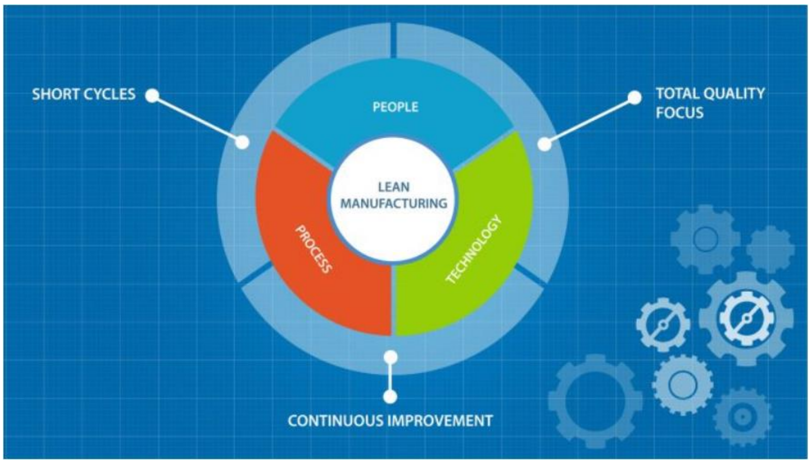
Department of Industrial and Systems Engineering

College of Engineering

Texas A&M University

ISEN 645 Lean Thinking and Lean Manufacturing

Kristen Distributing Bottling Line LPS



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1. Overview

1.1 Abstract:

Boots bottling plant is currently outsourcing their requirement of bottled beverages to Excel Bottling Company in Illinois. They intend to set up a new bottling line which is anticipated to be commissioned in 2019-20. The motivation behind setting up a new bottling line instead of subcontracting the current demand is to increase the profit margin/percentage of Boots bottling plant. Currently, Boots are paying \$14.50 per case while they intend to reduce this cost to \$11.75 by producing it in-house. Boots beverages will add a copacker to earn the additional \$2.75. This reduction in the cost per case calls for a lean production system which will assist in achieving this profit margin. This LPS should be capable of producing a throughput of 5 million bottles per year. Firstly, we will be carrying out a thorough analysis of the current production system (Excel Bottling Plant) with the help of various tools such as IDEF0, VSM, and IDEF3 to identify the waste as well as the non-value-added processes in the system. After the exhaustive analysis of the ASIS system, we will be analyzing the various alternatives possible for realizing an LPS. Depending on the feasible alternative we will finalize the micro-level as well as the macro-level design of the LPS. The realization of the improved LPS will be carried out with the help of IDEF0, VSM, and IDEF3 model as per the 8-core design steps. We will be planning the setup/flow of the machineries and processes as per the floor layout provided. The improved LPS will include a new vendor base so that the procurement of raw materials can be done weekly or monthly as required thus reducing the inventory cost. Kaizen events will be carried out such as various trainings for the labour to incorporate the new SOP, Fluorescent floor markings, and 5S Kaizen. To ensure that the required objective is being fulfilled we will be performing a Cost/Benefit analysis to understand the effects of the LPS. After analyzing the results if the cost analysis, we will be formulating the recommendations for the new boots bottling line.

1.2 Objective

To design a Lean Production System for the new Boots bottling line which is planned to be commissioned in 2019-20. Additional to the macro level LPS design, a micro level LPS design for one of the functional areas is also required.

1.3 Clarity

The focus of this design will be task engineering of various processes involved in the production system. We will be focusing on removal of the various wastes and non-value-added process. We will be calculating the takt time according to the required demand and the available shift hours. After establishing the takt time, we will be using this to regulate the production and select the required machinery. After the conceptual design is complete, we will be planning the Implementation of these designs. The results of Cost/Benefit analysis will be the deciding factors for the implementation plan and the recommendation for the Lean Production System.

2. Analysis of ASIS

2.1 Assumptions

- The company is open to any kind of changes to the existing bottling operations
- The budget is limited, and extremely high cost solutions are not viable
- Delivery to the customers can be carried out on daily basis
- Ordering of raw material is possible at all times
- Pre-processing of water obtained from different sources is not carried out.
- All aspects of the plant setup like marketing department, financial department, etc except for the production line is taken care of.
- Raw material specifications can be changed.

2.2 IDEF0

This is the first step in analyzing a given PS. Using IDEF0 we identified the activities that are involved in in the system and how they are related to each other. IDEF0 consists of four major parts namely the Input, Control, Output and Mechanisms (ICOMs). This helped us find out how the existing bottling line operated and how various elements within it interacted. Analyzing the current system, we identified areas in the PS where we could incorporate the Voice of Customer (VOC) in the form of Ys which were broken down into categories such as Critical to Cost (CTC), Critical to Quality (CTQ), Critical to Performance (CTP) and Critical to Safety (CTS). Also, we found out the factors influencing these Voices of Customers and incorporated them to the IDEF0 model to identify activities that can help realize the VOC. The detailed explanation is as follows:

Level – 0

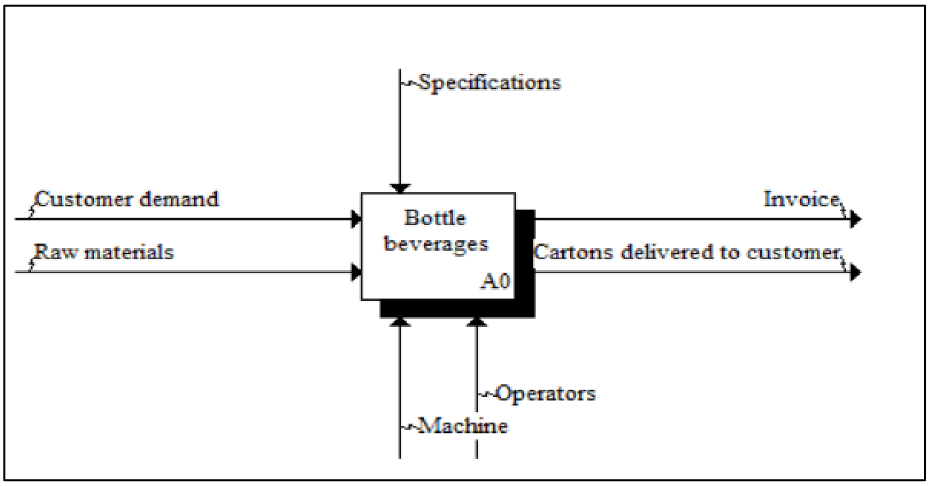


Fig 2.1: ASIS IDEF0 level 0

This is the level in which we define the PS and the main ICOMs of the PS. We have defined the main activity in our PS as bottling beverages and the main ICOMs as:

- Inputs - Customer demand, Raw materials
- Controls – Specifications
- Output – Invoice, Cartons delivered to customer
- Mechanisms -Machine, Operators.

Level – 1

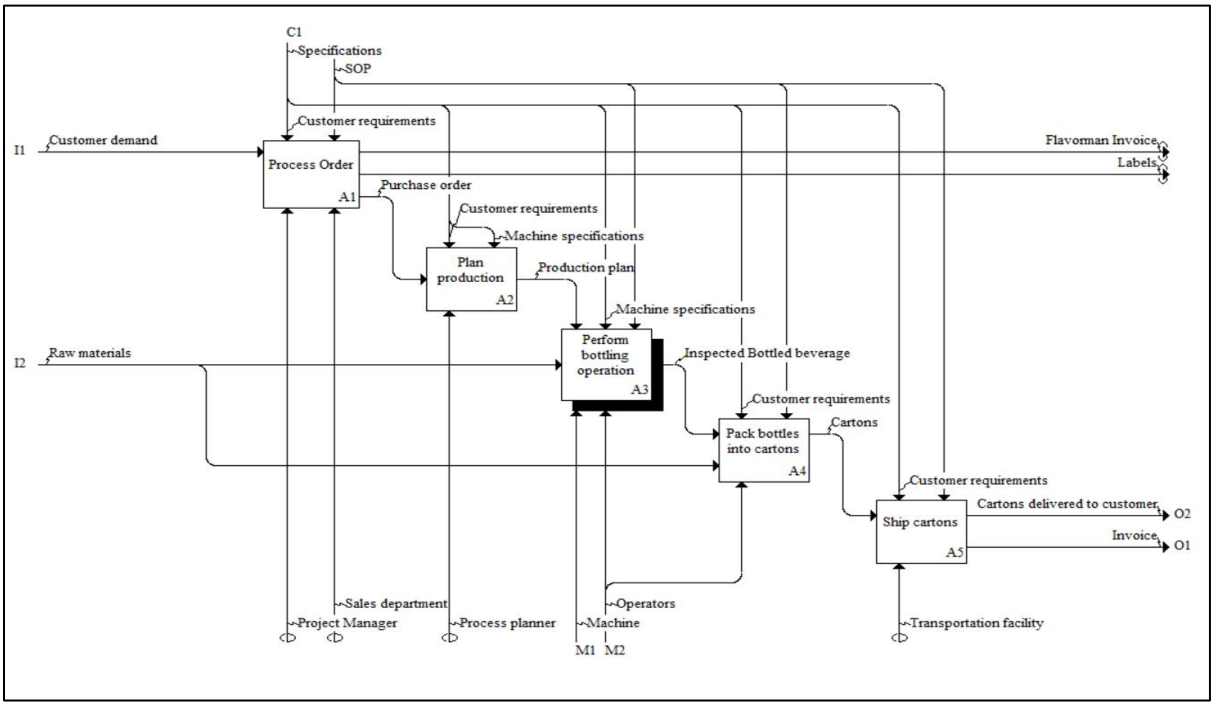


Fig 2.2: ASIS IDEF0 level 1

On digging a little deeper, we find an overview of the main activities. As we see here the process starts with order processing where it is converted into purchase order for the production planning department. This activity is constrained by the product and machine specifications, and the Standard Operating Procedures and is carried out by the project manager with the sales department. The purchase order is then sent to the production planning department where based on all the inputs received and the constraints shown, a production plan is made which decides the production sequence, and the various operations required to bottle the beverages. The next process is obviously the bottling operation itself which is guided by the production plan, SOPs and customer requirements. After the bottling operation, the bottles are sent for packaging where they are packed into cartons and sent for shipping to the customer. During shipping phase, the invoices are generated, and the cartons are delivered using transportation facilities.

Level – 2

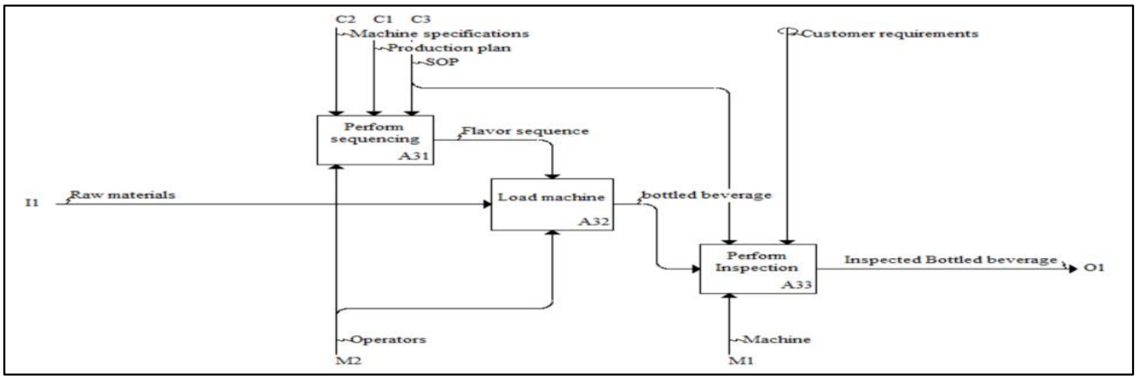


Fig 2.3: ASIS IDEF0 level 2

Since our focus here is the bottling operation, we decomposed that operation for further clarity. We see that at first sequencing is performed in terms of all the changeover and sanitation operations required before starting the bottling process. After this the bottling line is loaded with all the required raw materials and the bottling operation is performed. The bottled beverage is then inspected for any anomalies and the final inspected bottle is sent for packaging.

2.3 Value Stream Mapping

The step is very important as it will help us analyze the flow of the processes from raw material to the customer that create value. With the help of VSM we can successfully identify the waste or non-value added processes in the system and eliminate them to design an LPS. This will also include the current structure of supply chain and help us analyze the wastes in the same.

