Project Dissertation Report on

Six Sigma at Hindustan Coca-Cola Beverages Private Limited

Improvement in Concentrate Yield of Carbonated SoftDrinks (CSD) on returnable Glass Bottles (RGB)

Submitted By

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CERTIFICATE

This is to certify that **Mukul Kapoor EMBA/2K19/533** has submitted the project report titled "**Six Sigma at Hindustan CocaCola Beverages Private Limited**" in partial fulfilment of require ments for the award of the degree of Master of Business Administration (Executive) from Delhi School of Management, Delhi Technological University, New Delhi during the academic year 2022-21.

Signature of Guide Signature of Head (DSM)

Seal of Head

Place:

Date:

DECLARATION

I, Mukul Kapoor, student of EMBA 2K19 of Delhi School of Management, Delhi Technological University, Bawana Road, Delhi 42, hereby declare that the dissertation report "**Six Sigma at Hindustan CocaCola Beverages Private Limited**" submitted in partial fulfillment of Degree of Masters of Business Administration is the original work conducted by me.

The information and data given in the report is authentic to the best of my knowledge

This report is not being submitted to any other University, for award of any other Deg ree, Diploma or Fellowship.

Place: Date:

ACKNOWLEDGEMENT

I would like to express my sincere gratitude towards my Guide, Mr. Dhiraj Pal (Assistant Professor, Delhi School of Management, DTU) for his support and valuable guidance throughout the duration of the project. I thank him for the constant encouragement and support at every stage.

My sincere gratitude goes out to my colleagues whose participation in the project gave many valuable inputs for its completion.

Mukul Kapoor

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EXECUTIVE SUMMARY

Purpose

The Purpose of this project is to reduce the beverage loss and Yield loss due to reasons such as increase in the no of bottles bursting in filler machine, increase in the number of bottles r ejections, improper amount of beverage filling and miscellaneous reasons for beverage loss. Due to this beverage loss, 100% yield is not achieved.

The objective is to analyze the factors affecting yield loss, measurement of filled rejects and f inding the root cause of beverage loss and finally suggesting ways of improvement

Design/methodology/approach

Keno model was followed to prioritize the CTQs (critical to quality) afterwards cause and effect diagram is used to identify, sort, and display possible causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the fac tors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagra m" because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the way it l ooks.

Random: Rational subgrouping sampling technique was used to gather the data and afterwards regression analysis was performed to interpret the results to do the residual analysis

Conclusion and improvements

Various observations were made with the patters in data and recommendations were given accordingly by finding out the root cause of the issue.

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1. Introduction

1.1. The Coca-Cola Company

CocaCola was first introduced by John Syth Pemberton, a pharmacist, in the year 1886 in Atlanta, Georgia concocted caramel-colored syrup in a three-
legged brass kettle in his backyard. He first "distributed" the product by carrying it in a ju g down the street to Jacob's Pharmacy and customers bought the drink for five cents at t he soda fountain. Carbonated water was teamed with the new syrup, whether by acciden t or otherwise, producing a drink that was proclaimed "delicious and refreshing", a theme that continues to echo today wherever Coca-Cola is enjoyed.
Dr. Pemberton's partner and book-
keeper, Frank M. Robinson, suggested the name and penned "Coca-
Cola" in the unique flowing script that is famous worldwide even today. He suggested that "the two Cs would look well in advertising." The first newspaper ad for Coca-
Cola soon appeared in *The Atlanta Journal*, inviting thirsty citizens to try "the new and po pular soda fountain drink." Hand-painted oil cloth signs reading "Coca-
Cola" appeared on store awnings, with the suggestions "Drink" added to inform passersby that the new beverage was for soda fountain refreshment.

By the year 1886, sales of CocaCola averaged nine drinks per day. The first year, Dr. Pemb erton sold 25 gallons of syrup, shipped in bright red wooden kegs. Red has been a distincti ve color associated with the soft drink ever since. For his efforts, Dr. Pemberton grossed $50 and spent
$73.96 on advertising. Dr. Pemberton never realized the potential of the beverage he crea ted. He gradually sold portions of his business to various partners and, just prior to hi

s death in 1888, sold his remaining interest in Coca-Cola to Asa G. Candler, an entrepreneur from Atlanta. By the year 1891, Mr. Candler proceeded to buy additional rights and acquire complete ownership and control of the Coca-Cola business. Within four years, his merchandising flair had helped expand consumption of Coca-Cola to every state and territory after which he liquidated his pharmaceutical business and focused his full attention on the soft drink. With his brother, John S. Candler, John Pemberton's former partner Frank Robinson and two other associates, Mr. Candler formed a Georgia corporation named the Coca-Cola Company. The trademark "Coca-Cola," used in the marketplace since 1886, was registered in the United States Patent Office on January 31, 1893.

The business continued to grow, and in 1894, the first syrup manufacturing plant outside Atlanta was opened in Dallas, Texas. Others were opened in Chicago, Illinois, and Los Angeles, California, the following year. In 1895, three years after The Coca-Cola Company's incorporation, Mr. Candler announced in his annual report to share owners that "Coca-Cola is now drunk in every state and territory in the United States."

As demand for Coca-Cola increased, the Company quickly outgrew its facilities. A new building erected in 1898 was the first headquarters building devoted exclusively to the production of syrup and the management of the business. In the year 1919, the Coca-Cola Company was sold to a group of investors for $25 million. Robert W. Woodruff became the President of the Company in the year 1923 and his more than sixty years of leadership took the business to unsurpassed heights of commercial success, making Coca-Cola one of the most recognized and valued brands around the world.

1.1.1. Hindustan Coca-Cola Beverages Private Limited (HCCBPL)

HCCBPL Nashik is one of the oldest and the smallest bottling plants owned by Coca-Cola India Pvt Ltd. This bottling unit was taken over from Parle. It has one RGB bottling line and one Kinley water line. RGB line works 24X7 during season which is for 4 months, 6 months in 2 shifts and 2 months in 1 shift. So the total working hours in a year = 5200 Hrs. The annual production of RGB line is 20, 00, 000 cases. Kinley water line works 24X7 throughout the year. Annual production of Kinley water line is 21, 00,000 cases per annum. Recently they setup a warehouse/distribution center in Nashik.

HCCBPL Nashik RGB line can bottle 12 SKUs. They are

- Thums Up 200ml
- Thums Up 300ml
- Sprite 200ml
- Sprite 300ml
- Fanta 200ml
- Fanta 300ml
- Coca-Cola 200ml
- Coca-Cola 300ml
- Limca 200ml
- Limca 300ml
- Kinley Soda 200ml
- Kinley Soda 300ml

33% of the annual production is for Thums Up, another 33% is for Sprite and the remaining 34% is distributed among Fanta, Kinley Soda, Coca-Cola and Limca SKUs. Maaza and Minute Maid, which are also available in Returnable Glass Bottles (RGBs) are not manufactured at Nashik plant.

1.2. Strategic Aspects

Mission

Our Roadmap starts with our mission, which is enduring. It declares our purpose as a compan yand serves as the standard against which we weigh our actions and decisions.

- To refresh the world...
- To inspire moments of optimism and happiness…
- To create value and make a difference…

Vision

Our vision serves as the framework for our Roadmap and guides every aspect of our busi nessby describing what we need to accomplish in order to continue achieving sustainable, quality growth.

- **People:** Be a great place to work where people are inspired to be the best they can be.
- **Portfolio:** Bring to the world a portfolio of quality beverage brands that anticipate a nd satisfy people's desires and needs.
- **Partners:** Nurture a winning network of customers and suppliers, together we cre ate mutual, enduring value.
- **Planet:** Be a responsible citizen that makes a difference by helping build and su pport sustainable communities.
- **Profit:** Maximize long-term return to shareowners while being mindful of our overall responsibilities.
- **Productivity:** Be a highly effective, lean and fast-moving organization

Quality Policy

“To ensure customer delight, we commit to quality in our thoughts, deeds and actions by continually improving our processes…Every time.”

Our Winning Culture

Our Winning Culture defines the attitudes and behaviors that will be required of us to make our 2020 Vision a reality.

Live Our Values

Our values serve as a compass for our actions and describe how we behave in the world.

- **Leadership:** The courage to shape a better future
- **Collaboration:** Leverage collective genius
- **Integrity:** Be real
- **Accountability:** If it is to be, it's up to me
- **Passion:** Committed in heart and mind
- **Diversity:** As inclusive as our brands
- **Quality:** What we do, we do well

Focus on the Market

- Focus on needs of our consumers, customers and franchise partners
- Get out into the market and listen, observe and learn
- Possess a world view
- Focus on execution in the marketplace every day
- Be insatiably curious

Work Smart

- Act with urgency
- Remain responsive to change
- Have the courage to change course when needed
- Remain constructively discontent
- Work efficiently

Act like Owners

- Be accountable for our actions and inactions
- Steward system assets and focus on building value
- Reward our people for taking risks and finding better ways to solve problems

- Learn from our outcomes -- what worked and what didn't

Be the Brand

- Inspire creativity, passion, optimism and fun

Coca-Cola's six strategic priorities:

1. Accelerate carbonated soft-drinks growth led by coca cola

- Coca Cola leads with their strengths. Carbonated soft drinks remain their most profit able business and Coca Cola is the most popular brand in the world. This strategy p aves the way for growth.

2. Selectively broaden our family of beverage brands to drive profitable growth

- Enormous opportunity exists in categories such as juice and juice drinks, bottled wa ter, teas, energy drinks, coffee and more.

3. Grow system profitability and capability together with our bottling partners

- Coca Cola is a company of relationships, and one of our most important relationship s is the one we share with our bottling partners. In 2003, those relationships became more profitable and productive.

4. Serve customers with creativity and consistency to generate growth across all channels

- We will continually strive to increase growth for the customer's businesses, hel ping create a context for the company's growth.

5. Direct investments to highest-potential areas across markets

- Coca Cola tailor their business approach to the individual marketplace based on its s

tage of development. In this way, we direct our investments in a way that makes the most business sense.

6. Drive efficiency and cost-effectiveness everywhere

- By leveraging technology, creating alignment across business units and achieving economies of scale, we are able to operate with more efficiency.

1.3. Six Sigma Methodology

The project is a green belt six sigma and is based upon the DMAIC methodology.

Various stages involved are:

Define the problem, the voice of the customer, and the project goals, specifically.

Measure key aspects of the current process and collect relevant data.

Analyze the data to investigate and verify cause-and-
effect relationships. Determine what the relationships are, and attempt to ensure that all fac tors have been considered. Seek out root cause of the defect under investigation.

Improve or optimize the current process based upon data analysis using techniques such as design of experiments, poka yoke or mistake proofing, and standard work to create a new, f uture state process. Set up pilot runs to establish process capability.

Control the future state process to ensure that any deviations from target are corrected bef ore they result in defects. Implement control systems such as statistical process control, pro duction boards, visual workplaces, and continuously monitor the process.

