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Abstract

Company XYZ is an employee owned international cheese and dairy product manufacturer with 19 domestic and 12 international production facilities, employing over 8,000 people worldwide. This company specializes in a variety of consumer and food service product lines, including but not limited to, natural and processed cheeses, yogurts, and plant-based products. In early 2019, the leadership team at Plant A noticed a spike in product loss and waste generated during the production of processed cheese. Plant A was on target to be $1.2 million over budget for acceptable loss and waste by the end of the fiscal year.

As a result, a task force was assembled and the goal of this study was to identify loss points in the process, identify potential solutions, and implement best practices to mitigate the product loss and waste during production. At the conclusion of this study, significant savings were realized and negative budget implications were rectified.

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Working in isolation will often result in shortsightedness, missed learning opportunities, and minimal growth or forward progress. When one is able to partner with a mentor who expects high quality research and a perfect finished product, it results in tremendous learning and personal growth. Admittedly, while painfully frustrating at times, such standards reap invaluable benefits and a finished product one never thought possible. I'd like to thank Dr. Sally Dresdow for believing in this project, demanding only the best work, and patiently navigating me through a research and publication process that was foreign to me in every sense of the word. While I am glad this stage in my educational career is nearing a close, it is with immense pride I present this paper, knowing it was only possible through the support of a high caliber professor and mentor. Dr. Dresdow, my sincere thanks and gratitude for supporting me this last year and half, without you, this paper would have never happened.

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Chapter I: Introduction

Company XYZ was an international cheese company with over six billion in sales in fiscal year 2018. The private, employee owned organization had 19 domestic facilities, 12 international facilities and a team of 8,000 plus employees. Company XYZ's product lines included: yogurt, natural slice, block, shredded products, cream cheese, and processed cheese. They were one of the major suppliers of name brand and house brand cheeses for grocery outlets, and processed cheeses for all the major fast food restaurant chains in America at that time.

To keep 31 facilities running, 24 hours a day, six days a week, it required constant ordering, distribution, and the consumption of multiple raw materials and solids across customer specific cheese orders. At one domestic plant, Plant A, the natural shred line ran from 28 to 30 million pounds per year, whereas the processed lines ran in excess of 135 million pounds per year. Processed cheese required multiple raw materials/solids, and as a result, processed cheese production had the most opportunity for loss. Plant A was significantly over budget on solids loss. There were several types of solids loss/raw material waste including supplier shortages. For example, outside suppliers stated they shipped X pounds of product, but less than the stated weight arrived. The employees either failed to catch a shortage, or if they did catch the shortage, it was not properly documented.

Another cause of solids loss/waste came from employees cleaning cookers between batches (orders). Cheese that was left inside the cookers was flushed instead of recovered for re-use. A third common reason the company had solids loss/waste was a result of employee errors. Staff may or may not have correctly added ingredients according to the formulations (recipes). Employees may not have put in what they accounted for, putting in too little or too much. Finally, the losses were also a result of finished goods moisture levels. After the product was produced, it went to a vacuum to test moisture levels. If there was too much moisture loss, or conversely, not enough moisture loss, that affected the profitability level. The standard acceptable variance was anything +/- .2 from the target moisture levels. Anything above or below that .2 mark resulted in solids loss/waste. Profitability was affected when too much cheese was added, above government requirements, or conversely when not enough was added and the product had to be re-worked.

Statement of the Problem

At Plant A, solids loss/raw material waste in processed cheese production through the first 12 weeks of the fiscal year resulted in a $283,000 negative impact to the annual operating budget. Without eliminating the loss of solids, Company XYZ faced a projected $1.2 million negative impact to the operating budget for the fiscal year.

Purpose of the Study

The purpose of this study was to eliminate solid loss/raw materials waste in order to reverse the negative costs impacting the overall operating budget at Plant A for the XYZ company. There were two primary objectives within this study.

1. The first objective was to identify the causes of the solids loss/waste. This was done through cross checking incoming barrel weights, running moisture tests on incoming cheese loads, and completing moisture analysis on non-fat dry milk. Additionally, identifying which production area(s) generated the most scrap and completing a comprehensive batch review were also part of the process.
2. The second objective was to rectify the loss points through new protocols and or equipment modifications.

Assumptions of the Study

To ensure this study would be viable, the following assumptions were made. It was assumed that five department managers and one six sigma black belt would be working on this project for no more than 12 weeks. Each team member would dedicate eight hours per week in order to meet study objectives. Discretionary funds were not to exceed $12,500, and no additional outside resources would be available.

Definition of Terms

The following terms were commonly used in manufacturing operations, and more specifically, were used throughout this processed cheese production study. There are a few terms specific to Company XYZ that have different meanings than the commonly assumed definitions, and therefore, will be clarified here.

Center lining. Center lining is when a machine used in the production of goods is properly programmed to ensure that that outputs are consistent and maximized to meet quality and productions standards. There is usually a range of acceptable variances that are allowed to ensure uniformity and consistency in the process (Hart, 2018).

Certificate of analysis. Suppliers provide written testing results on incoming bulk ingredients/products. The CoA includes information on moisture and fat content, pH levels, and if the product was tested for salmonella.

Formulations. Formulations are the recipes used for each specific cheese blend (product).

Karl Fischer testing. This is a scientific test used to measure moisture levels in solids, in this case, it is used to check the moisture levels in finished cheese (Karl Fischer Testing, n.d.).

Lean six sigma. In its simplest form, this is the practice of attempting to remove waste and reducing errors in production processes. The idea is to remove all elements or steps that do not add direct value to a process (Wamicha, n.d.).

Minitab. Minitab is a sophisticated software program that helps companies effectively interpret data. The software helps companies spot trends, complete high level statistically analysis, and assists in identifying process improvement opportunities. (About Us, n.d.)

Processed cheese. Any cheese product that has added ingredients, this could include, but not be limited to, emulsifiers and preservatives is considered processed cheese. Processed cheeses are more shelf stable, and provide better meltability (Fox, Guinee, Cogan, & McSweeney, 2016).

Raw materials. Raw materials are all ingredients, parts, elements etc. that are used in a final product. They are on hand but may or may not have been used in production (Bragg, 2017).

Rework. When errors in production of cheese are made, the cheese is recycled and reworked back into new cheese production. Typically, when starting a new blend/batch of processed cheese, up to 17% can be reworked cheese.

Solids loss. During the production of processed cheese, various raw materials are added to the blend according to formulations (recipe) guidelines. When too much of a material is added, it is considered a loss and wasted product. Additionally, during the cooking process, if too much moisture is lost, this results in waste as the customer is getting more solids than needed.

Standard operating procedure. Specific and routine approach to completing a task. This ensures fidelity to the process and that outcomes are the same across employees, shifts and plants ("Standard operating procedure," 2019).

