



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Waste Reduction in Line 3 Packing Area



Ethan Harris (1912242)

UNIVERSITY OF WALES TRINITY SAINT DAVIDS | BACHELOR OF ENGINEERING:
MECHANICAL AND MANUFACTURE ENGINEERING | 20th May 2024

Table of Contents

Abstract.....	2
Aims and objectives of the project. Introduction to the Topic	4
Statement of the Aim	4
Elaboration of the Aim	5
Objectives	5
Define and Quantify Waste Sources	5
Analyse Current Processes.....	5
Develop and Implement Waste Reduction Strategies	5
Evaluate the Impact of Implemented Strategies	5
Document and Recommend Best Practices	6
Relevance of the Objectives	6
Timing plan.	7
Research/literature survey.	9
Objective	9
Golden Bake	9
New Era Machines.....	10
Loyal Food Processing Line	11
Six Sigma - How DMAIC Can Help Your Business Improve Performance.....	12
Work conducted.....	13
Measure	13
Analyse.	18
Improve	30
Results and Final Benefits.....	32
Discussion and conclusions.	34
Conclusion	35
Defining the Problem	35
Measuring and Analysing the Current State	36
Improving the Process	36
Controlling the New Process	37
Results and Benefits	37
Scalability and Replication	37
Continuous Improvement and Future Steps	38
Conclusion	38
Recommended further work	38
References.	40

Abstract.

Waste reduction in manufacturing industries is crucial for operational success, particularly in food production where efficiency and sustainability are key. This project focuses on Fox's Burton's Companies' Line 3, the least efficient line with the highest waste levels in 2023, producing chocolate-covered digestive biscuits. The project aimed to devise and implement strategic interventions to reduce waste, enhance operational efficiency, reduce costs, and improve environmental sustainability. Utilizing the DMAIC (Define, Measure, Analyse, Improve, Control) framework, the project identified waste sources, developed targeted strategies, and assessed their effectiveness in real-time.

The project began by defining the problem, highlighting the multifaceted implications of waste on cost, efficiency, and environmental impact. The measurement phase involved a detailed analysis of the production process, identifying key waste contributors through tools such as process flow diagrams and Pareto charts. Root Cause Analysis (RCA) and the 5 Whys technique helped pinpoint fundamental causes of waste, including worn components, inadequate cooling, and accessibility issues.

The improvement phase implemented practical solutions like replacing worn parts, enhancing cooling systems, and improving operator access, validated through continuous monitoring. Key improvements included installing longer guides for biscuit alignment and replacing vibrators with V-belts, significantly reducing waste and operational disruptions. To sustain these improvements, a robust control plan was implemented, including regular performance monitoring, maintenance schedules, and Lineside Short Interval Control (SIC) huddles.

The project resulted in a significant reduction in weekly waste from 4854 kg to 4187 kg, translating to a waste percentage decrease from 5.55% to 3.84%. These improvements not only reduced financial losses but also enhanced environmental sustainability and increased employee morale by reducing the time spent on waste collection. The methodologies applied have clear potential for scalability and replication across other production lines and sites within the company.

Future work could potentially include integrating advanced automation and AI for predictive maintenance, enhancing data analytics, adopting energy-efficient technologies, and implementing a continuous improvement program. Collaboration with industry experts, regular equipment upgrades, and enhanced waste segregation and recycling initiatives are also recommended. By leveraging customer feedback and investing in research and development, Fox's Burton's Companies can align products with market demands, improve

efficiency, and maintain competitiveness. Developing a long-term sustainability strategy will ensure the company remains a leader in innovation and environmental stewardship. These initiatives will address immediate operational challenges and position the company for long-term success in a competitive and environmentally conscious market.

Aims and objectives of the project.

Introduction to the Topic

Waste reduction is a pivotal concern in manufacturing industries, where efficiency and sustainability intersect to define operational success (Tetrapak, 2024). In the realm of food production, and specifically biscuit manufacturing, waste not only signifies lost material and financial resources but also impacts environmental sustainability and corporate responsibility (Tetrapak, 2024). This dissertation focuses on Fox's Burtons Companies, specifically at Line 3, which currently produces chocolate-covered digestive biscuits. This line identified as the least efficient with the highest waste levels in 2023. This represents a critical area for intervention. The implications of such waste are multifaceted, affecting cost, operational efficiency, and environmental footprints (eufic, 2021). The urgency to address this issue is underscored by the substantial financial loss incurred, highlighting a pressing need for a strategic approach to waste reduction (eufic, 2021). This investigation is poised to offer insights that could not only rectify the inefficiencies on Line 3 but also serve as a blueprint for waste reduction across other lines, fostering a culture of continuous improvement and sustainability within the company.

Statement of the Aim

The aim of this project is to devise and implement strategic interventions for significant waste reduction on Line 3 at Fox's Burtons Companies. By targeting the line with the highest waste output, the research endeavours to enhance operational efficiency, reduce costs, and contribute to the company's environmental sustainability initiatives. The objective is to identify the root causes of waste, develop targeted strategies for waste minimization, and assess the effectiveness of these strategies in real-time operation. This initiative is not merely about immediate waste reduction but also about establishing a sustainable model of operation that aligns with the best practices in manufacturing efficiency and environmental stewardship. Ultimately, the project aims to demonstrate how focused improvements can lead to substantial benefits, both financially and environmentally, setting a precedent for waste management in the manufacturing sector.

Elaboration of the Aim

Delving deeper, the aim of reducing waste on Line 3 is multifaceted. It is not only about lowering the percentage points in waste metrics but also about understanding the systemic issues that lead to waste generation. This endeavour is poised to dissect the intricate operations of Line 3, isolating inefficiencies, and identifying leakage points in the production process. The financial ramifications are clear—with waste significantly overshooting the budget, there is a tangible urgency to rectify this discrepancy. However, the implications extend beyond the balance sheet. This project aligns with broader corporate goals of sustainability and efficiency, resonating with global calls for more responsible manufacturing practices. By addressing waste on Line 3, the research will contribute to the company's reputation, operational excellence, and environmental footprint, illustrating how strategic interventions can yield comprehensive benefits. The DMAIC (Define, Measure, Analyse, Improve, Control) approach, a proven methodology in process improvement, will serve as the backbone of this project, ensuring a structured, data-driven, and effective pathway to waste reduction (theleansixsigmacompany, 2024).

Objectives

Define and Quantify Waste Sources: Establish a detailed understanding of where and how waste is generated on Line 3, quantifying waste to identify major contributors and areas with the highest potential for improvement.

Analyse Current Processes: Utilize the DMAIC framework to dissect the existing processes, identifying inefficiencies and determining the root causes of waste production. This objective includes a thorough assessment of operational practices, material usage, and workflow to pinpoint areas for intervention.

Develop and Implement Waste Reduction Strategies: Based on the analysis, devise targeted strategies to address identified waste sources. This involves designing and executing interventions, whether they be processing optimizations, equipment upgrades, or behavioural changes among line operators.

Evaluate the Impact of Implemented Strategies: Monitor and assess the effectiveness of the implemented strategies, using predefined metrics to gauge success in waste reduction, cost savings, and efficiency improvements.

Document and Recommend Best Practices: Create a comprehensive report detailing the findings, strategies implemented, and outcomes achieved. Recommend best practices for waste reduction that can be scaled or adapted to other production lines within the company.

Relevance of the Objectives

Each objective is intricately linked to the overarching aim of reducing waste and enhancing efficiency on Line 3. By defining and quantifying waste sources, the project establishes a baseline, creating a targeted approach to tackling inefficiencies. Analysing current processes not only aids in identifying the root causes of waste but also fosters a deeper understanding of the production line's dynamics, which is crucial for crafting effective interventions (Team Asana, 2021). The development and implementation of waste reduction strategies are at the core of this project, translating insights into actionable changes that yield measurable results (Team Asana, 2021). Evaluating the impact of these strategies ensures that the project is grounded in data-driven outcomes, allowing for adjustments, and reinforcing the ethos of continuous improvement. Lastly, documenting and recommending best practices encapsulates the project's findings into a framework that can be replicated or adapted, amplifying the project's value beyond Line 3 (Diaz, 2024).

Timing plan.

To keep on track with the project, a Gantt chart was created to allow for targets to be met and to keep up to date where the projects objectives were at points during the year. A timing plan in a project ensures that tasks are completed efficiently and on schedule, helping manage resources, track progress, coordinate teams, control the budget, address risks, maintain quality, and meet stakeholder expectations (Atlassian, 2024). It is an essential communication tool as well as a planning and monitoring method. If there are any deviations from the plan, they would typically be discussed and addressed in project meetings, with potential updates to the chart to reflect any changes in the timeline (Zavala-Quinones, 2024). Altogether there were two timing plans produced. A plan was first created demonstrating the ideal timescale taken to complete the project.

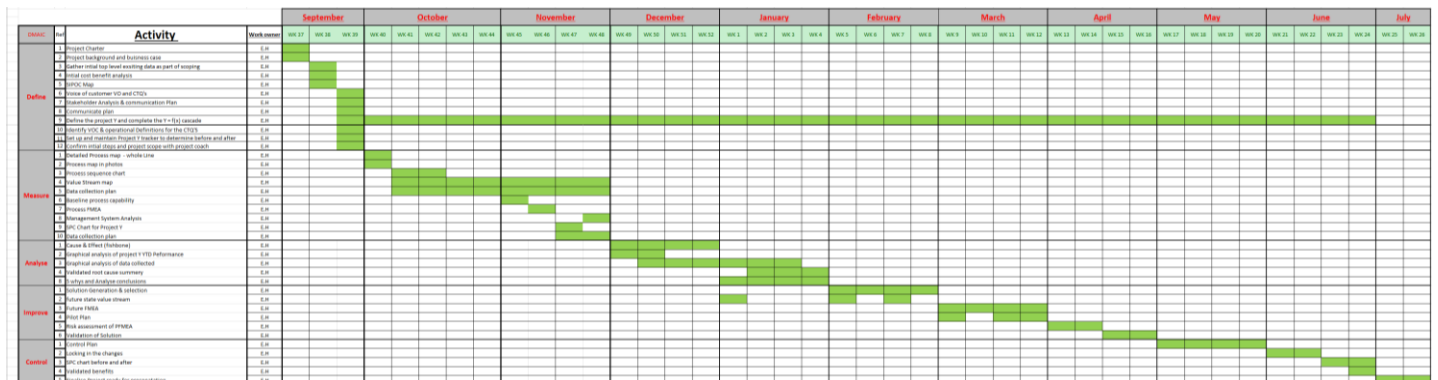


Figure 1- Initial Timing Plan

By having the Gantt chart to hand it shows where the project could have been at its current stage and how the project is going. As you can see from the Gantt chart the project was predicted but by the help and aid of some of the other filters within FBC some time was able to be reduced.