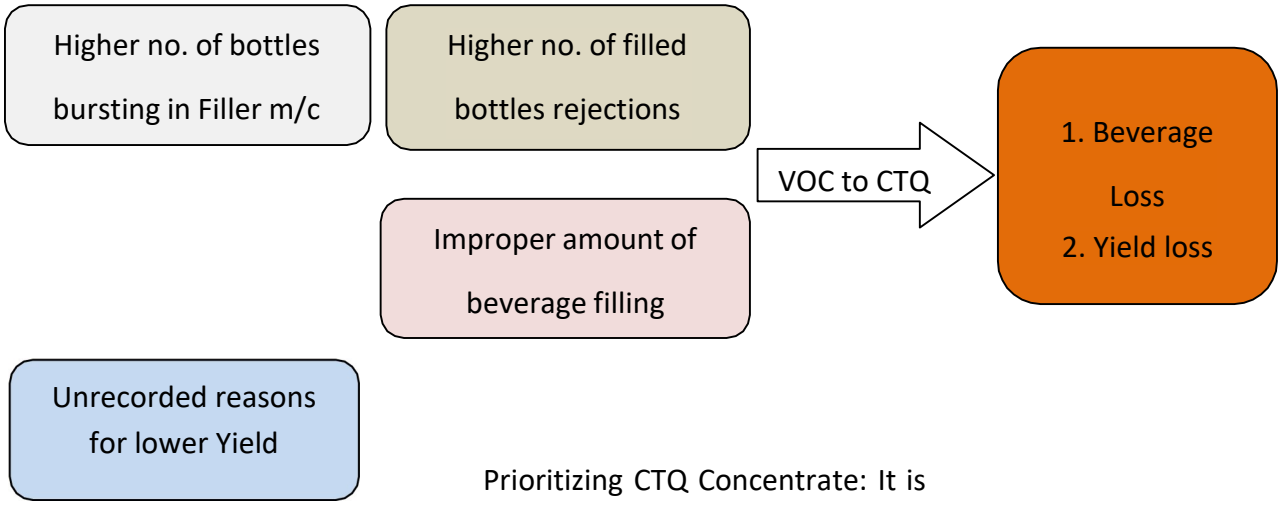
2. Define

2.1. Identification of Project CTQ

Customer: Hindustan Coca-Cola Beverages Pvt. Ltd.(HCCBPL) management and plant workers

Determining and Prioritizing of CTQ:

The following illustration shows the verbatim VOC's of the customers and subsequentidentification of CTQs from them.



Prioritizing CTQ Concentrate: It is the liquid in concentrated form for each SKU.

Beverage: It is prepared by mixing Concentrate with sugar syrup, which can be directly filled inbottles.

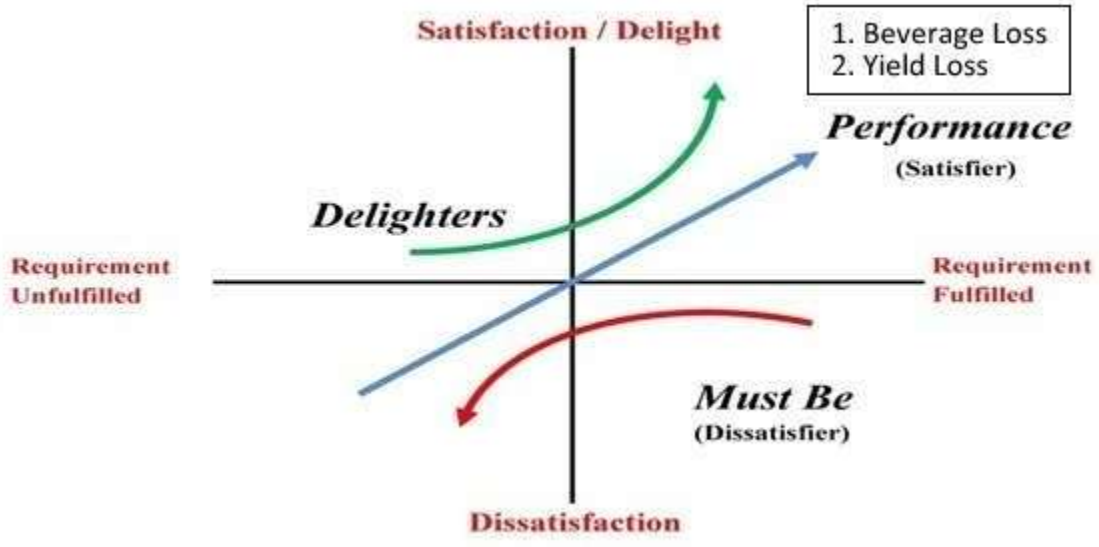
Yield = (Actual Output / Standard Output)*100

In case of bottling plant, output is measured in terms of number of Cases. Each Case contains24 bottles of Carbonated Soft Drink (CSD).

Concentrate Yield = (Actual number of Cases produced / Standard number of cases)*100

2.2. Kano Model

We use KANO model to prioritize the CTQ's identified, xbut we did not find any 'Must Be's or'Delighters' among them. So we decided to take above identified CTQ's as our Project Y's.



: Kano Mode

2.3. Project In Scope and Out Scope

Project Objectives:

- Analysis of factors affecting Yield loss SKU wise
- Measurements of filled rejects SKU wise
- Root cause analysis for beverage loss
- Suggesting improvement opportunities based on data analysis

Project KPI

- Improvement in Yield from 99.8% to 100%.
- Reduction in filled bottles rejects

In Scope

- All machines and processes involved in production process of bottle filling
- Support processes like boiler, syrup making, yard that may interfere with functioning ofmain processes

Out of Scope

- Internal functioning and logic control of ASEBI machine
- Kinley Retail water line

2.4. Project Charter

Following table exhibits the project charter:

Project Charter	
Project Title:	Improvement in Concentrate Yield of Carbonated Soft Drinks (CSD) onReturnable Glass Bottles (RGB) line
Business Case	**Problem/Opportunity Statement**
Due to losses at various stages of bottling plant, 100%Yield is not achieved.	As per existing data Yield of RGB line is 99.8%,which can be improved further to 100%
Goal Statement	**Scope**

<table>
<tr><td colspan="3">Improve the concentrate yield of Carbonated Soft Drinks (CSD) on Returnable Glass Bottles(RGB) line from 99.8% to100%</td><td colspan="3">In-Scope: Returnable Glass Bottles Soft DrinksLine
Out of Scope: Kinley Soda Line</td></tr>
<tr><td colspan="3">Team Members</td><td colspan="3">Project Timeline</td></tr>
<tr><td>Key Stakeholders</td><td colspan="2">Project CTQ</td><td>Key Milestone</td><td></td><td></td></tr>
<tr><td>Production Dept.</td><td>Unit</td><td>Existing Target</td><td>Define</td><td></td><td></td></tr>
<tr><td>Quality Dept.</td><td>Yield %</td><td>99.8 100</td><td>Measure</td><td></td><td></td></tr>
<tr><td>Maintenance Dept.</td><td></td><td></td><td>Analyze</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td>Recommendations</td><td></td><td></td></tr>
<tr><td colspan="6">Approval</td></tr>
<tr><td colspan="2">Project Sponsor:</td><td colspan="2">Hindustan Coca-Cola BeveragesLtd., Nasik</td><td colspan="2">Date:</td></tr>
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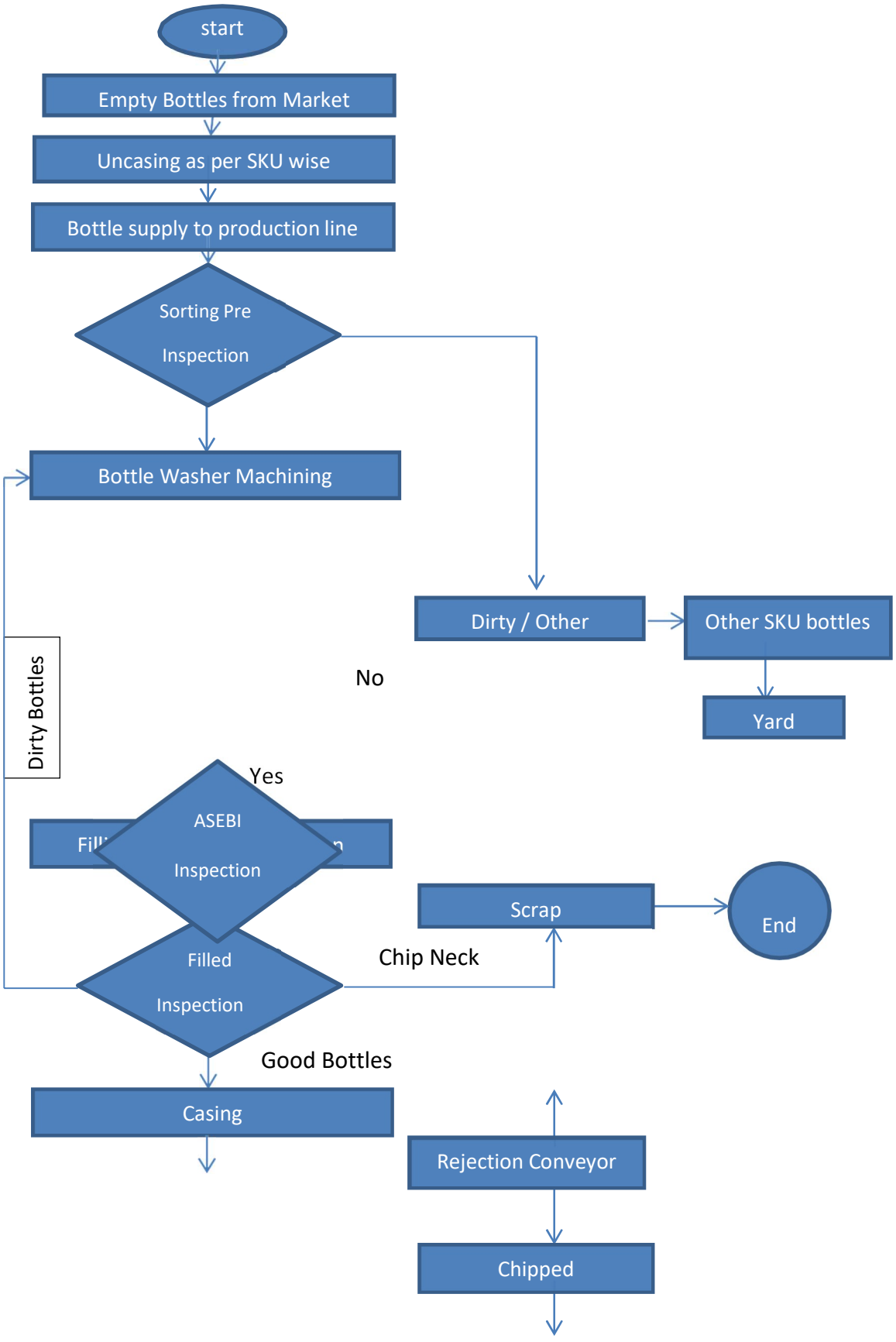
2.5. Process Mapping



HCCBPL Nashik plant is dedicated for bottling of returnable glass bottles (RGB). The bottle fillingis done in 2 sizes viz. 200 ml and 300 ml and 6 different brands viz. Coca-Cola, Thums-up, Fanta,Limca, Kinley Soda and Sprite. The process flow chart of entire bottling process is given below.

Important operations which are carried out are given below:

I. **Uncasing**:

a. Resources Used: Semi-automatic uncaser, operators

b. Operation: Empty glass bottles which are collected from retailers enter the production line in the form of cases. Each case consists of 24 bottles. Removal of bottles from cases and putting them onto the conveyor is known as uncasing.

c. Output: Empty dirty bottles which may need sorting and moved to washing station.

II. Sorting and pre-inspection:

a. Resources Used: Inspection Personnel, White backlit screen

b. Operation: Inspection person inspects dirty empty bottles for Crowns, straws, other foreign material. He also sorts the bottles that are from different brands than that of production run.

c. Output: All same brand bottles free from foreign material.

III. Bottle Washing

a. Resources Used: Bottle washer machine, operator, straightening tongue

b. Operation: Washing takes place at several stages. The stages include Caustic sodawash, Water wash at 3 different temperatures and finally chlorine wash.

c. Output: Cleaning bottles free from dirt.