Value stream mapping (VSM). The purpose of the VSM is to create a visual chart/display that is a detailed, step by step guide of any given work process. By mapping out each step, it allows the team to show bottlenecks, needless repetition, inefficiencies or waste (any of the seven kinds outlined in the lean approach) in that specific process ("What is Value Stream Mapping?," n.d.).

Limitations of the Study

This study was limited to 12 weeks to identify issues and research possible solutions to mitigate solids loss and waste in the production of processed cheese at Company XYZ. The implementation of recommended solutions was limited to the approval of Company XYZ along with the availability of allocated resources and labor.

Methodology

In order to identify and rectify loss points for solids loss and waste in the production of processed cheese blends, acceptable levels of loss and waste needed to be identified. From that point, adjustments to the process could be implemented to eliminate profit loss in Company XYZ's operating budget. The researcher identified the loss points/causes in the processes, such as: human error, machine errors, and incorrect raw product report errors from vendors. During this process, to ensure data driven decisions were made, various data points were collected. Additionally, several lean tools such as 5s reviews, fishbone diagrams, and control charts were used to identify problem areas and drive informed decision making and recommendations for Company XYZ to implement.

Chapter II: Literature Review

Company XYZ was experiencing solids loss and waste in their processed cheese production. This waste, and subsequent loss, happened for a variety of reasons, including but not limited to: human error, labeling errors, machine errors and incoming raw product report errors from vendors. The literature review examined the properties of processed cheese and its appeal to certain market segments, lean manufacturing and operating concepts as it applies to food and beverage production, and finally, common solid loss points in food production and possible lean tools to reduce loss and waste.

Processed Cheese

Dairy products have always been a staple of the American diet, but with the growing popularity of grab and go convenience foods, drive throughs, and quick service restaurants the consumption of cheese has increased (Kraus, 2019). In addition, there have been dietary shifts from thinking that all fats are bad, to the understanding that good fats, such as those found in cheese, are an important part of one's diet. These have both led to an overall increase in the production and consumption of cheese and cheese products (Kraus, 2019).

According to the most recent dairy data released by the United States Department of Agriculture, the average cheese consumption per person has more than doubled since 1975 (Cessna, 2019). In 1975 the average consumption of American (processed) cheese was 8.1 pounds per person, per year. As of 2018, that has almost doubled to 15.4 pounds per person (Cessna, 2019). Processed cheeses are often marketed as individually wrapped cheese slices, as blocks of meltable cheese spreads, or finally, as soft spreadable cheese dips/spreads. Additionally, in 1975, the average consumption per person of all other cheeses was 6.1 pounds per year; as of 2018 that has more than tripled to 22.5 pounds per person (Cessna, 2019). The

Environmental Protection Agency states that over 2.3 billion pounds of processed cheeses are produced and consumed annually in America alone (Environmental Protection Agency, 2018).

Approximately 35% of all milk produced is used in the manufacturing of cheese (McSweeney, 2007). Until 1911, all cheese produced was natural cheese. This means the only ingredients in cheese were milk, enzymes, and salt. While simple and easy to produce, these cheeses would quickly spoil and were not a shelf stable product. In an effort to increase profitability and sales, in 1911, Walter Gerber developed a process to make cheese more shelf stable, cost effective, and appealing to end consumers (Kapoor & Metzger, 2008). The result was using natural cheeses, sodium citrate, emulsifying agents, and salt blended together to create processed cheese (Kapoor & Metzger, 2008). Gerber was the first to create this process in Switzerland, but it was J.L. Kraft's modifications in 1916 that introduced this new food product to America; and from there, processed cheese went on to become an important and profitable cheese product (Favreau, n.d.).

Processed Cheese Characteristics and Requirements

Restaurants and food service industries were one of the largest buyers of processed cheese. Through highly specialized, proprietary blends of processed cheeses, manufactures were able to control the firmness, viscosity, stretching, and meltability of these products (Kapoor & Metzger, 2008). Whether it was a corporate restaurant chain buying millions of pounds of cheese, or a single-family buying cheese slices at a grocery store for a cookout, they all wanted a product that melted easily, was soft and easier to work with, and one that would stick to the food it melted to. There are very specific targets processed cheese makers must adhere to, and those targets are met through highly scientific formulations (recipes) of natural cheese, water, salt, citric acids, slurry blends, calcium phosphates, food coloring, preservatives and enzyme ingredients to name a few (Kapoor & Metzger, 2008).

While there were countless different proprietary blends of processed cheeses, in 1977 the Food and Drug Administration established guidelines for the required ingredients and ratios in a processed cheese product. Primarily, these guidelines stipulate the acceptable moisture, fat content and pH levels in the blends (Kapoor & Metzger, 2008). The specific requirements and general specifications for what constitutes processed cheese, or a pasteurized processed cheese product are as follows (Code of Federal Regulations Title 21, 2018):

- Processed cheese must be heated to a minimum temperature of 150 degrees for no less than 30 seconds.
- No more than 44% of the final product weight can be made up of moisture (water).
- The fat content can be no lower than 23% of final product weight.
- The natural cheese content must be at least 51% of the final product weight.
- The emulsifying agents (currently more than 15 acceptable emulsifiers are allowed) must be no more than 3% of the final weight.
- The pH is not to fall below 5.0.

Production Risks and Barriers

Processed cheese is a popular product line with highly regulated guidelines and requires multiple ingredients that inherently carry a greater risk of solids loss/waste throughout production. As a result, cheese manufactures have been working to reduce costs and losses as the markets become more competitive and the price of milk declines (Berlan, 2019). Where other industries have been using lean management and manufacturing approaches for the last several decades, the food and beverage industries have just begun to embrace lean in the past decade. Costa, Filho, Fredendall, and Paredas (2018) noted that food and beverage producers are notoriously conservative and late adopters of new ideas and innovations. This is due in part to the many barriers they face such as rapidly changing market demands, demands for lower cost products, fickle customer bases not allowing for development and research time, and strict food safety laws and regulations that stifle risk taking.

To this end, in their research, they noted that the first published study to specifically focus on lean applications in the food industry was not completed until 2013, which was 13 years after other industries started releasing studies on lean and their operations (Trends in Food Science and Technology, 2018).

The History of Lean Management

The Japanese, specifically, Toyota, are credited with creating what is now known as the lean management philosophy. In the 1940's, the Toyota Production System was created so Toyota could maximize outputs by identifying and reducing unnecessary steps, processes, materials in their production systems (Moujib, 2007). By identifying wasteful steps or processes in a production system, Toyota made adjustments to increase outputs without increasing time, effort, or product inputs. The Toyota Production System basically perfected the ability to do more with less (Dora, Kumar, Van Goubergen, Molnar, & Gellynck, 2013).