Figure 2- Updated Timing Plan (Before Christmas)

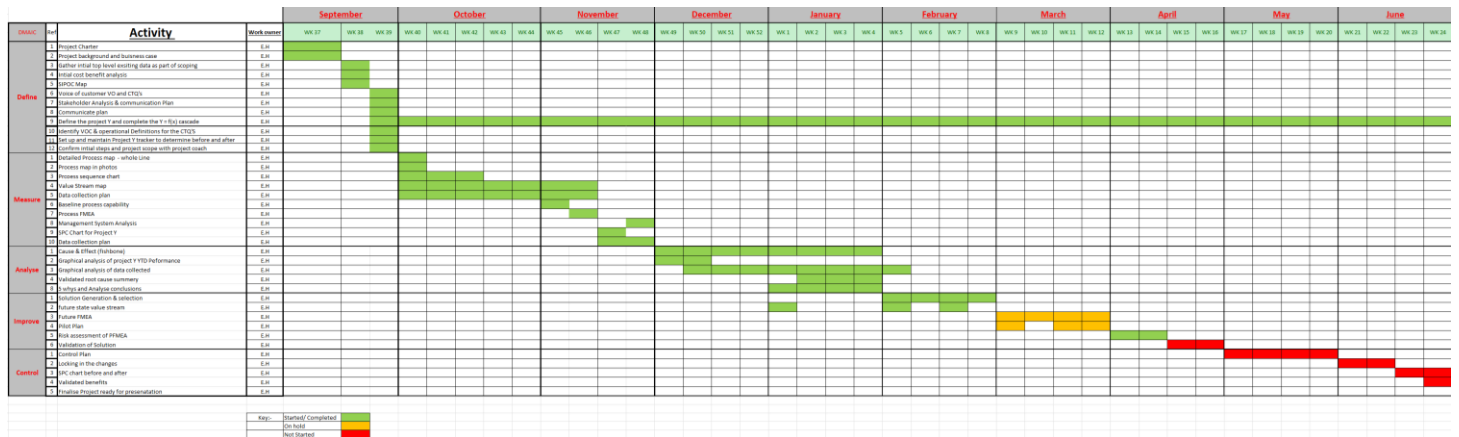


Figure 3- Recent Progression (25/03/2024)

With current progression there is visible progression when compared to the Gantt chart produced before Christmas of 2023. There are also tasks which can be visible to have been put on hold due to setbacks. One of those setbacks being that the cooling tunnel had a major breakdown. The sprocket which drives the conveyor snapped. The engineering team had none to hand, so the line was off for 3 days in total. Attached will be the report from out engineering PM system Shire. Setbacks are common when carryout projects as not everything in mind will go to plan. They can cause small or larger constraints which may affect progression (Team, 2011). To try and reduce setbacks there are steps to take to reduce the likelihood of these occurring. One of those steps can be basic communication. Through the project there was particularly effective communication between me, production, and the engineering department to ensure that there was ensure that the correct people where to hand along with the correct tools (Task2Bill, 2018). Another key step is to adapt. For example, by looking ahead in the engineering plan for line 3, it was noted that the line was off during one week after Christmas. This allowed for closer inspection to the line whilst it was not running. By doing this it allowed for steps to be carried out quicker as measurement and other data was recorded (Task2Bill, 2018).

Research/literature survey.

Objective

The primary objective of this dissertation is to systematically investigate and evaluate the existing waste management practices within line 3. With a primary focus on identifying inefficiencies and areas for improvement, this research aims to propose sustainable and technologically integrated solutions to minimize waste generation and optimize resource utilization. By conducting a comprehensive literature survey and empirical analysis (The University of Edinburgh, 2024), this study seeks to contribute to the industry's knowledge base, providing actionable insights that can lead to more environmentally friendly and cost-effective production processes. This will not only enhance the sustainability credentials of the manufacturing practices but also improve the overall operational efficiency, aligning with global environmental standards and regulations.

Golden Bake

1. Understanding the Importance of Consistency in Biscuit Production:

The article emphasizes the significance of consistency in biscuit production, stating its direct impact on taste, texture, appearance, and overall quality. This aligns with the project goals, which likely highlight the importance of maintaining consistent quality standards throughout the manufacturing process (Golden Bake, 2024).

2. Maintaining Optimal Equipment Performance for Consistent Results:

The article stresses the importance of well-maintained equipment to achieve consistent results. This relates to the project in which it focuses on operational efficiency and the role of machinery in minimizing waste and ensuring product uniformity (Golden Bake, 2024).

3. Implementing Standard Operating Procedures (SOPs) to Ensure Quality Control:

SOPs are mentioned in the article as essential for maintaining consistency. This corresponds to the project's end goal, which may include developing and implementing SOPs tailored to waste reduction strategies in biscuit manufacturing (Golden Bake, 2024).

4. Utilizing Efficient Packaging and Storage Solutions:

The article discusses the importance of packaging and storage solutions in preserving biscuit quality. While not related to waste reduction, efficient packaging can indirectly contribute to waste reduction by minimizing product damage and spoilage (Golden Bake, 2024).

5. Adopting Continuous Improvement Strategies for Long-Term Consistency:

Continuous improvement strategies are highlighted in the article as crucial for achieving long-term consistency. This aligns with your dissertation's emphasis on ongoing optimization and waste reduction efforts within the manufacturing process (Golden Bake, 2024).

Overall, while the article focuses on ensuring consistency in biscuit production, some elements, such as efficient packaging and continuous improvement strategies, indirectly contribute to waste reduction goals. The article drew parallels between the article's recommendations and the projects objectives, emphasizing the importance of consistency not only for product quality but also for waste reduction and overall operational efficiency in biscuit manufacturing.

New Era Machines

The article provides an extensive analysis of contemporary biscuit handling systems, delving into their myriad advantages in augmenting efficiency, precision, and product quality throughout the biscuit manufacturing landscape. It meticulously examines various critical facets, starting with the sophisticated control mechanisms enabling precise filling control, ensuring optimal utilization of ingredients, and minimizing material wastage (Machines, 2023). Moreover, it underscores the integration of innovative packaging solutions aimed at safeguarding product integrity and freshness, thereby indirectly contributing to waste reduction by mitigating potential spoilage or damage. Furthermore, the article elaborates on the deployment of specialized components within these systems to effectively combat production downtime, thereby enhancing operational continuity and resource utilization efficiency (Machines, 2023).

In addition to these primary functionalities, the article elucidates how modern biscuit handling systems offer unparalleled customization capabilities, enabling manufacturers to tailor packaging and production processes to specific requirements. By facilitating precise portion control and packaging customization, these systems assist in curbing overproduction and minimizing excess inventory, aligning seamlessly with the waste reduction objectives elucidated in your dissertation. Furthermore, the systems are lauded for their initiative-taking approach to maintaining cleanliness and hygiene standards, with features such as continuous crumb removal systems ensuring the elimination of debris and contaminants that could compromise product quality (Machines, 2023).

The article also sheds light on innovative features such as the "no product, no cycle" mechanism, which prevents wasteful packaging by initiating the packaging cycle only upon product detection. This feature not only enhances operational efficiency but also serves as a

strategic tool for waste reduction by eliminating the occurrence of empty packs. Additionally, the emphasis on speed and accuracy in packaging processes underscores the systems' potential to minimize resource wastage and enhance production throughput, thereby indirectly contributing to waste reduction efforts (Machines, 2023).

Furthermore, the article highlights the significance of maintaining uniformity in product alignment and presentation, citing its role in minimizing product damage and optimizing packaging efficiency. By ensuring consistent product placement and presentation, these systems mitigate the risk of rework and minimize material wastage, thereby bolstering overall operational efficiency. Moreover, the streamlined configuration processes and user-friendly control interfaces facilitate seamless transitions between product variations, reducing setup times and enhancing operational agility (Machines, 2023).

In conclusion, while the article primarily focuses on the efficiency and quality-enhancing features of new-age biscuit handling systems, it implicitly underscores their profound impact on waste reduction efforts within biscuit manufacturing operations. By optimizing production processes, enhancing packaging quality, and minimizing downtime, these systems contribute significantly to the overarching objectives outlined in the projects aims regarding waste reduction strategies within the biscuit manufacturing domain (Machines, 2023).

Loyal Food Processing Line

The provided text offers insightful guidance for optimizing the efficiency of biscuit production lines, highlighting six key tips for operational success. It emphasizes the critical importance of meticulous machine alignment, ensuring that each component is set to the correct specifications to maintain smooth workflow and minimize potential disruptions (Royal Food Processing Line, 2022). Furthermore, it underscores the significance of thorough ingredient preparation, emphasizing the need for properly combined dry and liquid ingredients to form a consistent paste for optimal biscuit formation (Royal Food Processing Line, 2022).

Additionally, the text advocates for the careful selection and configuration of equipment tailored to the specific biscuit type being produced, emphasizing the role of appropriate machinery in achieving desired product outcomes and minimizing waste. Moreover, it cautions against the pitfalls of multitasking, urging operators to focus on one task at a time to maintain efficiency and avoid errors (Royal Food Processing Line, 2022). Furthermore, it recommends strategic production line layout and organization to prevent bottlenecks and streamline workflow, ensuring that each machine operates at its maximum capacity without undue delays. Additionally, the text underscores the importance of regular shift inspections to identify and address any potential issues promptly, promoting initiative-taking maintenance and troubleshooting to minimize downtime and optimize productivity (Royal

Food Processing Line, 2022). Lastly, it stresses the significance of maintaining a clean and hygienic workspace to ensure employee well-being and product quality. Overall, these comprehensive insights align closely with the objectives of the project, particularly in terms of enhancing operational efficiency and implementing waste reduction strategies within the biscuit manufacturing process (Royal Food Processing Line, 2022).

Six Sigma - How DMAIC Can Help Your Business Improve Performance.

Firstly, DMAIC provides a structured framework for problem-solving and process improvement. By defining clear objectives and metrics in the Define phase, we can precisely identify areas of waste within the manufacturing line, whether it be in the form of excess materials, energy, or time (Ang, 2023).

Secondly, the Measure phase allows us to quantitatively assess the current state of the manufacturing process, identifying key performance indicators (KPIs) and establishing a baseline for waste levels. This data-driven approach enables us to accurately measure the impact of waste reduction initiatives and track progress over time (Ang, 2023).

In the Analyse phase, we delve deeper into the root causes of waste within the manufacturing process. By conducting thorough root cause analysis (RCA) and statistical analysis, we can pinpoint the underlying factors contributing to waste, whether it be inefficient equipment, suboptimal process parameters, or human error (Ang, 2023).

Once the root causes have been identified, the Improve phase focuses on implementing targeted solutions to address these issues and reduce waste. This may involve optimizing equipment settings, redesigning workflows, or implementing automation technologies to streamline processes and minimize material losses (Ang, 2023).

Finally, the Control phase ensures that the improvements made are sustained over the long term. By establishing robust control mechanisms and monitoring systems, we can prevent waste from recurring and continuously refine our processes to maintain optimal performance (Ang, 2023).

Overall, DMAIC provides a systematic and data-driven approach to waste reduction in biscuit manufacturing, enabling us to identify, analyse, and address inefficiencies within the production line effectively. By leveraging Six Sigma principles, we can drive tangible improvements in quality, efficiency, and sustainability, enhancing the overall performance of the manufacturing process (Ang, 2023).

Work conducted.

Measure

Once the define stage was finished the measure phase of the DMAIC can now be started. To show exactly where the investigation where be carried out a process flow diagram has been produced.

