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Role of Lean Manufacturing Tools in Soft Drink Company

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Abstract: *In a present customer-driven market, it urges the industry to implement lean tools to reduce waste. This paper utilizes the applications of Lean manufacturing tools like Value Stream Mapping (VSM) and Jidoka in continuously improving bottle filling and crowning operations at soft drink companies. Waste reduction becomes an increasingly dominant force in the modern manufacturing world. The most important tools in Jidoka are Andon and Poka-Yoke. Andonis a visual control that helps the operator notify the machines' status and manufacturing line in the manufacturing process. Poka-yoke devices are made for mistake-proving pieces. Because of that, they can be classified as proactive and reactive devices. The proactive prevents the defects, and the reactive detects the defects once they are already produced. The main parameters taken are missing operation, underfill, overfill, breakages. Data are collected for the filling and crowning operations so that the facts about the problem are accurately described. Pareto charts and cause & effect diagrams are used to present the key problems which can be improved. This paper also deals with the productivity improvement using VSM on the assembly line. It is a lean venture towards perfection and an attempt to identify non-value adding activities, thereby enhancing productivity.*

Keywords*:* *Jidoka, Value stream mapping (VSM), Lean Manufacturing (LM), Andon, Poka-yoke*

I. INTRODUCTION

Manufacturing firms have taken the lean Manufacturing (LM) system as a great management tool in solving problems, and many of them have adopted lean techniques in many different ways. Lean manufacturing's ultimate goal is to develop a high-quality organization that can produce finished products concerning the customers' demand with no waste. Though there are different issues involved in cost reduction internally spent by industry through finding wastages, preventing and correcting defective work would result in huge savings. Labor costs have increased in many industrialized countries. Reduce and control operating costs and just a few reasons why companies choose to move or outsource their operations. Typically a majority of companies outsource to countries where wages are low, and production costs are lower. To reduce costs and remain competitive with manufacturers abroad, companies use a variety of different methods.

The lean concept and its tools help us identify and rectify the problems we face in industry production methods, time utilization, and wastages. Product losses arising during the filling processes have their broad scope because there are different contributors to it and areas that can be focused on. Some losses could occur between the deposit tanks initially and the filler/crowner discharge operation due to incorrect measurement is being taken at either side. Further losses could be made up through overfills, no proper fixing of crowns, damaged crowns, underfills, bottle defects, start-up, shut down, and incorrect jetting. This paper focuses initially on VSM then on an in-depth study of the losses at the filler operation. This was the operation highlighted as the contributing factor within the overall process.

II. LEAN MANUFACTURING-JIDOKA AND VSM

Leading manufacturing companies have increasingly applied lean manufacturing throughout the world. Lean manufacturing is based on the concept that production can and should be driven by real customer demand. Lean manufacturing can produce customer wants with shorter lead times. Instead of pushing products to market, it is pulled there through a system set up to respond to customer demand quickly. Its principles include recognizing wastes, having standard processes, continuous flow, pull-production, quality at the source, and maintaining continuous improvement.VSM is a tool used to graphically represent the processes or activities involved in the manufacturing and delivery of a product. These activities can be divided into value-added and non-value added. Key process information and data and key performance measures are then added to the VSM to characterize various stages in the product flow and quantify current state performance with symbols shown in table 2.1. Process data include primarily cycle time (CT), capacity, and availability.

In lean manufacturing, *jidoka*means making defect-free processes by continually strengthening process capability, continuous improvement, and feedback. The term jidoka also suggests that if a person detects any defect during a process, he/she should immediately stop the process and correct the process. *Andon*is a visual control that helps the operator notify the machines' status and manufacturing line in the manufacturing process. The main item is the display to represent the state of the processes. Also, a system alarm can alert the workers when there is a problem. The responsible for the process can stop and ask for help or solve the problem if they know to do it. Thanks to this tool, they can control the quality and reduce the defects, so it helps the process of quality inside the company—the benefit ofJidokais in the introduction stage of an approach for the mistake-proofing design called Poka-Yoke. *Poka-Yoke* is a mechanism for detecting errors and defects. These devices avoid 100% of the defects, even with human mistakes, and are very useful devices (Shingo, 1988).