It was not until the early 1990s that American businesses were exposed to the ideas of lean and the Toyota Production System. Womack, Jones, and Roos (1990), introduced businesses in the United States to the principles, values, and benefits of a lean management system. While Toyota had been perfecting this process for nearly 50 years, Americans were just starting to understand how their organizations could be transformed with lean management improvements. As noted above, it would be another 23 years before the food and beverage industries began to adopt the lean approach (Trends in Food Science and Technology, 2018). Companies that have invested in fully implementing lean principles and practices across their corporations have been able to leverage substantial savings (Cyger, n.d.). Since implementing lean principles in the late 1990s, General Electric has saved 4.4 billion dollars, Honeywell has saved 1.4 billion dollars, and Ford has saved 1.2 billion dollars (Cyger, n.d.).

Principles of Lean Management

Melton (2005), explained that when lean is implemented correctly, “It (lean) requires half the human effort, half the manufacturing space, half the investment and half the engineering hours to develop product in half the time” (Melton, 2005, p. 663). In order to realize the benefits of lean, there are three overriding principles that Melton (2005) addressed. They are to identify where there is value in the process(es), reduce all waste (either materials or time) from the processes, and to create a flow of value for the end user, or in most cases, customers (Melton, 2005).

Lopes, Freitas, and Sousa (2015) studied the implementation of lean manufacturing tools across several food and beverage manufacturers. In their literature review, they stated that while it is unrealistic for all food and beverage producers to follow the same steps and be guaranteed the same outcomes, they noted there were several universal steps that all organizations could use when transitioning to a lean manufacturing approach. Lopes et al. (2015) wrote,

> Initial implementation stages typically involve an initial value stream mapping (VSM) for starting to change mentalities and raising awareness to the advantages of lean. Afterwards, production environments must be organized using the 5s (sort, set, shine, standardize, sustain). Then, following a continuous improvement culture, major issues are identified, for which the most appropriate (lean) tools are employed. (p. 121)

Through standardizing work and removing waste, which are the overriding principles of lean, doing more with less can be achieved. Appendix A introduces a lean toolkit for organizations to use when attempting to drive change and process improvements through lean.

The Seven Types of Waste

The toolkit items listed in Appendix A are designed to achieve the three overriding goals of lean: identify value, reduce waste, and increase flow. In the lean approach, seven types of wastes that reduce value and flow are identified. They are: over production, waiting, transport, inventory, over processing, motion, and defects (Figure 1).

Figure 1. Seven causes of waste. (The Benefits of Lean Manufacturing, 2005, p. 8)

Waste is essentially anything that does not add value to the process, and ultimately, for the organization or customer. In organizations that manufacture food and beverage items, employees struggle to overcome additional barriers to achieve a 100% lean operation. Lopes et al. (2015) noted that the machines used in food production and packaging are often outdated resulting in less efficient runs and operations. When a piece of equipment can cost hundreds of millions of dollars to update, companies often elect (or are forced) to use outdated, less efficient equipment rather than investing in capital improvements. Additionally, since manufacturers typically produce more than one type of product per production line, there are frequent changeovers that result in product loss, time loss, waiting, and motion loss to name a few.

Cheese manufactures are not immune to experiencing the seven types of waste (Melton, 2005). When raw ingredients or final products are transported, there are inevitably, storage limitations that require redundant product movements, wasted travel due to offsite storage of materials, and/or inefficient (outdated) plant layouts that require wasted employee movement. In order to ensure appropriate inventory levels, waste is often experienced in finished product that ages out prior to shipment due to overproduction, late customer order changes once product is finished, and/or as a result of over forecasting from production schedulers.

Another common waste/loss point in food manufacturing is a result of over processing (Kapoor & Metzger, 2008). This type of waste occurs when errors are made on the production line and product needs to be re-worked. Damage from wrapper or auto casing errors are typical processing waste points. Additionally, sister plants may have to open and rework another plant's errors/rework. Waste in defects can come from coding products incorrectly, mixed products in cases, blend specifications out of range, or as a result of cooking the cheese.

Waste in motion is another loss point in cheese production (Kapoor & Metzger, 2008). This can occur when machines are down and work has to be done by hand. Instead of automated machines doing the work, hand stacking when palletizers are down, hand casing when case packers are down, or traying up manually when a wrapper is down causes extensive wastes in motion. Another common waste point in motion comes from production halting while waiting for blenders to mix for the required forty minutes prior to production commencing. Over production is an incredibly costly waste point in food manufacturing (The Benefits of Lean Manufacturing, 2005). Another common example is when customers only purchase 200 cases in an order; however, the blenders must run in 600 case count orders. This results in 400 excess cases that must be absorbed by the company.

When cheese producers compete in an over saturated market, have to contend with low milk prices, and use a blend where multiple ingredients are required, the risk for waste and solids loss increases, while the profit margins and room for errors drastically decrease (Berlan, 2019). Therefore, it is essential for these companies to use lean tools and approaches that will have the greatest positive impact in reducing waste and achieving a lean operation (Thornton, 2005).

Benefits of Using Lean

Heneao, Sarache, and Gomez (2018) studied the positive effect on performances and outputs in lean operations. From there, they looked at what companies must do to not only maintain initial successes with lean, but to also, to reach 100% lean efficiency. Companies need to understand that when lean is used as a one and done approach, meaning companies use a few lean tools, see success then slip back into old ways, any gains will quickly be lost (Heneao et al. 2018). In order to avoid slipping back into old ways, company leadership must work to ensure a cultural shift towards lean practices takes place. Leaders must work to change the mindset of employees so they become active participants in the process. In cannot be just the leaders in the company driving change; employees must also actively look for ways to drive process improvements. The entire company must view lean as a cultural philosophy and not a checklist that once accomplished is put aside (Lopes et al., 2015). Heneao et al. (2018) noted that, "Successful implementation of synergistic lean management practices can account for an operational performance increase of up to 23% in dimensions such as quality, lead time, unit cost and flexibility" (p. 105).

Common Lean Tools Used in Food and Beverage Industries

Costa et al. (2018) found that the most beneficial (and commonly used) lean tools for the food and beverage industries were, value stream mapping, cause and effect diagrams, completing the 5s, and control charts. These tools are effective in identifying and rectifying common loss points for food and beverage manufacturers. These common loss and waste points were attributed to, “demand uncertainty, high cleaning time, frequent production change overs, high set up time, traditional layouts (machines/factories), perishability, seasonality, and variation in raw materials” (Costa et al., 2018, p. 128).