IV. ASEBI Machine Inspection

a. Resources: ASEBI machine, Operator, 3 conveyors.

b. Operation: ASEBI is acronym for All Surface Empty Bottles Identification. The machine consists of set of sensors and cameras that detect the physical damage to the bottles from all the surfaces. The machine can operate at the speed of up to1200 bottles per minute.

c. Output: Bottles are sorted onto 3 conveyors

i. No physical damage bottles acceptable for filling operation

ii. Dirty bottles that needed rewash before filling

iii. Physically damaged bottles (chip-necks) that have to be scrapped off

V. Filling and Capping Operation

a. Resources: filler machine, Skilled operator

b. Operation: Bottles are filled with respective flavor and then crowning takes place. Filler operates at rated speed of 340 bottles per minute.

c. Output: Filled and crowned bottles passes through date coder where date, batchand price are printed and then they go for final inspection.

VI. Filled bottles inspection:

a. Resources: inspector, White backlit screen

b. Operation: The inspector checks each bottle for the volume of content filled and crown.

c. Under filled and uncrowned bottles are taken aside and they again go for filling.

d. Output: Bottles ready for casing and storing in warehouse

VII. Casing and warehouse storage:

a. Resources: Casing personnel, empty cases, stacker and stacker operator

b. Operation: filled and inspected bottles are converted into cases. Cases are stackedon pallets such that each pallet consists of 63 cases. These pallets are then stackedin the warehouse by using stacker.

3. Measure

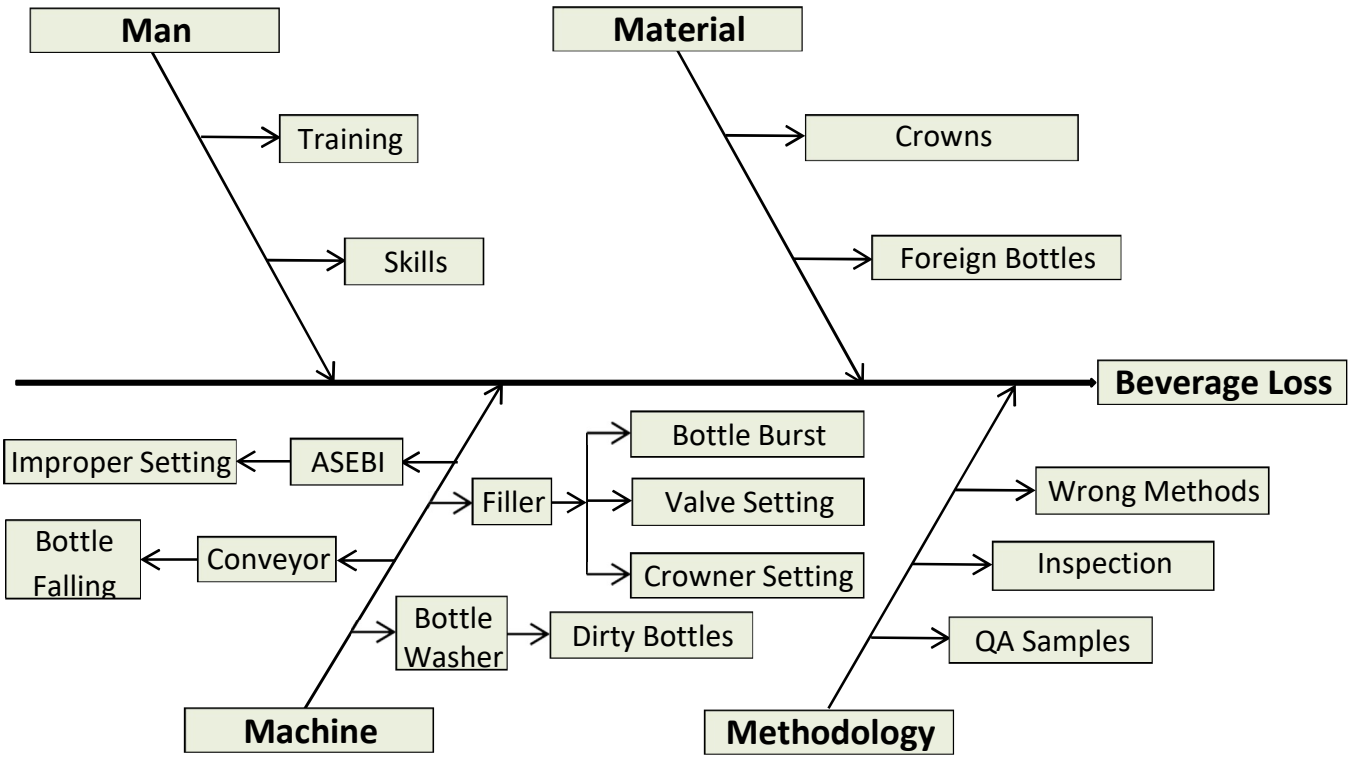
3.1. Cause and Effect Diagram

During this phase, the key activities in the entire process map that affect the CTQ (in this case beverage losses) are identified. Measurements related to the CTQ are made in this phase. The MEASURE phase involves more numerical study and data analysis than the DEFINE phase. This phase focuses on measurement system validation and gathering root causes.

A Cause-and-Effect Diagram is a tool that helps identify, sort, and display possible causes of a specific problem or quality characteristic. It graphically illustrates the relationship between a given outcome and all the factors that influence the outcome. This type of diagram is sometimes called an "Ishikawa diagram" because it was invented by Kaoru Ishikawa, or a "fishbone diagram" because of the way it looks.

As the project involved lot of complicated and interlinked factors affecting the problem, finding out the root cause became a tedious job. It required a lot of technical detailed study tounderstand which could be the probable cause. Hence, a cause and effect diagram was prepared to understand the various causes of losses.

The cause and effect diagram for Beverage losses (Concentrate Yield) is as shown below, which is used for finalizing data collection plan.



Cause and Effect diagram

3.2. Data Collection Plan

The data collection plan was prepared to maintain uniformity in the data collection process.Data collection plan for beverage losses is as shown below:

Table 1: Data Collection Plan

Particulars	Description
Purpose of Data Collection	To analyze the reasons for Beverage losses and hence for loss inConcentrate Yield
Measure	Loss of beverage (Number of bottles), Concentrate Yield

Operational Definition ofMeasure	Beverage Losses: Amount of saleable beverage wasted due losses in operations and rejections Concentrate Yield: It is calculated by using the data of theoreticaloutput and actual output Concentrate Yield(%) = (Actual Output/Theoretical output)*100
Sampling Strategy	Random: Rational Subgrouping
Sample Size	Readings are taken for 26 days, each day for 8 hours
Data Collection Plan	Record beverage losses for the whole system using filler processas the main process
Measurement System Analysis	Not Required (As counting of bottles and cases is done in unit ofnumbers)

3.3. Data Collection Template

Based on the cause & effect diagram and data collection plan, following template is made fordata collection:

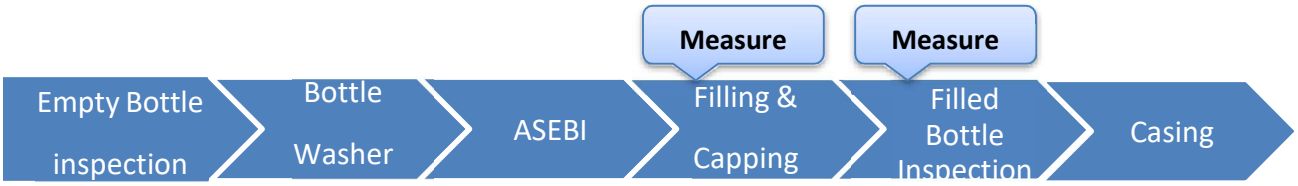
Table 2: Filled Bottles Inspection - Data Collection Template

Filled Bottles Inspection: Data Collection for Concentrate Yield					
	Sprite 200	**Fanta 200**	**Limca 200**	**THU 200**	**Fanta 300**
Parameter SKU					
Dirty Bottle					
Under filled & Over filled					
Bottle bursting at Filler					
Uncrowned Bottles					
Miscellaneous Losses					
Foreign Bottles					
Logo Missing					
Chip Neck					
Filler Stoppages/Drain					
QA Samples					

Theoretical Cases					
Actual Cases					
Concentrate Yield					

As indicated in below figure data collection is done at these two stations by manual counting ofnumber of bottles.

i. Bottle filling and capping
ii. Filled bottle inspection

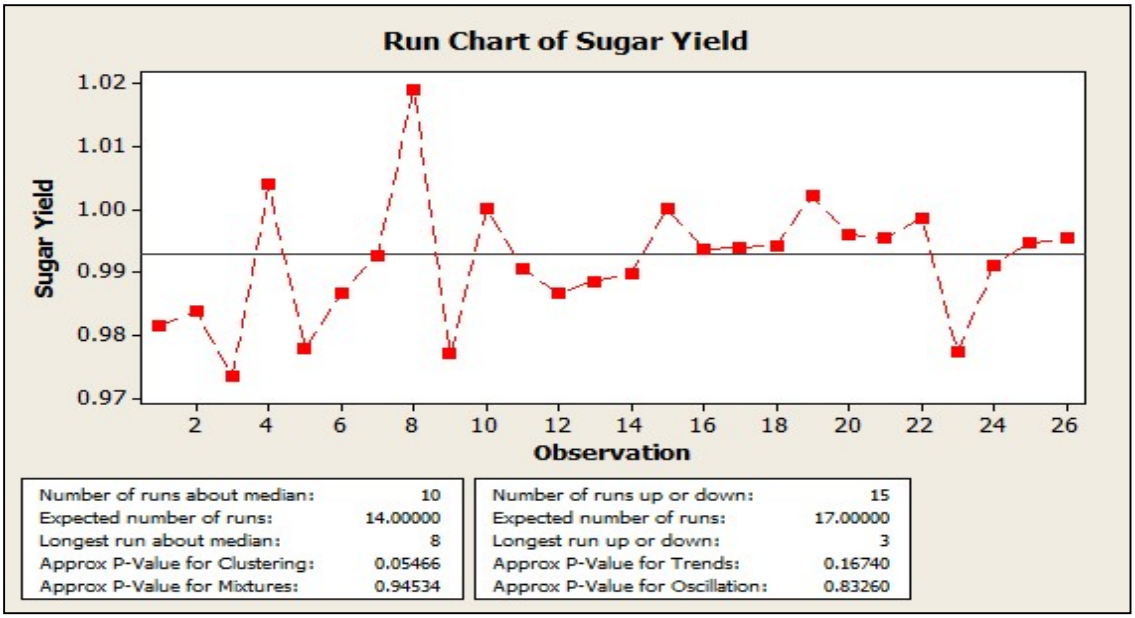


Filled Bottles Inspection: Data Collection for Concentrate Yield												
Parameter SKU	Sprite 200	Coke 200	Coke 200	Fanta 200	THU 300	THU 300	Sprite 300	Sprite 200	Sprite 200	Limca 300	Coke 300	Coke 200
Run wise Losses												
Dirty Bottle	21	2	58	50	16	17	9	19	25	26	3	10
Underfilled & Overfilled	34	22	60	72	13	21	30	44	41	39	10	18
Bottle bursting at Filler	14	1	5	10	3	7	7	8	5	6	2	2
Uncrowned Bottles	2	1	3	4	2	1	2	0	0	1	0	0
Miscellaneous Losses	4	2	6	6	3	3	4	5	5	4	2	3
Foreign Bottles												
Logo Missing												
Chip Neck												
Filler Stoppages/Drain												
QA Samples												
Theoretical Cases	7772	752	8873	6309	1929	4167	5418	9510	9933	3352	823	1975
Actual Cases	7697	724	8741	6167	1892	4118	5366	9434	9857	3276	806	1942
Concentrate Yield	99.03%	96.28%	98.51%	97.75%	98.08%	98.82%	99.04%	99.20%	99.23%	97.73%	97.93%	98.33%