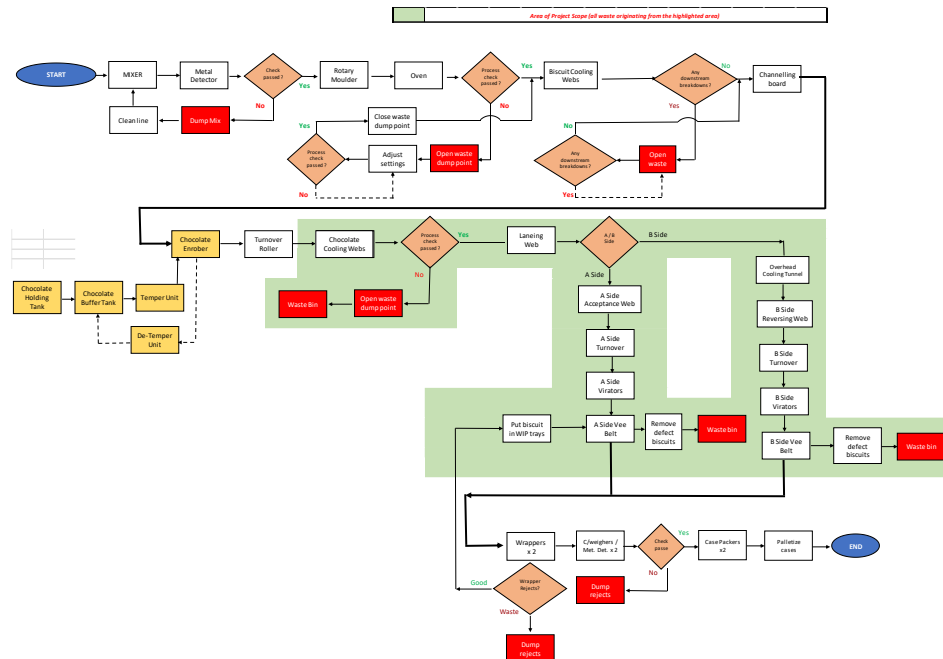


Figure 4- Process flow diagram for line 3.

In a DMAIC project, Process Flow Diagrams (PFDs) are essential because they provide a clear visual representation of a process, enabling teams to identify inefficiencies, bottlenecks, and variations. This clarity supports better decision-making throughout the DMAIC phases, facilitating effective analysis, targeted improvements, and sustainable control of the process improvements (LucidChart, 2024).

Even though this flow diagram shows the whole production process of line 3, the green highlighted area is where the focus of the project has been carried out.

Line 3 has two sides. It is to be noted that both sides are under the investigation and both sides were looked at to see if one side produced more waste than the other if they were both equal.

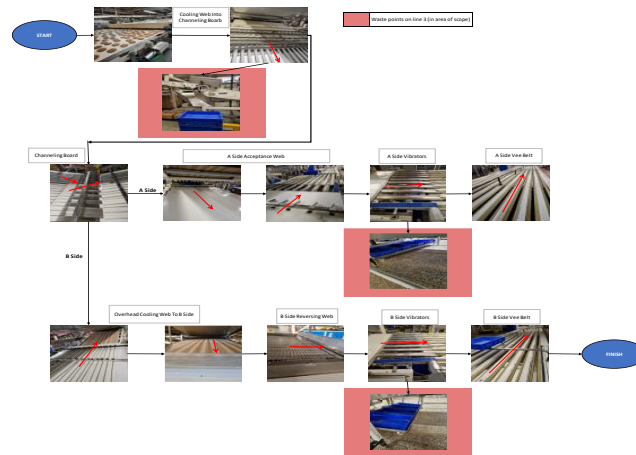


Figure 5- Line 3 area of scope.

Once the biscuits have been baked, they pass through a cooling tunnel for a short duration to ensure that they are ready for their chocolate coating. Once the chocolate coating has been applied, they then make another short journey through another cooling conveyor to make sure that the coating is suffice and is ready for the packaging stage.

To make sure that the correct data was collected a data collection plan was created. Creating a data collection plan is crucial because it ensures that the data gathered is relevant, accurate, and systematic, supporting informed decision-making. It outlines what data to collect, how to collect it, when to gather it, and who will be responsible (Villegas, 2022). This structured approach helps in minimizing biases, errors, and redundancies in data collection, ensuring that the data is dependable and valid for analysis (Hessing, 2013). A well-designed data collection plan enhances the efficiency and effectiveness of research or any data-driven project, leading to more credible and actionable insights. Below is said created data collection plan.

Data Item					Sampling				Analysis	
Name	Type of measure	Operational definition	Units of measure	Data type	Frequency	Who collects	Method	Data Source	How will the data be used	Analysis
% waste line 3	Output (Y)	Actual % waste to be collected for line 3	Percentage	Attribute	Weekly	E. Harris/ CI Dept	Data taken from finance report	Data to be used to understand baseline performance	Data to be used to understand the baseline performance	Line graph / SPC Chart
Line 3 waste Kg	Output (Y)	Weekly data for dates between 2023 & 24	Weight (Kg)	Continuous	Weekly	E. Harris/ CI Dept	Data taken from TM1 system	Compactor waste logged using TM1	Data used to identify the highest waste point on line 3	Pareto Chart
Packaging Waste Kg	Output (Y)	Weekly data for dates between 2023 & 24	Weight (Kg)	Continuous	Weekly	E. Harris/ CI Dept	Data taken from TM1 system	Compactor waste logged using TM1	To define the baseline performance and also to show the before and after of the project.	Line graph / SPC Chart
Waste at channelling board	Input (X)	Run 10, 1 hour data collection trials to see how much waste is accumulating at this location.	Weight (Kg)	Continuous	1 hour x 10	E. Harris/ CI Dept	Clear waste from line, set watch for an hour, collect and weigh after one hour, record.	Samples from line 3	Data used to establish where the highest waste point is in the packing area.	Pareto Chart
Waste at the vibrators	Input (X)	Run 10, 1 hour data collection trials to see how much waste is accumulating at this location.	Weight (Kg)	Continuous	1 hour x 10	E. Harris/ CI Dept	Clear waste from line, set watch for an hour, collect and weigh after one hour, record.	Samples from line 3	Data used to establish where the highest waste point is in the packing area.	Pareto Chart
Waste at V belts	Input (X)	Run 10, 1 hour data collection trials to see how much waste is accumulating at this location.	Weight (Kg)	Continuous	1 hour x 10	E. Harris/ CI Dept	Clear waste from line, set watch for an hour, collect and weigh after one hour, record.	Samples from line 3	Data used to establish where the highest waste point is in the packing area.	Pareto Chart
Waste on the floor	Input (X)	Run 10, 1 hour data collection trials to see how much waste is accumulating at this location.	Weight (Kg)	Continuous	1 hour x 10	E. Harris/ CI Dept	Clear waste from line, set watch for an hour, collect and weigh after one hour, record.	Samples from line 3	Data used to establish where the highest waste point is in the packing area.	Pareto Chart

Figure 6- Data Collection Plan

The data collection plan is designed to systematically capture information about waste accumulation in different areas of line 3. It targets specific points that have been identified as

critical in terms of waste generation. The plan has been created to detailed, indicating the type of data (weight or percentage), how frequently it should be collected (weekly or continuously), and who is responsible for the collection (Bhandari, 2022). By using both finance reports and real-time IT system data ensures a comprehensive capture of information (Solvexia, 2024). Sampling methods are tailored to each area, and the data collected will be analysed through line graphs and Statistical Process Control (SPC) charts, aiming to understand the current waste levels and to inform strategies for waste reduction (Oram, 2024). This approach provides a structured framework for ongoing monitoring, analysis, and improvement of waste management processes.

Using the plan from above a MSA (Measure Study Analysis) was put together and carried out. Below is the chosen methodology:

- Ten samples of finished biscuits were taken from the line (note: samples with weight variation were deliberately selected)
- 3 Operators were asked to weigh each of these ten samples three times: total of ninety measurements.
- The 3 Operators carried out the measurements at the normal location of the scales on the line.
- The 3 Operators carried out measurements without the others being present – to avoid any influence upon each other.
- As controller of the exercise, I called out samples to be measured in a random order – this ensured that measurements were made objectively with no `memory` factor taking place.
- Analysis was carried out in Minitab using the Gage R&R Study (Crossed) tool with the ANOVA option – this tool was selected because the data (biscuit weight) is Variable data.
- The `Crossed` tool was selected because the samples were re-usable (not destructive testing).



Figure 7- Weighing of biscuits.

	1	2	3	4	5	6	7	8	9	10
Target Weight	2.08	1.80	2.39	2.89	3.76	3.23	3.05	1.41	3.32	2.83

Operator / Sample	1	2	3	4	5	6	7	8	9	10
Operator 1	2.08	1.80	2.39	2.90	3.76	3.23	3.05	1.41	3.32	2.83
Operator 1	2.08	1.80	2.39	2.90	3.76	3.23	3.05	1.41	3.32	2.83
Operator 1	2.08	1.80	2.39	2.90	3.76	3.23	3.05	1.41	3.33	2.83

Operator / Sample	1	2	3	4	5	6	7	8	9	10
Operator 2	2.08	1.81	2.39	2.90	3.76	3.23	3.06	1.41	3.33	2.83
Operator 2	2.08	1.81	2.39	2.90	3.76	3.23	3.06	1.41	3.33	2.83
Operator 2	2.08	1.81	2.39	2.90	3.76	3.23	3.06	1.41	3.33	2.83

Operator / Sample	1	2	3	4	5	6	7	8	9	10
Operator 3	2.08	1.81	2.39	2.90	3.76	3.23	3.06	1.41	3.33	2.83
Operator 3	2.08	1.81	2.39	2.90	3.76	3.23	3.06	1.41	3.33	2.83
Operator 3	2.08	1.81	2.39	2.90	3.76	3.23	3.06	1.41	3.33	2.83

Figure 8- Recorded weights from operators.

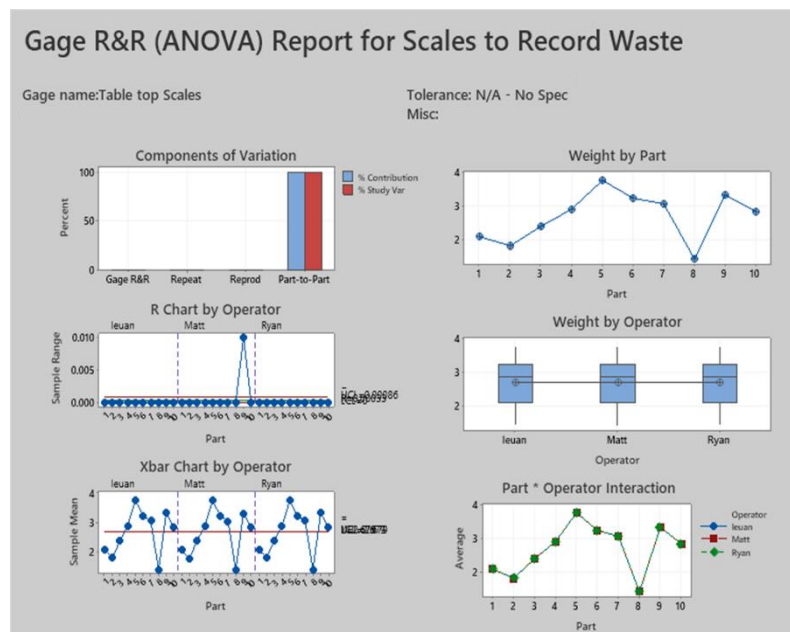


Figure 9- Results from biscuits weights.

The graphs presented above clearly demonstrate that the study was conducted with trustworthy consistency by the three operators, as evidenced by the negligible variance in their procedures and results. When tasked with weighing multiple sets of samples in a randomized sequence, all operators yielded clearly comparable outcomes, underscoring the reliability of their measurements. Additionally, the scales utilized in the Measurement System Analysis (MSA) performed by each operator were found to be especially precise, further affirming the dependability of the equipment used in the study.