III. LITERATURE SURVEY

Lean manufacturing involves a large number of concepts. The following two points of the Lean techniques (Jidoka and TQM) are more related to the organization, the managers, the intermediate positions, and workers, including the quality. Jidoka forms the other big pillar in the Toyota Production System. *Jidoka*is "the practice of stopping the process when a problem occurs."It is very focused on the people of the company because they need to realize the wrong running of the process and stop it to solve the problem just in that instant and in the same process. Jidoka is also called autonomation because it comes from a Japanese item that means that word. Autonomation is defined as intelligent automation or automation with a human touch (Ohno, 1988). This technique wants to enhance the employees' role and allows them to make decisions to fix the problems. According to Tommelein, I.D. and Grout, J. (2008), Poka-yoke devices can be sorted into three different types; (1) physical, if they block the flow of the piece, mass, energy, or information. There is no interpretation of the worker; (2) functional when they might be turned on or turned off to an occasion; (3) symbolic when it is necessary the interpretation, and it should be the worker at the moment to realize the signal. The poka-yoke devices are made for mistake-proving pieces. Because of that, they can be classified as proactive and reactive devices. The proactive prevents the defects, and the reactive detects the defects once they are already produced.

ShaikDawood A.K. et al. (2014) applied Lean Manufacturing as an applied methodology of VSM in minimizing waiting time with minimum non-value adding activities that are obtained and removed. Another classification by Shigno (Shingo, 1988) separates the control and warning. The control function can turn off the machine when a defect is detected and does not allow the next piece's entrance, or it can automatically exclude the piece that is not good from the production. The warning function of poka-yoke devices creates lights or alarm to show the occurrence of a defect (Shingo, 1988).Glass bottles are either a single trip or returnable, considering the cost factor. Returnable bottles are preferred more than single-trip bottles. Excellent barrier properties; Supporters claim the "feel" of the product creates a favorable impression in terms of quality; glass is synonymous with "class." According to Womack Jones, and Roos (1996), lean manufacturing uses less of everything compared to mass production- half the human effort in the factory, half the manufacturing space, half the investment in tools, and half the engineering hours to develop a new product. Besides, it requires keeping far less than half of the needed inventory on site, results in many fewer defects, and produces a greater and ever-growing variety of products

IV. METHODOLOGY

- ➢ Value Stream Mapping Creation- *The Current State Value Stream Map*
- ➢ Identify variables and factors, which one has a great influence cause defects
- ➢ Attempt to improve and enhance the performance parameters through eliminating or reducing wastes within the assembly line
- ➢ Analysis of the Current conditions and Plot Future *State Value Stream Map*
- ➢ Identify value-added and nonvalue added time, calculate lead time
- ➢ Choosing appropriate waste reduction methods and reconfigure process to eliminate waste by applying the JIHOKA method using lean tools Andon and Poka-yoke
- ❖ The methodology of Jidoka includes the basic steps, which are the following
- ❖ Jidoka Step 1: Detect the abnormality-(Andon)
- ❖ Jidoka step-2: Stop the equipment or line-(Poka-yoke)
- ❖ Jidoka step-3: Fix and correct the immediate condition-(Poka-yoke)
- ❖ Jidoka step 4: Investigate root cause and install a counter measure-(Poka-yoke)

A. Value Stream Mapping Creation- The Current State Value Stream Map

The VSM was used to evaluate the VD and NVD time of Cool Drink Company. The lead time is the time interval between the initiation and the completion of a production process. The required data for the construction of the present VSM were collected. From the present VSM, total VD & NVD time were observed respectively 5439 sec and 35826 sec from the bottom line of figure 2. The uptime of filtering, mixing, filling, labeling, and packaging was observed 72%, 67%, 75%, 62%, and 65%respectively. After the implementation of lean tools, uptime would be improved. Also the changes over time, cycle time, labor engagement were be assumed from the present VSM. The daily demand is 5000 bottles. The in-process inventory was observed between each two processing stages, like filling and labeling sections, which could be reduced using lean tools Fig 1. Shows present State VSM.