The major customers of Boots Bottling plant are HEB, Kruger, and Hyvee. The ASIS value stream map shows that the customer order lead time is 3 weeks. The demand for all the raw material is forecasted and according to the demand forecast the requirement is placed or various vendors. For labels the demand forecast of 6 months is calculated and sent in the form production order to Ample industries. For Flavors the monthly demand is placed as an order on Flavorman, while the demand for the glass bottles is also placed monthly. The shipment for these raw materials is brought in every month and is stored as inventory before processing.

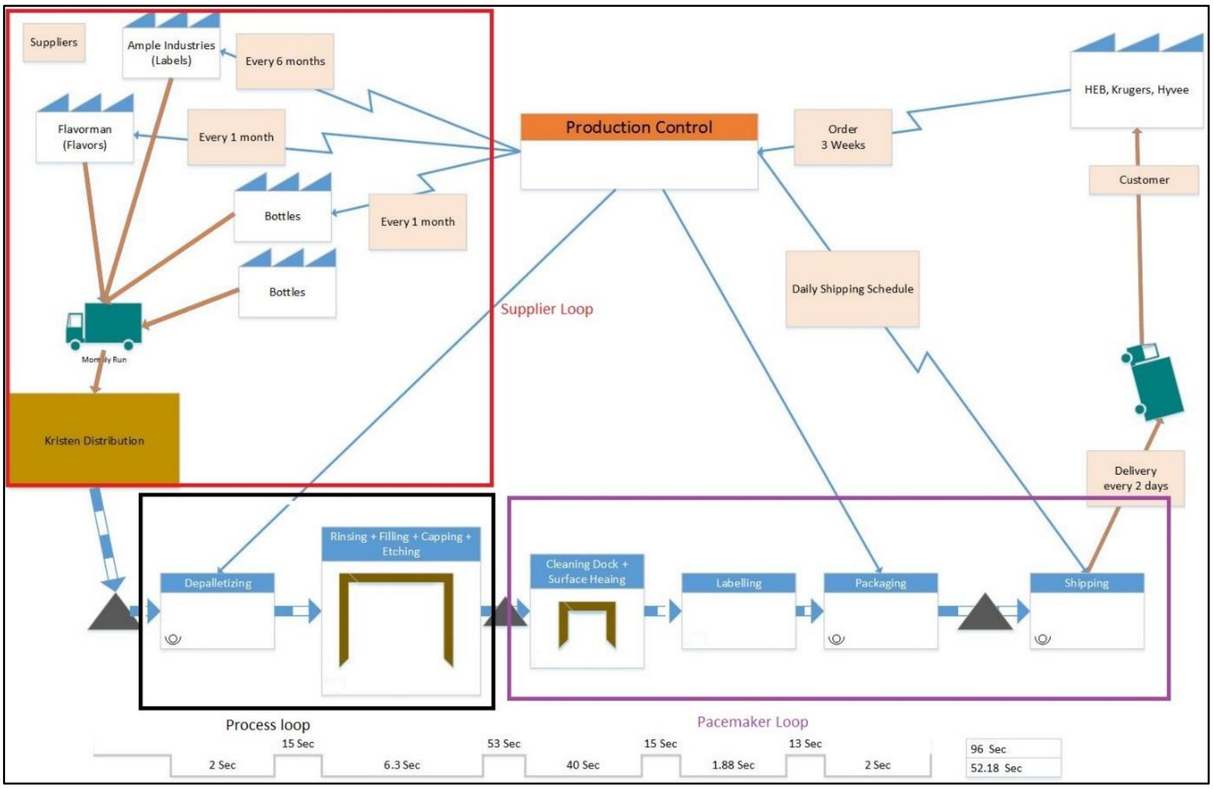


Fig 2.3: ASIS Value Stream Mapping

Once the raw materials are available for processing the first stage that is carried out on the shop floor is to Depalletize the glass bottles on the production line to initiate the production. The glass bottles are depalletized on a roller platform and pushed altogether. This can be seen as a health hazard as the bottles may tip over causing it to shatter and cause damage to humans as well as machines. After the bottles are depalletized, they are arranged on a conveyor belt line on which a single bottle flows and all the operations are carried out inline on each bottle one after the another. After traversing on the conveyor belt for 15 secs, the bottles will enter a rinsing machine which will clean the bottles in a continuous flow (8 bottles at a time) and the throughput of the rinsing machine is 1 bottle per 2 secs. The cycle time for cleaning machine is 17.5 secs. This continuous flow machines will help us reduce the cycle time of the machine by a greater factor as the required takt time per machine is 2 secs. After travelling for 12 secs on a conveyor belt, the bottles enter into the filling station where the required drink is filled in the similar manner as the bottles are cleaned. The WIP for this continuous flow machine is 8 bottles and the throughput is 1 bottle every sec. The cycle time for filling machine is 16 secs. After the bottles are filled with the required drink, they travel for 11 secs and then enter the machine which fits caps on these bottles. The WIP for this machine is 3 bottles, the cycle time is 6 secs and the throughput of this station is 1 bottle every 2 secs. After travelling for more 20 secs, the etching of required details on the bottle takes place. This is a really fast paced operation and it takes only 0.5 secs per bottle. Post etching the bottles will reach the cleaning dock after 10 secs where they are accumulated in a large space and sprayed with water for cleaning any spillage during the previous stages. Around 120 bottles are docked in this station and the cycle time for each bottle is around 60 secs, while the throughput of this station is 2 bottles every sec. Before we can paste the labels on these bottles, they need to thoroughly dried or else the labels may not be properly glued on these bottles. In order to avoid this, the bottles pass through a heating machine which lightly heats up the bottle as they are travelling towards the Labelling machine. After the bottles are dried, they enter into labelling machine wherein the bottles are held with the help of a rotary chuck and the label is glued on the bottle with the help of sets of rollers. The WIP of this machine is 5 bottles, the cycle time is 9 secs, and the throughput of this machine is 1 bottle every sec. After the bottle is labelled it enters into a packaging dock where the bottles are packed in a case (24 bottles in a case) by a worker. This activity takes 75 secs to completely pack a case. This is the slowest process in the bottling line as the cycle time is more than the takt time.

The various loops involved in this ASIS VSM are clearly highlighted in the above diagram. The supplier loop involves the order placement from the production control on the vendors and the shipments from the vendors. While the process loop involves different operations such as depalletizing, rinsing, filling, capping, and etching. The pacemaker loop here is the cleaning of the bottles post filling, labelling, packaging and shipping. This is the loop which should be controlled so that the pull from the customers will be without any interruptions. We can clearly see that we need to improve the cleaning, heating, drying, packaging and shipping processes.

We will be focusing on improving the packaging process so that we can achieve takt time during this process. Also, we will be focusing on eliminating the cleaning of the bottles on a dock and implement a better solution. The current depalletizing method is a safety hazard, therefore we will be incorporating an improved depalletizing method to avoid any accidents.

2.4 IDEF3

IDEF3 is a tool used to identify the transformative processes that are involved in a production system. It addresses both process and object state transformations. By analysis of processes transformation, it helps understand how a particular system works. It also identifies constraints on each process, thereby enabling ISyE's with means of understanding parameters that will control each process. During implementation of designed process, these parameters can be given attention so as to avoid stoppages and breakdowns. Resources required for each process are also identified in IDEF3. These may include: tools and equipment, human resource, raw material, workspace etc. This helps in planning the production system in advance. Object State transformation network, further referred to as OSTN, is used to identify states of the object undergoing transformation after every process. This diagram identifies the state in which the object should be after every process. It also identifies entry and exit conditions necessary for each process. This can be used to measure the precision of each cycle of process. IDEF3 thus enables thorough analysis of transformative process. Having noted this, IDEF3 was used for analysis of bottle filling operation at Excel industries subcontractors of Kristen Distributing Company (KD).

Process transformation diagram:

KD's ASIS bottling line has eight major processes: Depalletizing, Rinsing, Beverage filling, Capping, Etching, External rinsing and soaking, labeling and packing. Depalletizing and packing are manual operations while other six are fully automatic processes. The process starts with a workman unloading the bottles from the stacked pallets of empty bottle. These bottles are unloaded on the conveyer line that carries them through all subsequent automated processes. The process continues smoothly until rinsing and soaking operation, where bottles are piled up before they can continue to the process. This process thus controls the whole bottling line. The bottles then continue their transformation till they are ready to be packed. A workman packs two bottles at a time in the packing boxes. These boxes are stacked on the pallets and are ready to be shipped. For each of these processes required constraints and resource allocations have been identified.

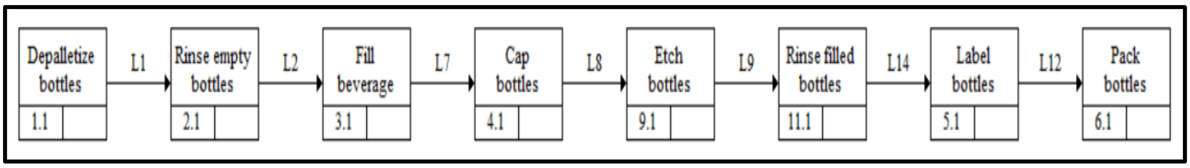


Fig 2.4: Process flow diagram

OSTN:

Bottle undergoes eight object state changes, one after each process, before it is ready to be shipped. Before a bottle enters any process or before its state can be changed further it is important that certain entry and exit conditions are satisfied.

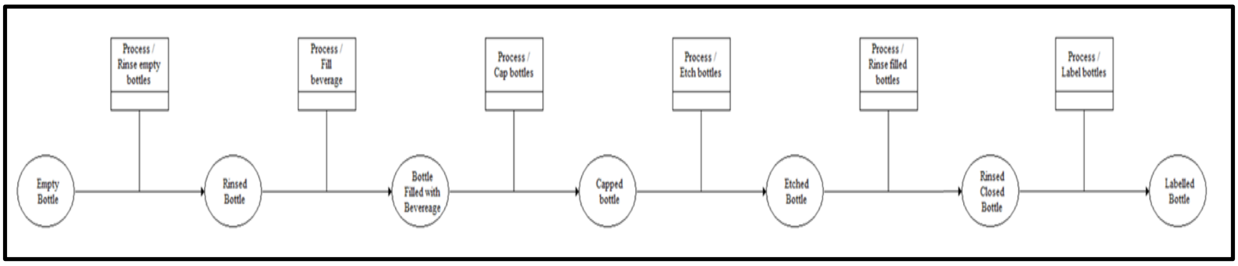


Fig 2.5: ASIS object state transition network

Based on the above analysis, it was observed that the Depalleting and Packing stations have excessive operator motion which can be addressed.

3. Analysis of Alternatives

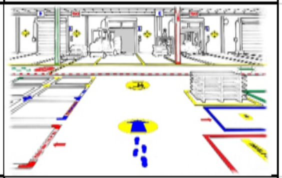
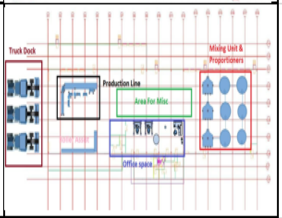
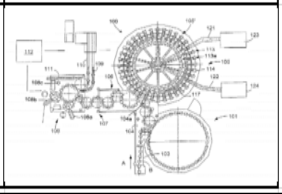
Alternative	Cost	Performance	Risk	Representation
Low automation	Low~220K. Is maintained by current workforce	Achieves 3M bottles per year but with lower costs due to implementation of kaizen activities like space allocation using fluoroscent stickers	High risk of line stoppage. Risk of injury to operators due to the excessive bending movements.	
Semi automation	$250k. Requires lower maintenance and the changeover time is reduced practically to zero.	Will achieve 5M bottles per year. Will reduce the cost by eliminating the need of operator in packing.	Lower risk of stoppage. Requires much lower maintenance due to elimination of changeover operations.	
Fully Automated	$400K. Requires almost no regular maintenance.	Can achieve >7M bottles per year	No risk of stoppage and no involvement of maual operator at all.	

Table 1: Alternatives proposed.