Incorporating multiple individuals in the measurement process is crucial for ensuring the accuracy and reliability of data (Price, 2018). It allows for cross-verification of results, mitigating individual measurement errors and reducing bias, thus enhancing objectivity (Price, 2018). The practice serves as a check for inter-rater reliability, confirming that the data collection process yields consistent results irrespective of the measurer (Sharma, 2022). This multiplicity of measurers also tests the robustness and user-independence of the measurement system, highlights differences in skill and perception that may necessitate further training and ensures that measurement procedures are sufficiently standardized (Sharma, 2022). This collaborative approach fortifies the data's integrity, making it a more trustworthy foundation for decision-making.

To check that the measurement system was fit for purpose trays of waste accumulated from line 3 were collected from packaging area and weighed on calibrated scales. This was carried out by three of the line workers from line 3. Test one was carried out by presenting trays 1 to 10 to each of the operators. For the second test, trays 10 to 1 were then provided to all three of the operators. Lastly, for the test three, the trays were presented in a randomised sequence. By doing this it would have hopefully eliminated the risk of the operators' remembering weights from the two previous tests. By carrying out three different tests helps by eliminating human error. "Human error is when someone makes a mistake which causes an accident or causes something bad to happen" (Human Error, 2024). By reducing the likelihood of human errors warrants superior quality results. Another key reason to carrying out multiple tests is to allow for consistency and reliability. By testing with multiple operators, you can assess the consistency and reliability of the process or equipment (Valin, 2024). If all operators achieve comparable results under the same conditions, it suggests that the process is stable and reliable (Valin, 2024). When carrying out the tests there were little to no issues. All operators carried out the tests with no issues and provided good reliable results. All three tests were conducted the same way by all three operators under the same conditions. There were also no measurement issues as the MSA was considered as acceptable. This can be seen pictured below.

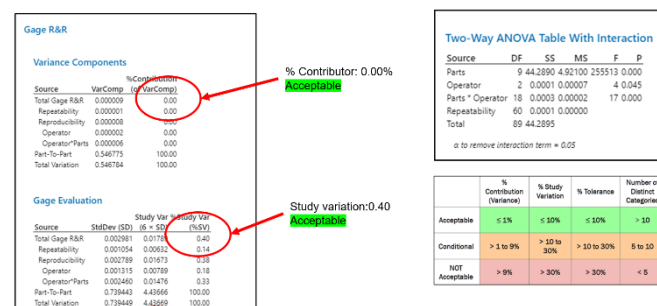


Figure 10- Acceptable figures from MSA.

In the Measure phase of the DMAIC project, valuable insights were gained that will steer the next steps. It was learned that consistent data collection is crucial for obtaining reliable and precise results. The active participation of knowledgeable operators, who possess a deep understanding of the production line, enriched the Failure Mode and Effects Analysis (FMEA) process. Their insights were particularly beneficial, highlighting areas prone to issues which are now aimed to be addressed more thoroughly.

Moving forward, A Fishbone analysis to further validate the root causes of the significant waste generated in specific areas. Additionally, there are plans to employ graphical analysis tools such as Pareto Charts and Bar Charts, which will help in pinpointing the primary sources of waste. A Root Cause Analysis (RCA) diagram will also be developed to delve deeper into the underlying reasons for these issues.

The Measurement Systems Analysis (MSA) yielded exceptionally satisfactory results, indicating that there are no areas requiring improvement in this aspect. The effectiveness of the FMEA was evident, as it successfully directed focus towards significant concerns raised by the operators regarding the line. This phase not only reinforced the importance of methodical approaches in data handling and process evaluation but also set a robust foundation for the forthcoming Analyse phase of the project.

While the Measurement Systems Analysis (MSA) showed exceptionally satisfactory results with minimal variation among the tests conducted by the three different operators, this uniformity raised some suspicions. The lack of variation, although positive, appeared unusually consistent, prompting questions about whether this could indeed be "too good to be true." This unexpected outcome suggests a potential oversight in the calibration of the measurement tools or in the testing procedure itself.

To address this anomaly, a review of the measurement tools and procedures will be incorporated in the next steps. This will ensure that the data collection methods are not only consistent but also accurately reflective of the real-world operations. By doing so, the integrity of the process improvement project is aimed to be maintained and ensure that subsequent phases are based on reliable and valid data. This step is crucial as the project continues to strive for genuine and impactful improvements in the analyse phase.

Analyse.

In the analyse part of the project, a small investigation into the potential root causes will be carried out followed by an analysis plan.

Carrying out a Root Cause Analysis (RCA) is essential across various fields like engineering and manufacturing because it helps identify the fundamental reasons behind problems,

allowing for effective, long-term solutions rather than temporary fixes (Tableau, 2024). This method enhances product quality, increases safety, and promotes cost efficiency by preventing the recurrence of issues and the associated costs (MindTools, 2023). RCA also optimizes processes, minimizes operational downtime, and supports continuous improvement by fostering a deep understanding of process interactions (Guevara, 2023). Furthermore, it builds a culture of learning and problem-solving within organizations and ensures compliance with industry regulations, leading to improved organizational performance and customer satisfaction (Horticulture, 2024).

Now looking at the different points of the manufacturing process a pareto chart was created to investigate which area of the packing floor produces the most waste (Kg). The reason for choosing a pareto chart is because it is a vital tool for prioritizing efforts in quality control and process improvement, illustrating that 80% of problems typically stem from 20% of causes (Editor, 2016). This helps teams concentrate resources on the most impactful issues, facilitating effective problem-solving and decision-making. The chart visually represents problems or defects in severity order, making complex data easy to understand and communicate to stakeholders (jmp, 2024). It also serves as an excellent tool for tracking the effectiveness of interventions over time, allowing for adjustments based on visual evidence of what issues remain most pressing. By focusing on the "vital few" issues, organizations can achieve more substantial improvements efficiently, enhancing overall performance and decision-making processes (ASQ, 2019)

Area	Waste Kg
A Channeling Board	28.72
B Channeling Board	18.49
A Vibrators	55.33
B Vibrators	22.05
A Vee Belt	16.28
B Vee Belt	28.45
A Floor	7.35
B Floor	10.54



Figure 11- Pareto Chart.

As evident from the results presented above, the data clearly indicates that the A side vibrators are the primary contributors to waste. The next two significant sources of waste are identified as the A side channelling board and the B side Vee belt.

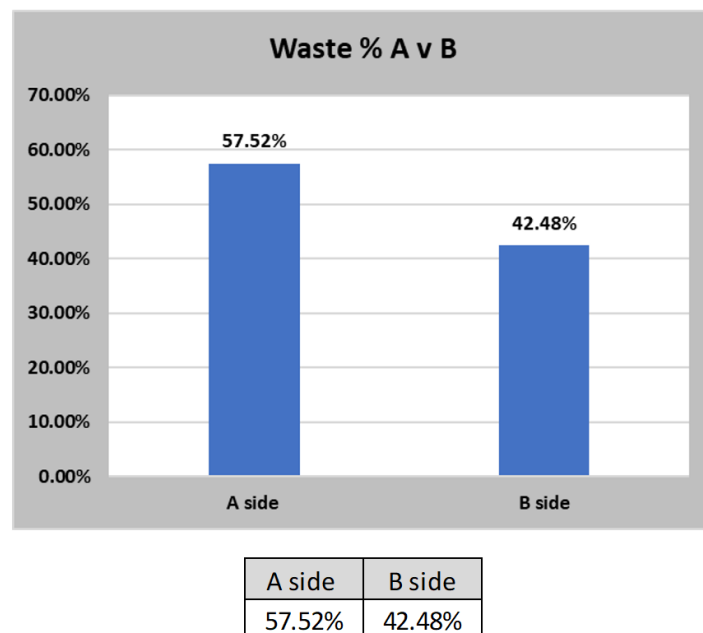


Figure 12- Waste chart for A and B side legs.

The bar chart above was produced to show which area created the most waste. From the above chart it is evident that the packing area is creating the most waste. The data above indicates that A side produces 57.52% waste within the packing area.

As sides A and B are mirrored a final chart was produced to investigate which area of the packing floor produces the most waste (Kg).

Area	Waste Kg	Area	Waste Kg
A Channeling Board	28.72	Channeling Board	47.21
B Channeling Board	18.49		
A Vibrators	55.33	Vbrators	77.38
B Vibrators	22.05		
A Vee Belt	16.28	Vee Belt	44.73
B Vee Belt	28.45		
A Floor	7.35	Floor	17.89
B Floor	10.54		

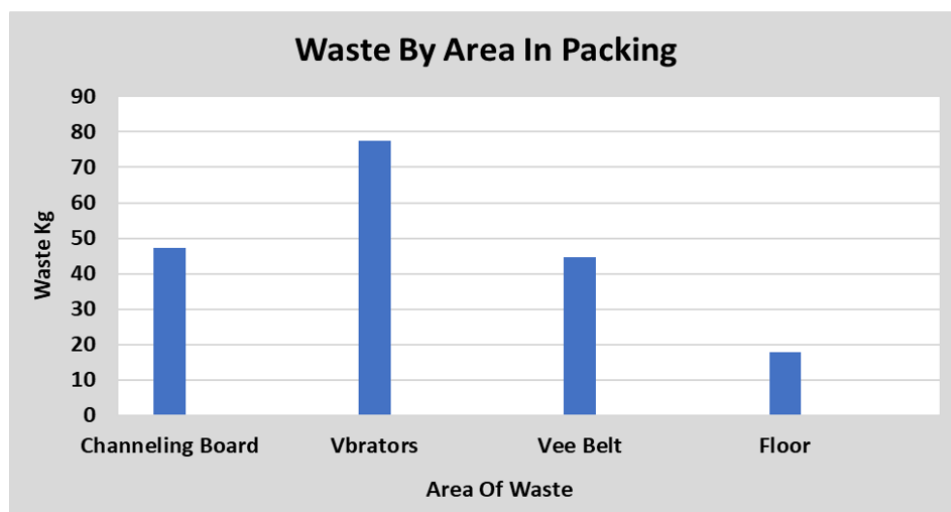


Figure 13- Combined weight of waste sides A & B.

From the data above it can be concluded that the vibrators appear to produce the most waste in the packing area. From the results a fishbone diagram was produced to show potential causes of waste within line 3. This can be found below.

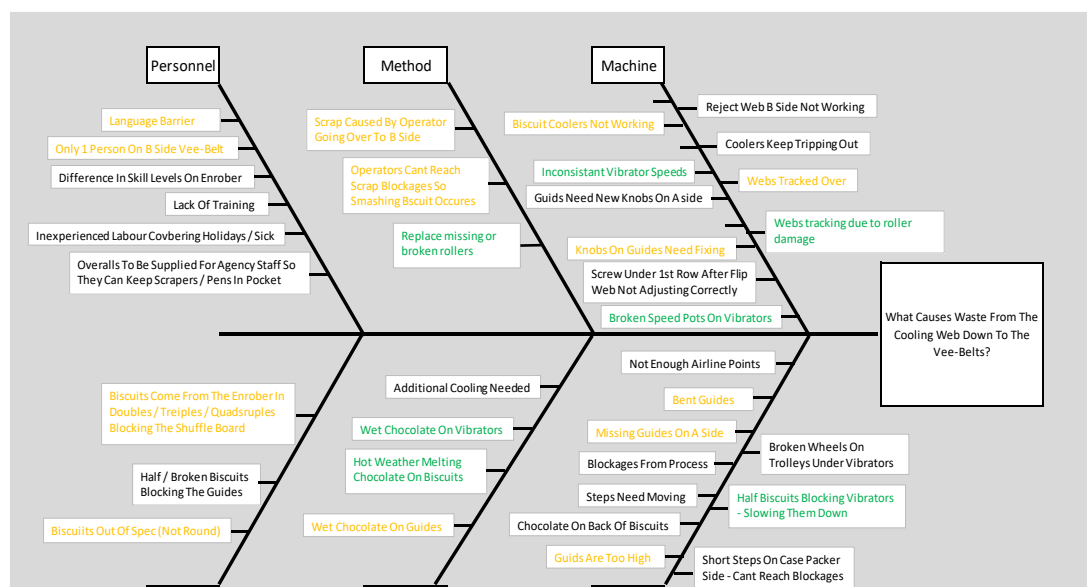


Figure 14- Fishbone Diagram for line 3.

