



Process Improvement Studies at Paramount Nutrition Pvt. Ltd.,

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PROJECT REPORT INFO

Received 10th May 2024,

Accepted 25th May 2024,

www.esrapublications.com

ABSTRACT

The project is carried out in M/s Paramount Nutrition Pvt. Ltd., located in Bidadi, Bangalore during 2020-2021. Paramount Nutrition Pvt. Ltd., are contract manufacturers for Britannia and produce six variants of Biscuits. As soon to be Industrial Engineers we were driven by the motivation to work in the Food Processing Industry to increase our on-field expertise and to better understand the work carried out by an Industrial Engineer. Our work and analysis is focused on a single line of manufacturing and packing which produces two of the variants *i.e.*, Good Day Butter and Good Day Cashew and Almond. Kick-starting any project first requires thorough understanding of the work area along with necessary research. So, we first started by understanding the working of the facility. As members carrying out the Project in the facility, the Manager required us to carry out thorough research on the organization and provide any valuable insights possible to the organization.

We then decided to follow a structured methodology to better understand the problems that are present and to find ways of countering these problems. So, the DMAIC approach was chosen. We started with the Define phase by stating the problem statement which was for us to set goals for the organization on waste reduction by analyzing factors that affected efficiency *i.e.* Downtime, Scrap and Reusable Defects. So, our Measure phase comprised of collecting Downtime data and Defects data to provide any observations noticed. Downtime data produced by the organization proved insufficient leading us to change the method of recording. So, a new form for recording Downtime Data was produced. Defects data was analyzed using Pareto Chart Analysis, leading us to an observation that maximum defects are produced in packaging. Hence, in the Analyze phase, Sigma Process Levels for Packaging and Manufacturing are calculated. Following that, in the Improve phase monthly goals are given to the organization for an improved Process Sigma Level in Packing and Manufacturing. To achieve these goals, Root Cause Analysis is carried out on the defects, followed by suggesting improvements. In the Control phase the improvements suggested should be considered by the organization and the system established should be controlled to achieve the goals suggested.

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**DEPARTMENT OF INDUSTRIAL ENGINEERING AND
MANAGEMENT**

**PROCESS IMPROVEMENT STUDIES AT
PARAMOUNT NUTRITION PVT. LTD.,**

PROJECT REPORT

Submitted by

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**In partial fulfillment for the award of
Degree of
Bachelor of Engineering
in
Industrial Engineering and Management
2020-2021**

RV COLLEGE OF ENGINEERING[®], BENGALURU-59
DEPARTMENT OF INDUSTRIAL ENGINEERING AND MANAGEMENT



CERTIFICATE

Certified that the major project work titled '*Process Improvement Studies at Paramount Nutrition Pvt. Ltd.,*' is carried out by **Gaurav Prabhu (1RV15IM018)**, **Mohamed Shihab (1RV15IM067)**, **Prashanth Reddy (1RV17IM042)** and **Risha Patil (1RV17IM064)** in partial fulfillment for the award of degree of **Bachelor of Engineering in Industrial Engineering and Management** of the Visvesvaraya Technological University, Belagavi during the year 2020-2021. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the major project report deposited in the departmental library. The major project report has been approved as it satisfies the academic requirements in respect of major project work prescribed by the institution for the said degree.

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17th June 2021

CERTIFICATE

This is to certify that the below Students were an intern with us.

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Student of BE 8TH Sem in Industrial Engineering and Management From RV College of Engineering, They have successfully completed their internship in our esteemed organization on the topic of "PROCESS IMPROVEMENT STUDIES" from 22-01-2021 to 15-06-2021.

During this period their conduct and character were good. We wish them all success in their future endeavors.

For Paramount Nutritions India Pvt Ltd.


Authorized signature

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DECLARATION

We, **Gaurav Prabhu, Mohamed Shihab, Prashanth Reddy and Risha Patil** students of eighth semester B. E., Department of Industrial Engineering and Management, RV College of Engineering, Bengaluru-59, hereby declare that the major project titled '***Process Improvement Studies at Paramount Nutrition Pvt. Ltd.***' has been carried out by us and submitted in partial fulfillment for the award of degree of **Bachelor of Engineering in Industrial Engineering and Management** during the year 2020-2021. We do declare that this work is not carried out by any other student for the award of degree in any other branch.

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ACKNOWLEDGEMENTS

We are indebted to our guide, **Ms. Nandini. B**, Assistant Professor, **Dept. of IEM, RVCE** for her wholehearted support, suggestions and invaluable advice throughout our project work and help in the preparation of this Report. We would also like to extend our gratitude to **Mr. B. R. Deepak, Paramount Nutrition Pvt. Ltd., Bengaluru** for his guidance in the essentials of the project.

Our sincere thanks to **Dr. C. K. Nagendra Gupta**, Professor and Head, Department of Industrial Engineering and Management, RVCE for his support and encouragement.

We also express our gratitude to our panel members **Dr. N. S. Narahari**, Professor, and **Dr. Rajeswara Rao K. V. S**, Associate Professor, Department of Industrial Engineering and Management for their valuable comments and suggestions.

We express sincere gratitude to our beloved Principal, **Dr. K. N. Subramanya, RVCE** for his appreciation towards this project work.

We thank all the **Teaching Staff and Technical Staff** of Industrial Engineering and Management department, RVCE for their help.

Lastly, we take this opportunity to thank our **family** members and **peers** who provided all the support throughout the project work

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Acronyms

1. *SOP – Standard Operating Procedure*
2. *TPM – Total Productive Maintenance*
3. *TQM – Total Quality Management*
4. *HACCP – Hazard Analysis and Critical Control Points*
5. *DMAIC – Define Measure Analyze Improve Control*
6. *QC – Quality Check*
7. *FS – Floor Sweepings*
8. *MD – Metal Detected*
9. *RM – Raw Materials*
10. *FG – Finished Goods*
11. *PQI – Product Quality Inspection*



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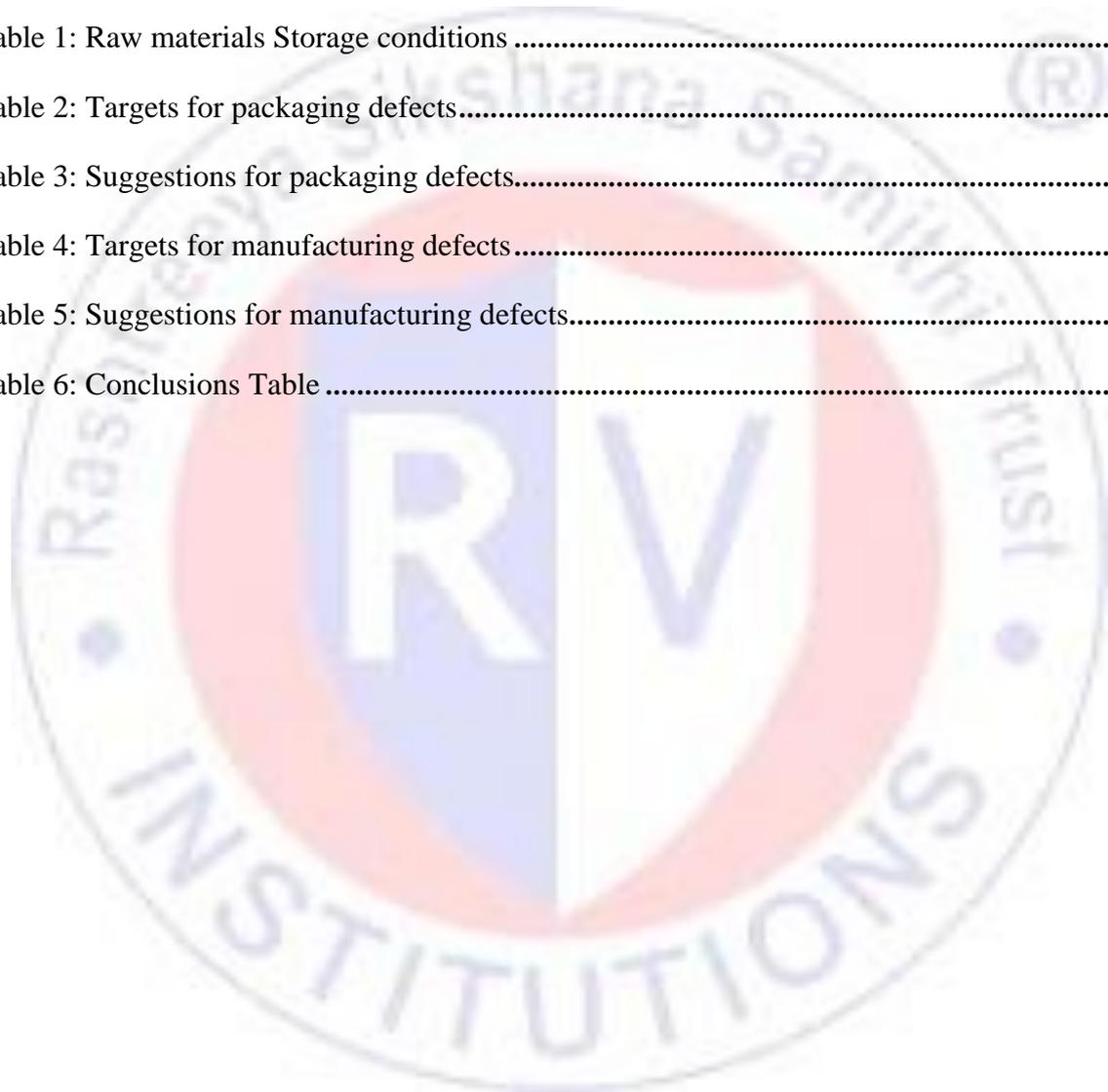
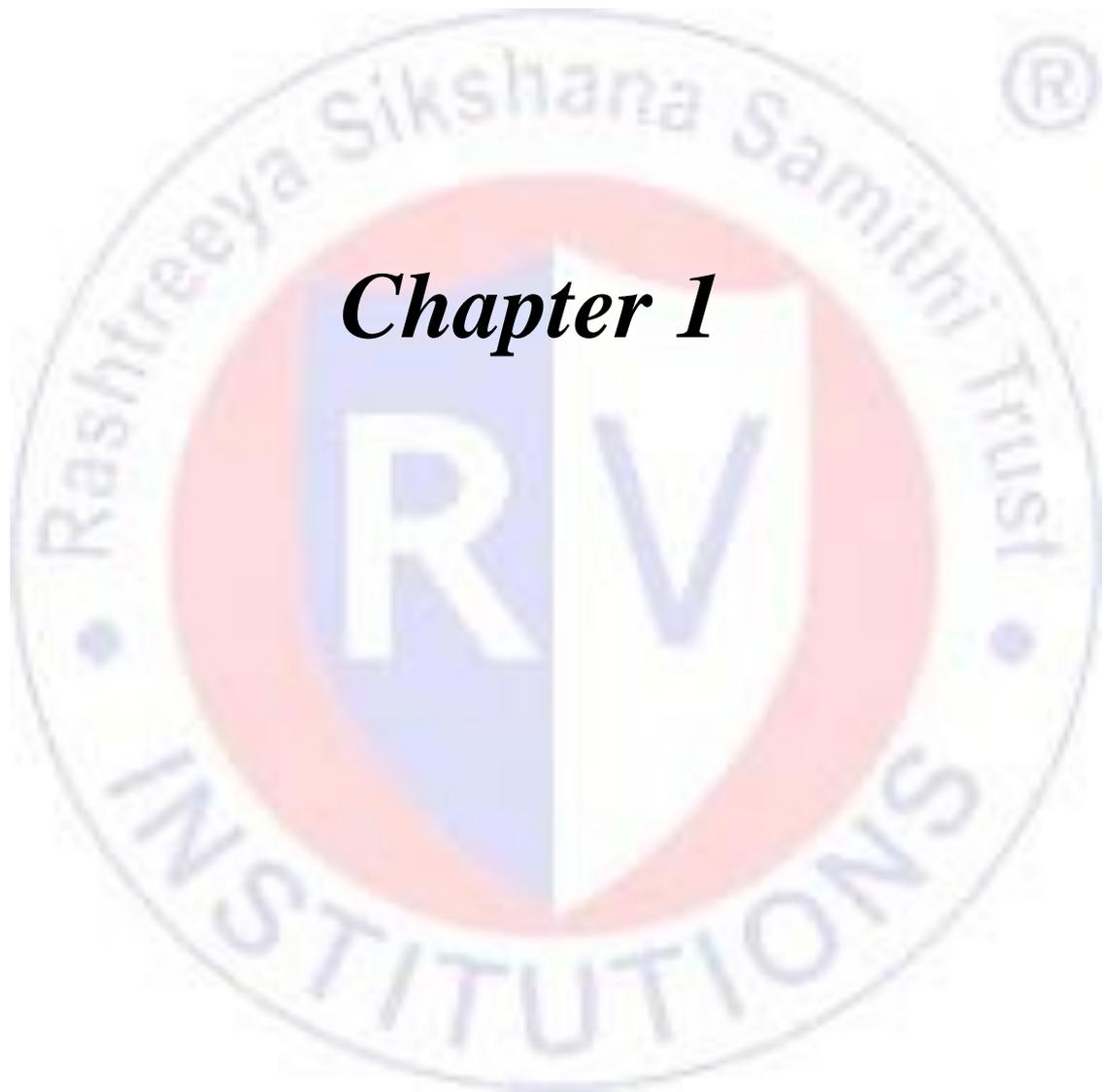


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Chapter 1

INTRODUCTION



Figure 1: Company Logo

1.1 Organization profile: Paramount Nutrition Pvt. Ltd.

Bangalore based Paramount Nutritions is a success story of two friends from divergent backgrounds. One fine morning, Mr. B. Krishnappa & Rakesh kumar Agarwal thought of venturing into entrepreneurship to do something challenging. They decided to plunge into the food processing sector. All they have was an unflinching commitment to good business practices and set benchmarks to deliver unquestionable quality. They set up a unit and decided to make biscuits. They impressed upon the biscuit giant 'Britannia' that all they has was a commitment to time and quality. Soon their enterprise became the most-preferred business partner of Britannia. There was no looking back since. Today, they manufacture the premier line of biscuits for Britannia. They now have an eye on the global majors to embark on large-scale expansion program.

They started with manufacturing Glucose Biscuit (Tiger Brand) and soon our efforts were recognized & encouraged by Britannia. They went on to add one more line and increased the production capacity. The main reason of their success is their capability to deliver the right quality product with target of zero error. This trait has helped them become the most preferred unit for Britannia. They are proud to say that the journey they started not long ago carried their determination to deliver the best quality and no compromise whatsoever and they knew that their unflinching commitment will make them stand out to face any competition.

Manufacturing of food products is always a challenging duty. They need to maintain consistent quality in the procurement of raw materials and process control. Maintaining right color, right appearance, right flavor, right taste, correct packing etc. are very important till the end product is consumed. With consumer democracy reaching new levels in recent times there has been a large

paradigm shift in lifestyle and awareness on health. People are increasingly becoming conscious of dietary care its correlation to wellness and matching the new pace to their lives with improved nutritional and dietary habits, over and above the health and nutrition they are the business partner for Britannia Industries Limited.

The products that are being manufactured with them are fortified with vitamins & micro nutrients which are making them march towards the elimination of malnutrition from the society.

They strictly adhere with process and quality standards set by Britannia and always believe in delivering quality, nutrient and healthy products to consumer to match Britannia's punch line "**Swasth Khao Tan Man Jagao**" (**Eat Healthy, Think Better**). They prefer quality rather than quantity. **Quality is the only mantra to move ahead of other competitors in the field.** They are delivering high quality products since last 5 years with lowest consumer complaints.