Cause and effect diagram (fishbone diagram). To identify and rectify waste points, many companies rely on a cause and effect diagram, or as it is more commonly called, a fishbone diagram. One of the many benefits of this tool is that it brings a diverse group of stakeholders together to dissect the problem (Simon, n.d.). Frequently, companies that are vertically aligned create insulated silos of teams and industry knowledge. When people are too close to the process, they may miss obvious loss or waste points (Simon, n.d.). By bringing in a team to complete this diagram there will be fresh sets of eyes and ideas working on the problem. Once the team is assembled a problem statement is identified (Rouse, n.d.). This is the “head” of the fish (Figure 2). From there, branches or “bones” extend from the fish body. Those represent different categories. According to Simon (n.d.) the categories most often used in manufacturing are, machines, methods, materials, measurements, mother nature, and manpower. Once those branches are added, the team brainstorms ideas and possible causes/failures in each of those categories. The visual, which is a hallmark tool used in lean, helps the team identify problems and forces the team to focus in on potential solution points (Simon, n.d.).

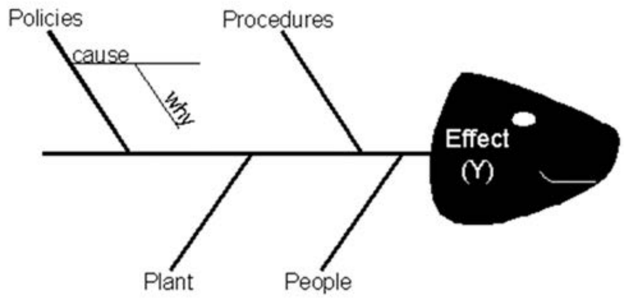


Figure 2. Fishbone diagram. (The Cause and Effect Diagram, n.d., p. 2)

Value stream mapping (VSM). One of the most common and critical lean tools used for reducing waste and improving a process is the value stream map. Rahani and al-Ashraf (2012) explained that by using a VSM activity, companies can look at the current process and identify overt and hidden wastes in their processes. It requires multiple people looking at the process, dissecting the process, and discussing the process to identify all causes of waste (Rahani & al-Ashraf, 2012). The purpose of the VSM is to create a visual chart/display that is a detailed, step by step guide for any given work process. By mapping out each step, it allows the team to show bottlenecks, needless repetition, inefficiencies or waste (any of the seven kinds) in that specific process ("What is Value Stream Mapping," n.d.). By visualizing the process, it not only creates standard operating procedures, but it also allows the negatives in a process to be identified and rectified ("What is Value Stream Mapping," n.d.). De Steur, Wesana, Dora, Pearce, and Gellynck (2016) found that when VSM was used as part of a lean approach to reduce waste in food production and supply chains, companies experienced the following benefits: an "83% reduction in lead time, 40% reduced the number of operator/employee expenses, and 75% reduced storage consumption/waste" (p. 363).

The five S (5s). The 5s are based on five Japanese words: seiri, seito, seiso, seiketsu, shitsuke, and when translated mean: sort, set in order, shine, standardize, sustain (Mahalik, n.d.).

When used together, and as an ongoing approach to completing work, these 5s tools/principles are extremely beneficial in driving out waste.

In the seiri/sort stage, the team should look around the workspace and identify all tools or materials that are critical to the job at hand. Anything that is not used would be removed. When removing items, they are “red tagged” and moved to another area (Mahalik, n.d). During the seito/set in order stage, all required items are organized in the workspace, in a specific place that allow for ease of retrieval when needed in the process.

In the seiso/shine stage, a deep cleaning is done in the workspace and ongoing daily/maintenance cleaning of the tools/materials and space are required (Mahalik, n.d.). The next step, seiketsu/standardized, involves creating visual work guidelines that will ensure that the space is kept tidy and organized (Mahalik, n.d.).

Finally, in shitsuke/sustain, ongoing training, monitoring, and modeling fidelity to the standard operating procedures and workspace organization requirements ensures that the workspace maintains its efficient system and setup (Mahalik, n.d.). Frequently, there are picture diagrams at the work spaces that demonstrate what each step looks like. This allows for standardization of the task across operators (Mahalik, n.d.). When the 5s are followed they decrease various types of waste such as waiting, motion, and inventory wastes (Marshall, 2016). Figure 3 below shows the order and summary of each step in 5s.

Figure 3. 5s explanation. (Marshall, 2016, p.1)

Control charts and lean. Once waste points are identified, value stream mapping is completed, and the 5s are firmly in place, an effective tool to monitor progress is the use of a control chart. According to Berardinelli (n.d.) there are a variety of charts to use depending upon what data a company is looking to track. Primarily, these charts track processes with the intention to keep them in control vs. out of control. There are four process states a company may encounter, they are: threshold state (in control but with occasional variances), ideal state (all control points are within acceptable range), brink of chaos (while not completely out of control, there are numerous variances outside of the acceptable range), and finally, state of chaos (this implies that the process is out of control and the process is out of range) (Berardinelli, n.d.). By establishing a control chart and acceptable levels of variance or range, an organization can progress monitor any given process and make adjustments before a process reaches a chaos state. By monitoring and catching process variances early, waste can be reduced, and ideally, completely mitigated (Berardinelli, n.d.).

Summary

Through a review of multiple sources and the work of many subject matter experts, this chapter explained what processed cheese is, its specifications, and the appeal for various consumer uses. Since processed cheeses require multiple raw ingredients and multiple steps in the formulation process, the research showed that solids loss and waste is greater than during the production of natural cheese products. In a competitive market fueled by an abundance of suppliers, and further driven by historically low dairy prices, cheese producers must run an efficient and cost-effective operation. Consequently, in the past ten years, many food and beverage producers, including cheese makers, have turned to lean manufacturing approaches to ensure quality, customer retention, and maximum profit margins. In order to mitigate these risks (solids loss and waste) and to achieve production goals, ideal lean tools that organizations should use were also discussed in this chapter.

Chapter III: Methodology

The purpose of this study was to identify and rectify loss points for solids and waste in the production process for various processed cheese blends. Company XYZ was nearly $300,000 over budget on acceptable levels of solids loss and waste and needed to rectify the loss in order to balance their operating budget. During the brainstorming and planning process, the team identified the following potential loss points/causes in the process, such possibilities included: human error, machine errors, and incorrect raw product report errors from vendors.

Weekly aggregate data review for salvage, scrap, and solids loss were evaluated to ensure high level data evaluation was occurring in order to understand if the action items were driving results that would ensure successful interventions. Lean protocols allowed the team to properly identify areas to collect data that would ultimately help to correctly identify and create action plans to rectify the loss and waste. The tools included: control charts, value stream mapping, and ensuring the implementation of 5s throughout the production process.

Instrumentation and Activities for Addressing Human Error

In addressing human error resulting in solids loss and waste, the team used various data points/reports to determine trends. Such reports were run weekly over a 12-week period and included tracking, unplanned downtime reports, late minutes start up report, on-hold reports, and salvage generated by reason code report.