As part of the root cause analysis plan a five why diagram was created. The "5 Whys" technique is a straightforward and effective tool for root cause analysis, valued for its simplicity and efficiency (Mind Tools, 2022). It involves asking "Why?" repeatedly, usually five times, to peel back the layers of symptoms and uncover the fundamental causes of a problem (Tulip, 2023). This method facilitates deep investigation and leads to insightful discoveries about underlying issues, promoting clear, focused discussions within teams. As it does not require complex data or statistical analysis, it can be quickly implemented, making it ideal for fast-paced environments needing immediate solutions (Lean Enterprise Institute, 2024). The 5 Whys is versatile, applicable across various sectors and problem types, and by addressing root causes, it helps prevent recurring issues, enhancing system reliability, and fostering a continuous improvement culture in organizations (Lean Enterprise Institute, 2024). Pictured below is the created "5 Whys chart".

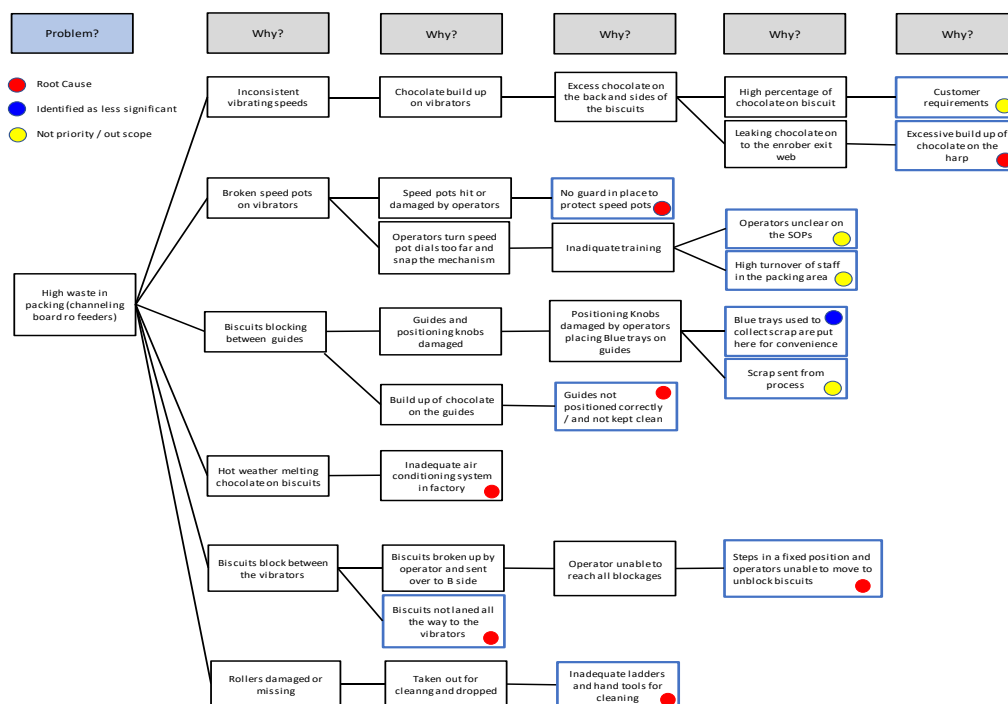


Figure 15- 5 Whys.

Moving onto the factory floor, investigations took place by physically inspecting the line whilst it was running to see firsthand issues. When investigating the line, I took images of the chocolate enrober. The role for this piece of plant is to coat the top of the biscuit and once completed traveller over an exit roller which flips the biscuit into its correct position. Each web has a scraper which helps the removal of chocolate build up. High build-up of chocolate on the enrober exit web will leave wet chocolate on the backs of the biscuits which will transfer onto other webs, guides, and vibrators.

The scraper that removes excess chocolate from the chocolate enrober exit web has worn causing excess chocolate to stay on the web. This can be seen in the image below.



Figure 16- Build-up of chocolate on enrober scraper.

During the time on line 3 it was also noted the exit web from the enrober had a small tear. Damage to any web can cause tracking issues. Tracking of a web is when the web travels past its travel range allowing the web to go off course. When this happens waste can occur, so it is vital to ensure that all webs are in good working order. The damage web can be seen below.

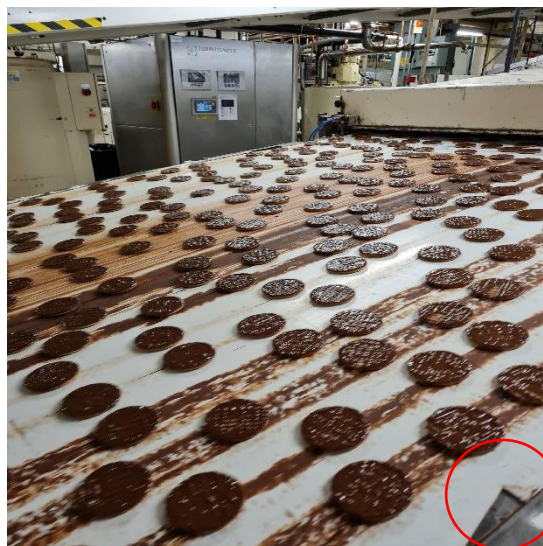


Figure 17- Damaged web.

When observing the packing area in another location it was apparent that there were small accumulations of chocolate on the guides. These guides ensure a clear transition onto the v belts which then run into the ZBV feeder. There were biscuits contained Tacky chocolate on the back and sides of the biscuits due to the scraper on the enrober exit web being worn. This can be seen pictured below.



Figure 18- Tacky chocolate on biscuit.

The problem with having tacky chocolate being found on the biscuits is that chocolate build up contributes to biscuits getting stuck between the guides causing the biscuits to back up and fall on the floor. When biscuits are stuck between the guides, they will force the guides out of line or even bend them out of shape leading to other issues further down the line. Pictured below is the stated problem.



Figure 20- Biscuits stuck in-between guide.

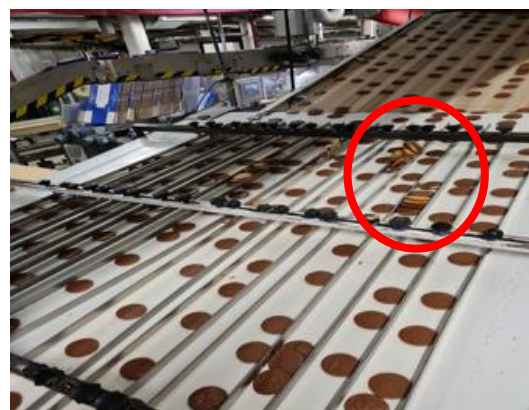


Figure 19- bent guides causing issues on the web.

Whilst examining the web that transfer the biscuits to the ZBV feeders it was noticed that there were several damaged rollers. Whilst reading our PM software Shire it was report that there were twenty-three rollers missing altogether! When rollers are damaged or missing this can effectively cause problems such as tracking. Tracking is the process of aligning a web/conveyor to it runs true (Tech, 2022). Most webs at FBC have auto tracking systems which consists of a roller connected to a pneumatic cylinder. This cylinder is then connected to a switch-when the web hits the switch it will operate the cylinder accordingly to allow for

the web to run as straight as possible. Although if rollers are missing, they can be the main cause to why a web may not run as smoothly (SEMCOR, 2018). As shown below, this is the common issue that was found when examining the rollers on line 3.



Figure 21- Damaged Roller.

Looking back at the guides, it could be seen that there was excessive build-up of chocolate on the guides. In some cases, this is acceptable as depending on the time of year, the factory does run into issues with cooling processes. In this case as the project was being carried out during winter, there should not really be any issues with cooling of the chocolate. After some investigated it had become apparent that the cooling is inadequate and there are no temporary cooling units in place to help chill the chocolate. Any elevated temperatures in the factory will cause the chocolate on the biscuits to melt. This then leads onto other problems such as the chocolate will then transfer onto the guides and vibrators. The chocolate builds up contributes to the biscuits not traveling down the vibrators at the correct speed, backing them up which will then force the biscuits to drop between the vibrators and on to the floor.



Figure 22- Excessive chocolate build up from inadequate cooling.

As some of the conveyors are at height there are fixed steps in place for operators to gain access to parts of the conveyor which may have blockages etc. Unfortunately, due to this the operators are unable to reach the blockage. To reach any blockages, they will use a poker to smash the biscuits free, causing scrap product to travel over to the other side causing more waste for the operator on B side Vee belt.

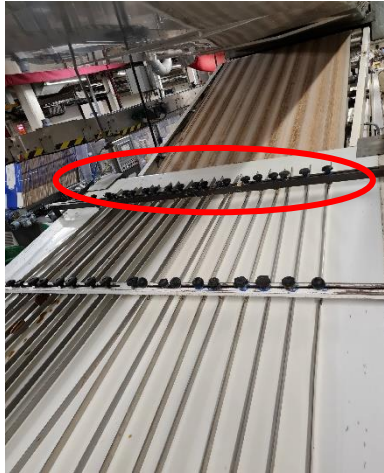


Figure 23-B Side V belts.

Due to the issue of the steps being in a fixed position, this causes more waste to be created as mentioned above. More waste is created due to the time it takes the operator to unblock, if the steps were mobile / wider the operator could get to the blockage quicker.

Another noted issue is that when the biscuit's finish traveling from the cooling conveyor, they do not seem to be in a "lane" position when they make their way to the vibrators. Guides that lane the biscuits stop before the acceptance web, waste could be caused due to the guides being out of line and biscuits not entering the vibrators correctly.



Figure 24- web after guiding conveyor.

Out of line product will hit the front of the vibrators and drop into the gaps between the vibrators then into the waste bins below. This can be seen below.



Figure 25- Trapped biscuits from not having a guide.

For the biscuits to be transferred efficiently, vibratory feeders transport the biscuits via vibration. These are electrically controlled in a panel that can be found in the line 3 area. When examining the vibrator feeders, it was noticed that there was zero guarding to protect them from any damage. There are multiple reasons as to why these need to be guarded. One of those reasons being that the speed pots get damaged when hit – therefore unable to set the vibrators to the correct speed. Another reason is speed pots gets incorrectly adjusted when the speed pot is accidentally hit and the last reason being that the speed pots will get over-turned causing the mechanism to snap inside the pots.



Figure 26- Damaged speed controllers.

To conclude the analysis of the problems contained on line 3, a small list has been generated to show the cause, the solution, and the verification of the solution to the problem.

Firstly, the worn scraper issue was causing excess build-up of chocolate on the web causing issues multiple areas of line 3, the solution to this problem was to simply replace the scraper and to ensure that the scraper is monitored to know when to change. This solution was verified as it was noticed by the machine operators that the build-up of chocolate was significantly reduced on the webs. It was also noted in the packing area- the operators noticed a decrease in biscuits with chocolate in none required areas of the biscuit.