Journey to Manufacturing Excellence

- Strengthening process SOPs to address quality non negotiable
 - Right color
 - Right appearance
 - Correct weight of packs
 - No missing codes on packs
 - No breakages
- Implementation of HACCP / ISO 22000:2005
- Driving TPM pillars
 - Kaizen
 - Autonomous maintenance

Journey to success

- Implement TQM philosophy in problem solving
- Adhering to Britannia systems and process
- Continuous monitoring of process and product to achieve continual improvement
- Customer focus
- Preventive maintenance

- Periodic review of performance
- Involvement of ground level workmen
- Employee training and engagement
- Wastage monitoring and reduction

The standards maintained by the company are quite impressive, and to maintain the standards it's important to have policies and strictly adhere to them. A brief of some of the policies has been discussed in *Appendix 1*.

1.2 Motivation for research

As soon to be Industrial Engineers we were driven by the motivation to work in the Food Processing Industry to increase our on-field expertise and better understand the work carried out by an Industrial Engineer. Upon visiting the industry we got a better idea of the processes involved and the industrial principles followed by the facility. We were required to carry out a thorough analysis on the processes and give any valuable insights obtained to the organization. So we decided to follow a structural methodology to carry out the project using the DMAIC approach which will be discussed in detail in chapter 3. This led us to obtaining observations on data collected using the required charts and giving goals to the organization to help achieve lower defect rates. The work carried out helped us better understand the role of an Industrial Engineer.

1.3 Problem Statement

Provide goals to the organization for waste reduction by analyzing the factors that affect efficiency - Downtime, Scrap and Reusable Defects, and giving insights obtained for improvements.

1.4 Objectives

To achieve the statement as per the problem definition, our project objectives were broken down as under:

- Observe the functioning of the organization

- Collect data required and analyze it to understand opportunities for waste reduction
- Find the current sigma level at which defects are being generated
- Provide goals for the organization to achieve in a periodic manner to help reduce the waste
- Suggest ways to achieve the goals

1.5 Brief methodology

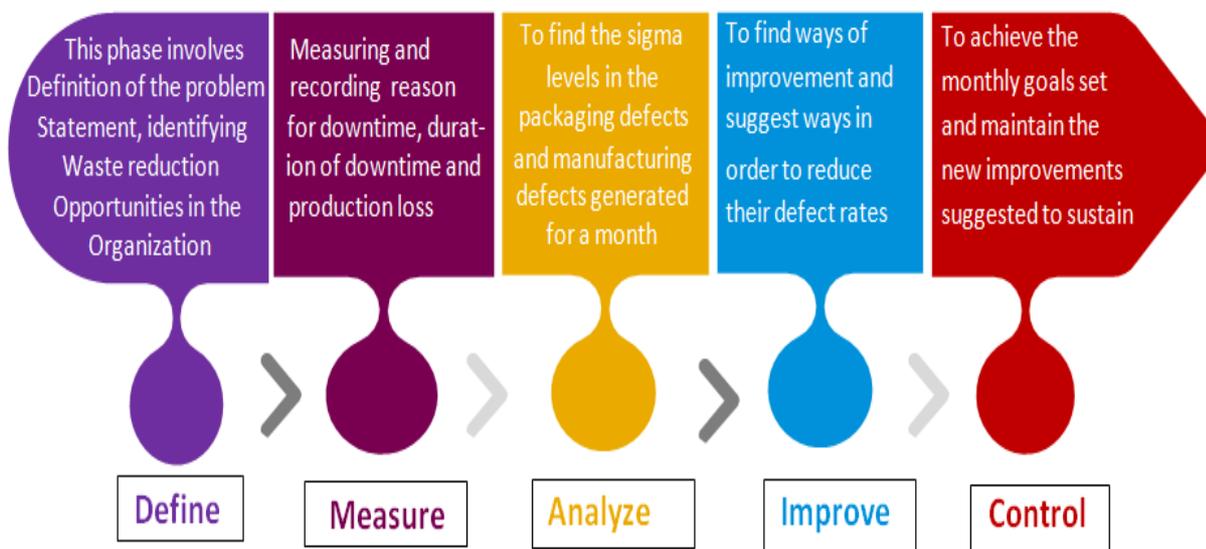


Figure 2: Methodology adopted

The DMAIC methodology is adopted, hence, the project is carried out in five phases which are explained in detail in chapter 3. The five phases are as under:

Define Phase: This phase involves definition of the problem statement, and as mentioned earlier our problem lies in providing goals to the organization for waste reduction by analyzing factors that affect its efficiency – Downtime, Scrap and Reusable defects. This phase starts with understanding the processes carried out in the facility.

Measure Phase: Data required for drawing observations on the Downtime and Defects occurring at the facility is obtained. After the data filtering process, the data is shown using charts or diagrams for data visualization. Based on the visuals, further examination is done to observe if the data has certain trends or key observations to be noted. This phase helps us decide on the factors to be analyzed in the Analyze phase.

Analyze Phase: Thorough analysis is carried out in this phase on the factor(s) that proved required attention from the Measure phase. Packaging defects and Manufacturing defects are analyzed separately using control charts to see if the defects are generated in a normal way, or if there is an anomaly to be noted. The anomalies are noted and further examined. The process sigma levels for Packaging defects and Manufacturing defects are calculated for a month's production. So, it provides us an opportunity to provide monthly goals for the organization in the Improve phase.

Improve Phase: After finding the defect levels for manufacturing and packaging, monthly goals are given to the organization to reach a defect level of 5σ . This involves monthly reduction of the defect rates in a step-by-step or systematic manner until the required defect rate is reached. To achieve this causes for the defects are analyzed using a Fishbone diagram. Each cause is then provided with a suggestion for change or improvement.

Control Phase: After providing the goals, suggestions and insights it is up to the organization to consider our input and make the changes they feel is required to achieve the monthly goals set for reducing defect rates. Upon reaching the goal set, it is essential for the organization to then maintain the new system established for keeping the defect rate under control at the new level that is reached.

1.6 Organization of the Report

The report is divided into different chapters that starts with the introduction and then moves on to talk about the methodology in which the project is carried out.

Chapter 1 deals with the introduction of the company i.e. Paramount Nutrition Pvt. Ltd. Their journey and profile is talked about. Then the objectives of the project and methodology of the product is talked about in brief. This chapter also contains the literature review of the project.

Chapter 2 talks in detail about the process of manufacture of biscuits that's incorporated at the organization. This chapter gives a better understanding or perspective of the processes and tools involved in the manufacturing and packing process. Therefore, it helps readers get a better idea about the improvements suggested in the Improve Phase.

Chapter 3 discusses the DMAIC process adopted. Here, each phase is explained in detail and the figures and tables related to the studies carried out are depicted. The observations drawn from the figures are explained in the phase discussions. This chapter also shows the results obtained based

on the methodology followed and the work carried out.

Chapter 4 talks about the overall results or understandings from the project work carried out. It discusses these results along with mentioning the future scope of the project. The conclusion drawn and the project outcome are to be seen in this chapter.

1.7 Literature Review

A Literature Review is a systematic and comprehensive analysis of books, scholarly articles, and other sources relevant to a specific topic providing a base of knowledge on a topic. It has two elements. First, it should concisely summarize the findings or claims that have emerged from prior research on a subject. Second, a literature review should reach a conclusion about how accurate and complete the knowledge is; it should present your considered judgments about what's right, what's wrong; what is inconclusive and what is missing in the existing literature. It can enable you to place your research in a larger context, so you can ensure what in your audience my context, so that in your conclusions my up context you are sure what new conclusions might result from your research.

A paper by Finsaria Fidiyanti and Novie Susanto titled Analysis of the cause of the defect packaging of capsule products using six sigma has taken up a case study of PT SM, a company engaged in the field of herbal medicine processing. This research paper aims to manage the amount of defective packaging of capsule products in the department of capsule products at PT SM. It is important because the number of defective packaging of capsule products is high and exceeds the limits of maximum, i.e. 5% of the total production. In addition, the defective packaging of capsule products cannot be reworked and will cause losses in terms of time and finances. This research uses the Six Sigma method to find out the capabilities of the production process from the defective packaging of capsule products. Application of the method of Six Sigma through the DMAIC process to eliminate the number of defective products and Fishbone diagram is used to identify the cause of the defect and provide recommendations on improvements to the production process. The data for this research is the amount of production, defective packaging of capsule products and interviews with the department of quality control, department of capsule product and operator. Data processing using Six Sigma methods showed that the value of sigma is 3.14 (sigma) with the number of DPMO is 2795.202. Using fish bone there are 9 causes of defective packaging of capsule products. With the help of case study this paper outlined a clear picture on eliminating defects while packaging and

also helped us in drawing out the fishbone diagram for manufacturing defects as well as packaging. The Fishbone diagram we used can be found under the Improve phase of chapter 3. [1]

A paper by Yash N. Jaiswal and Vikram R. Khanzode titled Defect Rate Reduction in Biscuit Production Industry using SPC Technique explains variability in a manufacturing process that causes defects in the final products which in turn hampers quality, productivity, profitability, and ultimately, the customer satisfaction. The main objective of this study is to minimize the defect rate and variability in the final product, i.e. biscuit packages, by using Statistical Process Control (SPC) tools in a biscuit production unit thereby increasing its productivity, profitability and competitive advantage in the market. Several problems in production have been scrutinized by using SPC tools like Pareto analysis, Cause-and-effect diagrams, attribute control charts (p-charts) and process capability analysis. For the sake of this study, several types of defects from two main categories have been considered namely biscuit defects and packaging defects. On executing the Pareto analysis, three most contributing types of defects were found which when summed up constituted approximately 82% of the total defects. These defects are Breakage (41%), Blisters (26%) and Off registration (15%). For the above-mentioned defects, cause-and-effect diagrams were constructed to pin point towards the possible root causes of those problems. On the basis of these root causes, certain improvements were recommended. Attribute control charts were plotted and process capability analysis was carried out for data of proportion of defects collected before and after the improvement recommendations were implemented. It was found that the process of production went from being erratically out of control to being well within the control limits after the improvement recommendations were implemented. Hence, the application of SPC tools in regularly monitoring the production processes for defects is extremely effective in improving the productivity and profitability of a production unit. This paper played a pivotal role in analyzing the defects using control charts and pareto charts where the total defects generated is split into various sections of the line where the defects are generated to get a better idea of the cause. The pareto chart used can be found in the Measure phase under chapter 3. This Pareto chart is used to see which section of the line the most defects are generated in. By doing so, we were able to prioritize the section on which the focus will be shifted towards in the Analyze phase. [2]

Extensive research has been done in the field of improving the process of the biscuit production through the DMAIC process improvement model. The cause of some problems are going to be really obvious and we can jump right into it fix them but other problems are going to be much more complex and for these type of problems we need a structured way of problem solving approach this

is where DMAIC comes in, Now as we know DMAIC stands for define, measure, analyze, improve and control it is a data driven iterative approach that you can use improve a process or fix a problem and DMAIC is a core part of the six sigma quality improvement methodology which mainly deals with business management strategy and aims to improve the process by removing variations and errors in both manufacturing and business processes. For the purpose of our study we went through some important journals and conference proceeding papers.

A paper by Nitin Upadhye, S. G. Deshmukh and Suresh Garg titled Lean manufacturing in biscuit manufacturing plant have taken up a case study in a medium sized biscuit manufacturing plant which is studied under the framework of lean manufacturing system and observed that 5S, kaizen, quick changeover, TPM and TEI are some of the tools, which can be effectively used to improve equipment availability, reduce wastage of material and improve quality. Objectives of implementation of LMS was to improve productivity by minimising waste, improve quality, reduce material wastage, shorten the lead time, reduce the in-process and finished goods inventory, proper utilisation of available space, and improve machine availability. Barriers to achieve lean processes where workers have a low literacy, knowledge, skills, and confidence level, low motivation, High breakdowns: The total time available per month is 1125 hours (375 hours per plant). Operational inefficiency, High level of inventory, Wastage of raw materials, High set-up time, and Poor quality due to in-process rejection, High breakage and expiry date items from market. Around 20% products are returned from market on account of damage and attainment of expiry date. These returned goods are sold at negligible price as an animal feed, Redesign of Marketing strategy was suggested. This paper helped us in defining and identifying the main points occurring in the industry. [3]

“Process and efficiency control in biscuit manufacture” D. Manley, Consultant, Duncan Manley Ltd, UK and M. Wilkes, MW Associates, UK. In this paper it states that Biscuit manufacturing involves a series of processing events that are dependent on the preceding one. It emphasizes on the importance of constantly monitoring the processes, either manually or with instruments is essential to keep production running smoothly. It also tells us how the inadequate process control leads to out-of- specification products and waste of materials, power, labour and time. A key business measure examined was overall effective efficiency (OEE) which measures the overall efficiency of a manufacturing plant. It reveals quality output as a percentage of what the plant can produce if there was no downtime, waste or loss of production. Manufacturing efficiency and business profitability is impacted on by the choice of plant and the ability of the manufacturing team to get the best from it. Process control plays a major role in managing the equation. This benefited us in

clearly understanding the processes involved in a biscuit manufacturing industry. [4]

A paper by Ahmad Mukti Almansur, Sukardi and Machfud titled *Improving performance of biscuit production process through lean six sigma at PT XYZ*. This research aims to analyze waste or loss using the 7-waste approach and value added/non value added activities in the production process at PT. XYZ. This research also aims to evaluate the production process capability and sigma values at PT. XYZ and used the DMAIC technique (Define, Measure, Analysis, Improvement, and Control) from Lean Six-sigma with an analysis using Failure Mode and Effect Analysis (FMEA). The results of the research obtained the values of Process Cycle Efficiency (PCE) of 47.29%, CTQ (Critical to Quality) and process capability value in the form of Cpm (Capability Index) for each process stage and yield. Line-5 has a DPMO (Defects per Million Opportunities) value of 29,632,607 with a Sigma Score 3.39, and FMEA (Failure Mode and Effect Analysis) analysis resulted in recommendations for improvement at each process stage. This paper helped us in implementing the DMAIC process as well as identifying the critical points for packaging and manufacturing which in turn helped us in evaluating the process sigma level. [5]

A paper by P. D. S. H. Gunawardane and P.T.R. Dabare titled *A Signature Based Approach for Quality Checking of Biscuits* explains that quality checking is a major aspect in production. Fatigue and boredom are major parameters of human involved operating which causes efficiency and productivity. Therefore, Biscuit manufacturing industries have to overcome these situations through finding novel ways and methods for their human involved quality inspection systems. This paper proposes a computer vision based quality checking system for the biscuit manufacturing industry. A signature based quality inspecting system was introduced with a backlighting system to identify cracked biscuits which are coming out from a biscuit oven. A biscuit quality parameter value was introduced to the system, either can be programmed according to the quality requirement or an intelligent control approach could be introduced. Also, this project addresses the possible noise additions in real industrial situations and the filtering of it. The use of backlighting reduced the accuracy of identifying surface cracks by 10% for biscuits. This can be improved by front lighting or the use of strobe lighting which are application dependent. This methodology was tested under static conditions and can be altered and improved for moving biscuits on a conveyor. Also introducing an intelligent approach for the variation parameter will make this system more robust. This paper mainly helped us in understanding the different parameters of human fatigue involved while operating which causes efficiency and productivity and how human fatigue can lead to error in quality checking before packaging. [6]

“Management and optimization of production lines of a food industry” by Raquel Nunes Dias talks about how it is important to increase the value of an organization’s products and services for the organization to sustain in a competitive environment. The work here is carried out in Cerealto Sintra Foods plant in Mem Martins, Portugal. Here, the goal was to optimize two production lines in the industry using lean six sigma methodologies. 5S and DMAIC are the tools adopted to carry out the project. 5S allows for a clean and organized work environment, and other advantages. The DMAIC cycle is used to decrease the number of stops per hour of critical equipment from the packaging zone of the 5th line which is the carton machine. However, the number of stops per hour could not be decreased here. This paper gives us an added idea along with the other papers for carrying out the DMAIC cycle. [7]