Unplanned downtime reports. When running any sort of production product, unplanned downtime is a result of having to shut down the line (stopping production of a product) due to equipment failure, operator error, or product deficiency. If the line is shut down for more than one hour, cheese will harden in the pipes and a clean in place of the cook system and pipes must be completed. When a clean in place (CIP) is done, it creates approximately

4,000 – 5,000 pounds of salvage and waste. These reports looked at how often unplanned shutdowns occurred and the subsequent salvage and waste that was created.

Late minute start-up reports. The late minute start up reports show how many minutes production started after committed time. With set production times, any delays resulted in bottlenecking future product runs and could result in the customer being shorted orders. Late start ups may also result in jumping from order to order (formula to formula) instead of running in an ideal order. This results in unnecessary product waste and salvage, in addition to increased labor costs and waste.

On hold reports. On-hold reports identify products that were on hold. A product could be put on hold due to many reasons, which include but are not limited to: code date error, case packing error, labeling error, incorrect formulations of cheese, cheese out of spec due to high moistures or high amps or burn-on. Product that is on hold cannot be released to customers until it is reviewed. If the cheese is deemed to be acceptable, there is still a loss in additional labor costs to assess. If the product cannot be released, it means the entire order must be re-worked, thus generating thousands of pounds in salvage cheese.

Variance reports. When the variance reports were pulled, research was completed to determine the cause of the variances (late start ups, unplanned downtime, and salvage created) that data was then used to create action plans to address and rectify the various human error trends.

A team comprised of production employees and managers was assembled to complete a 5s review of the processes used in the making the processed cheese. This 5s review was used to identify wasteful steps/activities in the process and to create a more standardized work space and standard work order process for the employees to follow.

During this seiri/sort stage, the team identified potential unnecessary tools and equipment in the work area. In the seito stage, the team worked to identify better organization of tools and the work area. Once in the seiso/shine stage, the team identified a cleaning plan for the work area. In the seiketsu stage, the team discussed how they could maintain the new system they were designing. For the final stage of the 5s review, the shitsuke/sustain stage, the team created a comprehensive training program to sustain the change.

Instrumentation and Activities for Addressing Machine Errors

Machines used during the production of processed cheese included belts, cookers and wrappers. These machines were old (the newest was 22 years old) and as a result, did not function with high efficiency due to outdated technology and wear and tear on the machines. All of the machines were past their useful life expectancy, and frequently created waste and salvage due to ongoing equipment failures. Three major data points: Weekly salvage reports, production finished salvage goods, and equipment cleanout salvage reports were monitored and researched with regards to machine errors and loss/waste.

Weekly salvage generated during start-up report. During startup, the machines had to be recalibrated for each product run. This meant that cheese loaves waiting to be sent to the wrappers were rejected into salvage because they did not meet weight requirements. Each belt had “in range” requirements that must be met before cheese can be sent to wrappers. During start up, adjustments were made to the manifold valves and metering pump settings to get the cheese loaf weights to spec. This process inherently generated salvage because it cannot be done without cheese flowing through the manifolds. There was an acceptable level of salvage; however, at times, salvage was over the acceptable limit and caused increased loss. The goal was to have no more than 4,000 pounds of salvage per start up. Anytime a machine error occurred, the line shut down and had to be restarted after adjustments are made. This resulted in another start up salvage loss of 4,000 pounds. By pulling data on salvage start up reports, waste/loss were categorized by reason (wrapper down time, loaf weight overages, underweight loaf weights) and systems could be put in place to address specific causes.

Total week production finished goods salvage. By identifying finished good product salvage weight over weekly runs, the team categorized by reason and product formulation. In collecting this data, the team was able to identify loss leaders in the process and started with the highest salvage formulations to address. This data was verified by using Programming Logic Control (PLC) cheese reject sensors and that was then checked against SQL aggregate data.

Equipment cleanout salvage. Over the course of each week (12 weeks total) data was collected on the total weight of salvage generated when cleaning out the equipment. Salvage could be reused later; however, generating the least amount of salvage is ideal. The team looked for trends during cleanup that could be addressed to improve the cleanup process and thus reduce salvage.

Instrumentation and Activities to Address Vendor Errors

Prior to implementing this research plan, Company XYZ was losing solids and generating waste due to unchecked errors from outside suppliers. Company XYZ was monitoring activities, but not in a timely manner. Once errors were discovered, lost costs and materials were near impossible to recover. As a result, data was collected to determine if the stated shipping weights of solids were the actual weights received. This was done by cross checking solids in curd and cheese to see if a true composition was reported on the supplier's certificate of analysis (COA). The data was validated by performing vac oven tests on cheese plug samples pulled at the facility – ensuring that the contents/makeup matched what was reported by the supplier. All non-fat dry milk was sampled at the facility and sent out for Karl Fischer testing. By verifying solids in incoming ingredients purchased for later use, the team was able to analyze that data in the Minitab program to generate process control, data normality and statistical difference data points, which was then used to make adjustments to the process to reduce waste.

Summary

In order to ensure the team was making informed decisions on what data points were collected, a variety of lean tools such as 5s reviews, fishbone diagrams, and control charts were used to inform their decision making. Additionally, during the 12-week time frame that the team was collecting and analyzing data, they used control charts for high level data evaluation, along with programs such as Minitab and Karl Fischer testing, which are industry standards for collecting and validating data. In the next chapter, the results of the methodology presented above will be discussed.

Chapter IV: Results

The previous chapter examined various methodologies that could address and mitigate solids loss and waste at Company XYZ. During the production of processed cheese, Company XYZ was nearly $300,000 over budget on acceptable levels of solids loss and waste. In order to rectify the losses and meet budgetary goals, several lean interventions were conducted and will be discussed in this chapter. This 12-week project included activities such as: holding brainstorming and planning meetings, along with the identification, monitoring and rectifying potential loss points/causes in the production process of processed cheese. Errors addressed included: human error, machine errors, and general process errors and inefficiencies. The outcomes of this study are as follows.

Addressing Human Error

Making processed cheese is a multiple step production process that not only involves many different machines, but also, substantial human input/activities. The opportunities for errors in the process as a result of human errors were numerous. Human error points were reviewed to address areas of high concern. One primary concern was late start ups.

Late startup reports. When production started late it caused delays in completing customer orders and further bottle necked future orders. By looking at the late minute startup report the team was able to adjust the pre-shift startup check list. Table 1 shows the top three reasons for late startups over a 26-week period prior to the start of the project.

Table 1

Top Three Reasons for Late Startups

Minutes Late/1st Package Out	Reason Code
590	Equipment Failures
411	Pump Replacements
235	Lecithin Issues

Upon initial review, production was late on average 31 minutes per week over the 26-week period. The cause of late start ups due to human error were primarily related to equipment assembly errors and damage to electrical equipment during cleanup that resulted in maintenance delays that were avoidable.