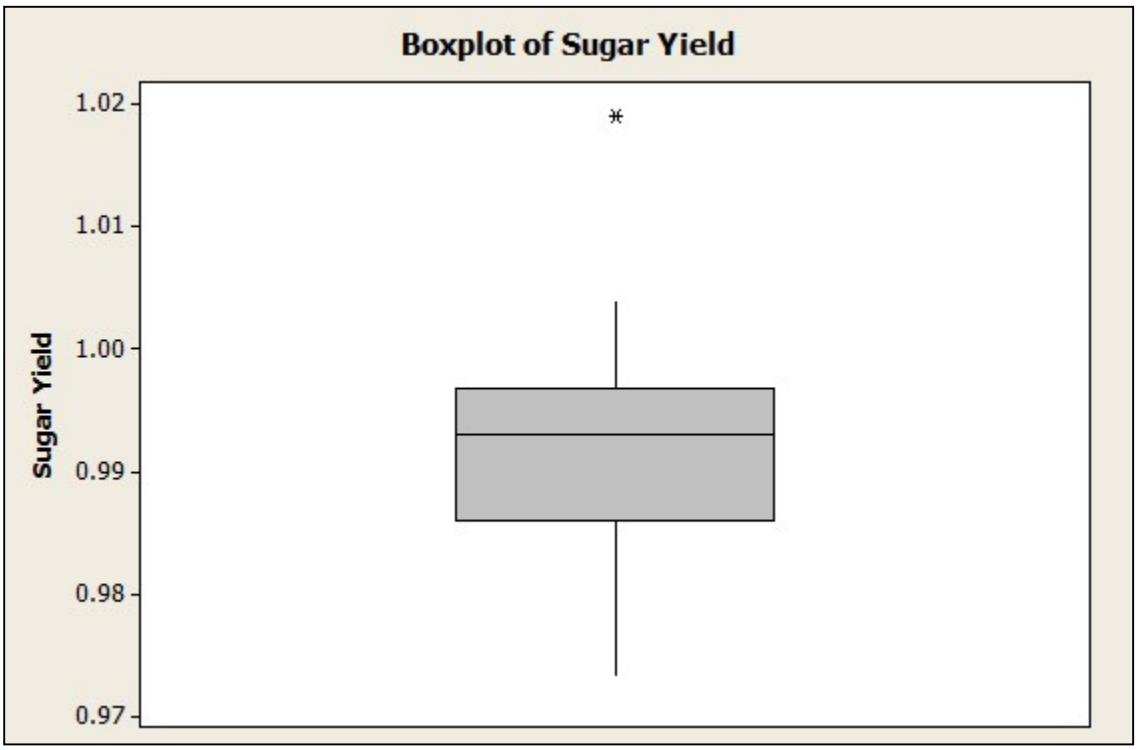
Table 3: Filled Bottles Inspection - Data Collection Sample

Boxplot and run chart for Yields

Following are the Run chart and box plot for various yields – Sugar, Concentrate and CO2. Runchart shows how yield fluctuates over 26 days for which we have taken the readings whereas box plot gives the median and quartile values for the same readings.



3.5.1. Sugar Yield



Boxplot of Sugar Yield

Average Yield: 99.16%

Yield Range: 97.3% - 101.9%

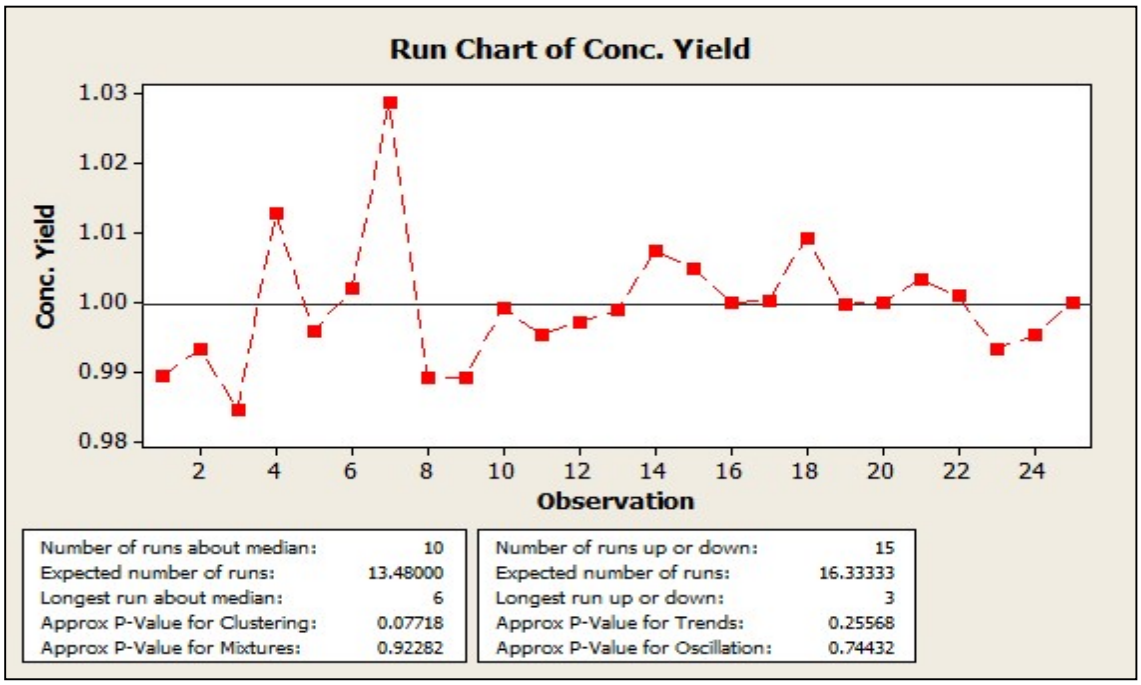
From the box plot, we can notice an outlier –

- 101.91% for Sprite 200 ml

Sugar is bought from different vendors with an allowed tolerance in weight up to ± 2% of the weight. But the calculations are done with a fixed value of sugar weight notified by the vendor. In case of presence of excess sugar than the notified figure, the actual yield exceeds 100%.

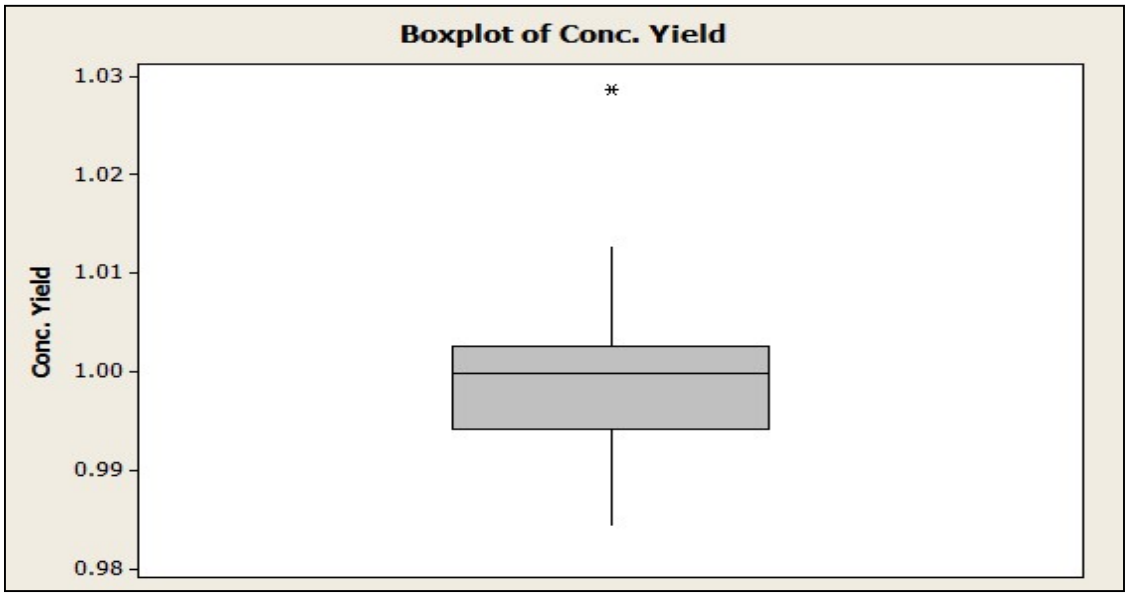
Say for E.g., sugar is bought in bags of 100 Kgs but one bag consists of 102 kgs of sugar in actual.The yield calculation is performed as per 100 kgs but because of an extra couple of grams sugar presence, the calculated yield might exceed 100%.

3.5.2. Concentrate Yield



Run Chart of Concentrate Yield

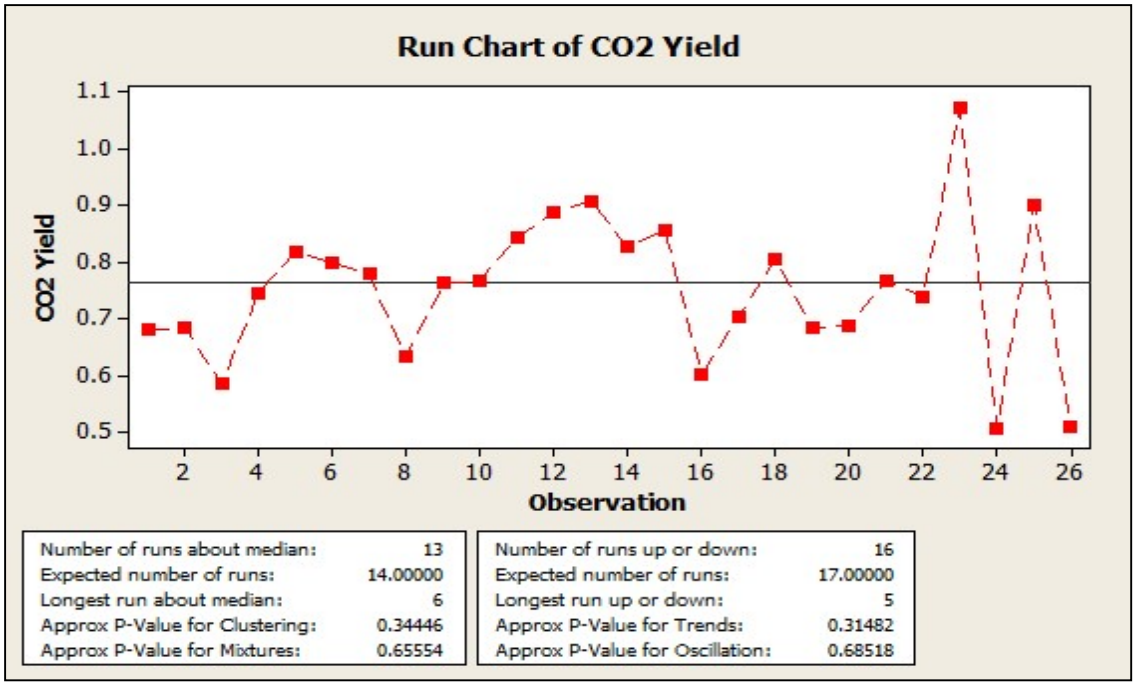
Average Yield: 99.95% Yield Range: 98.45% - 102.85%