We have come up with exciting alternative solutions for Kristen Distributing. As shown in the table we have low automation which is a no cost solution, semi automation which is a low-cost solution, fully automated solution which is high cost solution (As shown in table 1). We would suggest to implement a semi-automated bottling line as the capacity calculated for this type of industry can accommodate double the desired demand that is 10 million bottles per year. It is also flexible design which can be altered later. The no cost solution includes the mapping the factory with stickers, more manual intervention thereby increasing the risk of assembly line stoppage. There are more specifics for the semi-automated solution mentioned below. We also have gone through many patents, one of them is the current bottling line used in the Coca Cola industry. This is a very high cost solution which can be implemented, which will have minimum or no manual intervention, a completely automated bottling line. This is not required for the current demand of Kristen Distributing.

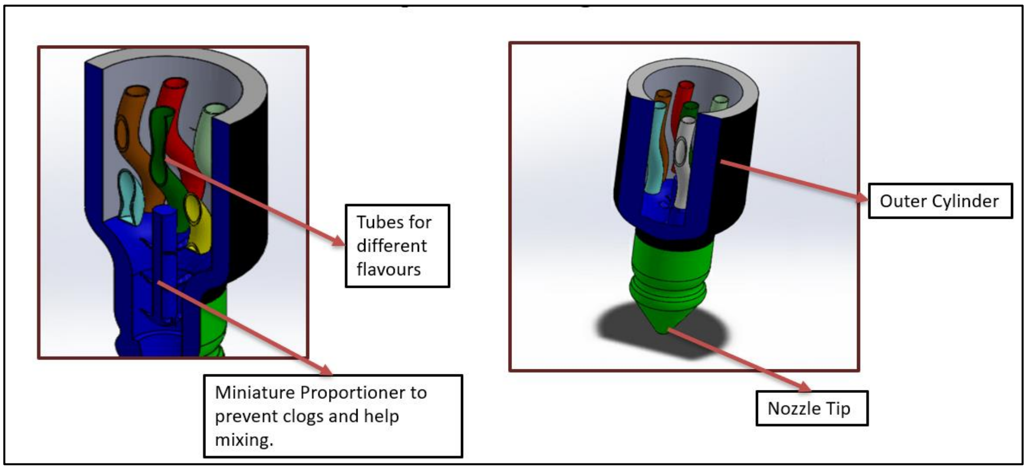


Figure 3.1: Concept of nozzle.

In the figure 3.1 we have modelled a concept of a nozzle which could be implemented at the tip of each dispenser. The advantage of this nozzle is that it has separate tubes for different flavors. This will reduce the time for sanitation or we can remove the sanitation process as a whole. Another problem that will be addressed by developing this concept is the clogging of acids or flavors. Currently in the industry there are mixers or proportioners used for the mixing of water and the acids and flavors, but still most of the time the mix I not complete, and the bottles are rotated 3 times to solve this problem. We have made a miniature form of proportioner to mix the acid or flavor well before it is dispensed into the bottle. This may give rise to a concern with respect to the flow rate at which the juice is dispensed into the bottle. To accompany this the nozzle head is designed in such a way that it will accelerate the fluid to the desired rate. This is still in concept phase we may have to develop and perform required analysis before using it which makes it a high cost solution.

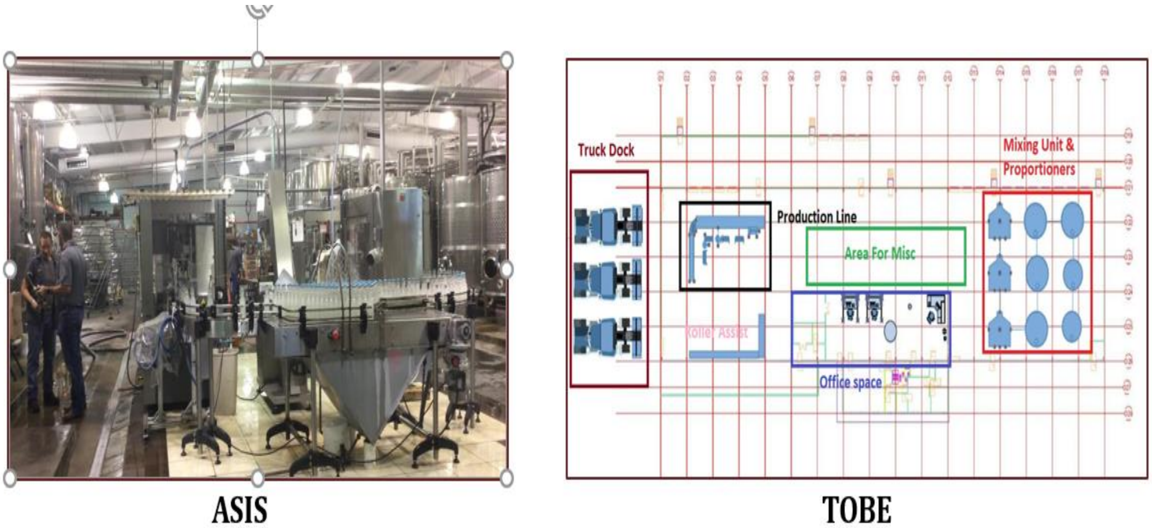


Figure 3.2**:** Suggested Plant Layout

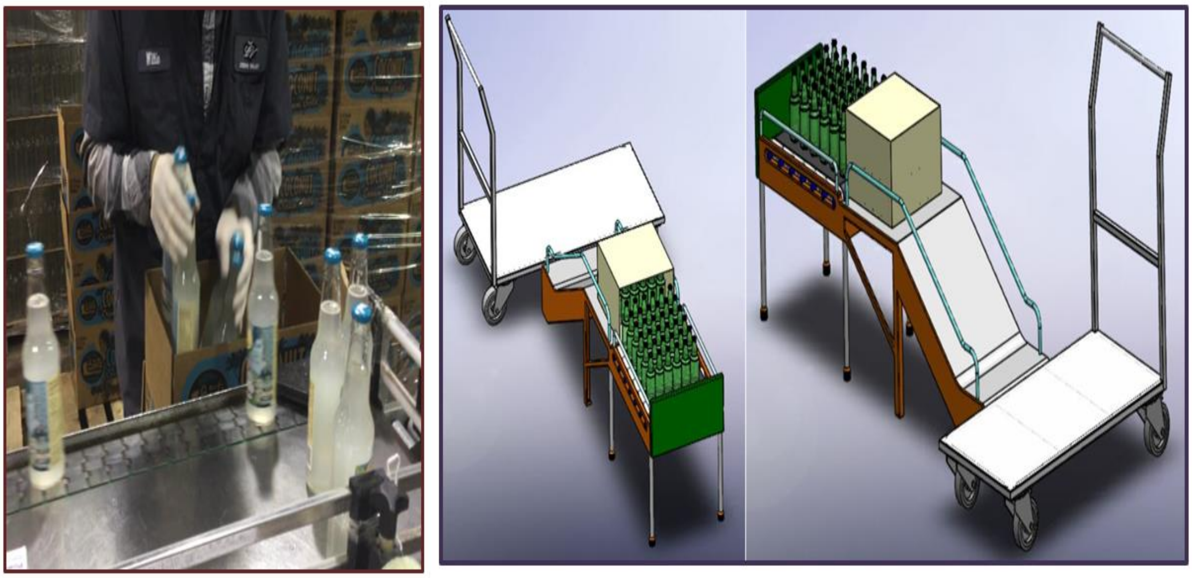
The Plant layout considered for reference is of Excel Bottling. We have made significant changes to these by adding certain relevant features to it. From the given layout of the warehouse provided to us, we have come up with a plan on where to place the machines, where the trucks will dock and where the proportioners will be placed as shown in figure 2. The layout will be well placed with fluorescent stickers and signs to properly navigate within the factory, this will help for efficient movement of operators and material, also helps to maintain order in the facility. The docking and undocking of trucks will happen in the same side as of the flow line in order to reduce the material movement. We are also planning to implement rollers to assist the movement of pallets of bottles from one place to another. The layout was planned and done in AutoCAD.

ASIS

Proposed alternative:

Figure 3.3: Depalletizing workstation

At the depalletizing work station there is a lot of unnecessary operator movement (figure 3). In the current scenario the bottles are picked up from the pallet then the operator turns and the places the bottles on the platform of the bottling line. There is a high risk of dropping the bottles and breaking it, and this adds a lot of waste movement and added time. Since the concept of lean is to minimize buffer, we have come up with an idea to install a hydraulic table at the depalletizing work station. How this will work is that the pallets will be placed on the hydraulic table directly. The operator then pulls the lever and the pallets come at level with the platform. Now the operator just needs to slide the bottles onto the bottling line by applying the pressure at the bottom of the bottles. The detailed work of the operator is mentioned in the standard operating procedure. A lot of time is saved by adopting this simple method and it is a very ergonomic solution as well.



ASIS packing workstation

Packing workstation

Figure 3.4: Packing Work Station

Like the depalletizing work station, we have a low-cost solution at the packaging work station as well. Now the operator lifts the bottles and places in to the packaging box. Meanwhile the bottles are stacked onto the corner. Instead of this, we keep a table as shown in figure 4. The table has an inclined surface at the end and a stopper which can be slide up/ down. The box is placed sideways rather than vertical to assist the operator to slide the bottles in. The bottles are safe this way and there is no risk of the bottles falling off, as the pressure is applied at the bottom of the bottles while sliding it in. The stopper is up and the operator slides the sealed package onto the trolley and arrange it (explained in the standard operating procedure). The trolley is also given a well-defined path within the industry. The trolley arrives, the package is loaded and the trolley is moved in the same direction forward.

4. TOBE LPS System

KD's ASIS bottling line was analyzed using lean tools such as IDEF0, VSM and IDEF3. Based on the observations of the ASIS, various areas of improvements in the system were identified. Further, requirements set by the customer were also considered for the TOBE lean production system design. These requirements are as follows:

1. Bottles to be supplied to an additional customer in the form of co-packer
2. Annual Demand to be met = 5 million bottles
3. Use of plastic bottles and recycled glass bottles is prohibited
4. 3 hrs. sanitation of equipment every Monday

With an aim to satisfy these requirements and to rectify the identified flaws in the ASIS, TOBE LPS bottling line was designed. To understand benefits of the new system same three lean tools - IDEF0, VSM and IDEF3 - were used.

4.1 IDEF0:

Level - 0:

There are no changes on the main level in the TOBE IDEF0 as it is not detailed enough to incorporate any VOCs and the factors affecting them.

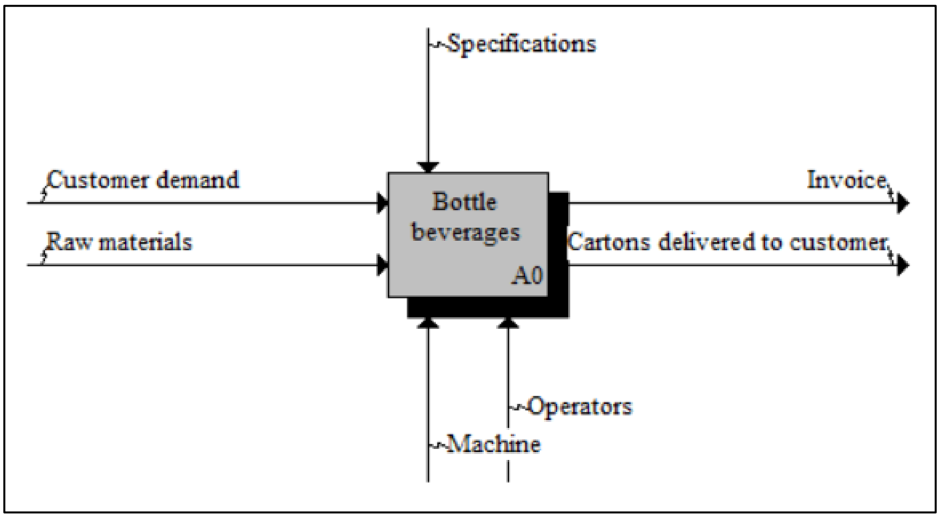


Fig 4.1: TOBE IDEF0 level 0

Level - 1:

The VOC is incorporated here in the form of CTXs(Ys). The VOC mainly acts as a control to the various activities. In our case, almost all the VOCs are incorporated in The bottling operation activity as that is our main focus here and the rest of them are incorporated in the packing operations which can be considered as part of the bottling operation too.