The second issue for line 3 was the damaged and torn webs which has been mentioned, can cause alignment issues when the web is running. The solution for this was to repair the web. Unfortunately, due to the location of the damage it was decided to change the whole web as it made more sense to eliminate the problem altogether. This issue can be verified as the number of tracking issues reported to engineering by the SOMS (Senior Lines Managers) was noticed to be reduced.

Another reportable issue the line was yet again issues with the web, but this time to tracking system for the web. Due to missing or damaged rollers from the conveyor system the web was unable to move correctly and causing difficulties for the transportation of the biscuit. This was counteracted by simply replacing or repairing said damaged rollers to ensure correct operation. Again, this was verified by the reduced calls from the lines SOM for web tracking issues.

The fourth issues reported with line 3 was inadequate cooling along with no additional cooling systems in place to improve. Again, by simply repairing the original cooling system and implementing other cooling systems to line 3 the problem of having incorrect temperature chocolate was drastically reduced. This issue was then validated by the decrease in stoppages for cleaning and other jobs to ensure the biscuits were travelling among a smooth surface.

Moving to the packing area location it was noted when investigating the area and from operators-the access to the web by the lane conveyor was extremely limited due to the fixed position of the steps that ran alongside the web. This issue was resolved by replacing the fixed steps with mobile stair system but at the same time ensuring safe access for the operators. This was verified by the operators that the problem was resolved as they felt that it was easy to have access to the web to clear any blockages that may occur.

It was noted when looking at the acceptance web that the guides that guided the biscuits to the vibratory feeders ended short of their end goal. By reducing the guidance of the biscuits had an increase in the blockages reported by the line operators. This issue was rectified by producing in house guides that are longer and that meet the vibratory feeders. By doing this it would reduce blockages within that area of the web. The issue was further verified by the reduction in waste noted from the waste bins under the vibrators.

Coming to completion of the errors found, chocolate seemed to be a very notable issues that could have the potential to cause problems. In this case when chocolate was found to be on the vibrators, it would cause blockages and feeding issues. By talking with the engineering department and production it was decided to completely remove the vibrators and replace them with simple v-belts. By doing this it will reduce any blockages as the v-belts will simply accept the biscuit and transfer it to the correct area with the risk of waste being formed.

Looking at the last reported issue, the damaged and incorrectly set speed pots for the vibratory feeders caused noticeable issues. To highly reduce the chance of these pots being damaged engineering created guards in house that would be fitted around the dials to ensure that they can stop becoming damaged or adjusted without permission from the engineering department. In doing so, the noted waste being collected from underneath the vibrators were drastically improved and noted within production.

From the issues noted above a priority matrix was produced to show a physically plan of what needs to be carried out. A priority matrix is a tool used in project management and decision-making to help prioritize tasks based on their level of urgency and importance (Asana, 2022). It helps individuals or teams to identify which tasks to focus on immediately, which to schedule for later, which to delegate, and which to drop or delay (Asana, 2022). The matrix is often visualized in a quadrant layout and is sometimes referred to as the Eisenhower Box, as it was popularized by President Dwight D. Eisenhower's approach to task management (Eby, 2021). It is a useful framework for maximizing productivity and ensuring that effort is focused where it will be most effective (Eby, 2021). Pictured below is the priority matrix produced for line 3.

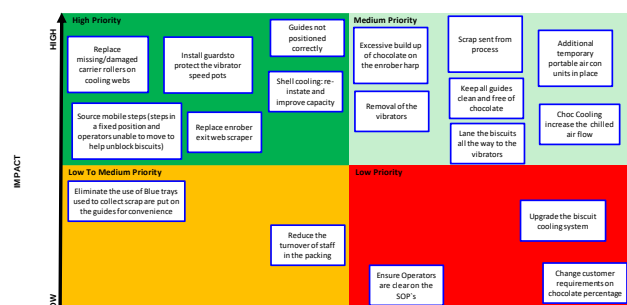


Figure 27- Priority Matrix

Improve

To improve the changes for line 3 a pilot plan was created. In the context of a DMAIC (Define, Measure, Analyse, Improve, Control) project, particularly during the "Improve" phase, the use of a pilot plan is highly advantageous and serves multiple strategic purposes. Primarily, a pilot plan acts as a risk mitigation tool, allowing proposed changes to be tested on a small scale before being rolled out across the entire process or system (APM, 2016). This small-scale implementation confines any potential failures to a limited area, minimizing operational disruptions and associated costs, thus safeguarding the larger system from unforeseen negative impacts. Furthermore, a pilot plan serves as a crucial validation step for the solutions developed during the Analyse phase (APM, 2016). It provides a practical, real-world testing ground to confirm whether the improvements will achieve the intended results, effectively acting as a proof of concept.

The insights gained from piloting are invaluable; they offer practical data and firsthand experiences that can be used to assess the effectiveness and feasibility of the changes. This data helps in identifying any unexpected obstacles or challenges that might not have been evident during the theoretical analysis stages of the DMAIC process (Terrell Hanna, 2023). From a stakeholder perspective, demonstrating successful results from a pilot project can significantly enhance confidence among all parties involved, including management, employees, and external stakeholders such as investors (Terrell Hanna, 2023). This increased confidence facilitates easier acceptance and support when implementing the changes on a larger scale.

Moreover, the pilot phase serves as an excellent opportunity for training employees on new processes or technologies (Endicott, 2021). It allows them to adapt to changes in a controlled and manageable environment, which can lead to smoother integration and less resistance during the full-scale implementation (Endicott, 2021). Adjustments and refinements based on employee feedback during this phase are also crucial, ensuring that the process or system is optimized before wider deployment.

Cost efficiency is another significant benefit of employing a pilot plan (Sungnoen, 2023). By testing changes on a smaller scale, the organization can understand the financial implications without the need for substantial initial investment. This approach not only prevents large-scale financial commitments but also provides a clearer picture of the cost-benefit ratio of the proposed improvements (Sungnoen, 2023).

Additionally, piloting generates specific, controlled data that can be compared against baseline data collected earlier in the project (pilot and feasibility studies, 2024). This comparison is essential for objectively assessing the degree of improvement and for making data-driven decisions regarding the effectiveness of the changes (pilot and feasibility studies, 2024). The controlled environment of a pilot also allows for the application of iterative development methods; based on the outcomes, project teams can refine and adjust the processes, ensuring that the solutions are as effective as possible (pilot and feasibility studies, 2024).

In conclusion, a pilot plan is not merely a preliminary step but a critical component of the DMAIC methodology. It ensures that improvements are not only theoretically sound but also practically viable and effective in a real-world setting. By providing a mechanism for testing, adjusting, and validating changes within a limited scope, a pilot plan significantly increases the likelihood of successful project outcomes. It enables more accurate forecasting of project impacts, facilitates smoother implementation, and ultimately supports the overarching goal of enhancing operational efficiency and effectiveness in a cost-effective manner. This approach is particularly pertinent in environments where changes can have significant operational and financial repercussions, such as in manufacturing processes.

Results and Final Benefits.

As the project is ending the results of the work that has been carried out look very positive. The project aimed at waste reduction within line 3, was carried out using the DMAIC (Define, Measure, Analyse, Improve, Control) approach to achieve significant improvements. Our journey began by defining the problem of excessive waste and its impact on production efficiency and cost.

The Area Operations Manager played a pivotal role in this project, overseeing the revised processes and ensuring that the improved line performance is sustained over time. Their responsibilities extend to maintaining ongoing performance monitoring and adherence to the new standards through the lineside performance boards. These boards will be used to communicate project results and ongoing performance to the team on a regular basis, fostering a culture of continuous improvement and accountability.

In conjunction with the Area Operations Manager, the Engineering Reliability Manager is tasked with incorporating relevant control measures into the Reliability Route Audits as part of the overall Planned Preventive Maintenance (PPM) schedule. This integration ensures that the control measures are consistently applied and maintained, preventing a regression to former waste levels and promoting sustained reliability and efficiency in the manufacturing process.

The Control Plan is another critical component of the project. The Area Operations Manager is responsible for ensuring that defined escalation protocols within the Operations team are followed as stipulated in the Control Plan. This structured approach to issue escalation ensures that any deviations from the desired performance levels are promptly addressed and rectified, thereby maintaining the integrity of the improvements made.

To ensure that the new processes continue to operate effectively well beyond the project's completion, there is an incorporated centreline settings into the Lineside Short Interval Control (SIC) huddles. These huddles will serve as regular check-ins to review and adjust the processes as necessary, ensuring that they remain aligned with our waste reduction goals. Additionally, the Packing Waste Key Performance Indicator (KPI) tracker, identified as the Project Y, will be diligently maintained. This tracker will monitor the performance metrics associated with waste reduction, providing a clear and ongoing measure of our success.

The Continuous Improvement (CI) Team will be responsible for ensuring that these practices are consistently applied and that their status is regularly communicated to all relevant stakeholders. The CI Team's role is crucial in embedding the improvements into the daily operations and fostering an environment of continuous learning and development. Their ongoing oversight will help to identify any emerging issues or opportunities for further improvement, ensuring that the gains achieved are not only maintained but built upon over time.

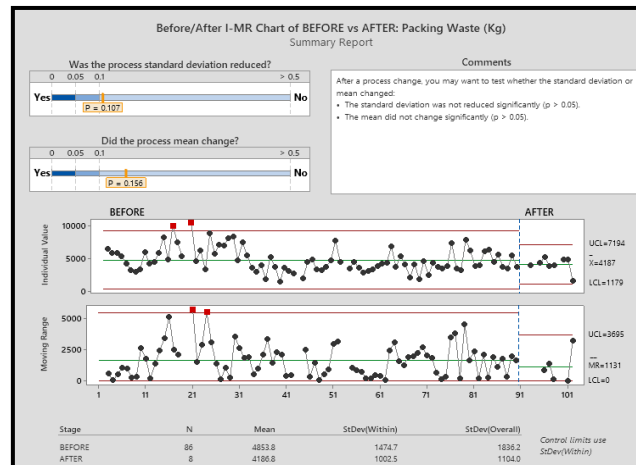
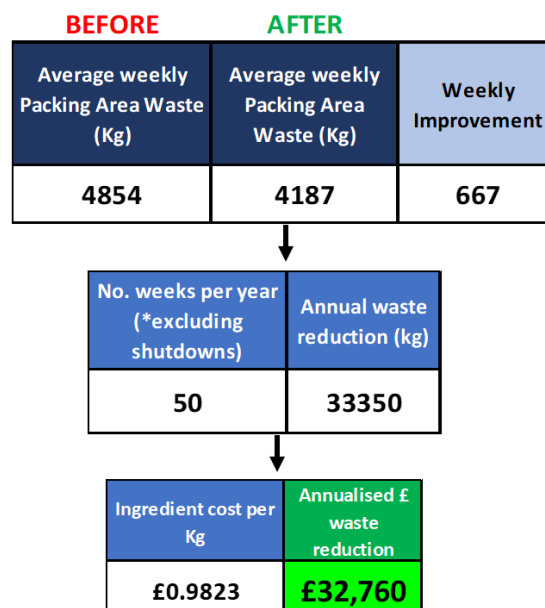


Figure 28- Comparison of waste from start to finish.