Boxplot of Concentrate Yield

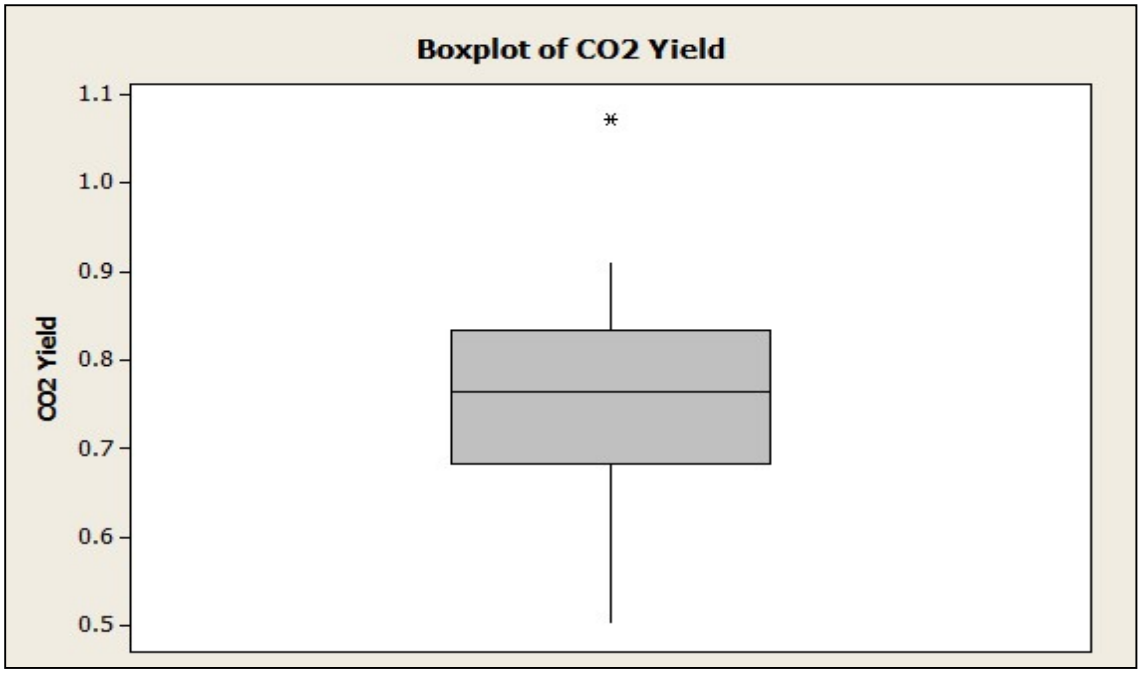
As expected, concentrate yield box plot displays an outlier in the same run as that of the oneseen in sugar yield,

3.5.3. CO2 Yield



Run Chart of CO2 Yield

Average Yield: 75.25% Yield Range: 50.57% - 107.2%



Boxplot of CO2 Yield

4. Analyze

4.1. Sigma Level

Avg. Concentrate yield for the readings taken is around 99.95% for one year, which indicates a sigma level of 4.8 (from the abridged sigma table) whereas the average annual concentrate yield is around 99.8% which indicates a sigma level of 4.3 (by interpolation).

The recommendations in the improvement phase are provided considering the annual concentrate yield (σ = 3.74) whereas the analysis is done on the data collected in the described time period (σ = 4.3

4.2. Regression Analysis

4.2.1. Regression Analysis

Loss versus (Dirty bottles + Underfilled & Overfilled bottles + Uncrowned bottles + Bottle burst)The regression equation is

Loss = 4.36 + 1.09 Dirty + 0.978 (Under + Over) filled + 0.826 Uncrowned + 1.04 Bottle Burst

Predictor	Coef	SE Coef	T	P
Constant	4.361	1.058	4.12	0.000
Dirty	1.08611	0.03021	35.95	0.000
Under+Over	0.97791	0.02810	34.80	0.000
Uncrowned	0.8257	0.3145	2.63	0.016
Bottle Burst	1.04153	0.07135	14.60	0.000

PRESS = 198.649 R-Sq(pred) = 99.76%

S = 2.55130 R-Sq = 99.8% R-Sq(adj) = 99.8%

Analysis of Variance

Source	DF	SS	MS	F	P
Regression	4	81414	20353	3126.91	0.000
Residual Error	21	137	7		
Total	25	81551			

Source	DF	Seq SS
Dirty	1	67763
Under+Over	1	11608
Uncrowned	1	655
Bottle Burst	1	1387

Unusual Observations

Obs	Dirty	Loss	Fit	SE Fit	Residual	St Resid
16	7	122.000	122.854	2.333	-0.854	-0.83 X
22	19	65.000	55.644	0.653	9.356	3.79R
24	132	290.000	289.285	2.042	0.715	0.47 X

R denotes an observation with a large standardized residual.

X denotes an observation whose X value gives it large influence.

4.2.1. Interpretation of the results

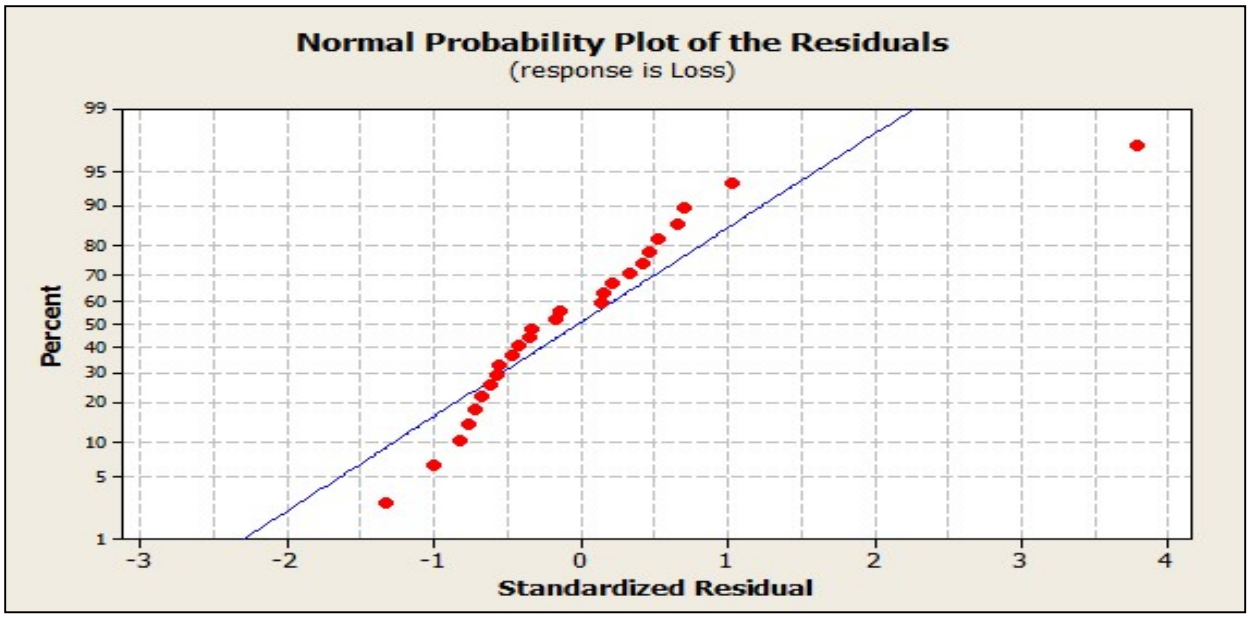
- The p-value in the Analysis of Variance table (0.000) shows that the model estimated by the regression procedure is significant at an α-level of 0.05. This indicates that at least one coefficient is different from zero.
- The p-values for the estimated coefficients of Dirty, (Under+Over) filled and Bottle Burst are 0.000, indicating that they are significantly related to Loss. The p-value for Uncrowned is 0.016, indicating that it is relatively less related to Loss at an α-level of 0.05.
- The R-Square value indicates that the predictors explain 99.8% of the variance in Loss. The adjusted R-Square is 99.8%, which accounts for the number of predictors in the model. Both values indicate that the model fits the data well.
- The predicted R-Square value is 99.76%. Because the predicted R2 value is close to the R-Square and adjusted R-Square values, the model does not appear to be over fit and

has adequate predictive ability.

- Observations 16, 22 & 24 are identified as unusual because either the absolute value of the standardized residuals are greater than 3 or it's X value has a large influence on the overall output. This may indicate they are outliers.

4.2.2. Residual Analysis

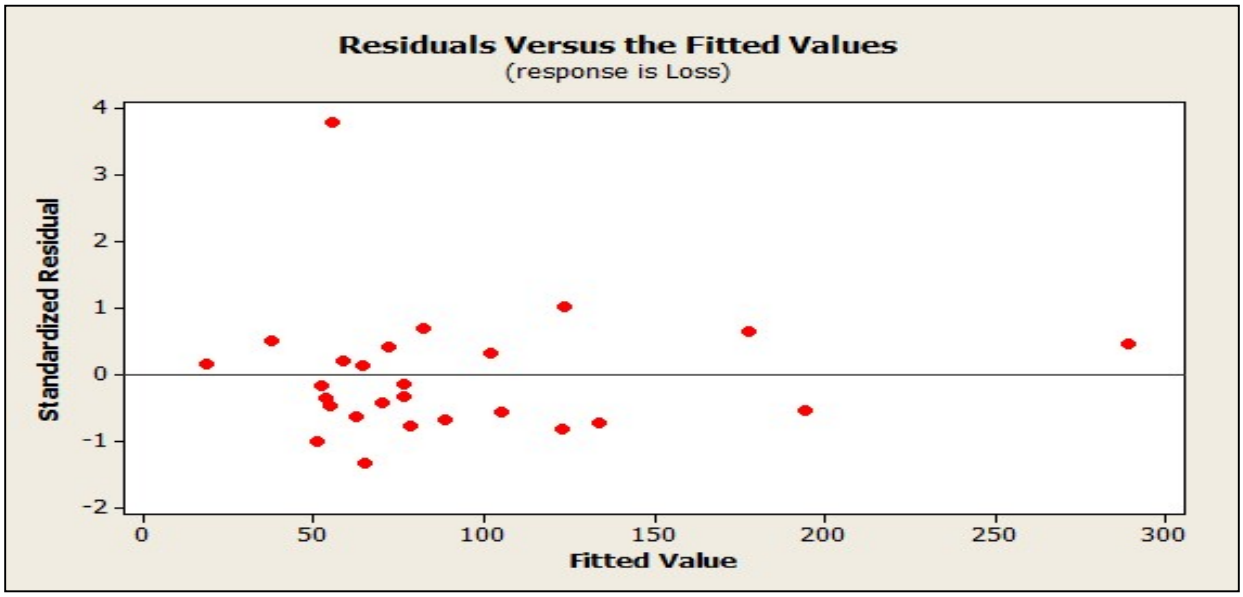
Normal Probability plot of Residuals for Loss:



: Normal Probability plot of Residuals for Loss

The normal probability plot shows an approximately linear pattern consistent with a normaldistribution. The point in the upper-right corner of the plot may be an outlier.