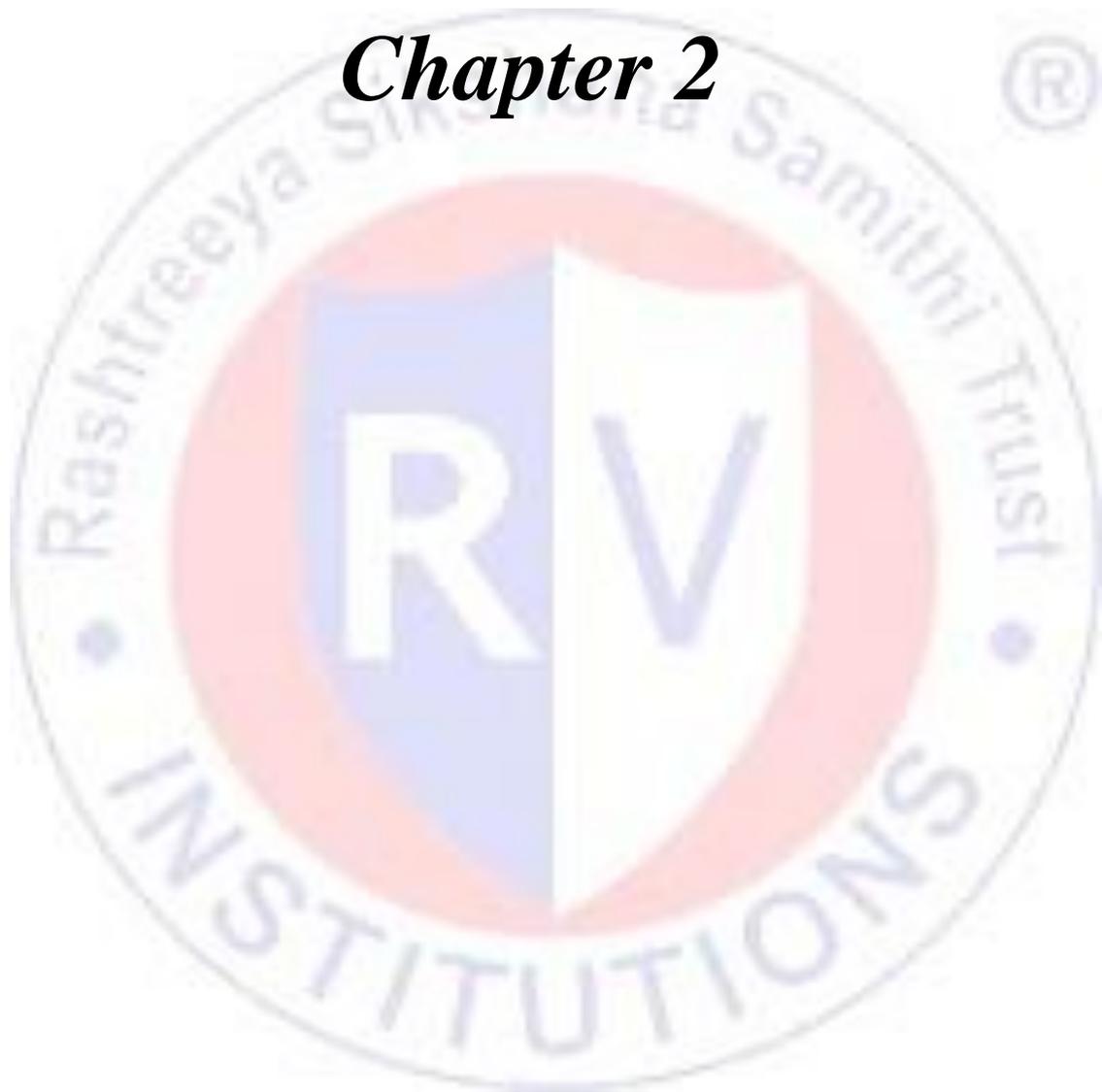
Fatima Carneiro’s and Americo’s Azevedo’s paper titled “ A Six Sigma Approach Applied to the Analysis of Variability of an Industrial Process in the Field of the Food Industry” throws light on the fact that it is important to ensure that key process variables and parameters are within the specification limits in a high-volume production environment such as biscuit manufacturing industry. Here, it is discussed that thickness and weight of the biscuit are two of the most important quality characteristics for the product. So, the paper revolves around reducing variability and overweight to improve profitability for the organization. In this paper too a six sigma approach is used to achieve the goals. The paper gives us an idea on how to choose factors to achieve the goals while carrying out a project. [8]

A paper by Hsiang-Chin Hung and Ming-Hsien Sung titled “Applying six sigma to manufacturing processes in the food industry to reduce quality cost” talks about the DMAIC approach they use to solve an underlying problem of reducing process variation and the associated high defect rate. It explores how a food company in Taiwan can use a systematic and disciplined approach to achieve the six sigma level. Defect rates of small custard buns were reduced by 70% as the defect rate was reduced from 0.45% to 0.141% over a period of six months. It helped us realize the necessity of periodic or monthly improvements. [9]

“Application of Lean Manufacturing Tools in the Food and Beverage Industries” by Rui Borges Lopes, Filipa Freitas and Ines Sousa talks about the implementation of Lean Manufacturing principles and tools in industrial sectors. Here, application of some LM tools in two Portuguese

food and beverage industries is shown. Through the project a significant improvement is made in both industries, by reducing cycle time by 23% to 45% along 4 lines. On reading this paper we get a better insight about Lean Manufacturing tools usage in Process Improvement. [10]

Chapter 2



OVERVIEW OF BISCUIT MANUFACTURING PROCESS

This chapter talks in detail about the process of manufacture of biscuits that's incorporated at the organization. The chapter gives a better understanding or perspective of the processes and tools involved in the manufacturing and packing process. Therefore, it helps readers get a better idea about the improvements suggested in the Improve Phase.

2.1 Biscuit Manufacturing Process Flow

A Process is a set of interrelated concurrent and consecutive activities that convert existing resource inputs into planned outputs. The speed and efficiency by which the output results are achieved in a large measure depends upon the structure of the process and sub-processes that convert the inputs into outputs. The entire process of Manufacturing can be classified into eight main stages, namely:

1. Sifting
2. Pre-Mixing
3. Mixing
4. Forming
5. Baking
6. Cooling
7. Packing

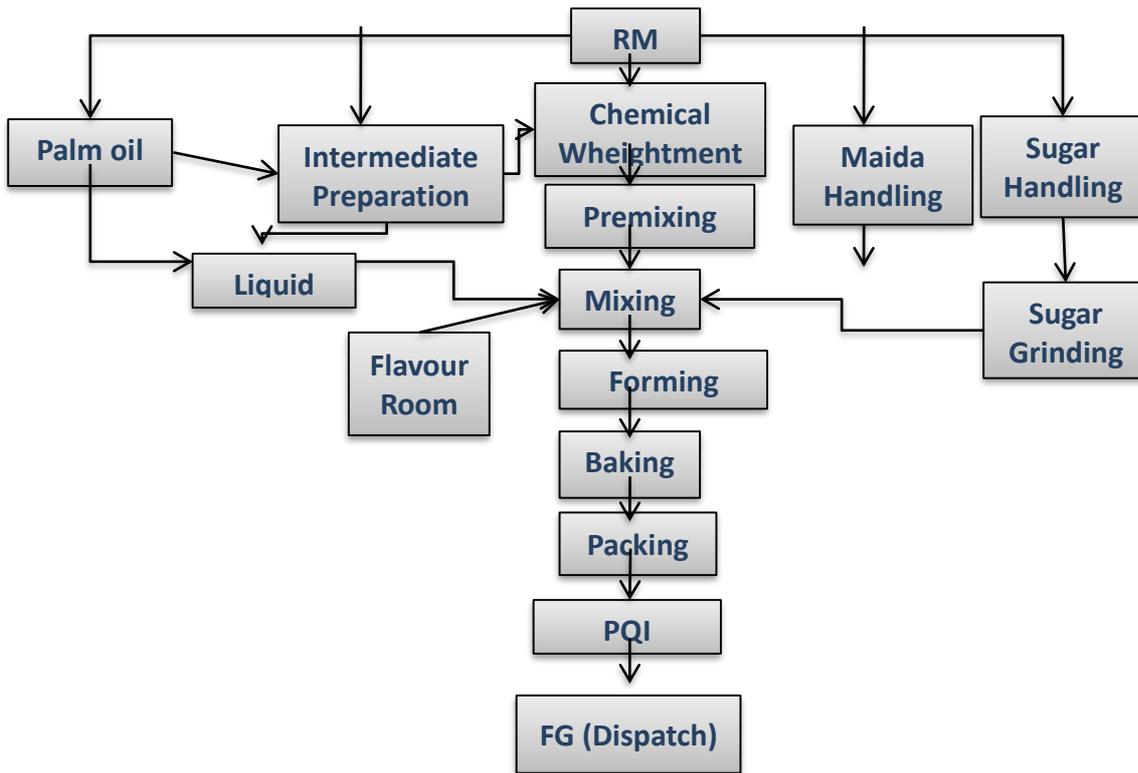


Figure 3: Biscuit Manufacturing Process flow

Step 1: Sifting

Flour for making biscuit dough normally contains impurities. Therefore, the commercially available wheat flour has to be refined before making biscuit dough. Hence, a flour sifter is used for removing any foreign particles from the flour by passing through and automatic vibrator sieve.

It has a side basket for feeding flour which has one horizontal screw conveyor and one vertical screw conveyor for feeding flour into sieve. Safety bars are incorporated to avoid direct contact of flour bag with the screw conveyor. The unit consists of an AC induction motor, flywheel and wire mesh. The wire mesh is made out of stainless steel. The wire mesh should be cleaned at regular intervals. The Quality of wheat flour is judged by its sieve size. The recommended size of sieve is 180 microns.

The basic process is that the flour bags are tilted and the flour is passed on to big storage silos. From silos, the flour is brought through screw feeders to the hopper where desired weight (usually 250 kg) of the flour is then discharged into the mixer using a load cell arrangement.



Figure 4: Maida Sifter & Sugar Sifter used in this Industry

Step 2: Pre-Mixing

The Major ingredients like Maida and sugar go through the sifter and sugar also undergoes grinding, in this industry there is an Automatic Grinding machine. These two major ingredients are directly connected through pipe to the Mixing machine. But the other ingredients like palm oil, HVO, Lecithin, Syrup, finamal 90, SSL fat, Invert Syrup are first prepared if required in tanks and are shifted to Storage tanks, from storage tanks the all together in the specified required quantity get collected in a Dosing Tank.

From Dosing tank it is connected to Mixing Machine, the mixing machine operator, controls the panel box, when seeks for these chemicals they will be sent batch wise for each Mixing machine.

Also there are certain Solid Chemicals like Salt, Soda, Ammonium bi-carbonate, and SAPP, which are mixed in water and manually, feed from the premixing area into a container from which it goes to the Mixing machines.

Role of each ingredient

- **Flour (Maida) -**

- Bulk ingredient. Gives the texture, hardness and shape.
- Source of gluten

- **Sugar -**

- Imparts Sweetness
- Gives flavor and colour
- Affects spread of biscuit
- Fuel for yeast
- Anti-oxidant and hence retards rancidity.
- Used as surface decorant for glossy appearance.

- **Fats and oils**

- Acts as shortening agent
- Provides texture to the biscuit
- Used as a surface spray in Snacky
- Provides for a soft bite
- Butter is also a source of flavor

- **Water**

- Forms gluten with wheat flour
- Medium to distribute various ingredients uniformly
- Absorbs excess heat
- Acts as a leavening agent

- **Yeast**

- Commonly used for fermentation of dough.
- Under anaerobic conditions, i.e., with the exclusion of oxygen, this organism is capable of the production of carbon dioxide gas and alcohol from sugars.

- **Invert Syrup**

- Increases sweetness
- Gives a cool sensation when it dissolves in the mouth
- Provides the reducing sugars for the Maillard reaction.
- Used as a humectant

- **SMP**

- Milky taste and color

- Supplies proteins for the Maillard reaction.
- Provides lactose which is a reducing sugar and takes part in the Maillard reaction.
- **SAPP**
 - Acidulant; Added to adjust pH.
 - Controls the rate of reaction of soda during baking.
- **SMBS**
 - SMBS is used as dough conditioner.
 - Increases machinability
- **Emulsifiers - Lecithin, DMG and SSL**
 - Reduces fat level.
 - Help water and oil to form an emulsion.
 - Used for proper mixing of two or more immiscible substances
 - Used for uniform spreading of fat in the dough
- **Salt**
 - Adds to the taste.
 - Surface dresser in Snacky.
- **Leavening agents**
 - ABC
 - Decomposes and gives gases: $\text{NH}_4\text{HCO}_3 \rightarrow \text{NH}_3 + \text{CO}_2 + \text{H}_2\text{O}$
 - These gases act as leavening agents and help in getting proper gauge of biscuit.
 - SBC
 - Decomposes to give gases and Na_2CO_3
 - $2\text{NaHCO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{Na}_2\text{CO}_3$
 - More stable than ABC so dissociates later in the oven thereby cushioning the biscuit and prevents collapsing.
 - Used along with an acidulant to adjust pH.
- **Citric acid**
 - Is used to provide the acidic medium for inversion during preparation of invert syrup.



Figure 5: Dosing Tank used in the industry

Step 3: Mixing

This is a process where all the ingredients are put together in right proportion into the Mixers for dough formation. Major ingredients are Maida, fat, Sugar and others that vary as per product one would like to have. Mixing can be done two stages.

1st Stage: CREAMING all in one (6-8 min)

- Palm Oil
- Lecithin
- Invert Syrup
- Liquid Glucose
- Broken (Biscuit Dust)
- Sugar
- SMP
- Sugar

2nd Stage: FINAL MIXING (Variable time)

- Maida
- SAPP
- SMBS

Mixing Process

- All ingredients except Maida, SAPP & SMBS added in creaming
- Fat added along with Emulsifiers in creaming
- Dissolution of chemicals in water is to ensure proper dispersion in the slurry and prevent lump formation
- A slurry is obtained at the end of creaming stage
- Maida is added at last to avoid excessive gluten formation.
-

Mixing Process has the following characteristics which have to be monitored for better results.

1. **Mixing time:** Normally, the mixing time carries between 18-20 minutes. Much depends on mixing speed of mixer, flour characteristics or temperatures required for the dough.
2. **Dough temperature:** This is a very important factor. Usually the temperature ranges from between 35° C- 42°C.
3. **Dough Consistency:** This is done manually by checking the dough and stretching it. Care is taken that the dough is neither too elastic (soft mixing) nor too inelastic (hard Mixing). These methods are mastered by bakers by trial and error method.

The dough Mixer has a capacity of 500 Kg; it is made of Cast iron, mild steel and stainless steel channels, angles and sheets. The machine is covered from all sides to avoid dust and accidents. The dough mixer has some unique features such as Mixing bowl, Arms and Covers made of stainless steel, Leak proof seals of Teflon and Heavy duty double row bearing. The PLC available has a Digital volume, Ampere Meter and the RPM indicator.

In Mixing Chamber one Z/sigma type mixing blade is fitted which rotates at different speeds to uniformly mix various types of soft and hard dough for achieving required gluten of dough. Finally, the mixing bowl is automatically tilted and the dough mass is transferred into wheel barrows by means of pulsating motion of the mixing blades. The filled wheel barrows are then moved to the forming section.