In preparing to run a cheese blend, equipment was not being set up/assembled by the employees correctly. This resulted in production being shut down. As noted earlier, once production had started and needed to be stopped, a significant amount of wasted cheese was generated. On average, about 4,000 pounds of cheese was lost to salvage or re-work when there was a work stoppage. When starting up late, there were additional costs that were compounded with the cheese loss and waste when the line shut down due to equipment issues

Addressing Equipment Error

A review of casting line salvage error codes was also studied. This included a snapshot review of the 12 weeks prior to the project starting, but it also included a fiscal year review to ensure any long-term potential trends were spotted and are as shown in Appendix B.

From this casting line salvage data review, wrapper down time and bottom seal/end seal issues were the areas of greatest concern. Wrappers were down for a variety of reasons, but primarily were due to jams in the wrapper equipment. Bottom seals and end seal issues were due to finished product containers not sealing correctly and resulted in employees having to open and re-work the product (waste). Prior to the start of the project, an average of 148,900 pounds of cheese salvage was created weekly as a result of wrapper error waste. This translated into a 10.24% salvage rate. The wrapper machine errors created a significant portion of the 148,900 pounds of waste. Salvage/rework cheese is not a total waste, as it can be reused in the production process; however, it is still a considerable waste point in the system. Salvaged cheese is devalued 3 cents per pound off the market rate. If the market rate were on average $2.00 per pound, the devaluated cheese would be valued at $1.97 per pound, for a loss of .03 cents per pound. While at first glance, the loss does not appear to be substantial, it was on track to average $202,800 in waste costs annually.

General Process Errors and Inefficiencies

Throughout this project, as the team met to brainstorm possible solutions and implement lean systems such as the 5s review and planned discussions using fish bone diagrams, several process improvement opportunities were identified.

5s review of the control room and operator work areas. The control room and operator work areas are critical areas in the production of processed cheese. One employee in the control was responsible for the entire operations through controlling line speeds, loaf weights, cooking temperatures and lecithin settings to name a few. It was imperative to create a work space that was well organized and free of clutter to ensure that materials and information needed could be quickly retrieved. During the 5s review of these areas, the following actions were taken.

Seiri/sort stage review. During this stage, the team cleaned out the control room and removed all clutter and unnecessary product, tools, and any materials that were not directly needed for the production activities. All operator production and work areas were cleaned and cleared of unnecessary product, tools, or other materials. Figure 4 shows a properly ordered work space in accordance with seiri/sort implementation.

Figure 4. Properly organized work space.

Seito/set stage review. In the seito stage all remaining and necessary materials were organized in a way that would allow for operator ease and efficiency when retrieving products and materials to be used in the production process. Tool shadow boards were created to ensure that tools were stored and returned to their proper spots. Figure 5 shows tool shadow boards in operator work areas.

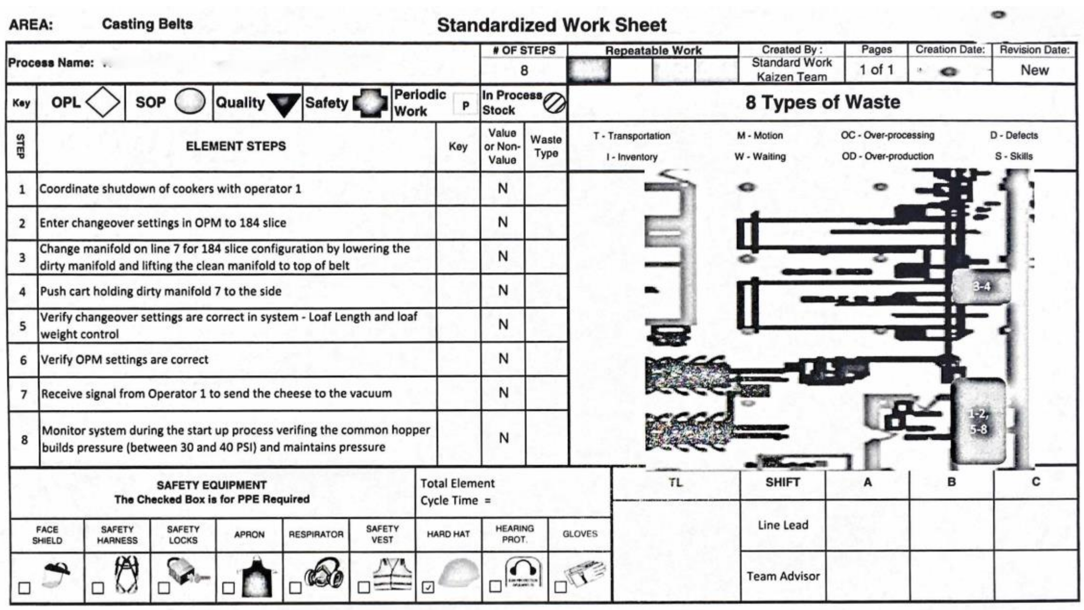
Figure 5. Tool shadow board.

Seiso/shine stage review. At this point in the 5s review, the employees completed a deep cleaning of the work and production areas. Leaders performed daily checks to ensure that the work areas stayed clean and organized. This included checking that tools were accounted for, floors were clean, stainless work and production surfaces were clean, and that no supplies were left out. Figure 6 shows the 5s action items belt operators complete and leaders must check daily.

		Responsibility	Leader	GEMBA
1	All items are within designated location at the control room desk.	Belt Operator		
2	All items are within designated location & cabinets have only designated items.	Belt Operator		
3	Drawers only contain designated items.	Belt Operator		
4	pH station items are within the designated markings and area is clean.	Belt Operator		
5	Scrapers and thermometers are in the proper location at the weight station.	Belt Operator		
6	All items are within the designated locations at the weight station.	Belt Operator		
7	Mouse is in designated location and labels are in good repair.	Belt Operator		
8	All tools are clean and in place on the common hopper shadow board.	Belt Operator		
9	All tools are clean and in place on the shadow board by belt 6.	Belt Operator		
10	All tools in place and clean in the filter changing station. Scraper and Pigs are ok in the locations indicated on the photo.	Belt Operator		
11	All tools are clean and in place on the shadow board by belt 7.	Belt Operator		
12	All tools are in place and clean at the manifold station and the parts basket is in its home.	Belt Operator		
		TOTALS		

Figure 6. 5s Action item checklist.

Seiketsu /standardized stage review. At this point in the 5s review, visual work instructions were loaded onto the computers for all employees to access and use during product changeovers. This created standardized work targets/instructions for all employees to use. Figure 7 below shows standardize work targets for casting belt operators.