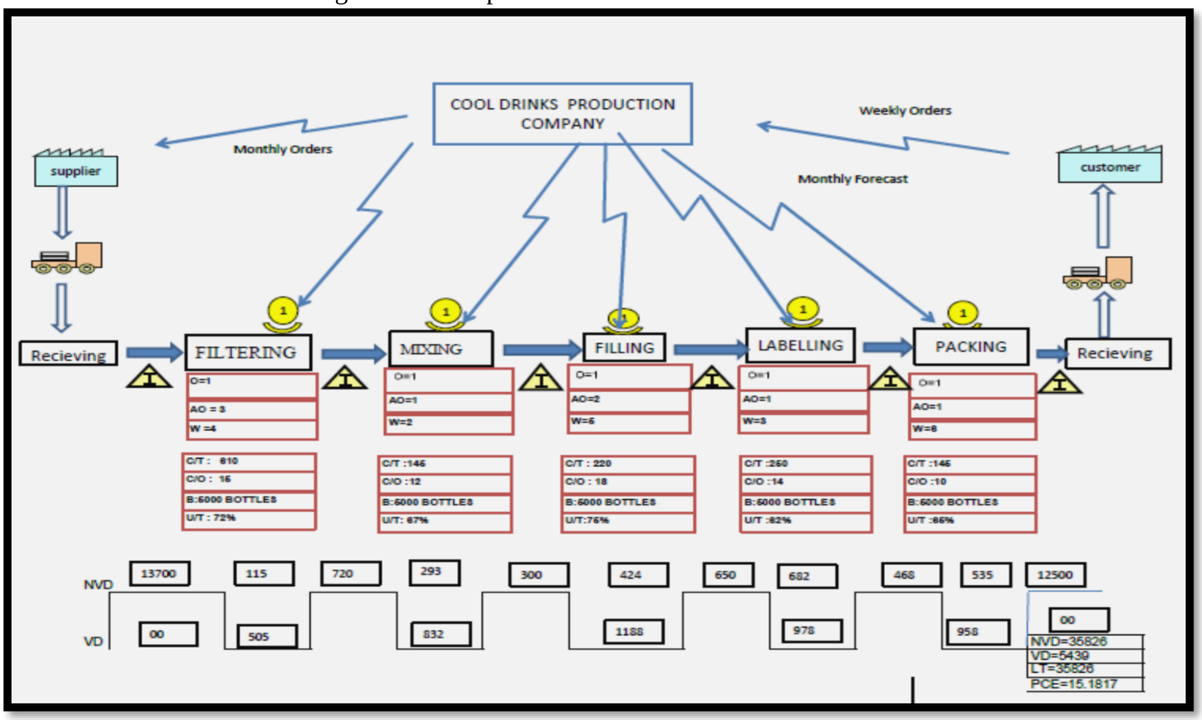

Figure 1 Current state VSM

1) Present Process Cycle Efficiency

At present, VSM, in the reduced NVD time and VD time, were observed; therefore, PCEwas calculated.