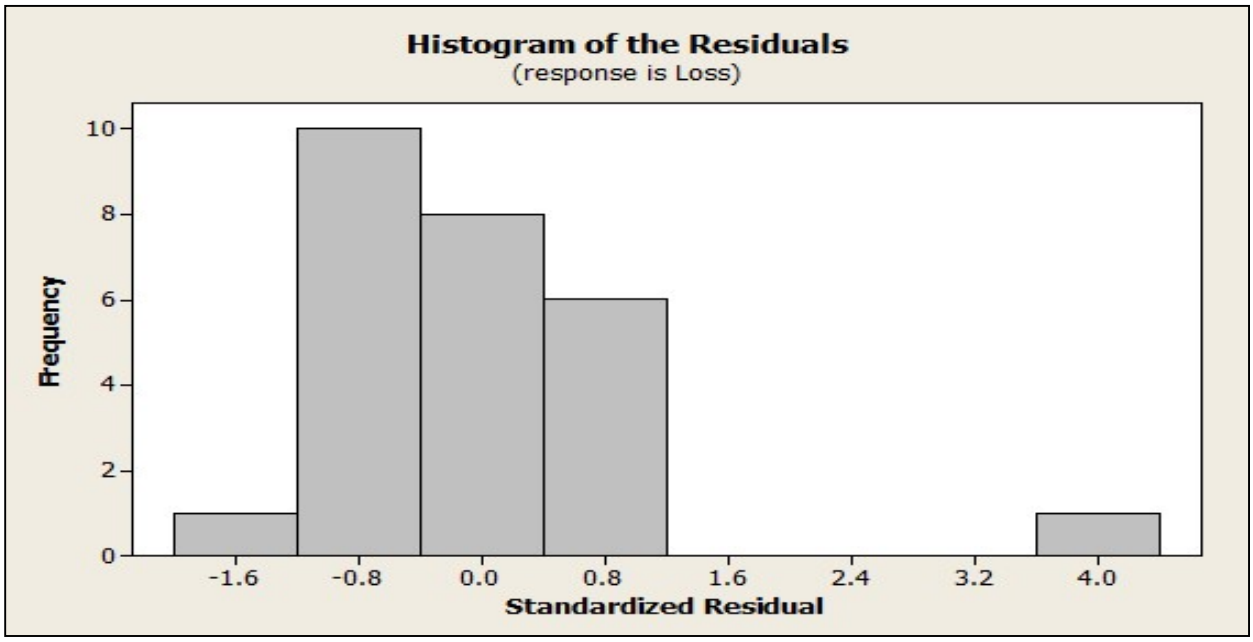
Residuals vs Fitted value for Loss:



: Residuals vs Fitted value for Loss

The plot of residuals versus the fitted values shows that the residuals get smaller (closer to thereference line) as the fitted values decrease, which may indicate the residuals have non constant variance.

Residual Histogram for Loss:

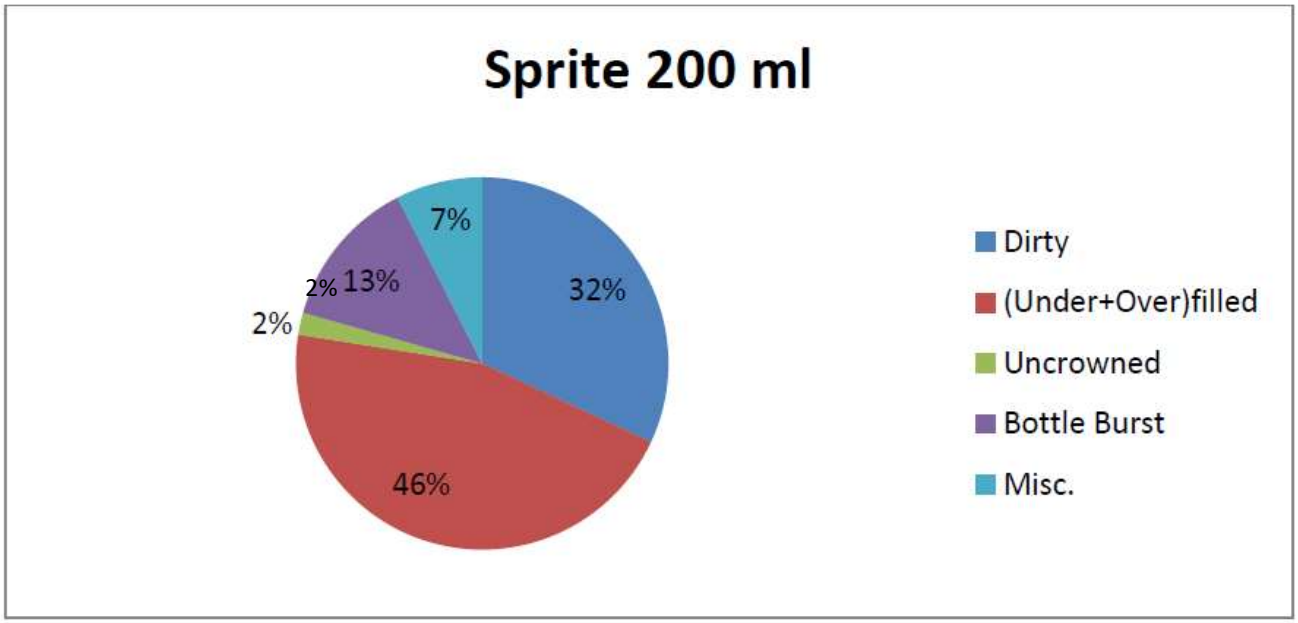


Residual Histogram for Loss

The histogram is showing the presence of outliers in the data shown by the extreme right handside bar.

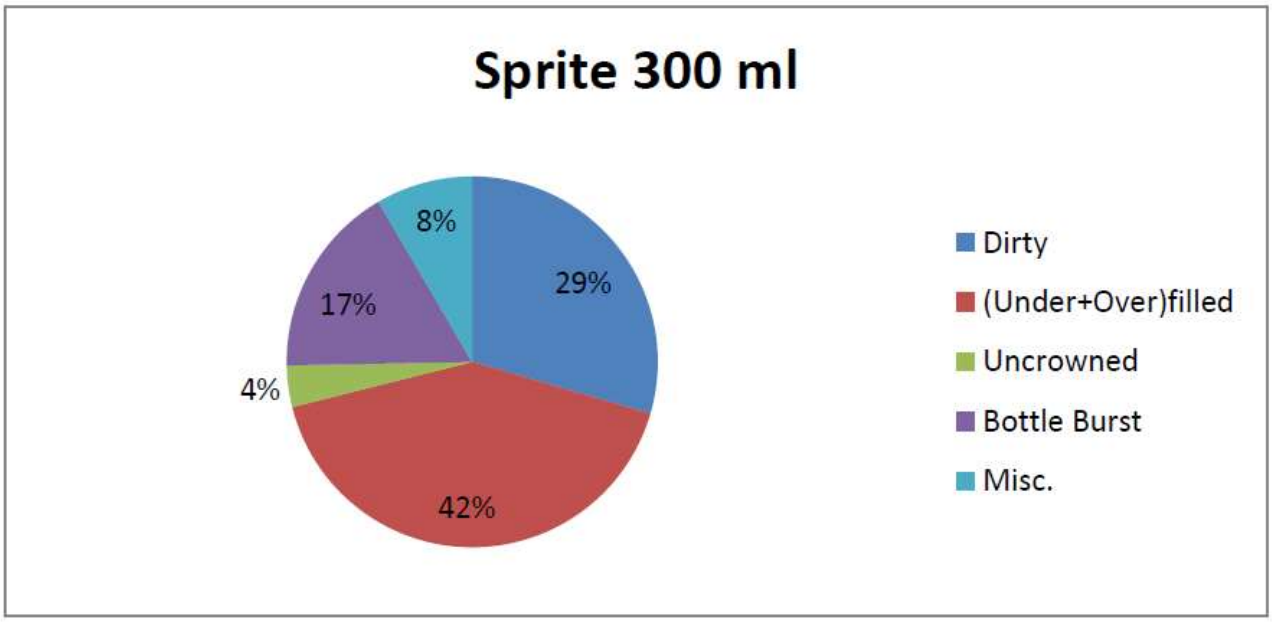
4.3. SKU wise analysis

1. **Sprite 200:**



: Pie Chart of beverage losses in Sprite 200MRP: Rs. 10/bottle
Planned Production: 70849
CasesActual Production: 70276
Cases Yield: 99.19%
Highest Contributors to Yield loss: (Under+Over) filled & Dirty bottlesOpportunity Cost: Rs. 1,37,520

