check sheet in various process and raw material storage area hygiene • Proposed an initiative for Machine not shutting down on power failure, which in turn will increase the production by 3 times and will lead to profit and cost reduction of materials and labor • Proposed for starting a new Blowing quality department

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2	Printing related	• Implementation of Flame standard and testing procedure of bottle flexibility for printing. • Also maintain the Operator defects arresting, Machine components, method check sheets in these department. • Educate the workers about standards of a bottle after printing
3	Filling related	• Implementation of machine maintenance, operator's defects arresting, standard methods check sheet in various process and cap heater directly connecting to cap dispenser. • Educate the workers about standards of a bottle and hygiene.

X. IMPLICATIONS AND LIMITATIONS

A) Implications

Identifying the major factors affecting the quality defect of the firm and controlling it.

The matrixes affect the efficiency of the firm and in terms increase the operational cost.

Identification of the issues by first measuring the current quality defect and then providing possible solutions can improve the customer satisfaction and improve the customer experience. Prepared Quality maintenance (TPM) process which can reduce future error. Suggestions and Quality Maintenance (TPM) process can be implemented for other seven production firms.

B) Limitations

Unavailability of Skilled operators and workers

Unavailability of Machine Maintenance and machine components status data

Unavailability of Defect arrest data in Blowing, Filling and Printing Departments

Unavailability of calibration report in Auto Dosing machine and Master batch machine.

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AUTHORS PROFILE

Sabjan S.N. is currently pursuing MBA in Operations Management at Amrita University Amritapuri. His graduation in Mechanical Engineering from Kerala University. About his work experience at Volkswagen for a period of 2 years. He has worked with Volkswagen sales and Aftersales in development, industrialization and commercialization of automobile field into emerging and regulated markets. In his free time, Sabjan enjoys playing cricket, reading and travelling.

Maheshwar Pratap is an Operations Management enthusiast and is a Faculty Associate at the Amritapuri campus. Prior to his teaching assignment at the ASB, Maheshwar has worked with Pharma major Biocon in development, industrialization and commercialization of biomedical devices into emerging and regulated markets. Maheshwar has also worked with retail operations of Pantaloons Retail India Limited and handled store operations for large format stores of the group.

His research interests include welfare economics and poverty alleviation, efficacy of government schemes and public policy interventions. Maheshwar is also involved in research works around technology aided learning and its implications on learners. Maheshwar has authored 8 research papers with his co-authors and presented them at leading conferences in his area.

In his free time, Maheshwar enjoys travelling, reading and watching movies