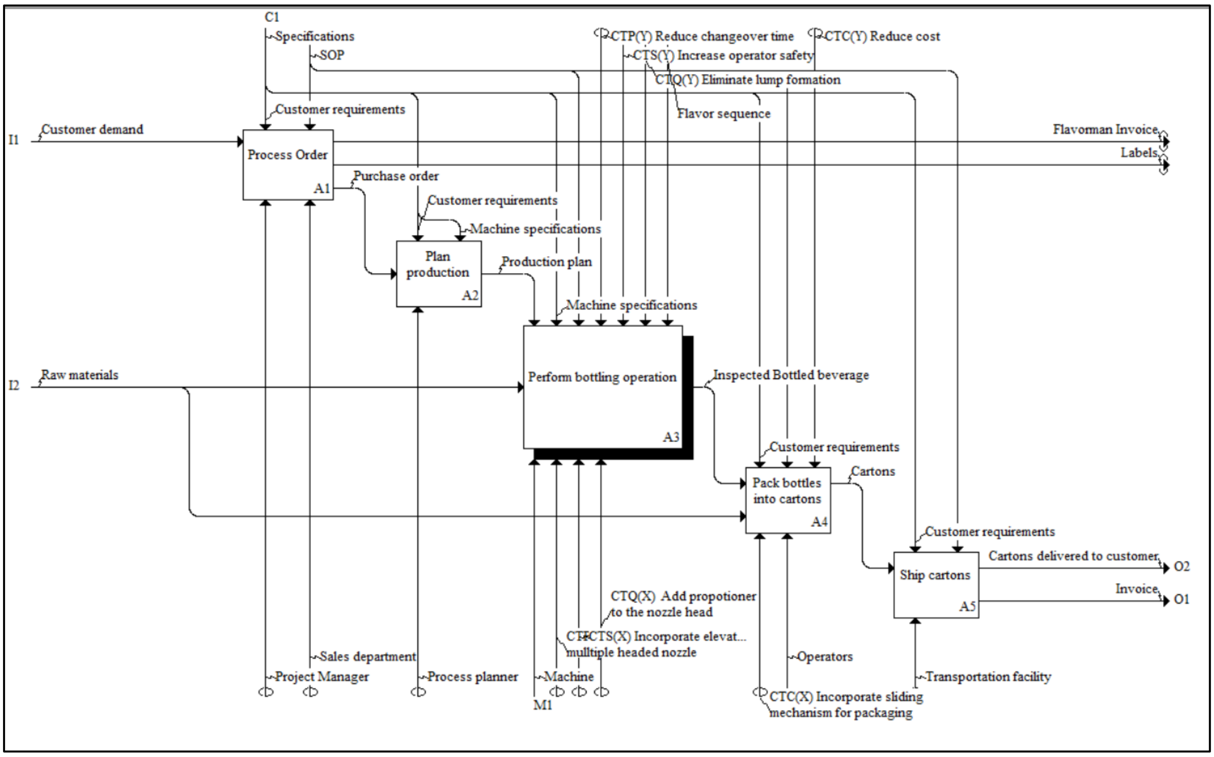


Fig 4.2: TOBE IDEF0 level 1

The VOCs (Ys) that we have included in our model are as follows:

- CTP – Reduce changeover

  This refers to the changeover time required to switch between various flavors which needs to be reduced.

- CTC – Reduce Cost

  The aim here is to bring down the costs by eliminating waste from the process.

- CTS – Increase operator safety

  This refers to the constant bending and movements of the operators at the start and at the end of the line and the objective is to increase the safety of the process so as to avoid injuries to them.

- CTQ – Eliminated lump formation

  This is one of the issues identifies by the customer where the flavour and soda wont mix properly.

- CTQ – Ensure consistent taste

  This is the second issue identified by the customer where the taste is inconsistent across the batches due to the variation in the source of water.

We found out that the following factors influence the VOCs respectively:

- CTP – Nozzle heads, labelling mechanism

  To reduce changeover time we decide that these are the parts of the PS we need to target to accomplish our objective.

- CTC – Waste in terms of extra activities and resources allocated

  We have identified the packaging and loading operations as candidates for waste elimination to reduce the overall costs.

- CTS – Ergonomics involved in operator's tasks at loading and unloading stations.

  Again, the packaging and loading operations are identified as potential areas of improvement here.

- CTQ – Proportioner for mixing fluids.

  To counter the issue of lump formation, we have identified the mixing operation as the source of problem and identified it as a possible are of improvement.

- CTQ – Source of water used in beverages.

  This is the obvious are needing improvement to tackle the problem of inconsistent taste.

Level - 2:

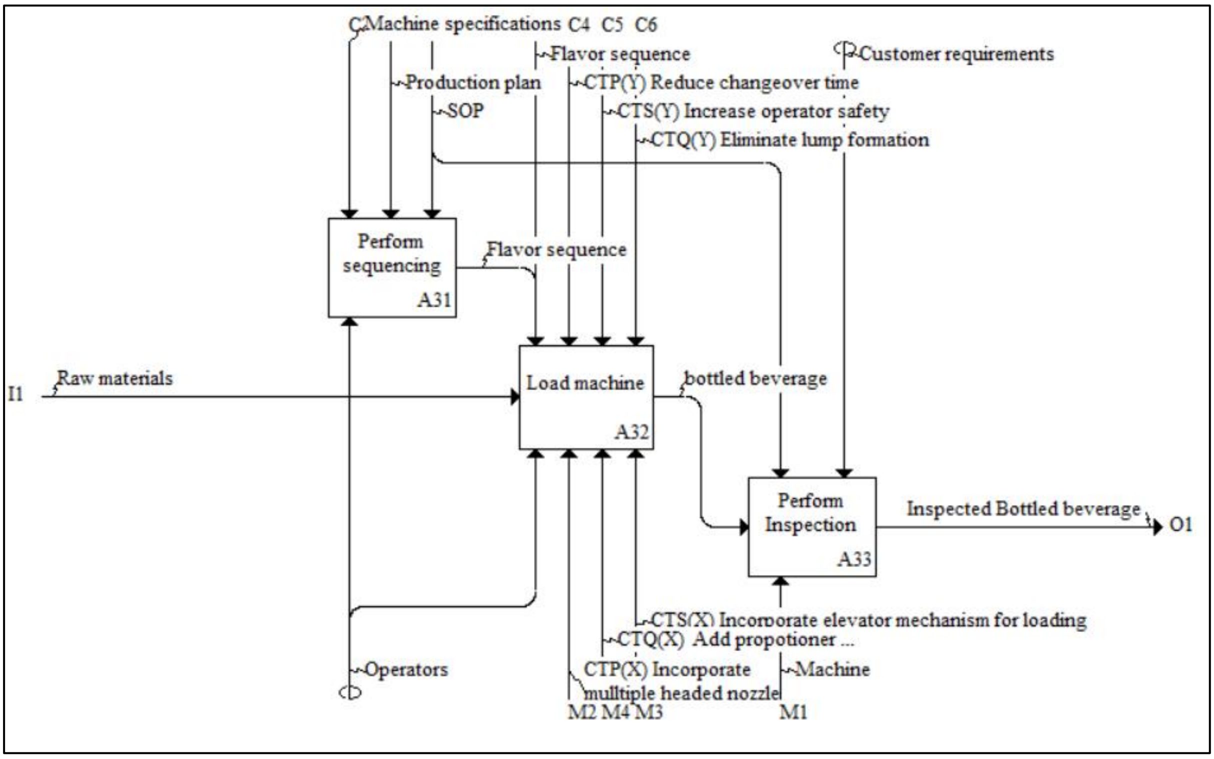


Fig 4.3: TOBE IDEF0 level 2

The explanations for each of the terms in this level are the same as explained as above but the VOCs are pointed to the specific parts of the bottling operation and the exact location of the factors influencing the VOCs have been identified.

4.2 Value Stream Mapping

After analyzing the ASIS system, with the help of IDEF0, VSM, and IDEF3 models, we can clearly understand that there is a lot of scope of improvement in both production line as well as the supply chain of the bottling plant. There were various safety hazards as well as non-value-added processes involved in the Excel Bottling plant. The analysis of alternatives provides us with various solutions that can be implemented to design a Lean production system.

The improved Lean production system has new vendor database which is located close to the factory. This will help curb down the transportation cost. The production control will receive order from the prominent vendors such as HEB, Kruger, and Hyvee and will process these orders to generate the MRP. As the vendors are located close to the factory, the deliveries can be initiated on a weekly as well as daily basis as in the demand for the particular item arises. The shipment for the raw materials will arrive at the factory every month. The received raw materials will be stored in the supermarkets which are located near the respective stations. This will help to load the raw material whenever required and also reduce the changeover time. The Depalletizing of glass bottles will be carried out in an improved way as the earlier procedure can be seen as a safety hazard. We will be using a hydraulic jack trolley for this operation and a flat bed which can be inclined with the help of a lever. This will reduce the operator motion as well as eliminate the pushing of the bottles to get it on the conveyor as the tilt table will help to do so. After the bottles are on the conveyor line, they will first go through rinsing process which will be similar to the current process. After the bottles are thoroughly cleaned, they will be sent to the filling station. An improved nozzle with different lines for different flavors is used to reduce the changeover time. This design will significantly reduce the changeover times for the flavors as few of them are pungent and to replace them with different flavor needs a thorough cleaning of the line. But with the help of this improved nozzle we only need to clean the lines for sanitation purposes. After the bottles are filled, they are sent to capping section where the bottles are fit with bottle caps. The bottles are then passed through the etching section where the required markings are etched on them. The cleaning dock which is seen in the earlier system is eliminated from this LPS. The heating, cleaning, and the drying of the bottles will take place on the conveyor belt as they are moving towards the tightness check and labelling section. After the bottles are cleaned and dried, they will be sent to the label station wherein the labels will be glued to the glass bottles. The raw material is placed near the labelling station so that the changeover time can be reduced. After the bottles are labelled, they are sent to packaging section wherein a new packaging methodology is incorporated. In this new method, the packaging box will be placed with the opening on the side. The bottles will be self-arranged in an array of 6X4 with the help of a stopper and then a force will be applied on the bottom section of the bottles with the help of a stopper and pushed inside. After the bottles are pushed in the box, the worker will pack the side edge of the box and slide it down the incline table. This will tremendously reduce the cycle time of this operation. After this the box will be placed on a trolley and then it will be loaded directly into the truck which will be used to make daily runs or once after every 2 days depending on the requirement. This will help to reduce the inventory space as well as the time required for delivery as the shipment will always be ready for transportation.

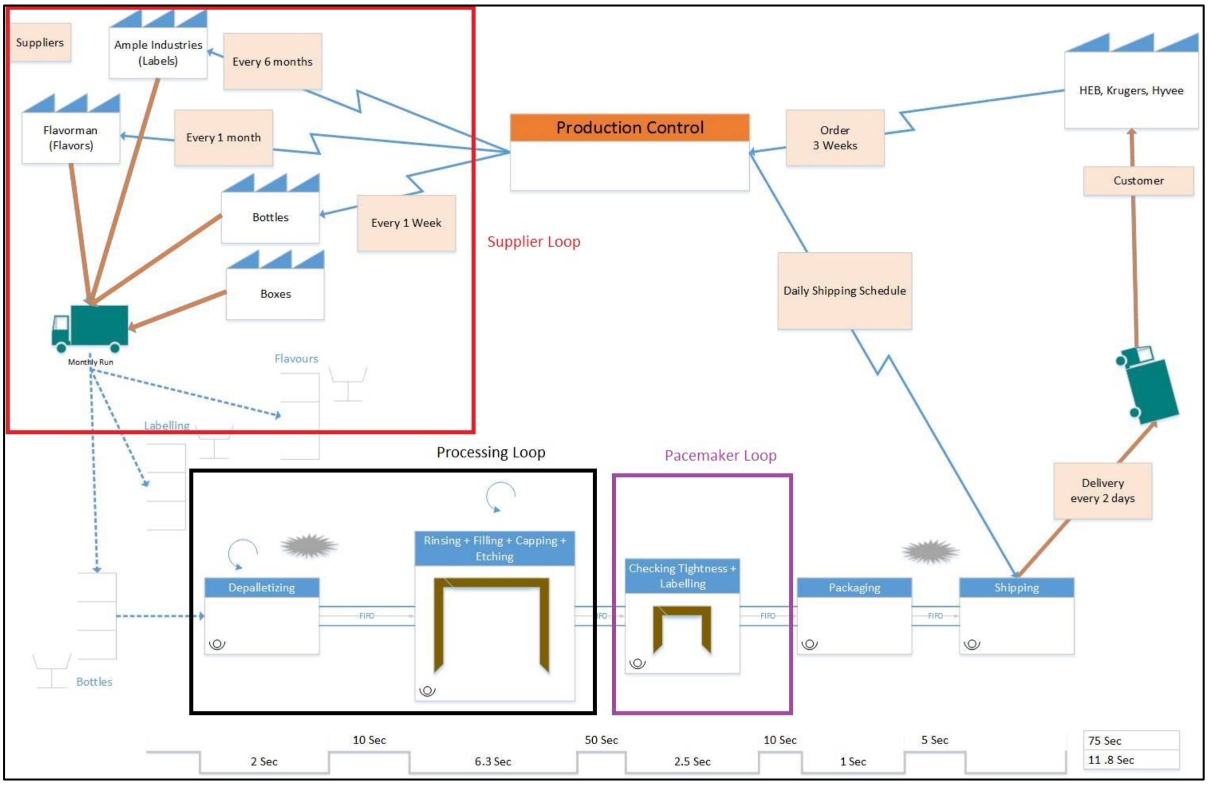


Fig 4.4: TOBE VSM

4.3 IDEF 3

Process transformation diagram:

Based on the observations from ASIS analysis, and to meet customer's requirements changes have been made to the bottling operations and the way processes are performed. In order to address the situation of excessive operator motion at packing and depalleting stages, new tools and equipment have been introduced. Further, to avoid in-line inventory piling up before external rinsing process, the process has been re-engineered to be an inline process.