2. **Sprite 300:**



Pie Chart of beverage losses in Sprite 300

MRP: Rs. 15/bottle

Planned Production: 18423

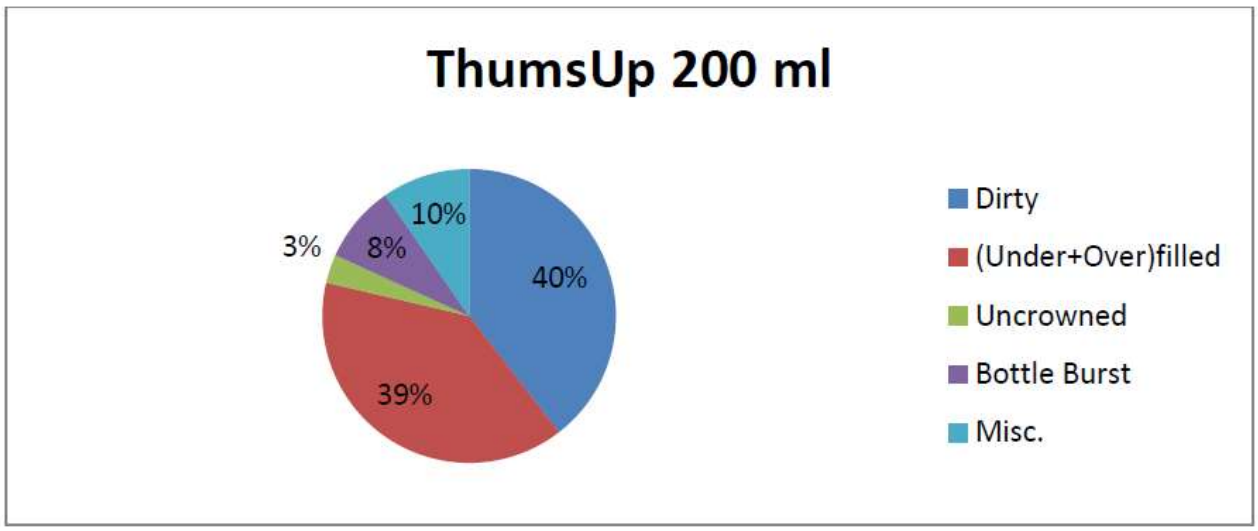
CasesActual Production: 18257

Cases Yield: 99.09%

Highest Contributors to Yield loss: (Under+Over) filled & Dirty

bottlesOpportunity Cost: Rs. 59,760

3. **ThumsUp 200:**



Pie Chart of beverage losses in ThumsUp 200

MRP: Rs. 10/bottle

Planned Production: 43122

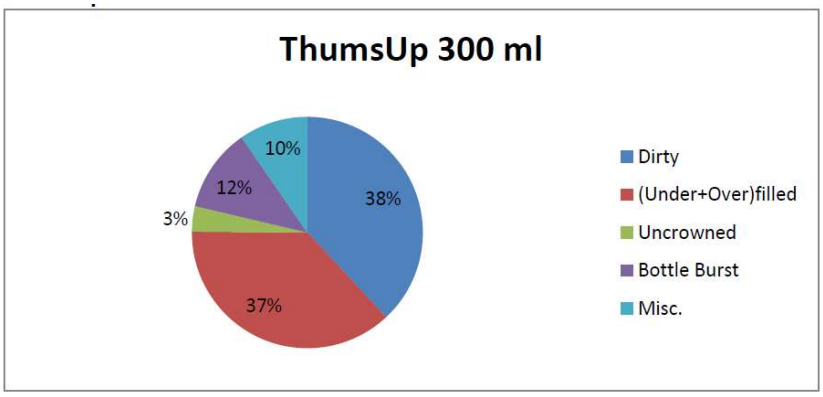
CasesActual Production: 42677

Cases Yield: 98.97%

Highest Contributors to Yield loss: Dirty bottles & (Under+Over)filled

Opportunity Cost: Rs. 1,06,800

4. ThumsUp 300:



Pie Chart of beverage losses in ThumsUp 300

MRP: Rs. 15/bottle

Planned Production: 19478

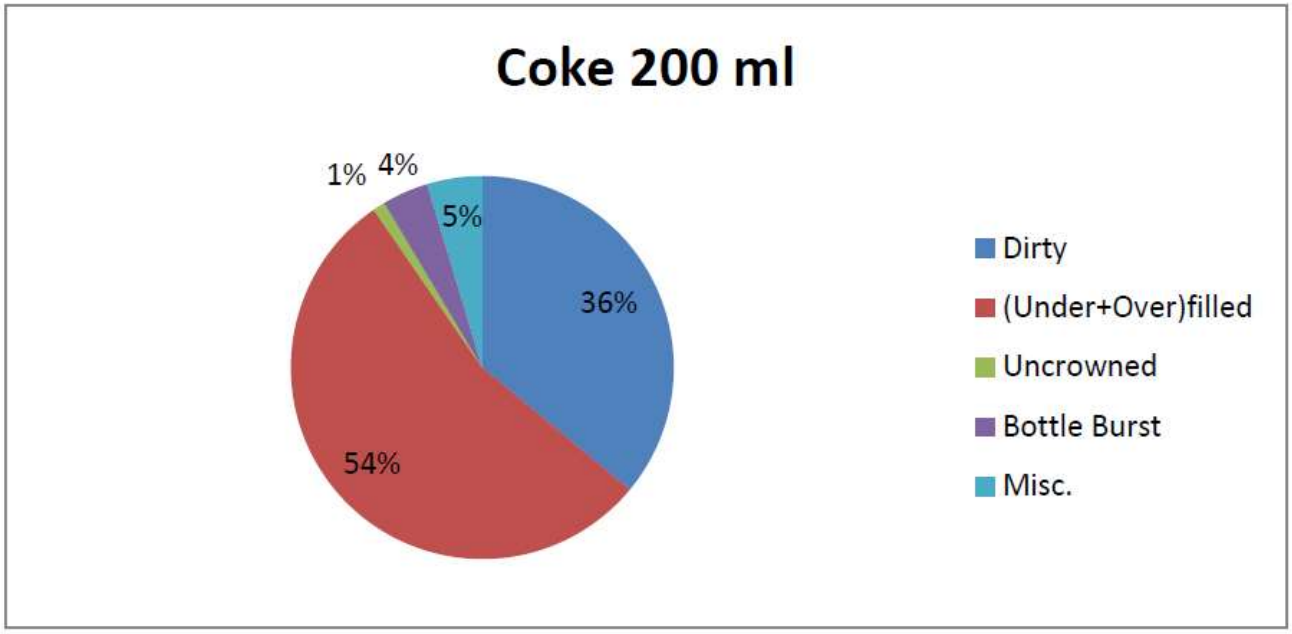
CasesActual Production: 19281

Cases Yield: 98.99%

Highest Contributors to Yield loss: Dirty bottles & (Under+Over)filled

Opportunity Cost: Rs. 70,920

5. **Coke 200:**



Pie Chart of beverage losses in Coke 200

MRP: Rs. 8/bottle

Planned Production: 21329

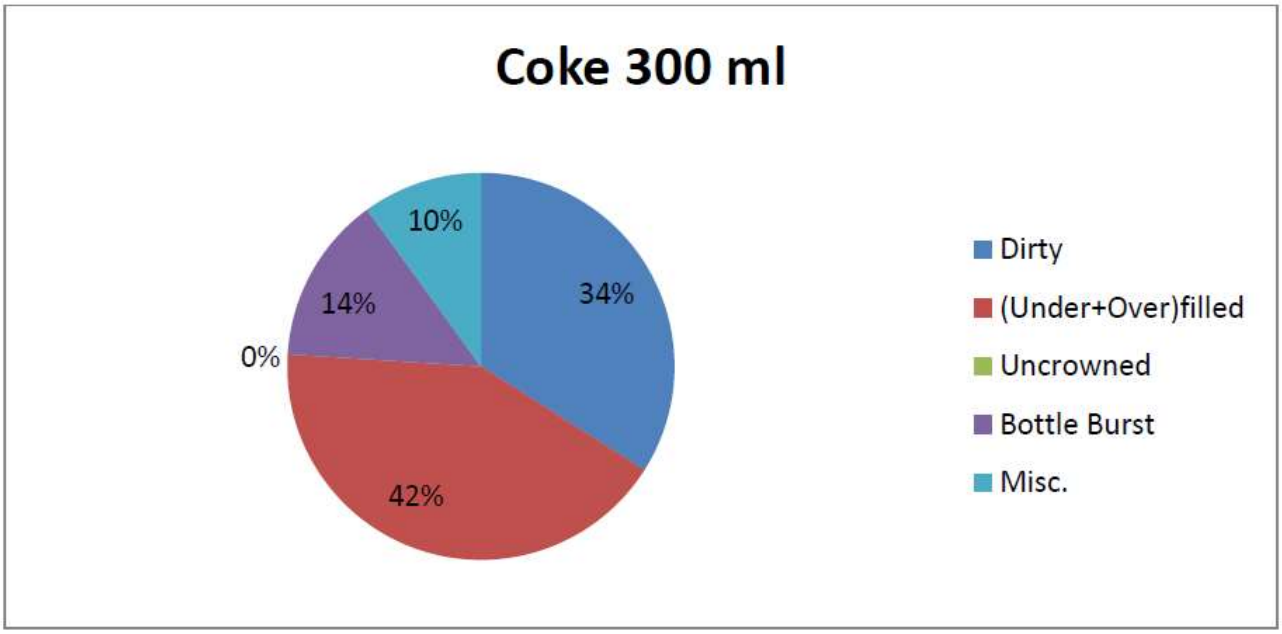
CasesActual Production: 20943

Cases Yield: 98.19%

Highest Contributors to Yield loss: (Under+Over)filled & Dirty

bottlesOpportunity Cost: Rs. 74,112

6. **Coke 300:**



Pie Chart of beverage losses in Coke 300

MRP: Rs. 15/bottle

Planned Production: 856

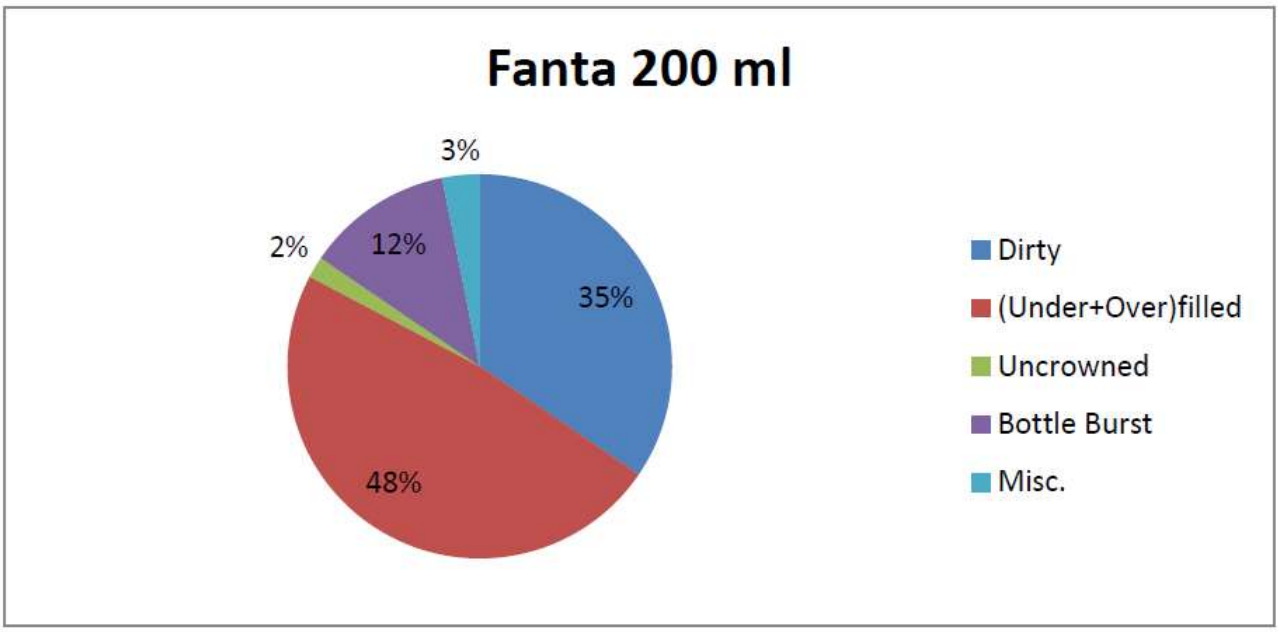
CasesActual Production: 806

Cases Yield: 94.16%

Highest Contributors to Yield loss: (Under+Over)filled & Dirty

bottlesOpportunity Cost: Rs. 18,000

7. **Fanta 200:**



Pie Chart of beverage losses in Fanta 200

MRP: Rs. 10/bottle

Planned Production: 17886

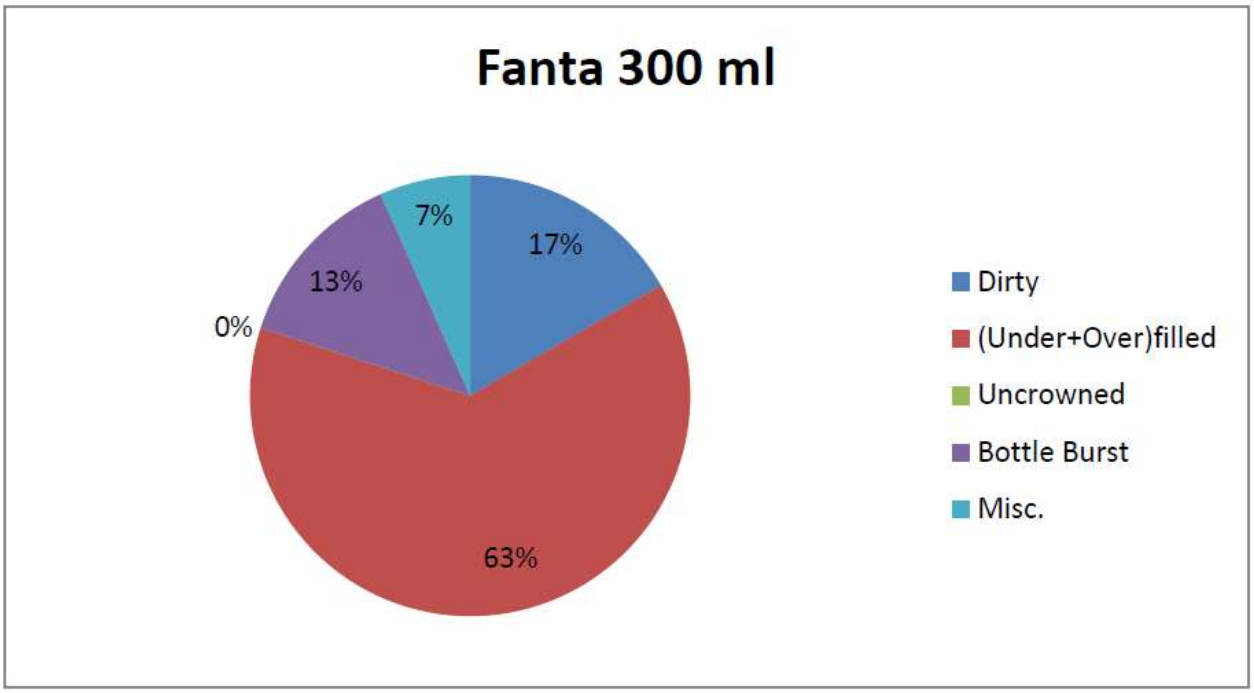
CasesActual Production: 17440

Cases Yield: 97.5%

Highest Contributors to Yield loss: (Under+Over)filled & Dirty

bottlesOpportunity Cost: Rs. 1,07,040

8. **Fanta 300:**



Pie Chart of beverage losses in Coke 300

MRP: Rs. 15/bottle

Planned Production: 2197

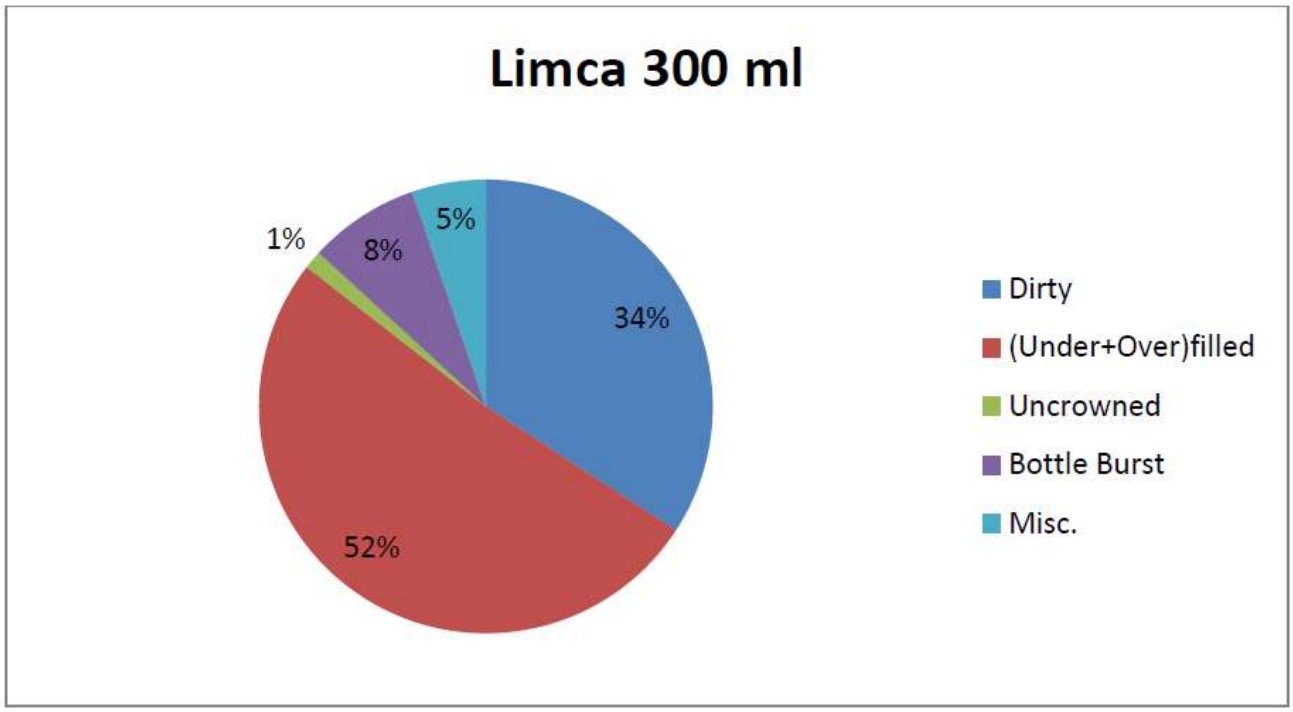
CasesActual Production: 2167

Cases Yield: 98.6 %

Highest Contributors to Yield loss: (Under+Over)filled & Dirty

bottlesOpportunity Cost: Rs. 10,800

9. **Limca 300:**



Pie Chart of beverage losses in Limca 300

MRP: Rs. 15/bottle

Planned Production: 3352

CasesActual Production: 3276

Cases Yield: 97.73%

Highest Contributors to Yield loss: (Under+Over)filled & Dirty

bottlesOpportunity Cost: Rs. 10,800

Inference:

1. Sprite 200, ThumsUp 200 & Fanta 200 are the fast moving SKU
2. Coca-Cola 300, Fanta 300 & Limca 300 are the slow moving SKU
3. Total Oppurtunity Cost of Rs. 5,95,752

4.4. Why Analysis

For Filler & Crowning Machine:

Table 4: Why Analysis - Filler & Crowning machine

S.N.	Problem	Indication	Why
1	Bottle Filling	Under Filling	Filler Valve Setting
2	Bottle Filling	Over Filling	Filler Valve Setting
3	Bottle setting in Filler	Bottle bursting	Bottle alignment, valve operation, Beverage filling pressure
4	Bottle Crowning	Uncrowned bottles	Crown jamming in crown chute line
5	Bottle Crowning	Uncrowned bottles	Crown unavailability in hopper
6	Bottle Crowning	Improper crowning	Crown jamming in crown chute line
7	Bottle setting in Crowner	Bottle bursting	Bottle alignment
8	Filler stoppages/drainage	Bottle bursting	Bottle alignment
9	Bottle Crowning	Chip neck at bottle	Bottle alignment

For ASEBI Machine:

Table 5: Why Analysis – ASEBI machine

S.N.	Problem	Indication	Why Why
1	Automated Inspection	SKU Logo Missing	ASEBI setting neglects SKU logo area
2	Automated Inspection	Wrong SKU bottle	ASEBI setting neglects SKU logo area
3	Automated Inspection	Dirty bottles	ASEBI setting neglects SKU logo area

5. Improve

5.1. Generic recommendations

5.1.1. Problem: Under filling and over filling of bottles

Observation:

During data collection process it has been observed that there are frequent incidencesof number of under filled and over filled bottles getting rejected at filled bottles inspection station.

Root Cause:

Bottle filling process consists of positioning, pre evacuation, pressurization and filling stages, which are majorly controlled by valve and vent tube operation. Any mismatch between preset specifications and available SKU results in improper functioning of fillingoperation.

Suggestion:

Define schedule for timely maintenance of filler machine and related subassemblies,which will ensure proper bottle filling operation.

Maintenance activities should include:

- Valve setting for beverage filling operation
- Vent tube setting
- Co2 pressure setting
- Bottle sealing

Appoint well trained and skilled Filler machine operator.

5.1.2. Problem: Dirty bottles at filled bottles inspection station

Observation:

It has been observed that there are number of dirty filled bottles getting rejected atfilled bottles inspection station, which leads to beverage loss.

Root Cause:

The current bottle washing & cleaning process is incapable of cleaning all dirt in some of the bottles. Dirty bottles observed at filled bottles inspection station are not segregated according to defect observed. There is high probability that these same bottles rejected at filled bottles inspection station remain dirty after one more run in bottle washer.

Suggestion:

Dirty bottles observed at filled bottles inspection station need to be stored separately,which can further undergo special process of cleaning in bottle washer.
In addition to this additional worker should be appointed at pre-inspection station to

identify incidences of extreme dirt.

5.1.3. Problem: Bottle bursting

Observation:

From data analysis calculations, it can be observed that bottle bursting leads to approx. 30% of total losses. This bottle bursting majorly occurs in bottle filling and bottle crowning operation.

Root Cause:

Bottle bursting in bottle filling and bottle crowning operation occurs due to various factors like filler speed, crowner gear setting, bottle platform setting etc.

Suggestion:

- Replace crowner transfer gear (Already implemented)
- Replace the crowner spider and SS pad
- Replace the in feed running track and guide
- Leveling of bottle platform
- Replace the out feed guide and spider

5.1.4. Problem: Uncrowned filled bottles- Crown Hopper Problem

Observation*:*

During data collection process it has been observed that there are frequent incidences of number of uncrowned filled bottles getting rejected at filled bottles inspection station. Although frequently 4-5 uncrowned bottles are observed coming in sequence out of crowner assembly, in some extreme cases this number goes beyond 15 bottles in sequence.

Root cause:

There are two major reasons for occurrence of this problem of uncrowned bottles-

a. Unavailability of crowns in hopper
b. Jamming of crowns in crown chute line passage

Maintenance of stock of crowns in hopper and its refilling is manual activity, which getsaffected by operator availability and in some cases operator negligence.

Suggestion:

A sensor can be installed in hopper assembly of crowner, which will ensure availability of minimum quantity of crowns in hopper. In case, crown level in hopper drops beyond certain limit, it will provide signal through alarm and stop crowner operation. Thismechanism will avoid beverage loss due to uncrowned bottles.

5.1.5. Problem: Uncrowned filled bottles-Crowner Problem

Observation:

During data collection process it has been observed that there are frequent incidencesof number of uncrowned filled bottles getting rejected at filled bottles inspection station. Although frequently 4-5 uncrowned bottles are observed coming in sequence out of crowner assembly, in some extreme cases this number goes beyond 15 bottles in sequence.

Root cause:

There are two major reasons for occurrence of this problem of uncrowned bottles-

a. Unavailability of crowns in hopper
b. Jamming of crowns in crown chute line passage

Maintenance of stock of crowns in hopper and its refilling is manual activity, which getsaffected by operator availability and in some cases operator negligence.

Suggestion:

A sensor can be installed at the output point of crowner assembly, which will check availability of crown on every filled bottle. In case of unavailability of crown for two bottles in sequence, it will provide signal through alarm and stop crowner operation. This mechanism will avoid beverage loss due to uncrowned bottles.

5.1.6. Problem: SKU Logo Missing from bottle

Observation:

During data collection process it has been observed that there are incidences of missing SKU logo from some of the bottles, which are then rejected at filled bottles inspection station leading to beverage loss.

Root Cause:

Due to rough handling of bottles SKU logo is damaged. Such bottles need to be rejected at Pre-inspection station before bottle washer. Due unskilled labour or labour negligence some of these bottles are passed on to RGB line and get rejected at filled bottles inspection station.

Suggestion:

Proper training needs to be provided to labour working at Pre-inspection station toidentify SKU logo missing bottles.

5.1.7. Problem: Wrong SKU bottle

Observation:

During data collection process it has been observed that there are incidences of wrong SKU bottles getting filled, which are then rejected at filled bottles inspection station leading to beverage loss.

Root Cause:

During unloading operation at yard sometimes different SKU bottles get mixed. Such bottles need to be rejected at Pre-inspection station before bottle washer. Due unskilledlabour or labour negligence some of these bottles are passed on to RGB line and get rejected at filled bottles inspection station.

Suggestion:

Proper training needs to be provided to labour working at Pre-inspection station toidentify different SKU bottles.

5.2. SKU wise recommendations

5.2.1. SKU: Fanta

Problem: Bottle burstingObservation:

From data analysis calculations, it can be observed that bottle bursting leads to approx. 30% of total losses. This bottle bursting majorly occurs in bottle filling and bottle crowning operation.

Root Cause:

Since the introduction of Fanta product there have been different suppliers of new bottles, which resulted into minor deviations in bottle design. Due to difference in sizes of bottles and inability of filler machine to accommodate these deviations bottles get broken.

Suggestion:

Define specifications in filler machine to accommodate size deviations of different supplier bottle.

5.2.2. SKU: Limca

Problem: Dirty bottlesObservation:

From data analysis calculations, it can be observed that dirty bottles lead to approx. 35%of total losses.

Root Cause:

Due to lesser market demand and seasonality Limca is produced less frequently.

Thisresults in storage of bottles for longer duration leading to accumulation of more dirt.

Suggestion:

Bottle washing process should be modified for Limca bottles to clean all types of dirt.

5.3. Project Impact

Currently the yield of HCCBPL, is 98.8 % and incurs a loss of 1.2 %.

E.g. Average daily production = 7900 Cases

Average daily production (theoretical) = 7992 Cases

Average daily difference = 92 Cases = (92*24 bottles) = 2208 bottles

Avg. loss = 2208*300 (days) = 662400 bottles

Yearly loss = 662400*10 = Rs. 6624000

It is very difficult to achieve 100% Concentrate Yield due to inherent losses in the system. But if recommendations mentioned above are implemented successfully then the yearly loss which atpresent amounts to Rs. 66.24 lacs can be reduced significantly.

References

1. Six Sigma Study Material by KPMG India
2. http://www.isixsigma.com/
3. http://www.sixsigma.in/
4. http://www.whatissixsigma.net
5. www.coca-cola.com