Figure 6: Mixing Machine used in the Industry

Step 4: Forming

In forming section the dough is passed through several rolls to form the required sheet. This sheet is 5-6 mm thick. Cutters are used to cut the sheet as and when required.

In this industry, the dough in the trolley, after being filled by the mixer, is manually transferred from the wheel barrow onto the conveyor, which is connected to Laminators. The dough then passes through vertical laminators and the Gauge rollers.

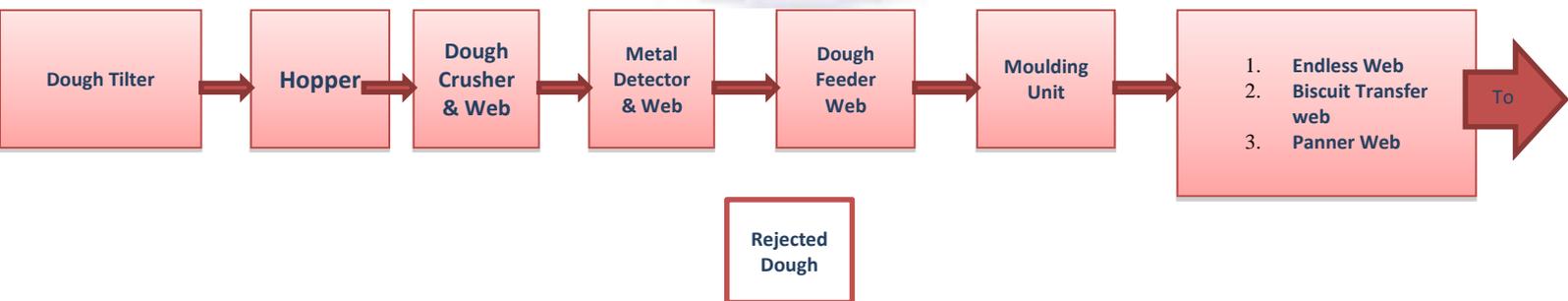


Figure 7: Forming process in biscuits

Vertical type Laminators: These are useful if space is a constraint. Dough is passed through three-stage rollers and after lamination of sheet; it is carried to rollers through inclined webs. The only disadvantage is that it is difficult to carry out the maintenance work on this type of laminator.

Gauge Rollers Laminator: Dough moves by its own weight towards the rollers and is not pressed manually, for this, the dough should be soft enough to go into the roller gap. Depending upon the

Quality of the biscuits to be produced and the required surface finish, the roller gap is to be adjusted. There are two handles for adjusting the gap between the rollers.

Rotary Cutter: Rotary cutter consists of cups which are attached to the cutter shell and have edges which cut the sheet into desired shape and size and delivers the same to the oven through a panner web. Various types of cups and dies are available as per requisite size and shape. This shell is then fixed to the shaft and a drive mechanism. Cutter is coupled with rubber roller of shore hardness approximately about 80-85. Rubber roller or the pressure roller helps in increasing wet biscuit. Basic material for cutters is gunmetal with anti-sticking plastic inserted on to the cups.

The Laminator, Gauge roller, and Rotary cutters used in the industry are shown



Figure 8: Laminator, Gauge Roller and rotary cutters

Step 5: Baking

Wet dough pieces of desired weight and shape are then passed on to the oven band through the swivel panner web. The biscuits are baked to the desired temperatures. Heat is transferred to the biscuits on the band through all the three modes of heat transfer *i.e.*, Conduction, Convection and Radiation.

Baking helps in

- Removing excess moisture from the biscuit
- Developing and setting the structure of the biscuit
- Colouring the biscuit surfaces

The wet dough passes through 7 zones inside the Oven at FCPL, it passes through travelling type ovens which is indirect fired type. The characteristics of the travelling type indirect fired oven are:

- Hot gases pass through tubes above and below the baking band and circulate back to the burner
- No products of combustion pass into the baking chamber
- A separate air circulation system moves air in the baking chamber and over the hot tube
- FCPL oven length is 240 ft. & 7 Zone one motor of 7.5HP
- Nozzle size: 2.25 GPH 2 .5 GPH
- Burner motor 1HP, circulation fan 7.5HP, Turbulance fan 5HP
- FO is the fuel for burner two stages are there.

Oven Controls

- **Temperature Settings**

- Only the top temperature is automatically maintained in each zone.
- The bottom temperature has to be adjusted by controlling the main damper.

- **Dampers Settings**

- Main damper
 - The main damper controls the ratio of top and bottom heat distribution from the combustion chamber.
- Moisture damper
 - The steam damper controls the outflow of the steam and other gases generated within each zone when the biscuit is baked.



Figure 9: Oven used in the Industry

Step 6: Cooling

The fresh biscuits coming from the oven are made to pass through cooling conveyor to make them ready for stacking and packing. The biscuit are cooled under ambient temperature without any forced air circulation or refrigeration.

- Transfer system of two tier conveyors is used so that biscuits are reversed and both sides cooling is possible.
- The cooling conveyors can be made multi-tiered depending upon the space available. Either Manual or pneumatic web tensioning system is provided as per customer requirements.

Stacking Machine is used stacking together the biscuits for easy lifting. The biscuits coming from the cooling conveyor are made to pass through star shaped wheels in order to make them in standing (vertical) position.



Figure 10: Cooling conveyor in the industry

Step 8: Packaging

After Cooling, biscuits are fed into the packing machines in continuous stacks. They are then wrapped in packing machines using wrappers and are sealed with the help of heaters. Packs vary both in shape and size. Popular packing types are pillow pack and family packs with weight ranging between 150 gm and 400 gm.

Major functions of packing are:

1. Protect the contents from mechanical damage in transit, loading and unloading.
2. Protect the biscuits from loss of moisture and any foreign odor contaminations.
3. Protect them from foreign body infestation and increasing the product's shelf life.
4. Provide legal compliance for values and ingredients for consumers.
5. Help in promotion and advertising purpose.

Types of packing

- Primary packing (BOPP laminate)
- Secondary packing (HDPE poly bag)
- Tertiary packing (line separator, CFC box).

Steps in packing

- Stacking after cooling conveyer.
- Manually stacking in chute.
- Inline feeder & cross feeder.
- Stack hold by infeed chain.
- Wrapping in former box.
- Packet hold by latter chain.
- Long seal sealed by rollers
- End seal sealed by jaw.

Types of packing machines

- **Horizontal packaging machine**

It is used for Slug packs, single packs, and Jumbo packs with centre sealing or pillow type sealing. It is very robust machine. The present speed ranges between 60 to 90 packets /min.

- Pillow pack (cross pusher, shoot type)
- Ticki pack
- Family pack (2 row, 3 row)
- Tray pack

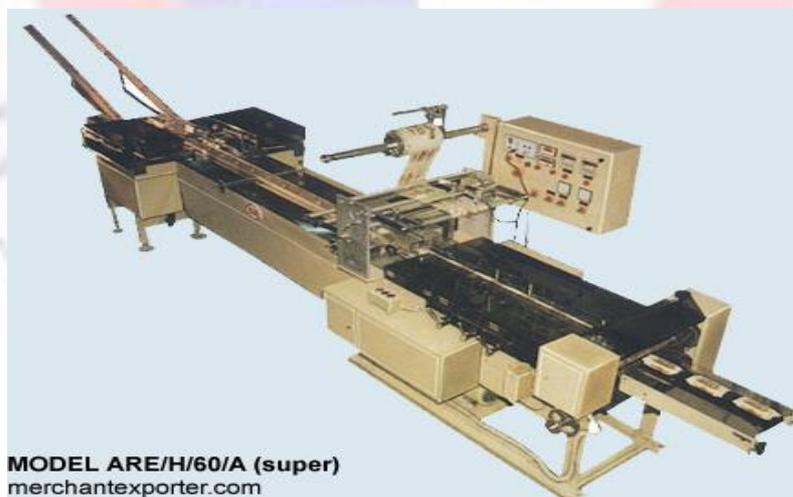


Figure 11: Packing Machine

- **Carton type packaging machine**

The packets are put into cartons manually and are then taped by passing it through carton taping machines. Carton taping machines tapes the carton flaps top as well as bottom. Guide rollers are provided on the top.



Figure 12: Carton sealing Machine

2.2 Storage Department Functions

There are two storage areas in the industry one for raw material and other for finished goods. There is a total of 300 tones storage space for raw material. Before the goods enter the stores they have to undergo 3 acceptance tests

- i. Security check
- ii. Stores verification
- iii. Lab verification

- **Security check**

- Material report to the security gate
- Check necessary document like invoice, material whom may concern, driving license & security check
- Security person make entry on TITO (Time In Time Out) register
- After that he issue the entry permit & inform the store person.

- **Store verification**

- Store person check all necessary document like tax invoice, form 6A, COA, material whom may concern.
- Weight the truck and maintain the TITO register.
- After that he will inform the lab person.

- **Lab verification**

- Quality person check vendor list & COA
- Check vehicle condition it should be clean covered with tarpaulin top & bottom
- Check the physical condition of material, batch no., DOM
- After that takes the sample as per ITC norms.
- Carried the entire test as per ITC norm. And make test report (2copies) one for store another for quality.

- **Store Person**

- If test will be ok store person make GRN(3copies) one for ITC other for store & one extra
- Allow unloading of material & BIN and ID card filled.
- Store register updated (stock)
- SAP entry done by ITC (FE)

- **In case of rejection**

- Quality person make rejection note(3copies) for supplier, store & quality department
- A photo copy for ITC head office

2.3 Quality Lab Functions

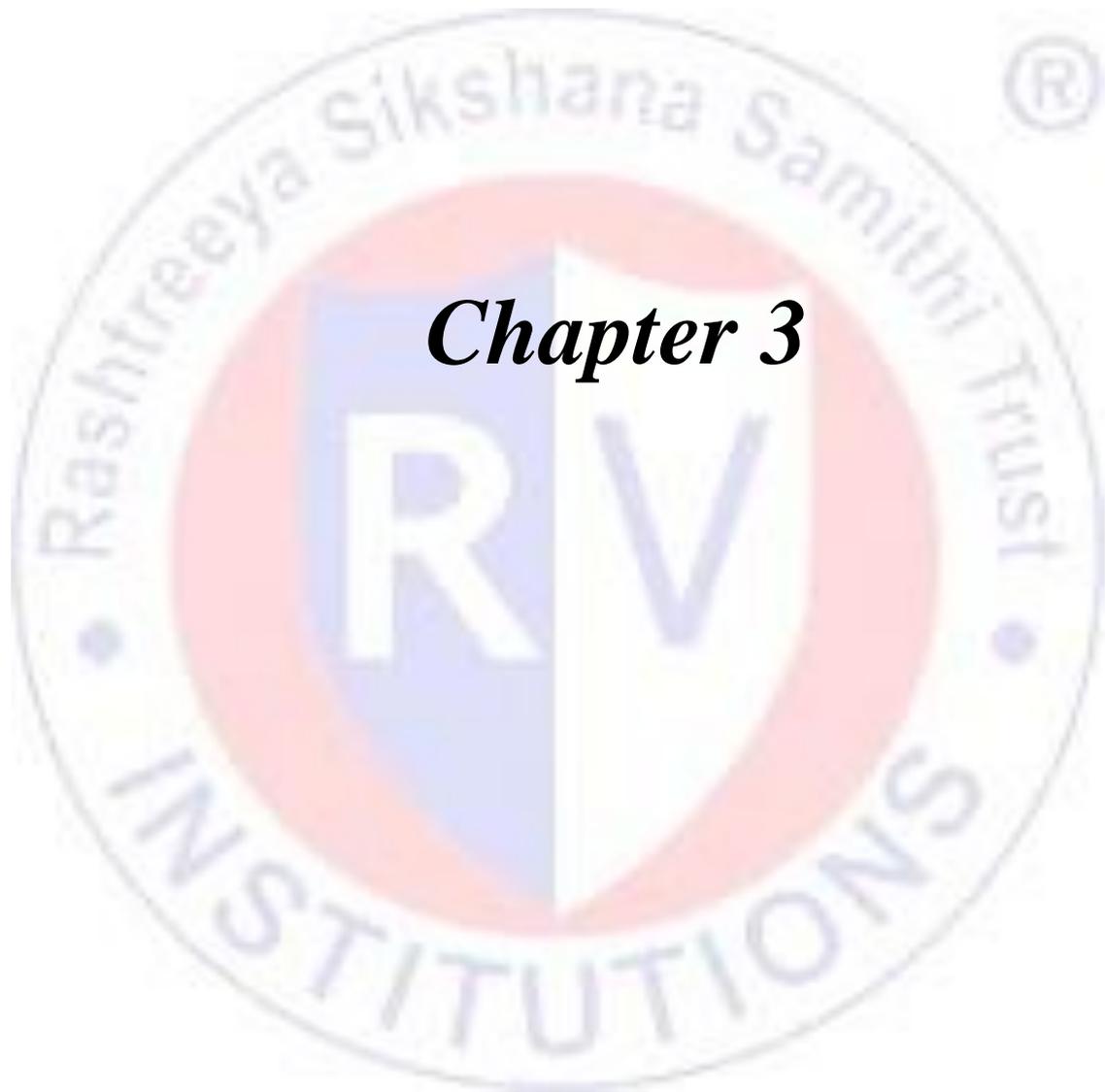
The industry has a quality lab consisting of 15 personnel. Quality personnel are sent to various departments in the industry wherever quality check is necessary. A sample piece is taken which is brought back to the lab and tests are done on the sample piece, once the tests are done it is reported to the concerned department either by paper or by means of telephone.

Table 1: Raw materials Storage conditions

At Ambient Temp.	At ≤ 25 °C	At 42 °C in Tank	In cold room
Maida Sugar ABC SBC SMP SMBS SALT SAPP etc. In form of stack on pallets RM store capacity is 300 Ton	All Flavour & Colour (In Dark)	Palm oil Palmolin Palm oil having 6 Storage tank each 30 KL & 2 Service tank each of 2.5 KL Palmolin having 2 Storage tank each 30 KL & 1 Service tank of 2.5 KL	Cold room No. 1. Temp: < 10 °C Ingredients: Cream, Admol, Cashew Cold room No. 2. Temp: (-) 5 °C to (-) 7 °C. Ingredients: Butter, Yeast Cold room No. 3. Temp: < 15 °C Ingredients: Condensed milk, HVO.

Quality tests are done in three production stages:

- **Pre-process Testing**
 - Testing of raw materials
 - Test of packing material
- **During Process Testing**
 - Product quality (Done by Product inspector)
- **Post process Testing**
 - PQI (done every shift)
 - Testing of finished good



Chapter 3

OVERVIEW OF PROJECT METHODOLOGY

This chapter discusses the DMAIC process adopted. Here, each phase is explained in detail and the figures and tables related to the studies carried out are depicted. The observations drawn from the figures are explained in the phase discussions. This chapter also shows the results obtained based on the methodology followed and the work carried out.

DMAIC which stands for Define Measure Analyze Improve Control is a lean six sigma tool used for process improvement. While some problems have an easy solution that can be thought of without following a structured approach, there are some that require a structure to be followed to understand the problems and provide the required solutions. DMAIC is one such approach.

3.1 Define Phase

This phase involves definition of the problem statement, and as mentioned earlier our problem lies in providing goals to the organization for waste reduction by analyzing factors that affect its efficiency – Downtime, Scrap and Reusable defects, and to give insights that will aid them in improvement. This phase starts with understanding the processes carried out in the facility. To depict the processes a SIPOC diagram is shown below.