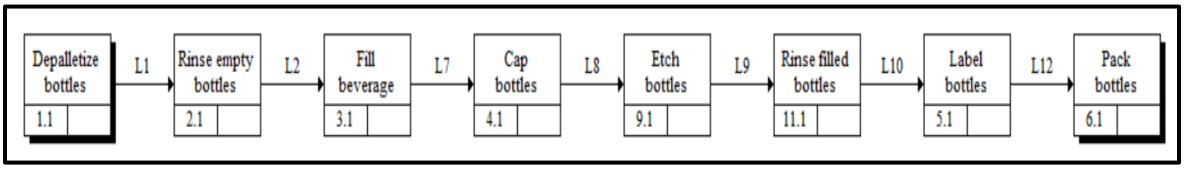


Fig 4.5: TOBE IDEF3 Process transformation diagram

Modified processes:

Depalleting:

A hydraulic table will be used in front of the depalleting station. The level of the table will be adjusted such that the level of bottle pallet to be unloaded matches the level of conveyer line. Thus, eliminating the need for the operator to bend down or stretch to unload the bottles. Further, since the bottles are in line with the conveyer, they can be slided on to the conveyer in rows. To ensure fall free slide of bottles, a frame is to be used. The frame will be inserted between each row of bottle. The bottles will be pushed using the frame by applying pressure at the bottom of the bottles. This change in process, is more efficient and ergonomic, thus addressing time and safety aspects of the process.

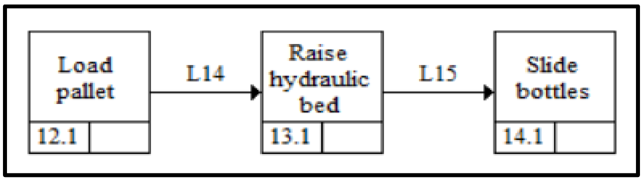


Fig 4.6: TOBE IDEF3 depalleting process

Packing:

A concept similar to that used for depalleting is used for packing too. A new table and ramp will be implemented at the packing station. The packer will place the box on the packing table with opening facing the conveyor. The bottles will be slid in using the same process as in the depalleting. Once the box is full, it will be sealed and slid on to the ramp. A trolley will be ready at the end of the ramp to collect the box. The trolley when full, will direct the boxes of bottle to the trucks for shipment.

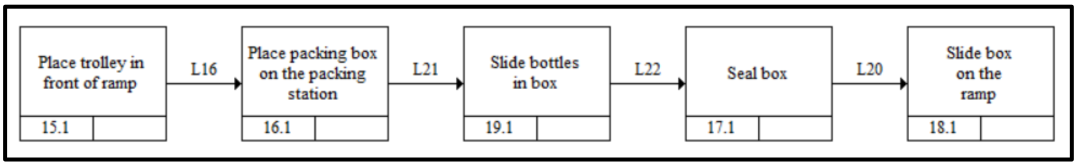


Fig 4.7: TOBE IDEF3 packing process

External rinsing and soaking:

To avoid bottle pile up in the line, a water jet will be directed on the bottles as they travel from the etching process to labelling process. Further, two wipe rollers, one at each side of the conveyer line, will be used to soak the bottles. An in-line heater will be used to evaporate any residue moisture from the bottle, thus making it clean and ready for labelling operation.

OSTN:

The change in state of the bottle through the process remains the same. But, the entry and exit constraints for state change at the modified processes have changed.

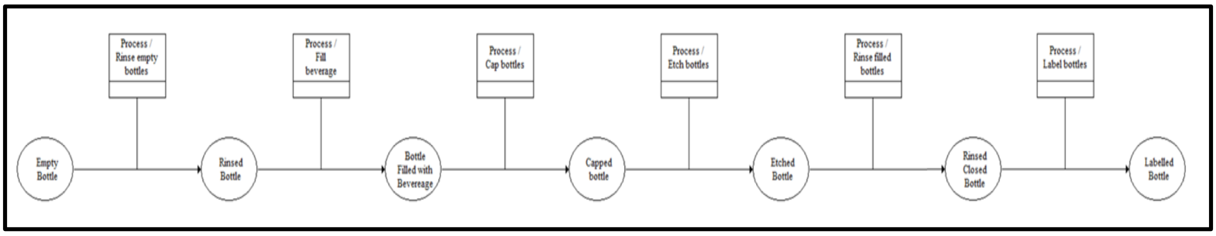


Fig 4.8: TOBE IDEF3 OSTN

4.4 Detailed Design

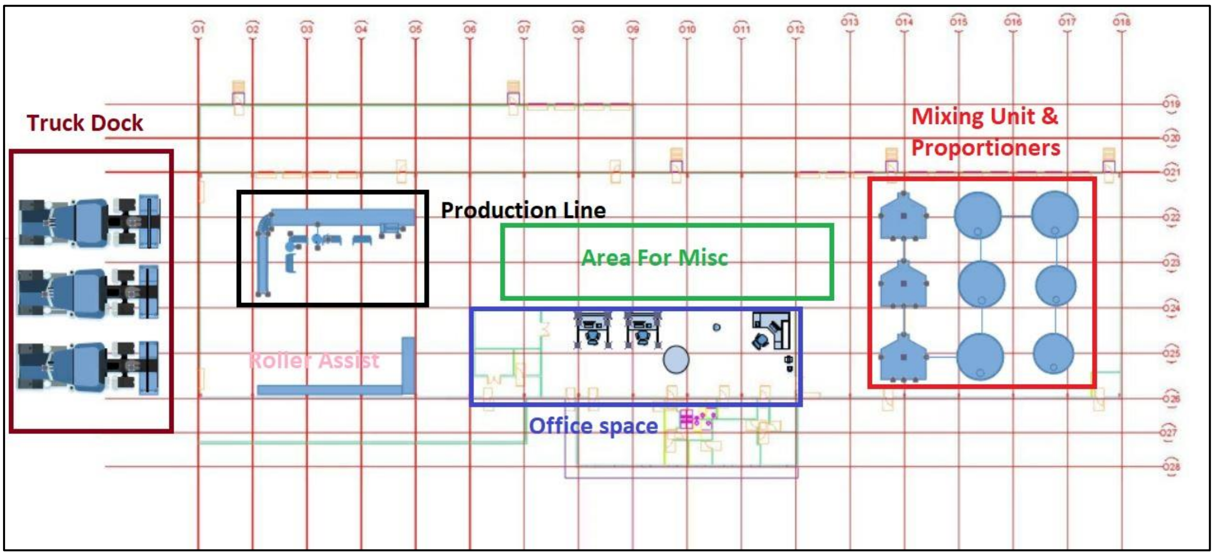


Fig 4.9: Detailed floor layout

In the design layout we have reduced the space required for office materials. The factory requires an office but not as big as the plant bottling line area. The new space can be formed by replacing the walls as shown in the sketch. The bottling line is placed in an L shape. We have placed certain images in the layout which depicts the machines used for the process. Opposite the bottling line we have arranged rollers for easy movement of the material or pallets of empty bottles undocked from the truck. In addition to this the layout will be properly labelled for easy operator and material movement. The trucks are docked on the same side for loading and unloading. This will reduce the total material movement and reduce the overall cycle time. The proportioners and mixers are placed on the other side of the office. The bottling line and the proportioners will be connected using pipelines. Since the production is continuous this pipeline setup does not affect the process timings. This in turn helps us easy maintenance and undisturbed production of bottling line while loading the proportioners with acids and flavors. The chairs tables computers are all as shown in the layout.