- Value Added time= 5439 sec
- Non Value Added time = 35826 sec
- Lead time= Value Added time + Non Value Added time

= 5439sec + 35826sec= 41265 sec

Process cycle efficiency = Value added time/lead time *100 = 13.18%

2) Takt Time Calculation- Present State Vsm

Takt time is the average time allowed to produce unit production to meet customer demand, and the processing time should be less than or equal to the take time. Takt time is calculated based on machine available time and the required number of units. The procedure followed to determine takt time for the current production of soft drinks as follows:

Working shift per day	=2 shift
One shift time	=9 hours and 7 minutes or 35826 sec
Two shift time	=19 hours and 5 minutes or 71652 sec
Total change over time	=1 hour or 3600 sec
Lunch time	=30 minutes or 1800 sec
Net available time per day	=Two shift time – (Total change over time + Lunch time)
	= 71652 sec – 5400 sec
	= 66252 sec
Daily saleable demand	=5000 bottles

Takt time = 66252/5000 = 13.25 sec/Bottle

B. Value Stream Mapping Creationthefuture State Value Stream Map

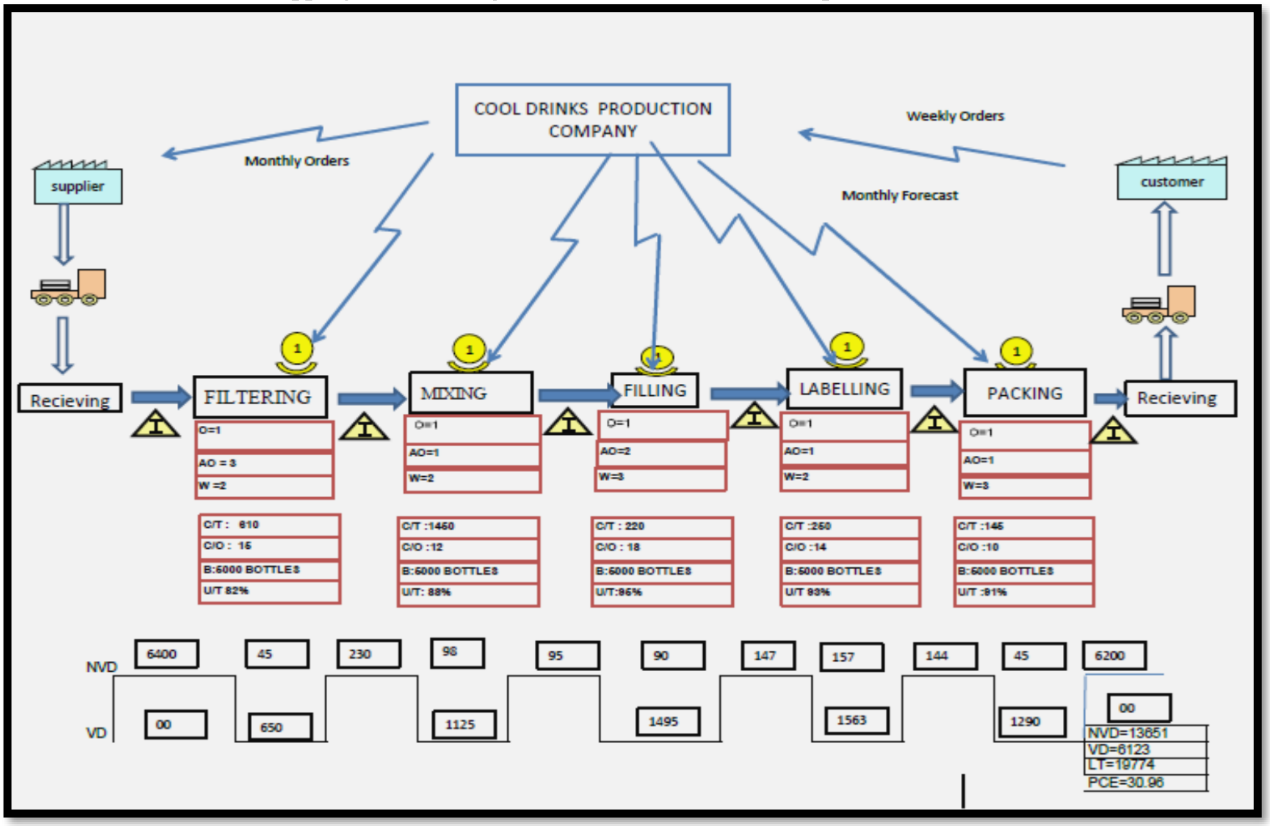

Figure 2 Future State VSM

1) Takt Time Calculation- Future State Vsm

Working shift per day	=2 shift
One shift time	=5 hours and 4 minutes or 19774 sec
Two shift time	=10 Hours 8 minutes or 39548 sec
Total change over time	=1 hour or 3600 sec
Lunch time	=30 minutes or 1800 sec
Net available time per day	=Two shift time – (Total change over time + Lunch time)
	= 39548 sec – 5400 sec
	= 3418 sec
Daily saleable demand	=5000 bottles

Takt time = 3418/5000 = 6.82 sec/Bottle

2) Future Process Cycle Efficiency

At future VSM, in the, reduced NVD time and increased VD time were observed therefore, improvement in PCE was calculated.

- Value Added time = 6123 sec
- Non Value Added time = 13651sec
- Lead time = Value Added time + Non Value Added time

= 6123sec + 13651 sec= 19774 sec

Process cycle efficiency = Value added time/lead time *100 = 30.96

At future VSM, as shown in Fig 2 Future State VSM, it is observed that NVD time and the total number of labor are reduced, VD and uptime is increased, an in-process inventory delay time is also reduced. The VD & NVD time were observed respectively 6123 sec and 13651 sec from the bottom line of figure 2. The uptime of filtering, mixing, filling, labeling, and packaging was observed 82%, 88%, 95%, 93%, and 91%respectively.

Focus On Assembly Lines