While the steps are explained in detail in chapter 2, here we will give a brief about the important steps. The process starts with receiving raw materials for manufacturing and wrapper materials for packaging from the suppliers. A small sample of each raw material is taken to perform quality tests. Then preparation of dough takes place with the required ingredients and mixes. The dough is then placed in a hopper and is passed through a rotary moulder that places the moulded dough (Biscuits) on the conveyor belt. The conveyor belt then passes through a long oven for the baking process. Then the baked biscuits are naturally cooled by taking them along a long stretch of conveyor belt. The cooled biscuits are then stacked manually on the stacker. The stacked biscuits are moved by a machine arm and assembled at the packing machine. These

biscuits are then packed, after which the packed biscuits are sent for a Quality Check test before storing in the Finished Goods inventory.

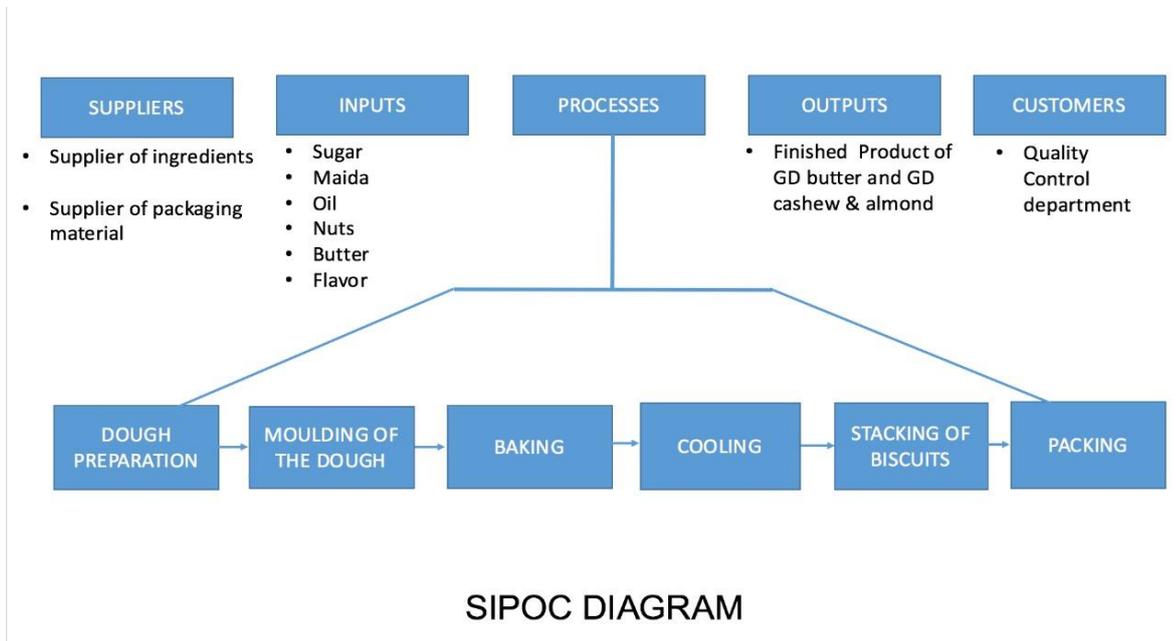


Figure 13

3.2 Measure Phase

Data required for drawing observations on the Downtime and Defects occurring at the facility is obtained. After the data filtering process, the data is shown using charts or diagrams for data visualization. Based on the visuals, further examination is done to observe if the data has certain trends or key observations to be noted. This phase helps us decide on the factors to be analyzed in the Analyze phase.

In this phase production data for 6 months is also observed. The production data is collected for 6 months in the form shown in Fig.13. It is noticed that there is non-uniformity in the day-to-day production output after plotting a scatter plot for the data. This is discussed in detail in

Appendix 2. Here, we will focus on discussions related to observations from Downtime Data and Defects Data.

Oct-20			Nov-20		
Date	Shift Production	DAY'S PROD	Date	Shift Production	DAY'S PROD
01.10.20			01.11.20		
	0	0	02.11.20	0	0
02.10.20	0	0	03.11.20	25890.5	58.1954
	0	0		32304.9	
03.10.20	0	0		35232.1	72.194
	30530.8	66.5613	04.11.20	36961.9	
04.10.20	36030.5			0	36.0185
	35354.1	35.3541	05.11.20	36018.5	
05.10.20	0			40723.5	81.7854
	35297.1	77.5848	06.11.20	41061.9	
06.10.20	42287.6			38725.3	82.0344
	40040.4	82.3408	07.11.20	43309.1	
07.10.20	42300.4			22765.3	63.4187
	40653.3	82.0344	08.11.20	40653.3	
08.10.20	41381.1			41879	83.5538
	0	0	09.11.20	41674.8	
09.10.20	0			27687.4	69.975
	38814.7	80.9683	10.11.20	42287.6	
10.10.20	42153.6			41017.2	81.2683
	0	30.3751	11.11.20	40251.1	
11.10.20	30375.1			41061.9	84.5752
	0	0	12.11.20	43513.3	
12.10.20	0			36363.3	77.5784
	37199.6	77.0613	13.11.20	41215.1	
13.10.20	39861.7			41266.2	83.2729
	41061.9	83.0878	14.11.20	42006.7	
14.10.20	42025.9				

Figure 14: Production Data

3.2.1 Measure for Downtime

It was observed that the form earlier used to record downtime lacked structure and was not enough to carry out an analysis as the duration of downtime was unknown. Therefore, along

with the external guide's help a new form for recording downtime was proposed where: 1). Reason for Downtime; 2). Duration of Downtime; 3). Possible loss in production during this duration in Kg, are all mentioned along with other requirements for the external guide. The two forms are shown below. The proposed form was used to record downtime for the months of April and May and the data was obtained as shown in Fig. 16.

The form is a vertical rectangular sheet with a white background and a black border. It is divided into three distinct sections by horizontal lines. The top section is labeled 'Production Down Time Details' and contains a large empty rectangular box for text entry. The middle section is labeled 'Packing Machine Break Down Details' and also contains a large empty rectangular box. The bottom section is labeled 'Shift hand over/Communication Details' and contains a large empty rectangular box. The text labels for each section are centered above their respective boxes.

Figure 15: Earlier Downtime Form

Using the proposed form downtime was recorded for the months of April and May and data was obtained in the following form.

May Downtime Details						
Date	Shift	Down Time From	Down Time To	Total (Mins)	Reasons	Production Loss (Kg)
01.05.21	A & B Shift Maintenance (RM Store Mezzaling work)					
02.05.21	A	Maintenance				
	B	7:00	8:15	75	Oven Band Cleaning & Start up	4663.43
		8:50	9:15	25	P.Sugar Loading Late	1554.48
		9:30	10:00	30	P.Sugar Loading Late	1865.37
		5:20	6:05	45	P.Sugar Loading Late	2798.06
03.05.21	A	11:00	12:25	85	Montral Sugar Shortage	5285.22
	B	7:00	7:10	10	Maida Shifter Jam	621.79
		10:50	11:00	10	Maida Shifter Jam	621.79
04.05.21	A	12:02	1:20	78	G Sugar Pipe Line Jam	4849.96
		4:05	4:45	40	G Sugar Pipe Line Jam	2487.16
	B	11:40	11:55	15	Sugar Grinder Endless Web Tracking	932.69
		6:40	6:45	5	Packing Canvas Sticking	310.90
05.05.21	A	9:25	9:37	12	G Sugar Pipe Line Jam	746.15
		10:35	10:50	15	G Sugar Pipe Line Jam	932.69
		2:05	2:15	10	Tray Pack	621.79
		4:45	4:50	5	Pom Oil Filter Jam	310.90
	B	No Break down				0.00
06.05.21	A	8:10	8:25	15	Maida Shifter Chocking	932.69
	B	11:50	11:55	5	Maida Shifter Chocking	310.90
07.05.21	A	10:35	11:10	35	Stracker Canvas Sticking	2176.27
		1:05	1:30	25	Weight Variation Moulder Knife Setting	1554.48
		4:05	4:40	35	Weight Variation Moulder Knife Setting	2176.27
		5:30	5:45	15	Weight Variation Moulder Knife Setting	932.69
	B	7:40	8:00	20	Tray Pack	1243.58
		12:35	12:50	15	Sugar Late	932.69
08.05.21	A	10:00	10:15	15	Packing Stracker Canvas Sticking	932.69
		11:40	12:00	20	Oven Burnel Trip	1243.58

Figure 17: Downtime Data

The recorded downtime data was then filtered using MS Excel to find the frequency in which each cause of downtime occurred. The most recurring causes are highlighted. The frequency tables for April and May are shown in Figures 17 and 18 respectively. This data is then divided into their primary sources: Maintenance, Breakdown and Process. The distribution of each of these downtimes is then shown using pie charts for April and May as shown in Figure 19.

Upon observing the downtime data, it was observed that the data was not integral or there was discrepancy in the data. In April there was proper recording of the Oven Band Cleaning

downtime (665 min) , however in May it is shown to occur lesser number of times (75 min) even though it is a periodic maintenance process. This shows that there is data inaccuracy. However since it is a new process for the workers, it is important to train them on the process of recording downtime.

Reasons	Frequency	Time Lost (min)
Oven Band Cleaning	21	665
Sugar Late	8	93
Tray Pack	25	385
Sugar Loading late	12	250
Sugar Jam	3	100
P Sugar Loading Late	1	5
Production Stop	2	60
Mixing Problem	1	20
Cremer pipeline Jam	1	15
Almond Weight Checking	3	15
Stracker Canvas Sticking	1	60
Pigeon Come plant inside due to production gap	1	85
Maida Motor Problem	1	30
Maida Magenet Jam	1	20
Table Canvas Sticking	5	87
Maida Late	6	72
Stracker Problem	2	30
Stracker Canvas Change	1	165
Moulding Problem	1	10
Packing Table Canvas cut & Sticking	1	125
Batch Problem	1	10
G Sugar Valve air pipe out	1	12
Moulding Canvas Sticking	1	15
Maida Shifter Jam	1	5
Sugar Grinder Problem	1	20
Secondary M/c Problem	2	70
Nuts Weight Checking	8	60
Packing M/c Setting	2	75
Cremer Problem	1	5
Moulder Chocking Cleaning	3	60
Mld Canvas Problem	1	5
G Sugar Valve Not open	1	17
Batch Return	1	10
Pom Oil Loading Late	1	10
Moulding Dai Cleaning	1	10
Endless Web tracking	1	10
Maida Shifter Chocking	1	10

Figure 18: Frequency table for April

Reasons	Frequency	Time Lost (min)
Oven Band Cleaning & Start up	1	75
P.Sugar Loading Late	3	100
Montral Sugar Shortage	1	85
Maida Shifter Jam	3	30
G Sugar Pipe Line Jam	4	145
Sugar Grinder Endless Web Tracking	1	15
Packing Canvas Sticking	1	5
Tray Pack	6	85
Pom Oil Filter Jam	1	5
Maida Shifter Chocking	2	20
Stracker Canvas Sticking	2	40
Weight Variation Moulder Knife Setting	3	75
Sugar Late	1	15
Packing Stracker Canvas Sticking	4	105
Oven Burnel Trip	1	20
Moulder Problem	1	5
Moulder Knifer Cleaning	1	30
Almond Weight Checking	25	125
Cooling Canvas Sticking	1	15
M/d canvas Sticking	1	5
Maida Late	2	25
Production Stop	3	88
Batch Reject	1	20
Maida Shifter Cleaning	2	50
Packing M/c Setting	1	10
Liquied Bariaction	1	20
Light Fittings	1	5
M/d Problem	2	10
Sugar Blower Trip	1	10
Sugar Feeder Motor Jam	1	6
Production Start up	1	60
Maida Cremer Late	1	20
CQI Audit Gap	2	300
Sugar Discharge late	2	55
Sugar Feeder Problem	1	35
Pom Oil Problem	1	46

Figure 19: Frequency table for May

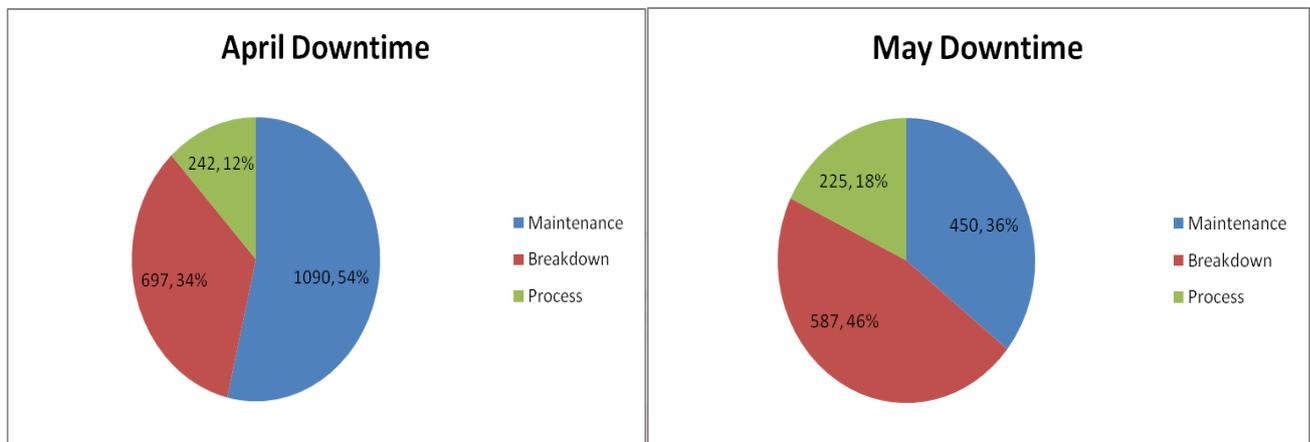


Figure 20: Pie Charts for Downtime

After we decided to work with the data obtained, it was observed that a large part of the downtime occurred due to maintenance - Oven Band Cleaning, Mixer Cleaning, Canvas Stitching. These are unavoidable.

The second highest downtime is from breakdown of various parts of the line. There was no trend observed on why it happens. These breakdowns occur randomly. However, it can be accounted to overproduction! Britannia requires an average production of 75000 Kg a day, while the organization has several days where they produce more than 80000 Kg. While this is an amazing feat to achieve, it leads to overproduction. There are a few days in each month where no production takes place because of High Finished Goods Inventory. Overproduction leads to excess load on the machines and higher inventory levels.

The third highest downtime occurs due to processes. While most process downtimes are small and non-recurring, it is seen that downtime due to Almond/Nut weighing occurs frequently and accumulates to 125 minutes in May and 75 minutes in April. This leads to a loss of 7123 Kg in May and 4274 Kg in April. Since it occurs in small durations, it can be ignored in a day. However, when looking at it in a monthly perspective there's a big loss. This can be avoided with a simple step of storing weighed almonds/nuts, ready to be mixed instantly.

3.2.2 Measure for Defects

Defects data is collected for 6 months from the month of October 2020 to March 2021. The total defects generated are split into the various sections of the production line in which they are found, to get a better idea on which section has the maximum defects, hence to get a better understanding on what the causes for these might be. The various types of defects include – Oven End, Dirty Bottom, Cooling, MD, Stacker, Table End and Packaging.