5. Implementation Plan

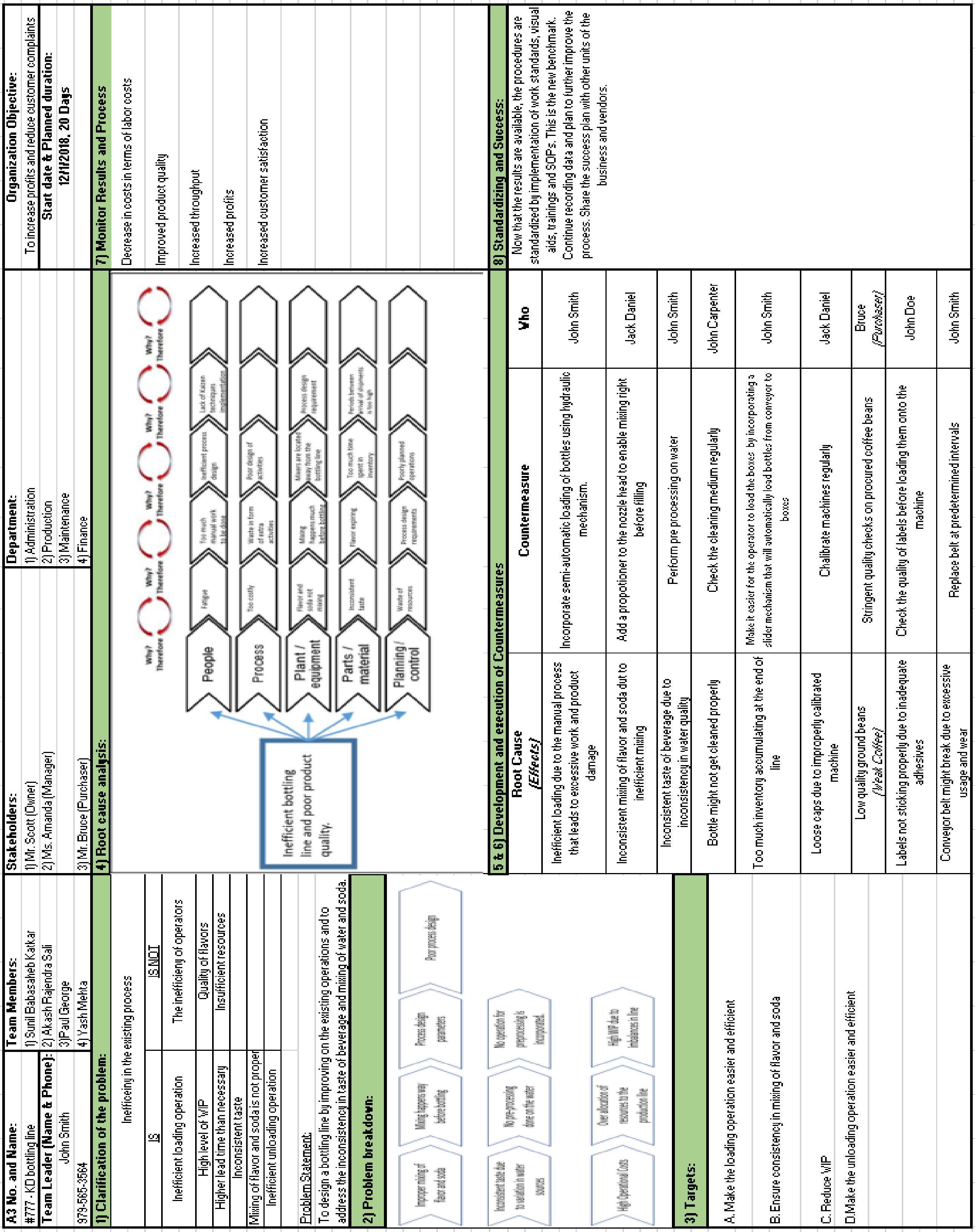


Fig 5.1: A3 chart

5.1 Process Life Cycle

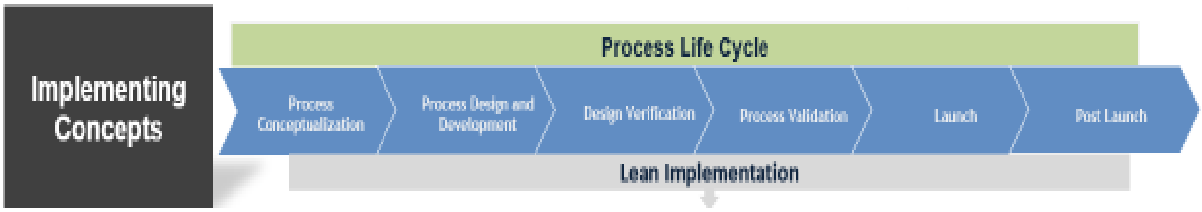


Fig 5.2: Implementation process life cycle

The above flow chart depicts a summary of how we are planning to implement a lean system into the factory. We start with process conceptualization which involves the idea generation and brain storming sessions. Developing the Idef0 and VSM and to understand the voice of customer in order to bring the best solutions possible. The next step is to design and develop the process. This include the floor layouts, CAD modelling of new parts, Standard operating procedures etc. We will do an analysis of the developed system before actual set up of the bottling line. The design verification and the process validation will be done in this fashion. Since lean is all about continuous improvement, we will monitor the processes even after the launch. The below are some specifics related to the lean implementation while we set up the factory.

5.2 Lean Implementation

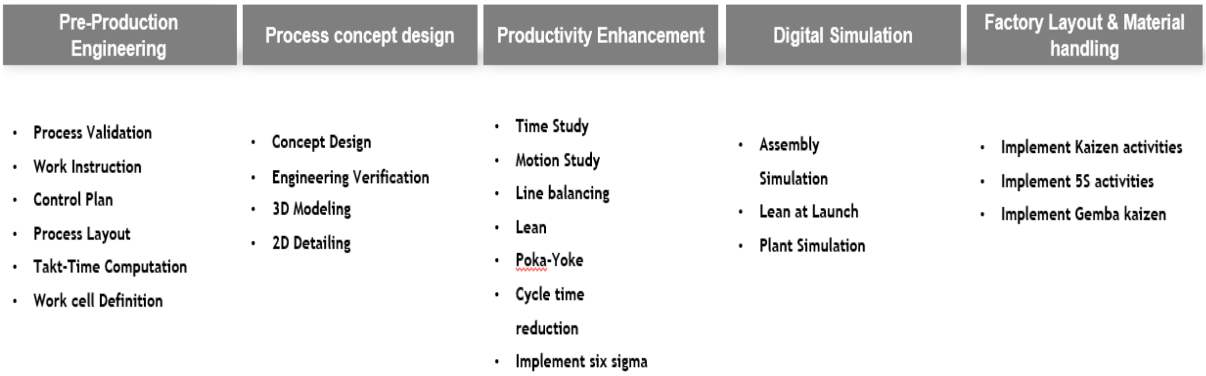


Fig 5.3: Implementation process life cycle components

- Pre – Production Engineering - Implementing the Takt, defining work cells, capacity calculations, accommodating the change over time etc. are part of this phase. The improvements are based on the numbers. We need these values in order to establish an engineering system that barely stands, which lean is all about.
- Process concept design – This phase consists of visual representation of the setups and alternatives planned in order to make the customer understand. These involve the 2D modelling, 3D modelling etc. This will be a foundation for further processes.
- Productivity Enhancement – This is where most of the lean principles are applied. We move towards achieving a bottling line with minimum buffer. The Time study, motion study, line balancing, poka-yoke, cycle time reduction, six sigma, other lean concepts

are all included at this phase. This the major portion of what we intend to do while setting up the bottling line for Kristen Distributing.

- Digital Simulation – Another important step to be considered is the simulation. The are various software's used for simulating the working of the industry such as Simio. FlexSim etc.
- Factory Layout and Material Handing – This is another important aspect which we will implement. The kaizen activities, pull control, Kanban cards, 5S, Gemba are all part of this phase.

An approximate time period required for the overall set up of these would be around 3 months.

5.3 Standard operating procedures (Micro-level design)

Standard operating procedure (SOP) is an important tool aimed at reducing variabilities in the production system. It is a detailed procedure set out by an organization for its workers to carry out the tasks with minimal errors. It reduces miscommunication and helps workmen to adhere to company's guidelines. SOPs also adds structure to work as the activities to be performed are set out on paper. This improves efficiency and quality of the process.

Proposed bottling line for KD requires two workmen. One at depalletizing and one packing workstations. Thus, job breakdown and standard operating procedures have been identified for these processes. They are as shown in the tables below:

Depalletizing operation:

Re-engineered depalletizing operation requires only one operator. Job breakdown is as follows:

Job breakdown sheet for depalletizing operation					
	Department:	KD Bottle Manufacturing	Date:	10/18/2018	
	Process:	Assembly Line	By:	Operator 1	
	Work Station:	Depalletizing	Pre-Requisites:	Ability to lift 50 lb	
	Tools & Material:	Process line machinery			
	Safety Equipment:	Safety gloves			
#	Major Steps	Key Points	Reasons		
1	Gather Details	Checklist	To ensure all the dial gages (Ex. pressure, temperature, volume) are at safe levels before the operation begins.		
2	Place the pallet on the hydraulic platform	Check for gap between platform and bottle tray	To prevent bottles from falling.		
3	Slide the bottles onto the platform	Slide to available space	The bottles need to be stacked onto the platform for continous process flow.		

Fig 5.4: Job breakdown sheet for depalletizing operation

Standard operating procedure to be followed by the operator at the depalletizing workstation is as follows:

Standard operating procedure for depalletizing workstation						
	Operation Number: 1				Prepared By:	
	KD Bottling line				Yash Mehta	
					Akash Sali	
					Sunil Katkar	
					Paul George	
No	Main Steps	Q	S	E	Key points	Reason
1	Check the gage reading	X	X		Check for appropriate gage readings as per	To prevent assembly line break
2	Ensure the pallet is on the hydraulic table.		X		Check if the pallet is fully supported by the	To prevent the pallet from falling
3	Raise the hydraulic bed to the level of the		X		Check the level of the tray and the	To prevent bottles from falling off.
4	Slide a row of bottles from the pallet to the production belt.		X		Make sure to wear gloves	To prevent injuries
			X	X	Use frame to slide the bottles	To ensure that all the bottles in the
			X	X	While pushing the bottles, place pressure at	To prevent bottles from falling off
5	Repeat step 4 till a pallet tray is empty	X			Ensure all the bottles are loaded on the	To prevent inventory wastage
		X			Ensure that the bottles are stacked onto the	To prevent assembly line break
6	Remove the tray from the pallet		X		Ensure that the bottles on the lower level are	To prevent the bottles from falling
				X	Ensure that the tray is disposed off properly.	To Ensure clean and hygenic

Fig 5.5: SOP sheet for depalletizing operation

Packing operation:

Re-engineered packing operation requires only one operator. Job breakdown is as follows:

Job breakdown sheet for packing operation				
	Department:	KD Bottling line	Date:	10/18/2018
	Process:	Assembly Line	By:	Operator 2
	Work Station:	Packing	Pre-Requisites:	Ability to lift 50 lb
	Tools & Material:	Packaging boxes		
	Safety Equipment:	Safety gloves		
#	Major Steps	Key Points	Reasons	
1	Gather Details	Checklist	To ensure quality aspects related to packing.	
2	Place the box and push the	Check for gap between box and platform	To prevent bottles from falling	
3	Slide the box onto the rollers	Slide to the pallet	The pallet will be directly loaded onto the truck.	

Fig 5.6: Job breakdown sheet for packing operation

Standard operating procedure for packing operation is as follows:

Standard operating procedure for packing workstation						
	Operation Number: 2				Prepared By:	
	KD Bottling line				Yash Mehta	
					Akash Sali	
					Sunil Katkar	
					Paul George	
No	Main Steps	Q	S	E	Key points	Reason
1	Obtain the Checklist	X	X		Ensure availabilty of materials for packing	For uninterupted packing of bottles
		X	X		Make sure the boxes are not damaged	Boxes might tear and bottles will
2	Take and place the empty box on the	X		X	Place the box such that the end is in contact	To ensure smooth sliding of bottles
3	Slide the bottles into the packing box			X	Apply less pressure	The new table designed ensure
			X		Ensure the hands are placed at the bottom of	To prevent bottles from falling
4	Close and seal	X	X		Seal the case as per the packing norms	To prevent damages while
5	Slide the package down the inclined rollers			X	Push the package on the incline	The rollers will guide the package onto the trolley which is directed towards loading the truck

Fig 5.7: SOP sheet for packing operation

6. Cost Benefit Analysis

The cost objective for this project is to reduce the cost per case from $ 14.50 to $ 11.75 and achieve the $ 2.75 extra profit margin. We have made reasonable assumptions for this analysis with respect to cost of various variables.

Assumptions:

1. The Demand is distributed equally over the year.
2. The selling price of the case is $ 24 per case (24 bottles)
3. The cost for renting the building for the bottling plant is $ 0.9 per sq. feet per month. And the floor space area is calculated with the help of the given floor layout which is around 44444 sq. feet.
4. The factory works for 52 weeks a year and 5 days a week. Two shifts, each of 7 hrs is assumed. 4 workers are needed to operate the entire plant and the cost of labour is $14 per hour.
5. Each 12 oz bottle requires 30 ml of flavour.
6. The cost of Flavour is $ 90 per 5-gallon pack.
7. All of the demand is met and there is no loss of demand or any backlogs.
8. The cost of bottle caps is assumed to be $ 0.08 per cap.
9. The cost of Labels is assumed to be $ 0.02 per label.
10. The cost of bottles is considered to be $ 0.13 per bottles.
11. The overhead cost is assumed to be 5% of the total Revenue.

Demand per month = (Yearly Demand)/ 12 = 5000000/12
= 416667 bottles per month

Revenue per month = (Demand) * (Cost per bottle) = (416667) * (1)
= $ 416667 per month

a) Labor Cost:

As per the assumptions, the factory will be operating for 52 weeks a year, and 5 days a week. The Labor cost is $ 14 per hour.

So, the monthly labor cost = (No. of working days in a month) X (No. of working hours in a day) X (Labor cost per hour) X (No. of workers)
= 20*14*14*4
= **$ 15680 per month**

b) Flavor Cost:

As mentioned in the assumptions the cost of flavour is $ 90 per 5-gallon pack. And 30 ml of flavour is required per 12 oz bottle.

Therefore, Flavor required per month = (Flavor per bottle) * (Demand)
= (30) * (416667)
= 12500010 ml or 3302.15 gallon

Required packets of 5 gallon per month = 3302.15/5
= 660.43 packets or approx. 661 packets

Cost of Flavor per month = (No. of packets) * (Cost per packet)
= (661) * (90)
= **$ 59439 per month**

c) Bottle Cap cost:

As assumed, the cost per cap is $ 0.08.

Cost of bottle caps per month = (Cost per Bottle Cap) * (Demand)
= (0.08) * (416667)
= **$ 33333 per month**

d) Labels Cost:

The cost per Label is $ 0.02.

Cost of Labels per month = (Cost per Label) * (Demand)
= (0.02) * (416667)
= **$ 8333 per month**

e) Glass bottle Cost:

The cost per glass bottle is assumed as $ 0.13.