The graph above shows and proves that over the 8 weeks of the implementation stage of the DMAIC project, the recorded waste was a significant drop! Before the project started the average weekly packing area waste (Kg) was 4854 kg being a 5.55% average weekly waste. Once the improvements were made to line 3 the average weekly packing area waste was reduced to 4187 kg being an average weekly waste percentage of 3.84%. In total the decrease was 667 totally 1.71%. An infographic can be found below.



In the results, soft benefits were found in which that the reduction in waste was found to have an increase in a larger output of product. This soft benefit provides benefits to our customers in terms of improved customer service level. Another soft benefit gained through the project was morale had increased and stress had decreased within the line 3 packing team. This was because the amount of time spent of collecting waste was reduced allowing them to focus primarily on their main job role within the packing area.

Discussion and conclusions.

This style of project and waste reduction plan can be applied to other areas with in FBC Line 8 for example. During the line 3 project, it focused on waste reduction within line 3.

Significant improvements were achieved by addressing inefficiencies and implementing strategic enhancements. Initially, thorough analysis was conducted within the production process, identifying key areas where waste was most prevalent. The primary focus was on optimizing the conveyor systems and feeders, which were identified as major sources of product loss and inefficiency. By implementing advanced sensors and automated control systems, we were able to synchronize the speed and flow of the biscuits along the production line. This synchronization not only reduced product breakage and waste but also improved the overall efficiency of the line.

To further enhance waste reduction, it was decided to introduce a comprehensive training program for the operators. This program emphasized the importance of proper handling techniques and the correct operation of the machinery. By equipping the operators with the necessary skills and knowledge, it was to be ensured that they could maintain the improved processes and identify potential issues before they escalated. Additionally, regular maintenance schedules were established to keep the machinery in optimal condition, thereby preventing breakdowns and reducing downtime.

A key aspect of this project was its scalability and potential for replication across other production lines and sites within the organization. For instance, Line 8, which produces similar chocolate-coated products and involves the use of laned conveyors, vibratory feeders, and V-belts, can greatly benefit from the methodologies applied in this project. By adapting the improvements made on the initial line to Line 8, the company can achieve similar waste reduction and efficiency gains. This involves implementing the same advanced sensors and control systems, along with providing targeted training to the operators on this line.

Furthermore, there are five additional manufacturing sites across the country with production lines that also utilize vibratory feeders and V-belts. These sites present further opportunities to replicate the successful waste reduction strategies implemented in the biscuit manufacturing line. By conducting site-specific assessments and tailoring the improvements to the unique requirements of each site, we can extend the benefits of this project on a broader scale. The replication process involves a detailed review of each site's production processes, followed by the implementation of the advanced technologies and training programs that proved effective in the initial project.

In summary, the waste reduction project not only yielded substantial improvements in the biscuit manufacturing line but also demonstrated a clear path for replicating these successes across other production lines and sites within the organization. By focusing on optimizing conveyor systems, enhancing operator training, and maintaining rigorous machinery upkeep, the project achieved significant waste reduction and efficiency gains. The scalability of these improvements ensures that similar benefits can be realized in other areas of the organization, including Line 8 and additional sites using similar equipment. This holistic approach to waste reduction not only enhances productivity but also contributes to the overall sustainability and profitability of the organization.

Conclusion

In conclusion, the waste reduction project undertaken on Line 3 of Fox's Burtons Companies stands as a testament to the effectiveness of systematic, data-driven interventions in enhancing operational efficiency and sustainability in the biscuit manufacturing sector. By employing the DMAIC (Define, Measure, Analyse, Improve, Control) framework, the project not only addressed the pressing issue of waste but also laid the groundwork for a culture of continuous improvement within the company.

Defining the Problem

The project began with a comprehensive definition of the problem, highlighting the inefficiencies on Line 3, which was identified as the least efficient with the highest waste levels in 2023. Waste in this context not only represented a financial burden but also an environmental concern, affecting the company's sustainability goals and corporate responsibility. The urgency to address this issue was underscored by significant financial losses and operational inefficiencies, prompting the need for a strategic approach to waste reduction.

Measuring and Analysing the Current State

The measurement phase involved a detailed process flow analysis and data collection to quantify waste sources accurately. Using tools like process flow diagrams, data collection plans, and Measurement System Analysis (MSA), the project team identified critical points where waste was most prevalent. The analysis revealed that the A side vibrators, channelling board, and B side Vee belt were major contributors to waste. This phase also included the use of Pareto charts and bar charts to visualize the data, enabling a clear understanding of the primary sources of waste.

Root Cause Analysis (RCA) and the 5 Whys technique were pivotal in identifying the fundamental causes of waste. Physical inspections and detailed observations of the production line highlighted issues such as worn scrapers, damaged webs, inadequate cooling, and accessibility problems for operators. These findings were crucial in formulating targeted interventions to address these inefficiencies.

Improving the Process

The improvement phase focused on implementing practical solutions to the identified problems. Actions taken included replacing worn components like scrapers and damaged webs, enhancing cooling systems, and providing mobile stair systems for better operator access. These interventions were validated through continuous monitoring and feedback from line operators, ensuring that the changes led to tangible improvements.

One of the key improvements was the installation of longer guides to ensure biscuits were correctly aligned when entering the vibrators, reducing blockages and waste. Additionally, replacing vibrators with V-belts and protecting speed pots from damage through in-house engineered guards significantly reduced waste and operational disruptions.

Controlling the New Process

To ensure the sustainability of these improvements, a robust control plan was implemented. The Area Operations Manager and Engineering Reliability Manager played crucial roles in maintaining ongoing performance monitoring and adherence to new standards. Lineside performance boards were introduced to communicate project results and ongoing performance, fostering a culture of continuous improvement and accountability.

The integration of control measures into the Reliability Route Audits and the Planned Preventive Maintenance (PPM) schedule ensured that the improvements were consistently applied and maintained. The Lineside Short Interval Control (SIC) huddles were established for regular check-ins to review and adjust processes, ensuring alignment with waste reduction goals. The Packing Waste Key Performance Indicator (KPI) tracker provided a clear and ongoing measure of success.

Results and Benefits

The project yielded significant results, demonstrating a substantial reduction in waste from 4854 kg to 4187 kg weekly, which translated to a decrease in waste percentage from 5.55% to 3.84%. These improvements not only reduced financial losses but also enhanced environmental sustainability by minimizing resource wastage. The successful implementation of these interventions had a positive impact on the work environment, increasing morale and reducing stress among the Line 3 packing team, as they could now focus more on their primary roles rather than waste collection.

Scalability and Replication

The methodologies and improvements applied in this project have clear potential for scalability and replication across other production lines and sites within Fox's Burtons Companies. For instance, Line 8, which produces similar chocolate-coated products, can benefit from the same advanced sensors, control systems, and operator training implemented on Line 3. The project provides a replicable model for addressing inefficiencies and achieving waste reduction on a broader scale.

Moreover, the project's success offers valuable insights for the five additional manufacturing sites across the country that use similar equipment. By conducting site-specific assessments and tailoring improvements to each site's unique requirements, the company can extend the benefits of this project organization wide. This approach will not only enhance productivity but also contribute to overall sustainability and profitability.

Continuous Improvement and Future Steps

The project has also set a strong foundation for ongoing improvements. The Continuous Improvement (CI) Team will play a critical role in ensuring that best practices are consistently applied, and that the status of these practices is regularly communicated to all relevant stakeholders. Their oversight will help identify emerging issues or opportunities for further improvement, ensuring that the gains achieved are not only maintained but built upon over time.

The success of this project underscores the importance of a structured, data-driven approach to problem-solving in manufacturing. By focusing on systematic interventions and fostering a culture of continuous improvement, Fox's Burtons Companies can achieve substantial benefits both financially and environmentally.

Conclusion

In summary, the waste reduction project on Line 3 has demonstrated the profound impact of targeted, systematic interventions in enhancing operational efficiency and sustainability in the biscuit manufacturing industry. Through the meticulous application of the DMAIC framework, the project achieved significant waste reduction and improved production performance. The scalability of these improvements ensures that similar benefits can be realized across other production lines and sites within the organization. This holistic approach to waste reduction not only enhances productivity but also contributes to the overall sustainability and profitability of Fox's Burtons Companies. By continuing to prioritize data-driven, continuous improvement practices, the company is well-positioned to maintain its competitive edge and uphold its commitment to environmental stewardship.

Recommended further work.

Building on the success of the waste reduction project on Line 3, Fox's Burtons Companies can further enhance operational efficiency, sustainability, and overall performance through several strategic initiatives. Advanced automation and AI integration can streamline production processes, improve consistency, and enable predictive maintenance, minimizing unplanned downtime and extending equipment lifespan. Enhanced data analytics and real-time monitoring systems will allow for immediate identification and rectification of issues, optimizing production parameters. Implementing energy-efficient technologies and green manufacturing practices will reduce operational costs and environmental impact.

Establishing a continuous improvement (CI) program and comprehensive training for employees will sustain and build on waste reduction and efficiency gains, fostering a proactive workforce. Collaboration with industry experts and benchmarking against

standards will provide access to new technologies and best practices, ensuring competitiveness. Regular equipment upgrades, advanced process controls, and rigorous maintenance schedules will minimize breakdowns and waste. Enhanced waste segregation, recycling, and zero-waste initiatives will support sustainability efforts and create additional revenue streams. Leveraging customer feedback and investing in R&D for new product lines will align products with market demands and improve manufacturing efficiency. Improved workplace safety measures and ergonomic designs will boost employee morale and productivity. Finally, developing a long-term sustainability strategy and investing in R&D will ensure the company remains at the forefront of innovation, maintaining competitiveness and environmental stewardship. These initiatives, when implemented, will not only address immediate operational challenges but also position Fox's Burtons Companies for long-term success in a competitive and environmentally conscious market.

References.

Reference list

American Society for Quality (2024). *DMAIC Process: Define, Measure, Analyse, Improve, Control* | ASQ. [online] asq.org. Available at: <https://asq.org/quality-resources/dmaic#:~:text=What%20Does%20DMAIC%20Stand%20For> [Accessed 25 Mar. 2024].

Ang, S.M. (2023). *DMAIC: a Six Sigma Tool for Business Success*. [online] Safety Culture. Available at: <https://safetyculture.com/topics/dmaic/> [Accessed 5 May 2024].

APM (2016). *What Is the Difference between a Trial and a pilot?* | APM. [online] Apm.org.uk. Available at: <https://www.apm.org.uk/resources/find-a-resource/what-is-the-difference-between-a-trial-and-a-pilot/> [Accessed 2 May 2024].

Asana (2022). *There's a Better Way to Prioritize Work*. [online] Asana. Available at: <https://asana.com/resources/priority-matrix> [Accessed 24 Apr. 2024].

ASQ (2019). *What Is a Pareto Chart? Analysis & Diagram* | ASQ. [online] Asq.org. Available at: <https://asq.org/quality-resources/pareto> [Accessed 14 Apr. 2024].

Atlassian (2024). *Project Management Timeline | the Workstream*. [online] Atlassian. Available at: <https://www.atlassian.com/work-management/project-management/project-planning/timeline> [Accessed 25 Mar. 2024].

Bhandari, P. (2022). *Data Collection Methods | Step-by-Step Guide & Examples*. [online] Scribbr. Available at: <https://www.scribbr.co.uk/research-methods/data-collection-guide/>.

Collins Dictionary (2024). Human Error. In: *Collins Dictionary*. [online] HarperCollins Publisher. Available at: <https://www.collinsdictionary.com/dictionary/english/human-error#:~:text=Human%20error%20is%20when%20someone,a%20result%20of%20human%20error.> [Accessed 14 Apr. 2024].