Oct-20												
Date	Variety	Shift	Oven end	Dirty Bottom	Stacker	Cooling Conveyor	Table End	PKG M/C Def	Total Def Gen	FS	Usable def	MD
01.10.20		A	Maintenance						0		0	
		B							0		0	
02.10.20		A	Gandi Jayanthi						0		0	
		B							0		0	
03.10.20	GDCA	A	210	80	90	50	150	280	860	85	775	80
		B	180	100	60	30	150	300	820	85	735	80
04.10.20	GDCA	A	130	60	70	90	100	250	700	80	620	75
		B	Maintenance						0		0	
05.10.20	GDB LUP	A	90	50	100	40	110	280	670	40	630	80
		B	180	90	50	30	110	230	690	90	600	70
06.10.20	GDB LUP	A	90	50	90	60	110	170	570	90	480	120
		B	190	90	50	30	110	260	730	95	635	90
07.10.20	GDB LUP	A	110	80	70	40	80	200	580	78	502	92
		B	170	90	50	30	130	240	710	75	635	80
08.10.20		A	Maintenance						0		0	
		B							0		0	
09.10.20	GDB LUP	A	80	60	40	50	200	150	580	73	507	82
		B	140	60	40	20	90	220	570	82	488	75
10.10.20	Trial	A							0		0	
	GDB LUP	B	220	100	60	30	210	300	920	98	822	85
11.10.20	Maintenance	A							0		0	
		B							0		0	
12.10.20	GDB LUP	A	140	70	50	30	110	200	600	88	512	100
		B	110	60	50	60	110	330	720	63	657	77
13.10.20	GDB LUP	A	130	70	50	30	90	180	550	77	473	90
		B	80	50	70	50	230	140	620	71	549	86
14.10.20	GDB LUP	A	150	70	50	30	100	220	620	68	552	70
		B	70	40	40	30	110	110	400	67	333	78
15.10.20	GDB LUP	A	130	70	50	30	120	180	580	78	502	60

Figure 21: Defects data

Workers are stationed across different points of the production line to manually observe the biscuits and remove the defectives from the line. In the oven end there might be biscuits that are over-baked or deformed. Dirty bottom involves presence of carbon patches or black spots

at the bottom of the biscuits. Any biscuits which are found defective along the cooling conveyor are again taken out. MD refers to biscuits that are discarded due to metal detected. A metal detection sensor is placed at the end of the cooling conveyor, and a machine arm discards biscuits that contain metal. After this, the biscuits are stacked in a line manually on the packing table. Here, sometimes there may be breakage of biscuits. In the table end, a machine arm moves the stacked biscuits towards the packaging machine. Here again there may be breakage of biscuits due to speed of the machine arm. Packaging defects are related to errors in packaging – Loose packaging or wrapper issues.

The amount of defects for each type is summed for a period of 6 months and subjected to Pareto Chart analysis to get an idea on where the maximum defects are being generated, and which section requires higher priority.

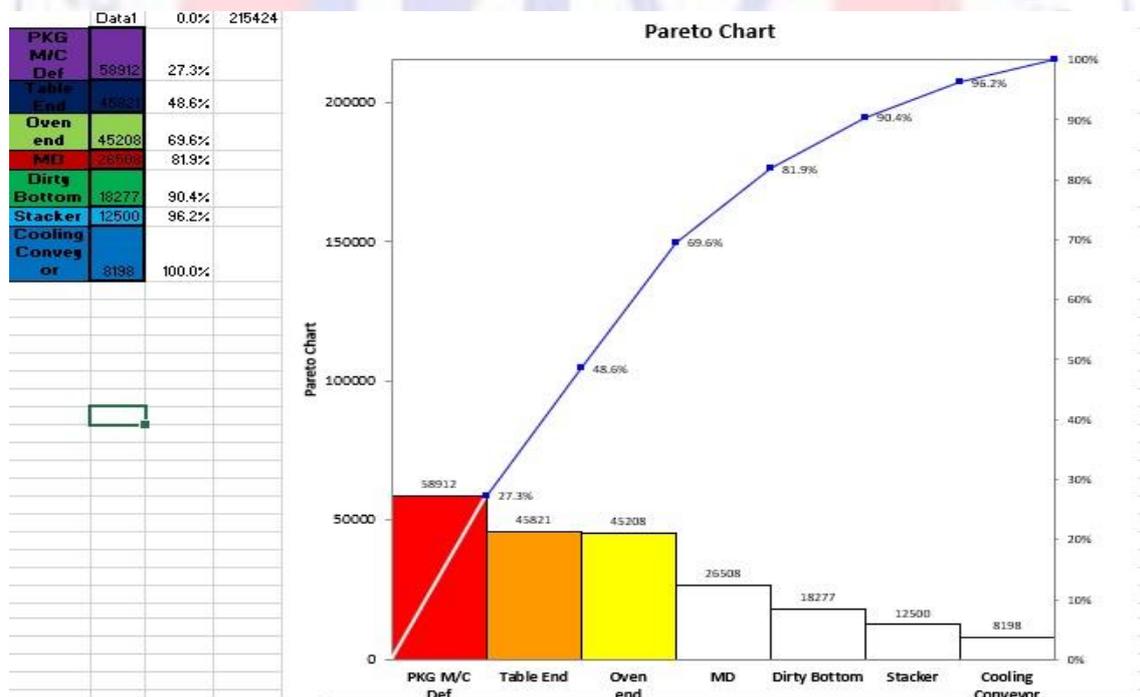


Figure 22: Pareto Chart for Defects

From the Pareto Chart we can observe that:

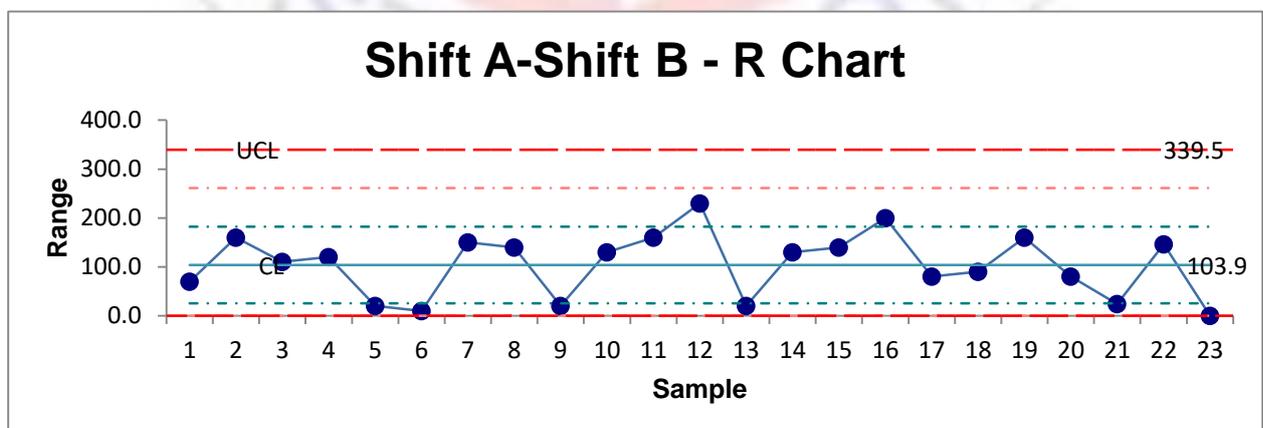
- 1) Maximum defects occur due to packaging which accounts to 27.3% of the overall defect rate.
- 2) Packaging, Oven end and Table end defects cumulatively account to about 70% of the overall defects.
- 3) Metal Detected Defects come up to 12.2% of the overall defect rate.
- 4) Dirty Bottom, Stacker and Cooling conveyor defects together accumulate to only 19.1% of the overall defects.

3.3 Analyze Phase

Thorough analysis is carried out in this phase on the factor(s) that proved required attention from the Measure phase. Since, the pareto chart showed that packaging defects occur at the highest rate, Packaging defects and Manufacturing defects are analyzed separately using control charts to see if the defects are generated in a normal way, or if there is an anomaly to be noted. The anomalies are noted and further examined. The process sigma levels for Packaging defects and Manufacturing defects are calculated for a month’s production. So, it provides us an opportunity to provide monthly goals for the organization in the Improve phase.

3.3.1 Analyze for Packaging Defects

X-bar and R chart is used to check if the process is in control, since the defects are spread across two subgroups - Shift A and Shift B, both of equal size, *i.e.*, 8 hours.



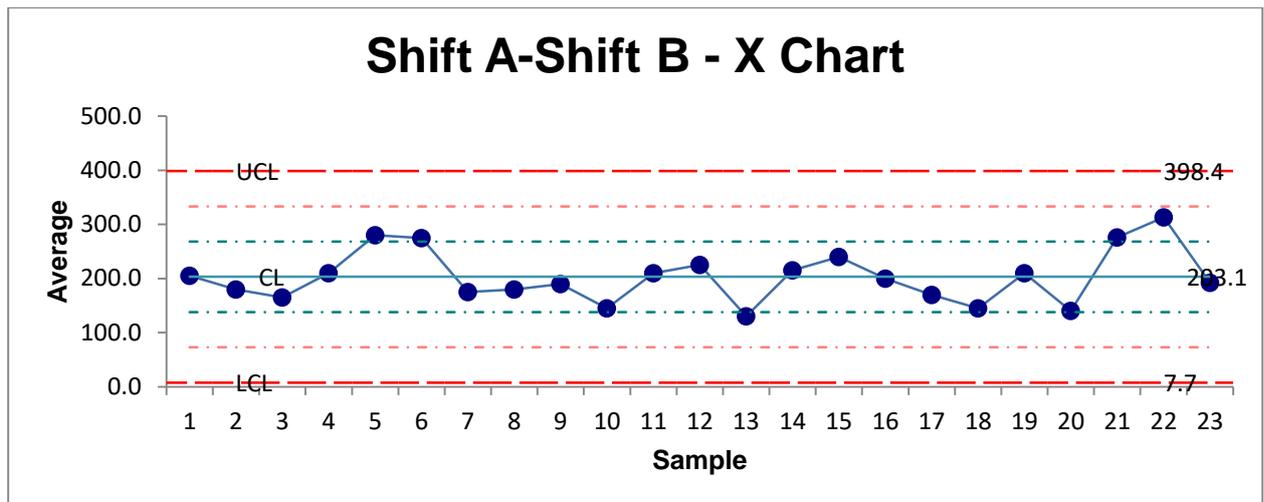


Figure 23: Control Chart for Packaging Defects

While the R chart shows the range of variation between defects generated in each phase, the X bar chart shows the mean amount of defects generated each day across both the shifts through the month. It is seen that the process mean is 203, which implies that an average of 203 defects are generated per day through the month. Since, no points are out of the control limits we can say that the process is in control and move onto the process sigma level calculation for packaging defects.

CTQ (Critical to Quality) is a key quality characteristic and is directly related to the specific needs of the customer. In packaging there are 2 types of characteristics that are not acceptable for quality output:

- 1) Loose packaging
- 2) Color of the packaging not complying to standards

Determination of process Sigma Level

$$\text{TOP (Total Opportunities)} = \text{Total product produced} \times \text{Number of CTQ}$$

$$= 1777460.944 \times 2$$

$$= 3554921.89$$

$$\text{DPO (Defect Per Opportunities)} = \text{Defects}/\text{TOP}$$

$$= 9482/3554921.89$$

$$= 0.00266729$$

$$\text{DPMO} = \text{DPO} \times 10^6$$

$$= 0.00266729 \times 10^6$$

$$= 2667.29$$

$$\text{SIGMA PERIOD} = \text{NORMSINV} [(1000000 - \text{DPMO}) / 1000000] + 1.5$$

$$= \text{NORMSINV} [(1000000 - 2667.29) / 1000000] + 1.5$$

$$= 4.29 \sigma$$

3.3.2 Analyze for Manufacturing Defects

Again, X-bar and R chart is used to check if the process is in control, since the defects are spread across two subgroups – Shift A and Shift B, both of equal size, i.e. 8 hours.

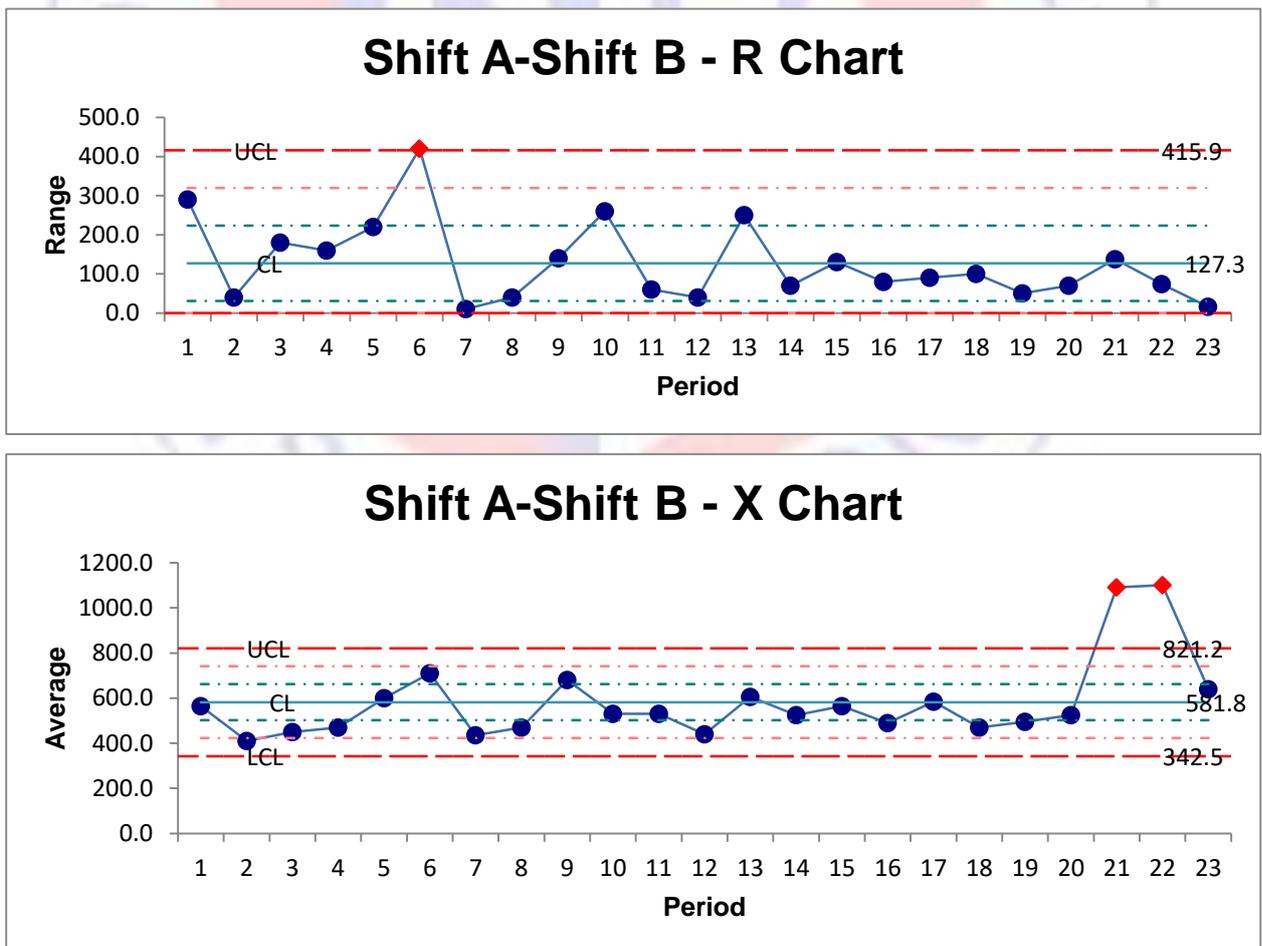


Figure 24: Control Chart for Manufacturing Defects

Here, it is seen that there are two points out of control, at period 21 and 22. This suggests a presence of an anomaly or a possible special cause for defect increase in that period. Upon further examination by checking the production details it was seen that on this day of the month, there was a changeover of production from one variant to the other. Therefore, there was a sudden increase in the number of defects generated. So change-over of production is treated as a possible cause for increase in defect rates and solutions to counter it are provided in the next phase discussion. These two points are then removed and the control limits are reset to see if there are any other points acting as an anomaly.