Cost of glass bottles per month = (Cost per glass bottle) * (Demand)
= (0.13) * (416667)
= **$ 54167 per month**

f) Overhead Cost:

The cost of overhead is assumed as 5% of the total revenue.

Overhead Cost per month = 5% of 416667
= **$ 20833 per month**

g) Machine/Tool Cost:

The cost of Machines (used) and tools is assumed as **$ 250000**.

h) Rent Cost:

The floor space of the factory is 44444 sq. feet and the rent is assumed as $ 0.9 per sq. feet per month.

The rent per month = (Area of the factory) * (Rate)
= (44444) * (0.9)
= **$ 40000 per month**

Cost per Case:

Total variable cost can be calculated as follow:

Cost per case = (Total cost per month / Demand) * (No. of bottles per case)

Sr. No.	Variable Cost	Per Month
1	Labor Cost	15680
2	Flavor Cost	59439
3	Bottle Cap Cost	33333
4	Labels Cost	8333
5	Glass bottle cost	54167
6	Overhead Cost	20833
	Total Cost	**191785**

= (191785 / 416667) * (24)
= **$ 11.05 per Case**

Achieved profit margin per case = 14.50 – 11.05 = **$ 3.45 per Case**

Breakeven Analysis:

To understand the cost benefits of the new LPS, we have carried out a breakeven analysis to understand how the factory will perform financially. The important assumption for calculating the breakeven point is that the company will be earning additional 15% of the base revenue every year. And the variable cost will be increased by 10% of the base variable cost. If this characteristic is plotted over 13 years, it can be clearly observed that the breakeven occurs in the 3rd year which is an impressive result.

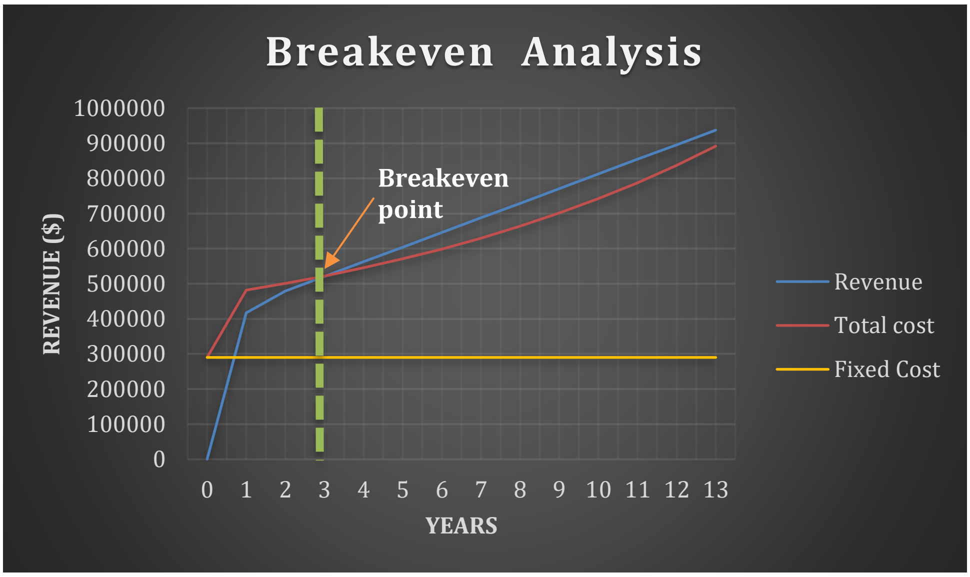


Fig 6.1: Breakeven analysis

Inferences:

By implementing the new LPS we can successfully achieve the given cost objective and also achieve a breakeven point in the 3rd year.

7. Conclusion and recommendation

Based on a thorough analysis of ASIS and the requirements set by the customer various improvements have been identified. Various alternatives to the proposed lean system were evaluated in terms of efficiency, quality, and associated costs. Based on these, the following alternatives are recommended to be implemented in KD's upcoming bottling plant:

1. To ensure an ordered flow of activities in the plant, fluorescent stickers shall be used to identify well defined and isolated paths for each type of motion (Human, Machine or Material)
2. Implementation of the semi-automatic version of plant design is highly recommended due to its cost and process efficiency benefits.
3. To address the issue of frequent changeovers and inefficient flavor mixing, multi-nozzle beverage dispenser is highly recommended.
4. Introduction of hydraulic lift table at the depalletizing workstation is recommended to improve plant operation ergonomics and operational health and safety of the workmen.
5. To improve the efficiency of packing operation with an added advantage of human safety, the implementation of new packing methodology is recommended.
6. Raw materials to be procured from local vendors to reduce inventory cost and cost associated with the supply chain.
7. Daily delivery runs are recommended to reduce costs associated with finished goods inventory

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3. MIXER FOR A BEVERAGE FILLING PLANT, Inventor: Erwin Engel, Donaustauf (DE), Assignee: KRONES AG, Neutraubling (DE)

4. Implementing traceability: practical challenges at a mineral water bottling plant, Kine Mari Karlsen, Petter Olsen, Kathryn Anne-Marie Donnelly

5. Various optimization models and an inconsistent numerical result in Chian-Son Yu, Han-Lin Li [InternationalJournal of Production Economics 64 (2000) 385–397].

6. Modelling and simulation of a bottling plant using hybrid Petri nets A. Giua , M. T. Pilloni & C. Seatzu

7. Solution approaches for the soft drink integrated production lot sizing and scheduling problem Deisemara Ferreira a, Reinaldo Morabito a,*, Socorro Rangel b

8. BEVERAGE BOTTLING PLANT FOR FILLING BOTTLES WITH A LIQUID BEVERAGE FILLING MATERIAL AND A CLEANING DEVICE FOR CLEANING BOTTLES IN A BEVERAGE BOTTLING PLANT, Inventors: Holger Grossmann, Hamburg (DE), Thomas Herold, Duvensee (DE)

Appendix

Appendix 1

FAILURE MODE AND EFFECTS ANALYSIS																
Item:	Bottled Beverage			Responsibility:	John Smith					FMEA number:	123456					
Model:	Current			Prepared by:	John Smith					Page :	1 of 1					
Core Team:	J. Doe (Engineering), J. Smith (Production), B. Jones (Quality)									FMEA Date (Orig):	01-12-2018	Rev.	1			
Process Function	Potential Failure Mode	Potential Effect(s) of Failure	Sev	Potential Cause(s)/ Mechanism(s) of Failure	OCC	Current Process Controls	Det	RPN	Recommended Action(s)	Responsibility and Target Completion Date	Action Results: Actions Taken	Sev	Occ	Det	RPN	
Labelling	May not stick properly	Unusable final product	8	Not enough adhesive on labels	3	None	8	192	Check label quality before installing it on the machine	John Doe		5	5	1	25	
Loading	Bottles breaking due to clashing against each other	Stopping of production line.	10	Operator loosing balance or not paying attention	4	None	10	400	Incorporate semi-automatic loading of bottles using hydraulic mechanism.	John Smith		10	1	10	100	
Cleaning	Bottle might not get cleaned properly	Poor quality pf the product	10	Cleaning medium might be faulty	6	None	0	0	Check the cleaning medium regularly	John Carpenter		10	2	0	0	
Filling	Bottle not filled to desired level	Poor quality pf the product	7	Machine calibration might be off	2	None	5	70	Calibrate the machine regularly	Jack Smith		7	1	5	35	
Capping	Loosely capped bottles	Caps might come off	8	Machine calibration might be off	2	None	6	96	Calibrate the machine regularly	John Smith		8	1	6	48	
Unloading and packing	Too much inventory accumulating at the end of line	Might have to stop production line or keep large buffer inventory	9	Slow operation on part of operators	3	None	10	270	Make it easier for the operator to load the boxes by incorporating a slider mechanism that will automatically load bottles from conveyor to boxes	John Wick		9	1	10	90	
Transportation	Conveyor belt might break	Stop the production line and the bottles might break	10	Belt not replaced at the end of its service life	1	None	10	100	Replace belt at the end of every predetermined period	John Smith		10	0	10	0	

Failure Mode Effective Analysis

Appendix 2

a. IDEF 0 Checklist

Kristen Distributing		DATE : 12/02/2018	
Quality Checklist Version 1.0			
Project name: Bottling line design		Project ID: 879	
SI No	Description	Status: WIP	
		Peer QC	Final QC
		NAME: John Smith	NAME: Jack Daniel
		DATE: 12/02/2018	DATE: 12/02/2018
	Diagram Architecture		
1	3-6 rule : Make sure in decomposition minimum 3 and maximum 6 activit	yes	yes
2	Input, Control, Output, Mechanism: Min one control and one output	yes	yes
3	Check for similar clusters and hierarchies	yes	yes
4	Check for link association and relevance, upwards and downwards	yes	yes
5	Try to increase Cohesion	yes	yes
6	Try to reduce Coupling	yes	yes
7	Identify missing activities	Remarks : vendor activities not considered	yes
	Descriptions/Glossary		
1	Mention correct and detailed context	yes	yes
2	Describe viewpoint	yes	yes
3	Describe purpose of the model (clear and to the point)	yes	yes
4	Descriptions (each arrow and activity block)	yes	yes
5	Activity name (Only active verb phrases)	yes	yes
6	Check for incomplete statements in descriptions.	yes	yes
7	Arrow name (Only noun)	yes	yes
	Informational (before start)		
1	Collect information and artifacts	yes	yes
2	Identify candidate functions	yes	yes
3	Identify candidate objects	yes	yes
	Value		
1	Check customer needs	yes	yes
2	Follow up questions to confirm customer requirements.	yes	yes
3	Verify the VOC with respect to CTX's before sending for VOP	yes	yes
4	Establish the driving element Y's	yes	yes
5	Establish parameters to control Y (X's)	yes	yes
6	Accommodate Changes in LPS (VOP)	yes	yes
7	Verify feasibilty with customer	yes	yes
8	Check final PS and approval sign from customer and production manager	yes	yes

b. Glossary for IDEF0 model:

Production system: KD bottling macro and micro level

Description:

This model depicts the ASIS macro level processes that are part of the bottling operation. This model is based on vendor's production facility and is used as the starting point to design a new system by improving upon it.

Purpose

The purpose of this diagram is to visualize the ASIS bottling process followed at Crown Valley. This is done so that it can be analyzed for the purposes of designing a bottling plant for KD. Currently KD outsources its bottling operation and wants to develop its own bottling operation so as to reduce the cost and make some extra revenue by acquiring a copacker.

Viewpoint

This is from the viewpoint of Industrial Engineer trying to design a new lean system by improving upon the existing process that is used for the same operation. The Industrial engineer will analyze this model to find areas of improvement.

Context

This model considers all the processes from ordering to shipping. Processes like storing in inventory and removing from inventory and changeover are not considered in this model.

Description of ICOMs in IDEF0:

Raw materials: The raw materials are in the form of empty glass bottles, labels and flavors required for the bottling operation. The raw materials term also includes the resources like fountain water used to mix with flavors to prepare the beverage.

Specifications: These are the customer specifications regarding the size of the bottle, the order quantity for any given flavor and other special specifications needed to the bottled beverage. The specifications term when mentioned as a control also refers to the capabilities of available machines.

Invoice: This is the invoice generated when the final products are shipped to the customer. The invoice mentions the shipment details like the qty of bottles and the cost incurred by the customer to avail the services.

Machine: This is the automated machine that does all the operations apart from loading, unloading of the conveyor and packing of the cartons.

Operators: These are the people that change the machine setting before each operations as required. The term operators term also include the personnel loading the bottles onto conveyor and unloading the bottled beverage and packing it in cartons.

Cartons delivered to customer: This is the final desired output in the form of customer receiving the final product.

Customer demand: This is the demand in terms of quantity, flavor required and other special specifications if any.

Raw materials: The raw materials are in the form of empty glass bottles, labels and flavors required for the bottling operation. The raw materials term also includes the resources like fountain water used to mix with flavors to prepare the beverage.

Specifications: These are the customer specifications regarding the size of the bottle, the order quantity for any given flavor and other special specifications needed to the bottled beverage. The specifications term when mentioned as a control also refers to the capabilities of available machines.

Inspected Bottled beverage : This is the final inspected product that comes off the line, ready to be shipped.

Invoice: This is the invoice generated when the final products are shipped to the customer.

The invoice mentions the shipment details like the qty of bottles and the cost incurred by the customer to avail the services.