The lean approach is focused on systematically reducing wastes in the assembly line. From the Value Steam Mapping, it was found that this assembly line's improvement can be made at zones like filling and labeling; hence, they were chosen for studying the losses done at those points. The main parameters take missing operation, underfill, overfill, breakages. A complete study was done in glass bottle filling losses through wastage on the filling operations adversely impact the company with losses amounting to hundreds of dollars per year being incurred. The bottling lines apply Jidoka practices from Lean Manufacturing.

During the bottling process, there are electronic devices or sensors which control that the activity is performed correctly. It is a way to reduce the defects after the stages, but this control does not monitor values. They do not register data of the attributes. The lines run automatically because they also have sensors to detect that there are bottles in the previous belt entrance. Consequently, the machines stop or reduce the speed when they do not detect enough bottles to fill the machine. The machines can auto-control the different speeds between stages because they don't have the same cycle time, and for this reason, the line works with intermediate stock to avoid downtimes and stoppages. Apart from VSM analysis, this paper focuses on lean manufacturing by avoiding the waste at the filler operation. This was the operation highlighted as the contributing factor within the overall process.

V. RESULT

A. Value Stream Analysis -Present Vsm

Lead time=41265sec
Takt time = 66252/5000 = 13.25 sec/Bottle
Process cycle efficiency is improved to 13.18%
VALUE STREAM ANALYSIS -Future VSM
Lead time=19774 sec
Takt time = 3418/5000 = 6.82 sec/Bottle
Process cycle efficiency is improved to 30.96%

Table 1 Labourdetails present and future using VSM

Name of the stages	No of labor at Present state			No of labor at Future state		
	O	AO	W	O	AO	W
Filtering	1	3	4	1	3	2
Mixing	1	1	2	1	1	2
Filling	1	2	5	1	1	3
Labeling	1	1	3	1	1	2
Packing	1	1	6	1	1	3
Total	5	8	20	5	7	12

The unnecessary labor movement in the production floor was considered as motion waste. After the analysis production line, it is expected that several unwanted laborers could be eliminated. From Table-1, At present state, it is seen that 33 laborers are engaged in the litchi juice production floor, and it can be assumed after the implementation of lean tools and six sigma techniques, the number of labor would be reduced to 24. It seems that several unwanted laborers are engaged to manage the different types of bottlenecks and NVD activities.