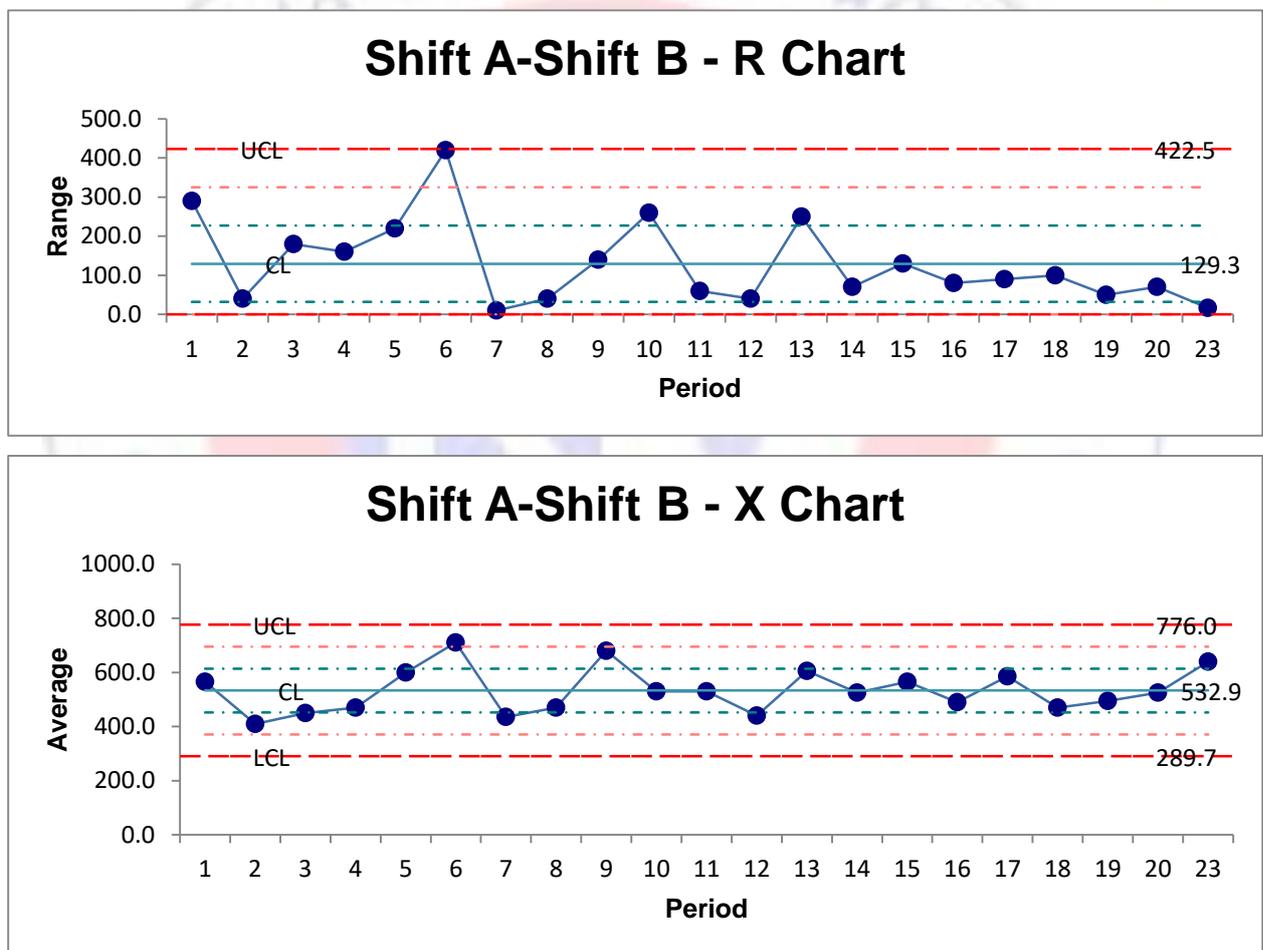


Figure 25: Improved Control Chart for Manufacturing Defects

In the improved control chart, we now see that there are no points out of the control limit, and the process is in control. We see that the process mean is 533, which implies that an average of 533 defects is generated per day through the month. We now move on to calculate the process sigma level for manufacturing defects.

CTQ (Critical to Quality) is a key quality characteristic and is directly related to the specific needs of the customer. In manufacturing there are 6 types of characteristics that are not acceptable for quality output:

- 1) Deformed Shape
- 2) Undesired cracks on surface
- 3) Presence of chipped biscuits
- 4) Black spots/ Carbon Spots
- 5) Burnt biscuits
- 6) Undesirable blisters bubbles on surface

Determination of Process Sigma Level

TOP (Total Opportunities) = Total product produced x Number of CTQ

$$= 1777460.944 \times 6$$

$$= 10664765.66$$

DPO (Defect per Opportunities) = D/TOP

$$= 26974/10664765.66$$

$$= 0.00252926$$

DPMO = DPO $\times 10^6$

$$= 0.00252926 \times 10^6$$

$$= 2529.26$$

SIGMA PERIOD = NORMSINV[(1000000-DPMO)/1000000] + 1.5

$$= \text{NORMSINV} [(1000000-2529.26)/1000000] + 1.5$$

$$= \boxed{4.30 \sigma}$$

3.4 Improve Phase

After finding the defect levels for manufacturing and packaging, monthly goals are given to the organization to reach a defect level of 5σ . This involves monthly reduction of the defect rates in a step-by-step or systematic manner until the required defect rate is reached. To achieve this causes for the defects are analyzed using a Fishbone diagram. Each cause is then provided with a suggestion for change or improvement.

While the organization does an incredible job of meeting the production targets set by Britannia, the defect rates even though small as compared to the production rates, are ignored. Therefore, we wanted to set monthly goals for the organization to reduce their defect rates. This ensures less time is spent on rework and the costs incurred due to defects or rework is also reduced.

3.4.1 Improve for packaging defects

Table 2: Targets for packaging defects

Period	Number of Units (In Kgs)	Sigma Value	CTQ	DPMO	TOP	Number of defects (In Kgs)
1	1950000	4.4	2	1866	3900000	7277
2	1950000	4.5	2	1350	3900000	5265
3	1950000	4.6	2	968	3900000	3775
4	1950000	4.7	2	687	3900000	2679
5	1950000	4.8	2	483	3900000	1884
6	1950000	4.9	2	337	3900000	1314
7	1950000	5	2	233	3900000	909

$$\text{Increasing in sigma (\%)} = (\text{Sigma Target} - \text{Sigma Baseline}) / \text{Sigma Target} \times 100$$

$$= (5 - 4.29) / 5 \times 100$$

$$= 14.2 \%$$

$$\text{Decrease in Defects (\%)} = (\text{Defects Baseline} - \text{Defects Target}) / \text{Defects Baseline} \times 100$$

$$= (9482 - 909) / 9482 \times 100$$

$$= 90.41\%$$

For each month (period) the number of units is taken to be a constant of 1950000 Kg. This is because average per day requirement of Britannia is for the facility to produce 75000 Kg, so this would come up to about 1950000 Kg during a month. Therefore, the defect rate targets to be measured are for every 1950000 Kg of production. Each month the sigma level is increased by 0.1, until the target of 5σ is reached. The respective amount of defects that need to be produced each month or for every 1950000 Kg of production to attain the required level of process sigma is mentioned in the table. If the goals/ targets are met, by the end of a 7 months period the organization would witness a decrease in the defect rates by 90.41%.

To achieve these goals, it is important to understand the causes for the defects, and to provide suggestions for improvement to counter these problems. Therefore, we look at the causes for packaging defects using a Fishbone diagram.

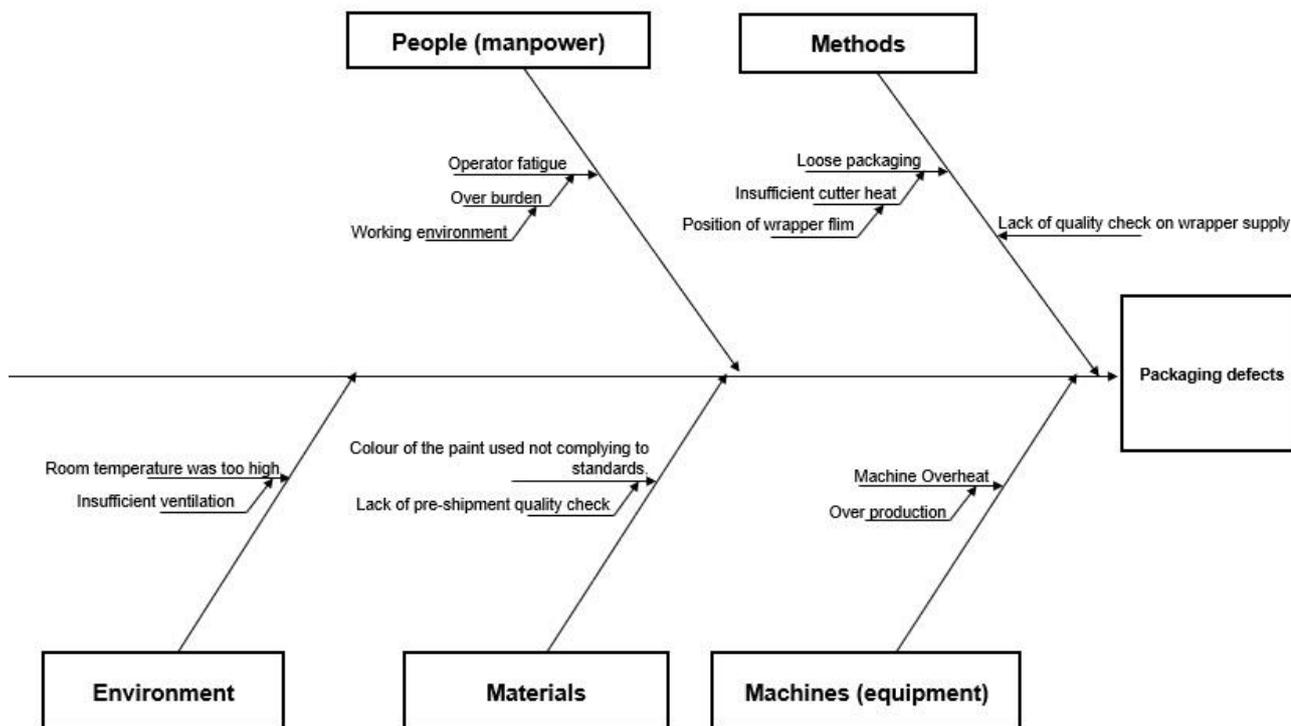


Figure 26: Fishbone diagram for packaging defects

The fishbone diagram shows the five primary sources for cause of packaging defects – Man, Machine, Environment, Material and Methods. Under each of these sources, the first arrow points to the primary causes - Loose packaging, Operator Fatigue, Machine Overheat, Color of paint used not complying to standards and Room temperature being too high. Under the primary causes, arrows point to secondary or root causes that give rise to the primary cause. For each cause a suggestion for improvement is provided in the table that follows. Out of these suggestions the organization can focus on ways that are focused on reducing loose packaging, and to ensure a thorough pre-shipment quality check and complete quality check of the shipment arrived before the production is started for reducing wastage due to problems with the wrapper material.

Table 3: Suggestions for packaging defects

Source	Cause	Suggestions
Material	Color of the paint used not complying to standards	1) Sending the supplier a QC checklist that includes clear packaging standards to be met before shipping 2) Conduct Quality Check for the entire wrapper supply before packaging
Method	Loose Packaging	1) Ensure cutter heat is maintained for perfect sealing of packets with regular checks on cutter heat 2) Ensure film is centered on the spindle 3) Ensure Rollers are spinning freely
	Lack of Quality Check on Wrapper Supply	Conduct Quality Check for the entire wrapper supply before packaging
Machine	Machine Overheat	1) Avoid overproduction 2) Regular heat checks

Man	Operator Fatigue	1) Ensure sufficient lighting 2) Ensure right room temperature 3) Cyclic shifting of workers – Shifting between a heavy task and a light task every 30 min
Environment	Room temperature too hot	Provide fans all over the plant and ensure sufficient ventilation

3.4.2 Improve for manufacturing defects

Just as in giving targets for reducing packaging defects, targets for reducing manufacturing defects are given. For each month (period) the number of units is taken to be a constant of 1950000 kg. This is because average per day requirement of Britannia is for the facility to produce 75000 kg, so this would come up to about 1950000 during a month. Therefore the defect rate targets to be measured are for every 1950000 kg of production. Each month the sigma level is increased by 0.1, until the target of 5σ is reached. The respective amount of defects that need to be produced each month or for every 1950000 kg of production to attain the required level of process sigma is mentioned in the table.

Table 4: Targets for manufacturing defects

Period	Number of Units (In Kgs)	Sigma Value	CTQ	DPMO	TOP	Number of defects (In Kgs)
1	1950000	4.4	6	1866	11700000	21832
2	1950000	4.5	6	1350	11700000	15795
3	1950000	4.6	6	968	11700000	11326
4	1950000	4.7	6	687	11700000	8038
5	1950000	4.8	6	483	11700000	5651
6	1950000	4.9	6	337	11700000	3943
7	1950000	5	6	233	11700000	2726

Increasing in sigma (%) = (Sigma Target – Sigma Baseline)/Sigma Target × 100

$$= (5 - 4.30)/5 \times 100$$

$$= 14 \%$$

$$\begin{aligned} \text{Decrease in Defects (\%)} &= (\text{Defects Baseline} - \text{Defects Target}) / \text{Defects Baseline} \times 100 \\ &= (26974 - 2726) / 26974 \times 100 \\ &= \boxed{89.89\%} \end{aligned}$$

Upon reaching the targets through a period of 7 months the organization would observe a reduction in the manufacturing defect rate by 89.89%. To achieve these goals, it is important to understand the causes for the defects, and to provide suggestions for improvement to counter these problems. Therefore, we look at the causes for manufacturing defects using a Fishbone diagram.

The fishbone diagram shows the four primary sources for cause of manufacturing defects – Man, Machine, Material and Methods. Under each of these sources, the first arrow points to the primary causes: Over-baking, Change-over of production, improper conveyer speeds, high speed of feeder, lack of training on machine adjustments, rough stacking of biscuits and problem with the dough mix.

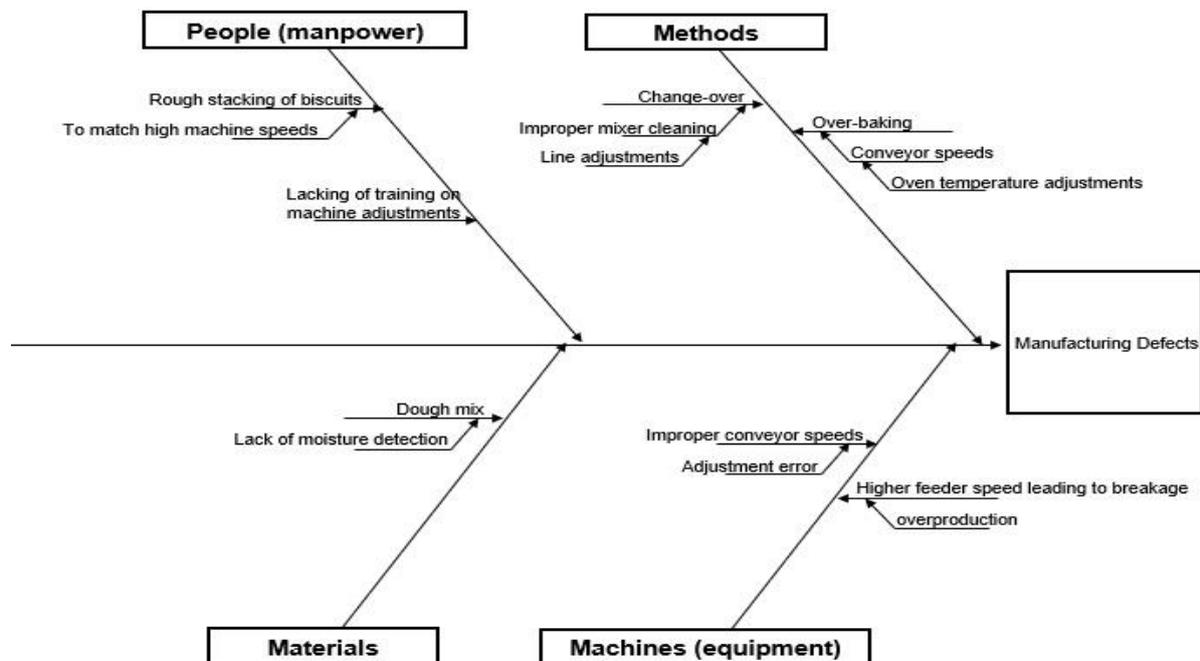


Figure 27: Fishbone diagram for manufacturing defects

Under the primary causes, arrows point to secondary or root causes that give rise to the primary cause. For each cause a suggestion for improvement is provided in the table that follows. Out of these suggestions the organization can focus on ways that are focused on reducing defects due to over baking and defects due to breakage. This is because through the Pareto chart we observed that the second and third highest defect rates are at the oven end and the table end. In the oven end defects due to over baking are collected, and in the table end defects due to breakage are observed.