AREA: Casting Belts — Standardized Work Sheet

Process Name:	# OF STEPS	Repeatable Work	Created By:	Pages	Creation Date:	Revision Date:
	8		Standard Work Kaizen Team	1 of 1		New

Key: OPL, SOP, Quality, Safety, Periodic Work P, In Process Stock

8 Types of Waste: T - Transportation, I - Inventory, M - Motion, W - Waiting, OC - Over-processing, OD - Over-production, D - Defects, S - Skills

STEP	ELEMENT STEPS	Key	Value or Non-Value	Waste Type
1	Coordinate shutdown of cookers with operator 1		N	
2	Enter changeover settings in OPM to 184 slice		N	
3	Change manifold on line 7 for 184 slice configuration by lowering the dirty manifold and lifting the clean manifold to top of belt		N	
4	Push cart holding dirty manifold 7 to the side		N	
5	Verify changeover settings are correct in system - Loaf Length and loaf weight control		N	
6	Verify OPM settings are correct		N	
7	Receive signal from Operator 1 to send the cheese to the vacuum		N	
8	Monitor system during the start up process verifing the common hopper builds pressure (between 30 and 40 PSI) and maintains pressure		N	

SAFETY EQUIPMENT
The Checked Box is for PPE Required

Total Element Cycle Time =

FACE SHIELD	SAFETY HARNESS	SAFETY LOCKS	APRON	RESPIRATOR	SAFETY VEST	HARD HAT	HEARING PROT.	GLOVES
☐	☐	☐	☐	☐	☐	☑	☐	☐

TL	SHIFT	A	B	C
	Line Lead			
	Team Advisor			

Figure 7. Standardized work targets for casting belt operators.

Shitsuke/sustain stage review. For the final stage of the 5s review, a comprehensive belt operator training was created and implemented. The program called, Belt Operator School, was created to retrain all belt operators. Belt operators were critical to the production process because they not only cook the cheese, but they also cast the cheese and send it to the wrappers. Errors in any of these stages created salvage and waste.

Blender scrape down process review. During the process review stage, the team identified additional areas of improvement opportunities in waste reduction during blender operations and cleanouts. After the last blends of the week, the blenders (four total), needed to be scrapped down and run clean before starting line cleanup. Prior to starting this project, the raw material waste from blender cleanouts (approximately 4,000 pounds per week – 1,000 pounds per blender) was scrapped out of the blenders and washed into solids recovery holding tanks to be used in later formulations. The solids recovery holding tanks could only hold 9,000 pounds. As a result, 3,000 pounds (on average) were wasted. This translated into $3,500 in lost materials cost per week.

Summary

In this chapter, the team identified and addressed several loss points in the processed cheese production process. This was done through a variety of lean approaches such as 5s reviews, centerlining events, implementing standard operating procedures and standard work programs. In order to reduce waste, Chapter 5 will show results from these initiatives and propose ongoing strategies and programs to ensure solids loss and waste in the production of processed cheese is achieved.

Chapter V: Discussion, Conclusion, and Recommendation

This project examined the waste generated in the production of processed cheese. Waste was found to be a result of process error, human errors, and machine errors. A variety of lean interventions and plans were put into place to mitigate waste and to rectify ongoing negative budgetary implications. This chapter will provide outcomes and recommendations for future consideration and use.

Discussion

Company XYZ was significantly over budget in solids loss YTD. This loss was due to a variety of factors that were part of the processed cheese production. At the time, 12 weeks into the fiscal year, the company was at $283,000 in solids loss and this was projected to have a $1.2 million dollar impact to the operating budget for the fiscal year. Immediate research and action were undertaken to identify and rectify the solids loss and wastes.

Addressing human waste. When producing processed cheese there are multiple points in the production process that are prone to human/operator errors. One of the most common errors found was late start ups as a result of employees not being ready to run the product. During the team analysis, it was further discovered that proper machine preparation and maintenance was not completed prior to starting production thus leading to delays in starting and/or work stoppages once started. In order to rectify this, a cooker/belt startup checklist was created to ensure standard operating procedures and troubleshooting tasks were done prior to the start of production. Figure 8 below shows a sample of the startup checklist employees completed.

COOKER/BELT STARTUP CHECKLIST

Date/Time________________________________

OPERATOR______________________________

1) Make sure control system is running

- ________ ☐ Check SCADA (Mouse works, No PLC communications error)
- ________ ☐ Check Panel view (No errors, starts/stops equipment)

2) Check Belts

- ________ ☐ Confirm lecithin is available and system operates correctly
- ________ ☐ Check schedule for first product
- ________ ☐ Check settings for metering pumps, cutoffs and belt speeds
- ________ ☐ Confirm correct slitters, lineup racks and EZ-Pick equipment available
- ________ ☐ Confirm rework and scrap boxes are prepared
- ________ ☐ Verify tickets, filter change record, log sheet, salvage sheet and gloves are available
- ________ ☐ Sanitize scales and check for operation
- ________ ☐ Check belt transfer wires for wear
- ________ ☐ Check equipment cleanliness
- ________ ☐ Test run belts, metering pumps, transfer conveyors, cutoffs, and diverter
- ________ ☐ Verify that there are 5 little orange belts under Servo 2 cutoff
- ________ ☐ Verify that there are 6 little orange out feed belts on Servo 2
- ________ ☐ Verify that there are 6 wide orange belts between Servo 2 and Servo 1
- ________ ☐ Verify that there are 5 little orange belts under Servo 1 cutoff
- ________ ☐ Verify that there are 6 little orange out feed belts on Servo 1
- ________ ☐ Check glycol return boots/valves are in proper production position
- ________ ☐ Turn on glycol pumps and verify glycol supply temperature less than 25°F
- ________ ☐ Confirm glycol is overflowing from the pans on belt 6, 7 and 8 (top and bottom).
- ________ ☐ Confirm manifolds are assembled and installed correctly
- ________ ☐ Check doctor blades/scraper blades
- ________ ☐ Check cutoffs for broken wires and make sure spare head is available
- ________ ☐ Check fittings (tight and aligned)
- ________ ☐ Verify CIP Line is disconnected and pressure transducer is installed
- ________ ☐ Calibrate and test run check weigher
- ________ ☐ Position salvage tubs
- ________ ☐ Check clamp/manifold wrenches, loaf length scale
- ________ ☐ Check for excess grease on check weigher rollers and Casting belts
- ________ ☐ Check for black build up on belts that may cause streaking
- ________ ☐ Turn cooling on and confirm glycol is overflowing from the pans on belt 6, 7 and 8.

Figure 8. Cooker/belt startup checklist.

For a 26-week period prior to starting the project, a cumulative 14 hours of lost production time was observed. For every hour the line was down, 20,000 pounds of cheese production was lost. This resulted in nearly 280,000 pounds of lost cheese production. When production employees completed the checklist, late minute start up and production outages due to equipment/operator issues were decreased by 70%. At the close of the study, the line had started up early and was no longer losing production minutes/hours due to late start ups.