B. Graphical Analysis On Assembly Line-Wastes Percent Loss Of Product As A Function Of Total Volume Produced Per Month

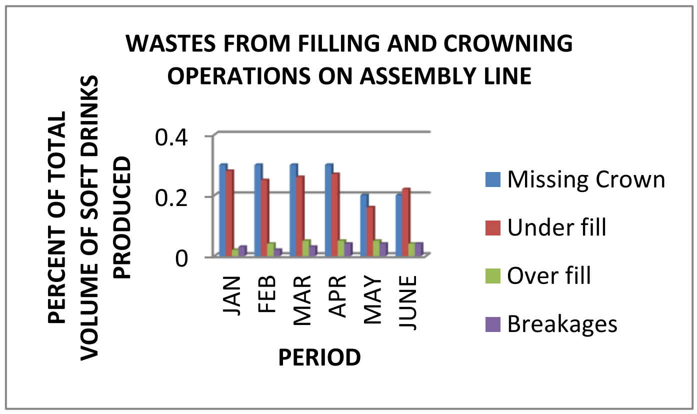

Figure 3 shows the data on wastes percent loss of product as a function of the total volume produced per month.

There is no major significant difference between the under-fills and the missing crowns, but it was found that the under-fills are still higher than the missing crowns. It was investigated during shifts to see if there were any significant differences in the waste ratio per shift and noted no significant difference between the two shifts, as shown in figure 3.