Machine: This is the automated machine that does all the operations apart from loading, unloading of the conveyor and packing of the cartons.

Operators: These are the people that change the machine setting before each operations as required. The term operators term also include the personnel loading the bottles onto conveyor and unloading the bottled beverage and packing it in cartons.

Project Manager: The Project manager is responsible for orders of particular companies and has tom make sure that the order is completed as expected.

Sales department: The sales department deals with the customer to finalize the customer orders and specifications.

Customer requirements: Customer requirements act as a control when they determine the production sequence and the flavor mixture to be used.

SOP: The term SOP stands for Standard Operating Procedures. These are the guidelines defined by the company for different processes. This helps maintain uniformity and order across the process.

Flavorman Invoice: This is the invoice demanding flavors from flavor man to facilitate the production process.

Labels: This is the invoice demanding the labels from the company called labels depending on the customer requirements received.

Machine specifications: These are the capabilities of the machines that restricts and guide the process plan to be used for the production.

Process planner: This is generally an Industrial Engineer that determines the production plan.

Production plan: This is the process plan made considering all the other factors like the customer requirements and machine specifications. The production plan gives the batch sizing to be used and the sequencing of the products.

Cartons: These are the boxes filled with bottled beverages that are sent for shipping.

Transportation facility: This consists of the vendors that are contracted for shipping cartons from production facility to the customer facility.

Cartons delivered to customer: This is the final desired output in the form of customer receiving the final product.

CTC(Y) Reduce cost: There are unnecessary costs being incurred on the bottling line, for example, the unloading and packing operation requires 2 operators in the current operations. We reduce these costs by incorporating alternative mechanism, CTC(X) Incorporate sliding mechanism for packaging: This helps lower the costs by reducing the labor requirement at the packing operation by incorporating a mechanism that will let a single operator handle the packing operations by themselves.

CTP(Y) Reduce changeover time: Currently changeover has to be performed for every product line which takes 30 mins for most products and 2 hours for some products. This downtime incurs significant costs for the company. We make it an objective to reduce the downtime and if possible eliminate it completely.

CTP(X) Incorporate multiple headed nozzle: This is new mechanism that helps eliminate changeover times by incorporating outlets for multiple products into the single nozzle head by using different supply lines to the nozzle head.

CTS(X) Incorporate elevator mechanism for loading: This is a new mechanism designed to increase the safety aspects for the operator loading the bottles onto the conveyor. It makes the operation for loading the bottles much easier.

CTS(Y) Increase operator safety: Right now an operator loads the bottles onto the conveyor manually. This has him bending and picking up bottles from the crate. Doing this over long time can cause severe back injury. Also chances are that the operator at some point might loose balance and the bottles might break thereby hurting the operator. We make it a point to improve upon this aspect.

Flavor sequence: This is the output obtained by determining the product sequence and the changeover methods.

Bottling operation diagram: This is a micro level diagram representing the bottling operation. This helps us better understand the start to end bottling process.

Raw materials: The raw materials are in the form of empty glass bottles, labels and flavors required for the bottling operation. The raw materials term also includes the resources like fountain water used to mix with flavors to prepare the beverage.

Production plan: This is the process plan made considering all the other factors like the customer requirements and machine specifications. The production plan gives the batch sizing to be used and the sequencing of the products.

SOP: The term SOP stands for Standard Operating Procedures. These are the guidelines defined by the company for different processes. This helps maintain uniformity and order across the process.

Inspected Bottled beverage : This is the final inspected product that comes off the line, ready to be shipped.

Machine: This is the automated machine that does all the operations apart from loading, unloading of the conveyor and packing of the cartons.

Operators: These are the people that change the machine setting before each operations as required. The term operators term also include the personnel loading the bottles onto conveyor and unloading the bottled beverage and packing it in cartons.

Machine specifications: These are the capabilities of the machines that restricts and guide the process plan to be used for the production.

Flavor sequence: This is the output obtained by determining the product sequence and the changeover methods.

Customer requirements: Customer requirements act as a control when they determine the production sequence and the flavor mixture to be used.

bottled beverage: This is the bottled beverage on the conveyor line just before inspection is performed

CTP(Y) Reduce changeover time: Currently changeover has to be performed for every product line which takes 30 mins for most products and 2 hours for some products. This downtime incurs significant costs for the company. We make it an objective to reduce the downtime and if possible eliminate it completely.

CTP(X) Incorporate multiple headed nozzle: This is new mechanism that helps eliminate changeover times by incorporating outlets for multiple products into the single nozzle head by using different supply lines to the nozzle head.

CTS(X) Incorporate elevator mechanism for loading: This is a new mechanism designed to increase the safety aspects for the operator loading the bottles onto the conveyor. It makes the operation for loading the bottles much easier.

CTS(Y) Increase operator safety: Right now an operator loads the bottles onto the conveyor manually. This has him bending and picking up bottles from the crate. Doing this over long time can cause severe back injury. Also chances are that the operator at some point might loose balance and the bottles might break thereby hurting the operator. We make it a point to improve upon this aspect.

Appendix 3

a. IDEF 3 Check list

Kristen Distributing		**DATE : 12/02/2018**	
Quality Checklist Version 1.0			
Project name: Bottling Line Design		**Project ID: 879**	
Sr No	**Description**	**Status: WIP**	
		Peer QC	**Final QC**
		NAME: John Smith	**NAME: John Doe**
		DATE : 12/02/2018	**DATE : 12/02/2018**
	Diagram Architecture		
1	Make sure all the blocks are connected	yes	yes
2	Check for link association and relevance	yes	yes
3	Identify missing activities	yes	yes
4	Check for the Fan in/ Fan out junction types.	yes	yes
5	Ensure correct process order	yes	yes
6	Link OSTN	yes	yes
7	Mention proper transformation process in OSTN	yes	yes
8	Check for proper referrant from the project scenario.	yes	yes
	Descriptions/Glossary		
1	Mention correct and detailed context	yes	yes
2	Describe viewpoint	yes	yes
3	Describe purpose of the model (clear and to the point)	yes	yes
4	Describe proper glossary for each block	yes	yes
5	Block name (Only active verb phrases)	yes	yes
6	Check for incomplete statements in descriptions.	yes	yes
7	Check for proper constraints at each block.	yes	yes
8	Check for proper objects at each block.	yes	yes
9	Check for proper facts at each block.	yes	yes

b. Glossary for IDEF3 models:

Glossary for the ASIS IDEF3:

Production System: KD bottling line ASIS

Purpose
The purpose of this model is to illustrate the operations of a beverage bottling plant. This depiction will be used for identifying the flow of the process, allocation of various resources at different stages, detect bottlenecks in the production flow, and identify means to improve the existing system.

Viewpoint
The viewpoint of this model is that of a systems engineer analyzing the transformative processes in KD bottling line to make it lean.

Context
The context of this model is to specify the activities involved in bottling beverage bottles. This model assumes that the raw material is readily available in for filling and the production is authorized

Description of processes:

1. **Depalletize bottles:** This is a process where a workman depalletizes bottles from the bottle pallets and places it on the conveyer of the bottling line.
2. **Rinse empty bottles:** This is a process where the bottles are rinsed with water internally
3. **Fill beverage:** It is the process of filling the bottles with an appropriate beverage.
4. **Cap bottles:** It is the process in which a cap is fixed on a bottle by a machine.
5. **Etch bottles:** It is a process where serial number and other details are marked on the bottle by a laser etching machine.
6. **Rinse filled bottles:** It is the process where the filled bottles are externally rinsed.
7. **Label bottles:** It is the process in which an appropriate label is pasted on the bottle.
8. **Pack bottles:** It is the process where a workman places bottles in the case.

OSTN Diagram

Purpose

The purpose of this model is to depict the changes in the state of a beverage bottle as it goes through the bottling line.

Viewpoint

The viewpoint of this model is that of a systems engineer for analyzing the changes in the states of a beverage bottle.

Context

An empty bottle is assumed to be at the depalletizing workstation. The state change has been depicted from depalletizing operation to packing operation.

Description of object states:

Object State	**Description**	**Entry Constraint**	**Exit Constraint**
Empty Bottle	It is the bottle received as raw material	Pallets of empty bottles should be available	Empty Bottle should be placed on the conveyor
Rinsed Bottle	The bottle is rinsed from the inside.	Empty Bottle should be placed on the conveyor	The bottle should be rinsed from inside:
Bottle Filled with Beverage	Bottle filled with required beverage	The rinsed bottle should be available	The bottle should be filled with beverage
Etched Bottle	The bottle is etched with the serial number and other data.	The capped bottle should be available	The bottle should be etched
Capped bottle	It is the bottle closed with	The filled bottle	The bottle should be

	a cap	should be available	capped
Rinsed Closed Bottle	It is capped bottle rinsed with water externally.	The capped bottle should be available	The bottle should be rinsed externally
Labeled Bottle	It is the bottle with a label pasted on it	The rinsed bottle should be available	The bottle should be labeled

Glossary for TOBE IDEF3:

Purpose
The purpose of this model is to illustrate the operations of a beverage bottling plant. This depiction will be used for identifying the flow of the process and allocation of various resources at different stages.

Viewpoint
The viewpoint of this model is that of a systems engineer analyzing the transformative processes to be implemented in Boots Beverage bottling line.

Context
The context of this model is to specify the activities involved in bottling beverage bottles. This model assumes that the raw material is readily available in for filling and the production is authorized.

Description of processes:

1. **Depalletize bottles:** This is a process where bottles are unloaded from the pallets on to the production belt.
    1. **Load pallet:** The pallets are arranged in the form of trays which are stacked one above the other. The pallet is loaded on a hydraulic jack bed.
    2. **Raise hydraulic bed:** The hydraulic bed is raised to match the level of the tray to that of the production belt.
    3. **Slide bottles:** Workman uses a frame to slide a row of bottles on the production belt.
2. **Rinse empty bottles:** This is a process where the bottles are rinsed with water internally.
3. **Fill beverage:** It is the process of filling the bottles with appropriate beverage.
4. **Cap bottles:** It is the process in which a cap is fixed on a bottle by a machine.
5. **Etch bottles:** It is a process where serial number and other details are marked on the bottle by a laser etching machine.
6. **Rinse filled bottles:** Bottles are rinsed externally by newly introduced inline rinser.
7. **Label bottles:** It is the process in which an appropriate label is pasted on the bottle.
8. **Pack bottles:** It is the process where bottles are packed into boxes which can be shipped to the customer.
    1. **Place trolley in front of ramp:** A trolley that will carry filled boxes to the trucks is kept in front of the ramp at the packaging station.

2. **Place packing box on the packing station:** Box is placed on the packaging table. such that it is open sideways i.e. its open face is facing the production line.
3. **Slide bottles in the box:** Workman slides a row of bottles in the box with the help of a frame.
4. **Seal box:** After a box is full of filled beverage bottles, it is sealed with tape.
5. **Slide box on the ramp:** Workman slides filled box on the ramp to direct it onto the trolley.

OSTN Diagram

Purpose
The purpose of this model is to depict the changes in the state of a beverage bottle as it goes through the bottling line.
Viewpoint
The viewpoint of this model is that of a systems engineer for analyzing the changes in the states of a beverage bottle.
Context
An empty bottle is assumed to be at the depalletizing workstation. The state change has been depicted from depalletizing operation to packing operation.

Description of object states:

Object State	**Description**	**Entry Constraint**	**Exit Constraint**
Empty Bottle	It is the bottle received as raw material	Pallets of empty bottles should be available	Empty Bottle should be placed on the conveyor
Rinsed Bottle	The bottle is rinsed from the inside.	Empty Bottle should be placed on the conveyor	The bottle should be rinsed from inside:
Bottle Filled with Beverage	Bottle filled with required beverage	The rinsed bottle should be available	The bottle should be filled with beverage
Etched Bottle	The bottle is etched with the serial number and other data.	The capped bottle should be available	The bottle should be etched
Capped bottle	It is the bottle closed with a cap	The filled bottle should be available	The bottle should be capped.
Rinsed Closed Bottle	It is capped bottle rinsed with water externally by an inline rinsing machine.	The capped bottle should be available	The bottle should be rinsed externally
Labeled Bottle	It is the bottle with a label pasted on it	The rinsed bottle should be available	The bottle should be labeled