Diaz , D. (2024). *How Do You Maintain Project Documents When Change happens?* [online] www.linkedin.com. Available at: <https://www.linkedin.com/advice/0/how-do-you-maintain-project-documents-when->

change#:~:text=Updating%20your%20project%20documents%20will [Accessed 25 Mar. 2024].

Eby, K. (2021). *How to Use Priority Matrices* | *Smartsheet*. [online] www.smartsheet.com. Available at: <https://www.smartsheet.com/content/priority-matrix> [Accessed 24 Apr. 2024].

Editor, M.B. (2016). *When to Use a Pareto Chart*. [online] blog.minitab.com. Available at: <https://blog.minitab.com/en/understanding-statistics/when-to-use-a-pareto-chart> [Accessed 14 Apr. 2024].

Endicott, B. (2021). *Build a Pilot Program: Test the Effectiveness of Your Continuous Performance Management Design*. [online] Simply Strategic. Available at: <https://www.simplystrategictalent.com/post/pilot-program> [Accessed 2 May 2024].

eufic (2021). *Food waste in Europe: statistics and facts about the problem*. [online] www.eufic.org. Available at: https://www.eufic.org/en/food-safety/article/food-waste-in-europe-statistics-and-facts-about-the-problem?gad_source=1&gclid=Cj0KCQjwwYSwBhDcARIsAOyL0fjzLbx_gwDav-_uLckM_yp97FY7J7kHni8Apju1P1f4iW1JwEkIYpUaApOYEALw_wcB [Accessed 25 Mar. 2024].

Golden Bake (2024). *How to Ensure Consistency in Biscuit Production Line*. [online] www.foodsmachine.net. Available at: <https://www.foodsmachine.net/a-news-how-to-ensure-consistency-in-biscuit-production-line.html> [Accessed 2 May 2024].

Guevara, P. (2023). *Root Cause Analysis: Definition and Examples*. [online] SafetyCulture. Available at: <https://safetyculture.com/topics/root-cause-analysis/> [Accessed 14 Apr. 2024].

Hessing, T. (2013). *Data Collection Plan*. [online] Six Sigma Study Guide. Available at: <https://sixsigmastudyguide.com/data-collection-plan/>.

Horticulture (2024). *Using Root Cause Analysis to Identify Issues* | *AHDB*. [online] horticulture.ahdb.org.uk. Available at: <https://horticulture.ahdb.org.uk/knowledge-library/using-root-cause-analysis-to-identify-issues> [Accessed 14 Apr. 2024].

jmp (2024). *Pareto Chart*. [online] www.jmp.com. Available at: https://www.jmp.com/en_gb/statistics-knowledge-portal/exploratory-data-analysis/pareto-chart.html#:~:text=Pareto%20charts%20help%20people%20decide [Accessed 14 Apr. 2024].

Lean Enterprise Institute (2024). *5 Whys - What Is it?* [online] Lean Enterprise Institute. Available at: <https://www.lean.org/lexicon-terms/5-whys/> [Accessed 14 Apr. 2024].

LucidChart (2024). *What Is a Process Flow Diagram*. [online] Lucidchart. Available at: <https://www.lucidchart.com/pages/process-flow-diagrams#:~:text=A%20Process%20Flow%20Diagram%20has>.

Machines, N.E. (2023). *Powering the Future of Biscuit, Cookie & Cracker Production with new-age Biscuit Handling Systems - New Era Machines*. [online] New Era Machines. Available at: <https://www.neweramachines.com/blog/new-age-biscuit-handling-systems/#:~:text=Intelligent%20biscuit%20handling%20systems%20that> [Accessed 5 May 2024].

Mind Tools (2022). *5 Whys*. [online] www.mindtools.com. Available at: <https://www.mindtools.com/a3mi00v/5-whys> [Accessed 14 Apr. 2024].

MindTools (2023). *Root Cause Analysis*. [online] www.mindtools.com. Available at: <https://www.mindtools.com/ag6pkn9/root-cause-analysis> [Accessed 14 Apr. 2024].

Oram, B. (2024). *How Do You Select the Best Sampling Methods for Different Types of waste?* [online] www.linkedin.com. Available at: <https://www.linkedin.com/advice/1/how-do-you-select-best-sampling-methods#:~:text=Some%20common%20sampling%20methods%20are> [Accessed 9 Apr. 2024].

pilot and feasibility studies (2024). *Introduction | Pilot and feasibility studies*. [online] Pilotandfeasibilitystudies. Available at: <https://pilotandfeasibilitystudies.qmul.ac.uk/introduction/> [Accessed 2 May 2024].

Price, P.C. (2018). *Reliability and Validity of Measurement – Research Methods in Psychology*. [online] Opentextbc.ca. Available at: <https://opentextbc.ca/researchmethods/chapter/reliability-and-validity-of-measurement/> [Accessed 9 Apr. 2024].

Royal Food Processing Line (2022). *6 Tips for Efficient Operation of Biscuit Lines*. [online] Shandong Loyal Industrial Co.,Ltd. Available at: <https://loyalfoodprocessingline.com/food-processing/6-tips-for-efficient-operation-of-biscuit-lines.html> [Accessed 5 May 2024].

SEMCOR (2018). *Conveyor Belt Maintenance & Common Conveyor Problems*. [online] SEMCOR. Available at: <https://www.semcor.net/blog/common-conveyor-belt-problems/#seized-rollers> [Accessed 22 Apr. 2024].

Sharma, S. (2022). *Data Collection Plan For Six Sigma: How to Create One?* [online] www.knowledgehut.com. Available at: <https://www.knowledgehut.com/blog/quality/data-collection-plan#when-and-how%C2%A0to-use-a-data-collection-plan?> [Accessed 9 Apr. 2024].

Solvexia (2024). *8 Best Financial Data Software: Ultimate Reporting Tools*. [online] www.solvexia.com. Available at: <https://www.solvexia.com/blog/financial-data-software#:~:text=Financial%20reporting%20software%20transforms%20data> [Accessed 9 Apr. 2024].

Sungnoen, B. (2023). *22. Strategies for Reducing Cost and Schedules in Pilot Plants*. [online] www.linkedin.com. Available at: <https://www.linkedin.com/pulse/strategies-reducing-cost-schedules-pilot-plants-bamrung-sungnoen-njsqc/> [Accessed 2 May 2024].

Tableau (2024). *Root Cause Analysis Explained with Examples and Methods*. [online] Tableau. Available at: <https://www.tableau.com/en-gb/learn/articles/root-cause-analysis#:~:text=The%20first%20goal%20of%20root> [Accessed 14 Apr. 2024].

Task2Bill (2018). *Task2Bill - Projects, Timesheets & Billings*. [online] Task2Bill. Available at: <https://www.task2bill.com/community/7-proven-steps-to-avoid-project-setbacks/> [Accessed 25 Mar. 2024].

Team Asana (2021). *What Is a Change Control Process? (with Example Change Log)* • Asana. [online] Asana. Available at: <https://asana.com/resources/change-control-process> [Accessed 25 Mar. 2024].

Team, Pmh. (2011). *How to Deal with Project Setbacks*. [online] PMHut - Project Management Articles for Project Managers. Available at: <https://pmhut.com/how-to-deal-with-project-setbacks> [Accessed 25 Mar. 2024].

Tech, S. (2022). *Guide to Conveyor Belt Tracking | Span Tech*. [online] Span Tech Conveyors. Available at: <https://spantechconveyors.com/2022/04/15/guide-to-conveyor-belt-tracking/#:~:text=Conveyor%20belt%20tracking%20is%20the> [Accessed 22 Apr. 2024].

Terrell Hanna, K. (2023). *What Is Pilot Program (pilot study)? - Definition from WhatIs.com*. [online] SearchCIO. Available at: <https://www.techtarget.com/searchcio/definition/pilot-program-pilot-study> [Accessed 2 May 2024].

Tetrapak (2024). *Food Loss & Waste*. [online] Tetrapak. Available at: https://www.tetrapak.com/sustainability/focus-areas/food-loss-and-waste?utm_source=google&utm_medium=cpc&utm_campaign=SI_Sustainability_Food&utm_content=sustainability-food-group-preventing-food-waste&gad_source=1&gclid=Cj0KCQjwwYSwBhDcARIsAOyL0fiNXfRa--RFUZj8CtkoK2_qDhbR9Vxw4_-4lfMdcRctjDqk7m-CLy0aAlUOEALw_wcB [Accessed 25 Mar. 2024].

The University of Edinburgh (2024). *Literature Review*. [online] The University of Edinburgh. Available at: <https://institute-academic-development.ed.ac.uk/study-hub/learning-resources/literature-review> [Accessed 2 May 2024].

theleansixsigmacompany (2024). *DMAIC model: What is it?* [online] The Lean Six Sigma Company. Available at: <https://www.theleansixsigmacompany.co.uk/dmaic-model/> [Accessed 25 Mar. 2024].

Tulip (2023). *What Are the Five Whys? a Tool for Root Cause Analysis*. [online] Tulip. Available at: <https://tulip.co/glossary/five-whys/> [Accessed 14 Apr. 2024].

Valin (2024). *The Importance of Repeatability, Reliability, Consistency and Accuracy | Valin*. [online] www.valin.com. Available at: <https://www.valin.com/resources/videos/importance-of-repeatability-reliability-consistency-and-accuracy#:~:text=Reliability%20is%20maintaining%20the%20level> [Accessed 14 Apr. 2024].

Villegas, F. (2022). *Data Collection Plan: What It Is + Steps to Do It*. [online] QuestionPro. Available at: <https://www.questionpro.com/blog/data-collection-plan/#:~:text=A%20data%2Dcollecting%20plan%20ensures>.

Zavala-Quinones, A. (2024). *Timing and Its Importance in Project Management*. [online] [www.linkedin.com](https://www.linkedin.com/pulse/timing-its-importance-project-management-abraham-zavala-quinones-zembc/). Available at: <https://www.linkedin.com/pulse/timing-its-importance-project-management-abraham-zavala-quinones-zembc/> [Accessed 25 Mar. 2024].

Figure 1- Initial Timing Plan.....	7
Figure 2- Updated Timing Plan (Before Christmas)	7
Figure 3- Recent Progression (25/03/2024)	8
Figure 4- Process flow diagram for line 3.	13
Figure 5- Line 3 area of scope.	14
Figure 6- Data Collection Plan	14
Figure 7- Weighing of biscuits.	15
Figure 8- Recorded weights from operators.	16
Figure 9- Results from biscuits weights.	16
Figure 10- Acceptable figures from MSA.....	17
Figure 11- Pareto Chart.	19
Figure 12- Waste chart for A and B side legs.	20
Figure 13- Combined weight of waste sides A & B.	21
Figure 14- Fishbone Diagram for line 3.	21
Figure 15- 5 Whys.....	22
Figure 16- Build-up of chocolate on enrober scraper.....	23
Figure 17- Damaged web.....	23
Figure 18- Tacky chocolate on biscuit.	24
Figure 19- bent guides causing issues on the web.	24
Figure 20- Biscuits stuck in-between guide.	24
Figure 21- Damaged Roller.....	25
Figure 22- Excessive chocolate build up from inadequate cooling.....	25
Figure 23-B Side V belts.	26
Figure 24- web after guiding conveyor.	26
Figure 25-Trapped biscuits from not having a guide.....	27
Figure 26- Damaged speed controllers.	27
Figure 27- Priority Matrix.....	29
Figure 28- Comparison of waste from start to finish.	33