To reduce these defects it is important to ensure that the conveyor speeds are right so that the dough spends the right amount of time for baking and doesn't undergo baking for longer times than required. The line engineers should be trained and knowledgeable regarding the oven temperature and machine adjustments for each biscuit variant. To reduce defects due to breakage it is important to reduce the speed of the feeder arm that moves the biscuits from the table end to the packaging machine. When speed of the feeder arm is reduced, workers at the stacker end can handle the biscuits more easily, thereby reducing breakage at the stacker end as well. The table for suggestions for improvements to reduce manufacturing defects is as under.

Table 5: Suggestions for manufacturing defects

Source	Cause	Suggestion
Machinery	Improper conveyor speeds	To ensure right conveyor speeds for the biscuits to get the exact time required in the baking and cooling sections
	High Feeder speed leading to breakage	The high speed of feeder often leads to breakage of biscuit, to reduce this it is important to lower the machine speed from 148 to 130

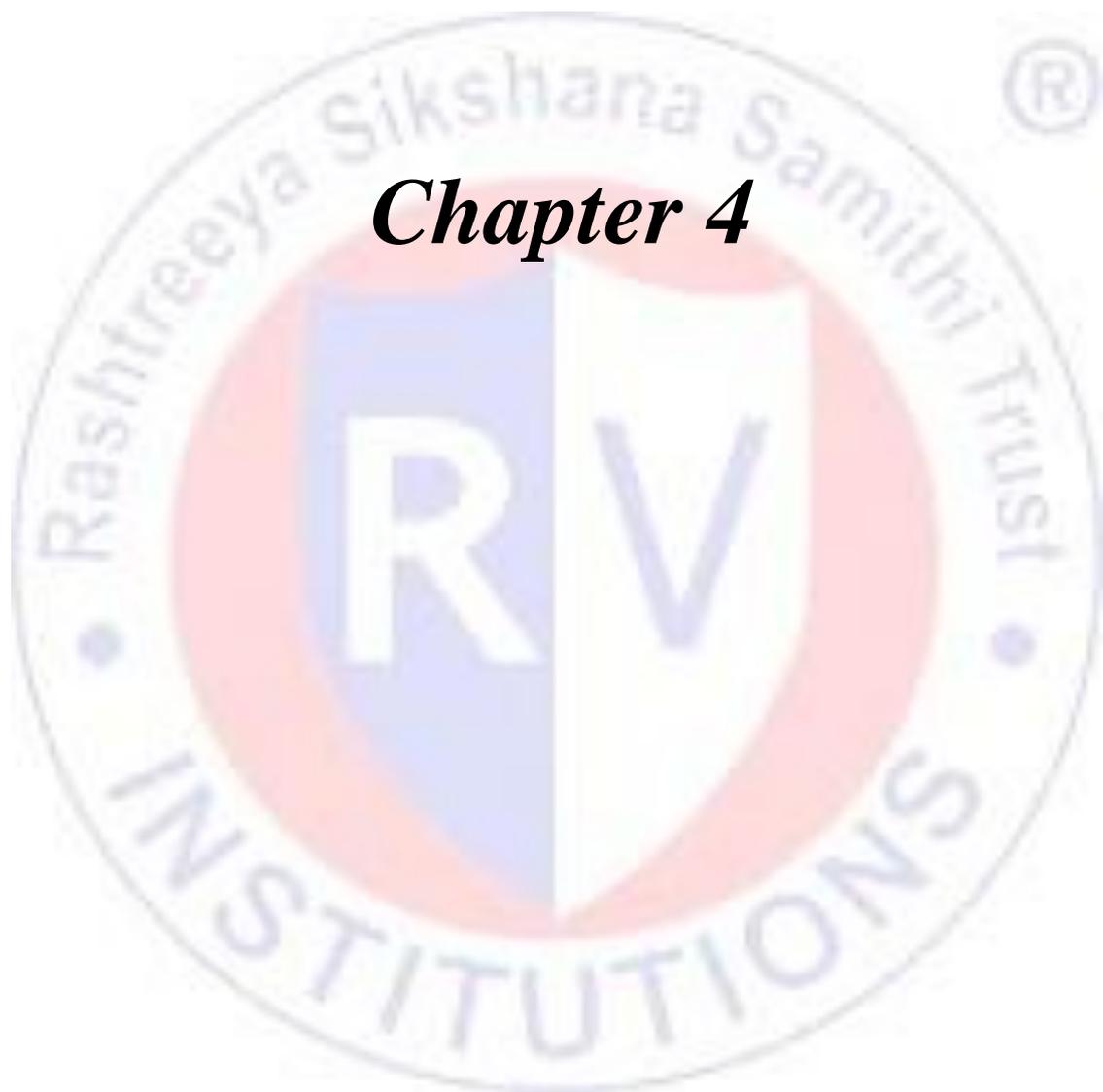
Materials	Dough Mix	Use of moisture sensors in the process of mixing to sense extra moisture
Man	Lack of training on machine adjustments	The line engineers need to be trained on the adjustment required for conveyor speeds and oven temperatures for the different variants, and for adjustments required based on the observed output
	Rough Stacking of biscuits	To match the high speed of the packing machine, it is observed that workers have to stack the biscuits on the table end quickly often leading to breakage. Therefore, on reducing the machine speed workers can handle the stacking process of biscuits in a more gentle manner reducing breakage
	Fatigue	<ol style="list-style-type: none"> 1). Ensure sufficient lighting 2). Ensure right room temperature 3). Cyclic shifting of workers – Shifting between a heavy task and a light task every 30 min
Methods	Change-over	<ol style="list-style-type: none"> 1). Ensure thorough cleaning of mixers before change-over of variant 2). Ensure right adjustments of conveyor speeds and oven temperature as per requirement of variant
	Over-baking	<ol style="list-style-type: none"> 1). Ensure conveyor speeds are set right so that the biscuits don't spend more time than required in the oven 2). Oven temperature should be checked at the various points before start of production

3.5 Control Phase

This phase focuses on controlling the results obtained, and to systematically compare the results obtained with respect to the target value.

After providing the goals, suggestions and insights it is up to the organization to consider our input and make the changes they feel is required to achieve the monthly goals set for reducing defect rates. Upon reaching the goal set, it is essential for the organization to then maintain the new system established for keeping the defect rate under control at the new level that is reached. This would then see the organization functioning at 5σ level with respect to both packaging and manufacturing defects produced.





Chapter 4

RESULTS, DISCUSSION & CONCLUSIONS

This chapter talks about the overall results or understandings from the project work carried out. It discusses these results along with mentioning the future scope of the project. The conclusion drawn and the project outcome are to be seen in this chapter.

4.1 Results and Discussion

In the measure phase of the project downtime data is first observed. Upon finding out that the form existing lacked structure and was not enough to maintain downtime, a new form was proposed where 1) Reason for downtime 2) Duration of Downtime and 3) Production loss in kg due to downtime, are all measured. This form was used to record data for April and May, and downtime data was obtained for these 2 months. It was observed that Downtime Data collected was inaccurate and not appropriate to carry out analysis as it would offer inconclusive results. Training is required on personnel to record the downtime in the proposed form. However, it is seen that the highest downtime occurs due to maintenance procedures which are unavoidable. The second highest downtime occurs due to breakdown, however the breakdowns occur in different parts of the production line at random and there was no trend observed. The third highest downtime occurs due to processes involved, however these are small and non-recurring.

Defects data was available for different sections in which the defects are generated. This proved valuable in assessing the section in which the most defects are generated. Using the Pareto Chart we were able to notice that the highest numbers of defects were generated in the packaging section which comprised of 27.3% of the overall defect rate. This was followed by Table end and Oven end defects. Together these three defects alone accounted to 69.6% of the overall defect rate. Therefore, the process sigma levels for packaging and manufacturing are calculated separately. Packaging defects sigma level was found to be 4.29σ and that of manufacturing defects was found to be 4.3σ . To reduce the defect rates in the organization, monthly goals are given to the organization to reach a sigma level of 5σ for both packaging

and manufacturing. The causes for the defects are then analyzed and suggestions for improvement are provided, with the focus being to reduce defects in the Packaging, Table end and Oven end sections.

4.2 Conclusion and Project Outcome

Table 6: Conclusions Table

Area	Existing process sigma level	Targeted process sigma level	Increase in sigma level (%)	Decrease in defect rate (%)
Packaging	4.29 σ	5 σ	14.2	90.41
Manufacturing	4.3 σ	5 σ	14	89.89

While the organization does an impressive job of meeting the production targets, it is seen that the defect rates are ignored, or in other words the possibility to reduce defect rates are not treated as a priority. It is important for the organization to have set goals in any domain to excel further. Therefore, we offer the organization set monthly goals to be achieved over a period of 7 months which would see the organization reducing the defects rate of Packaging by 90.41% and that of Manufacturing by 89.89% by reaching a 5 σ process level in both manufacturing and packaging.

4.3 Future Scope

Recording of downtime is important to be carried out, as it gives the organization a better idea on the types and duration of downtime causes. Downtime is basically a loss of precious time for manufacturing, so in industries such as biscuit manufacturing where the amount of output generated per minute is high, even a few min of downtime is linked to a big loss in production. Therefore, only by recording and analyzing the downtime, there can be attempts to tackle the losses. Since, it proved that manual recording of downtime was not efficient, implementation of an automated downtime tracking system would help the organization in getting valuable information related to downtime.

To better show the necessity of reducing the defect rates, a Cost Benefit Analysis can be carried out to show the benefits or the reduction in costs incurred by meeting the defect rate targets. Commercial data such as costs incurred by the company could not be disclosed to us. However, carrying out this analysis would help in emphasizing the need for reducing defects.

The work presented in this Report has been published in a Journal of repute. [11]

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Appendix-1

Some of the policies followed by the company are mentioned here. This is to throw light on the standards maintained by the organization and to show the importance of maintaining sanity in the workspace or production space in a food processing sector.

GLOVES POLICY

USAGE OF COTTON / CLOTH GLOVES IN PROCESS AREAS:

- Usage of cotton /cloth gloves is allowed to maintain hygienic condition in the plant.
- Reused cloth gloves where ever used in process area should be kept clean without loose threads.
- Used gloves should be disposed in the container meant for it and concerned area FPR's need to ensure it.

OTHER GLOVES:

- Other than cotton/ cloth gloves, rubber gloves and surgical gloves are used for electrical and welding safety purpose and these gloves are reusable.
- Rubber gloves can be used for chemical handlings and is reusable.
- The reusable gloves will be kept in designated areas only.

VISITOR POLICY

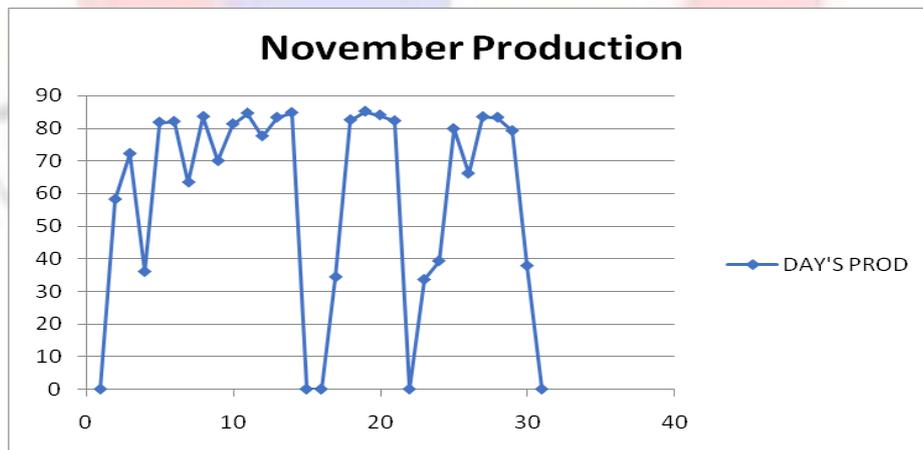
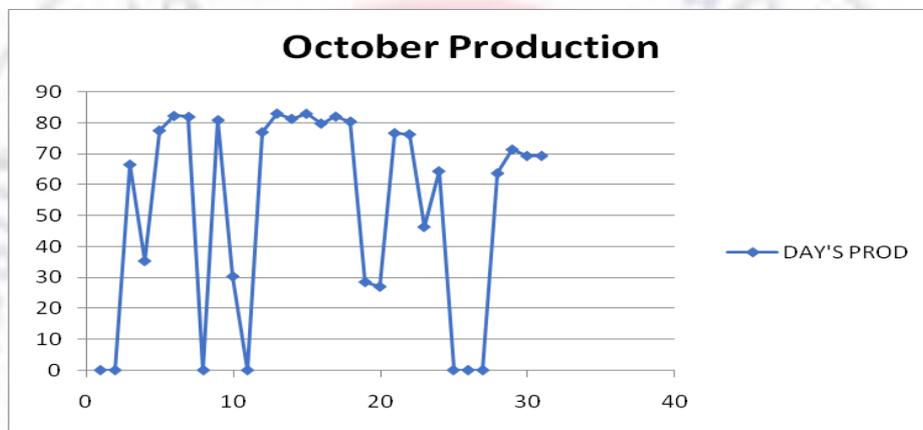
The following are the precaution to be taken by a visitor when he/she enters PARAMOUNT NUTRITIONSINDIA PVT. LTD.,

- The visitor must have the permission of the management before entering the factory. The visitors must read / understand the GMP pamphlet guidelines & to be followed.
- **The visitor must wear hair net & apron when he/she enters the processing area. The processing area includes S & F as well as Stores, to cover hair on arms as well.**
- The visitor must not have any contagious disease.
- **The visitor must not have open cuts or wounds.**
- The visitor must not enter the factory with lethal weapons.

- The visitor must not have physical contact with any of the processing materials & machines.
- Visitor with Perfumes, Jewelry, Flowers with them are not entertained inside processing area.
- Cigarettes and Pan/Tobacco should be left with security while entering inside the factory.

Appendix-2

This is to talk about the non-uniformity in the day-to-day production data, which takes the focus away from the discussion of Downtime and Defects analysis.



Production data for 6 months was observed. Every month had a similar curve for day-to-day production. This shows the existence of Mura or non-uniformity in the daily production. Also it can be seen that on most days the production is more than 80000 Kg while the target is only 75000 Kg.