C. Pareto Analysis On Assembly Line

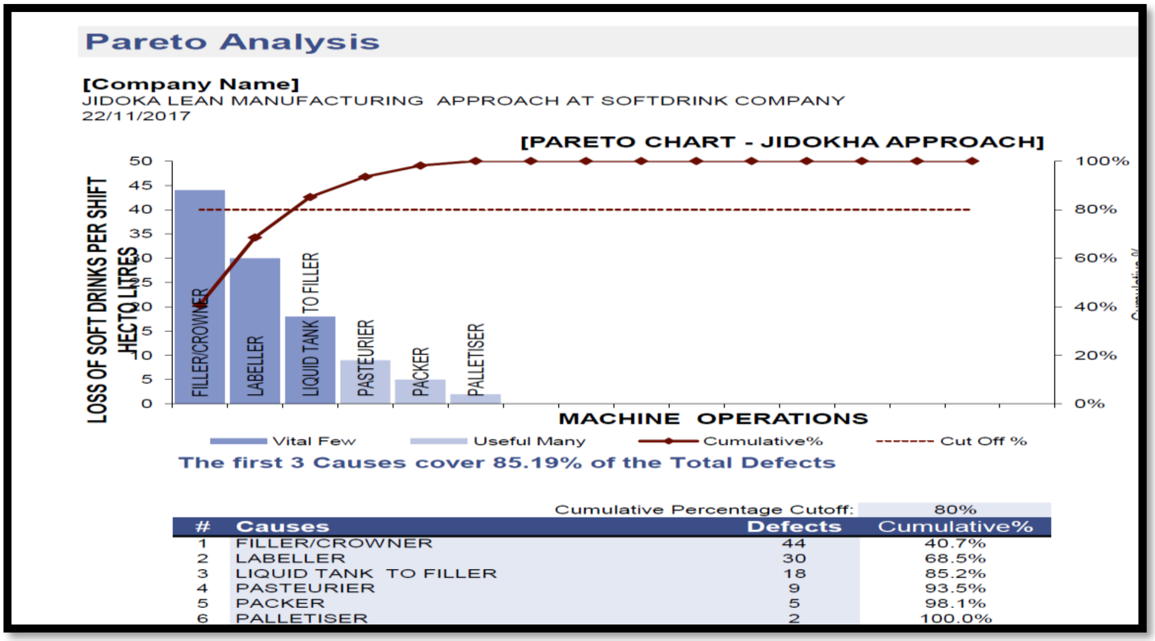

Figure 4 shows the Pareto Analysis on the Assembly line

With the use of Pareto, scarce resources are efficiently allocated. The principle dictates that 80% of the failures are coming from 20% of the causes. It is important to note that this tool wholly bases recommended actions on present data. It does not consider probable increase or decrease and projected movements of anyone contributing factor. To further illustrate, the Pareto chart has been designed to represent the vital few against the trivial many. With the chart's help, it is easy to identify the causes of most of the problems. Here Fig 4 Pareto chart displays machine parameters like filler/ crowner, liquid tank pasteurizer, packer, and palletizer against machine operations. The result is filler/crowner contributes a cumulative percentage cutoff of 44 defects. Labeller contributes 30 defects, and Liquid tank to filler contributes 18 defects. The first three factors cause 85.19% of total defects.

D. Cause And Effect Diagram Analysis On Assembly Line

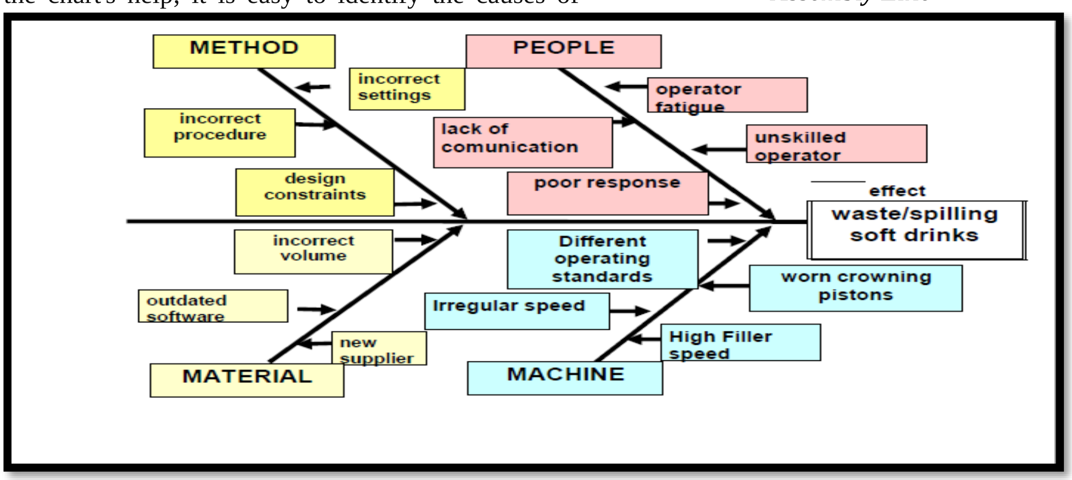

Figure 5 shows the Cause and effect analysis

High speed overfilling also contributes towards product losses. Poor filling control caused by filling problems can cause the soft drink to gush during the shifting process. Mishandling the bottle at the filler to crowner transfer will cause the liquid to be agitated, resulting in the product gushing out of the bottles. The incorrect setting method will cause excessive liquid loss from the bottle, resulting in a bottle's underfilling. Damaged filling valve components will also result in underfilling and overfilling. Also, the incorrect volume of soft drinks and the sudden change in design constraints of various sizes contribute to overfilling. Then there are rejects caused by incorrect crowning and missing crowns. Uncrowned bottles will be rejected at the filler discharge.

VI. CONCLUSION

VSM and Jidoka practices of lean manufacturing applications are utilized for removing the waste from the company. Pareto analysis can be used to identify key areas in the process that could benefit from a focus improvement initiative, thereby benefiting the overall company. The analysis of the filling and crowning process through Ishikawa diagrams revealed the critical process inputs and parameters which influenced excessive waste. Recommended solutions were identified and implemented to reduce the wastes of these critical process inputs. It is crucial to ensure that the workers comply with the standard operating procedures for waste to be reduced. The employee involvement actions focused on layout changing for assembly and raw materials, as shown in Figure 5. Hence we focus on studying the process in detail and reducing the waste related to motion and assembly line operations.

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