Addressing equipment error. As noted in Chapter 4, substantial equipment errors were found to be contributing to the solids loss and waste created during the production process. Upon further review, wrapper down time due to bottom seal/end seal issues were noted as the area of most critical concern. These wrapper machine errors were contributing to the 148,900 pounds of salvage created weekly.

Once the equipment issues were identified, a wrapper centerline event was held. During the centerline event, the team tracked and marked the best run settings for the wrappers. The goal for wrapper run time was increased from 80% to 90%. Since centerlining the wrappers and running at ideal settings, at the close of the project, Company XYZ was running at 120,900 pounds of salvage per week. This resulted in a projected $43,800 reduction in salvage annually.

Addressing 5s improvements. Chapter 4 discussed several 5s improvements, most notably, during the shitsuke/sustain stage review a comprehensive training and periodic retraining program for Belt Operators was created. This program, named Belt Operator School, was conducted to properly train employees in their positions. In the BOS, employees learned how to handle common production problems, how to trouble shoot cooker issues, and learned how to adjust settings based on cheese flow. By ensuring that production employees were properly trained, and frequently re-trained, ongoing process improvements and waste reduction were possible. Since implementing the BOS there have been no major shutdowns/work stoppages as compared to the 12-week period prior to the start of the program.

Additionally, the team noted potential waste savings during a review of blender operations and blender cleanout activities. By safely adjusting the time between blender cleanouts and diverting waste from recovery tanks a substantial savings was noted. In order to mitigate this waste, the operators scraped down the blenders prior to cleaning to capture any remaining cheese (see Appendix C). This prevented adding unnecessary cheese to the solids recovery tank where it risked becoming waste. This (on average) prevented 2,000 pounds of cheese being diverted to solids recovery tanks per week. At the close of the project, the projected savings was determined to be $104,000 annually.

Conclusions

The goal of this project was to identify and rectify solids loss and waste during the production of processed cheese at Plant A for Company XYZ. The most important accomplishment for this project was twofold. First, correctly identifying loss points, and secondly, successfully addressing and implementing loss prevention initiatives. The new processes in place addressed human, equipment, and process errors as the production of processed cheese continues. At the close of the study, a total projected savings, across all project implementation points, was $147,800 per year. This does not include the intangible savings from cleaning and organizing work areas and streamlining work processes in the 5s review.

Recommendations

By researching and implementing lean manufacturing tools, Plant A was able to make critical cost-effective adjustments. As noted in Chapter 2, one of the main issues in loss and waste in manufacturing is old, inefficient equipment. The majority of companies do not have the capital to replace multi-million-dollar machines, hire outside consultants, or invest in additional staffing; therefore, it is imperative that teams use lean manufacturing tools to do more with less. Through the proper use of lean implementations, and most importantly, continued fidelity to the lean program, companies can reduce and prevent solids loss and waste without adding substantial operating costs to the budget. This project had a budget of $12,500 in discretionary funding. At the close, the team used approximately $9,500. While there is still room for process and waste improvements, a savings of $147,800 in waste/solids loss reduction was realized. To that end, Plant A is one of 31 production facilities in Company XYZ. If all the sites implemented the tools outlined in this paper, and saw similar success, Company XYZ could see a $4.5 million dollar reduction in waste and solids loss company wide. Therefore, continued implementation is recommended.

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Appendix A: A Sample Lean Tool Kit

Tool	Description	Typical Use
Force Field Diagramming	A tool which allows analysis of the forces supporting or resisting particular change	When looking at a potential design. When looking at the implementation planning for a change following design
IPO Diagramming	A basic flowchart tool mapping inputs, processes and outputs. Base on the required outputs, the appropriate process can be defined and the required inputs specified	To design a team session at any stage of the implementation of lean e.x data collection day, kaizen day, implantation planning.
Process Flow Mapping	A map showing each process step in the value stream	A data collection activity Also used to analyze the VA and NVA steps and as a tool for redesign.
Time-Value Mapping	A map of the time taken for each process step in the value stream	A data collection activity. Also used to analyze the VA and NVA steps and as a tool for redesign.
Spaghetti Diagraming	A map of the physical path take by a product as it passes down the value stream.	A data collection activity.
Five Whys	Asking "why" five times whenever a problem is found. In this way, the root caused is solved rather than the symptom.	Data analysis tool.
Five S's	Five activities used to create a workplace suited for visual control and lean practices: Seiri, Seiton, Seiso, Seiketsu, Shitsuke.	Can be used at the start of a lean induction to break down barriers and get a team to own their work space. Often used during Kaizens
Risk Assessment	A structured assessment of what could stop the achievement of specific objectives and how this can be mitigated.	Assessment of a design prior to implementation as a final challenge of the design. Assessment of the issues post-implementation – looking specifically at what would stop the sustainability of the change.
Kaizen	An improvement activity to create more value and remove waste.	Kaizen workshops are a common method to kick-off the start of a large step change within an area or value stream.
Kanban	Japanese for "signboard." This is a "visual" shop floor pulls system which means that each supplying work center does not make anything until the next work center requests supply.	This is a design solution to materials flow problems within a process.

The Benefits of Lean Manufacturing, 2005, p 666.

Appendix B: Casting Line Salvage Report

Week	A SHIFT	A SHIFT	B SHIFT	B SHIFT	C SHIFT	C SHIFT	A SHIFT	B SHIFT	C SHIFT	Weekly	Weekly	Weekly
FY19	PROD #	# SAL	PROD #	# SAL	PROD #	# SAL	% SAL	% SAL	% SAL	Prod	Sal	% Sal
1A	551,540	39,865	684,060	98,781			7.23	14.44		1,235,600	138,646	11.22
1B	534,579	71,529	647,040	77,955			13.38	12.05		1,181,619	149,484	12.65
1C	641,000	83,503	698,120	88,205			13.03	12.63		1,339,120	171,708	12.82
1D	509,560	73,220	743,240	94,920			14.37	12.77		1,252,800	168,140	13.42
2A	502,980	81,672	808,920	74,437			16.24	9.20		1,311,900	156,109	11.90
2B	772,440	89,635	890,385	103,695			11.60	11.65		1,662,825	193,330	11.63
2C	755,380	118,114	1,023,378	68,695			15.64	6.71		1,778,758	186,809	10.50
2D	223,840	41,235	565,340	54,884			18.42	9.71		789,180	96,119	12.18
3A	765,420	86,935	1,015,715	83,750			11.36	8.25		1,781,135	170,685	9.58
3B	466,220	76,280	846,920	59,568			16.36	7.03		1,313,140	135,848	10.35
3C	769,440	94,830	1,066,200	87,460			12.32	8.20		1,835,640	182,290	9.93
3D	818,640	77,756	815,612	87,351			9.50	10.71		1,634,252	165,107	10.10
4A	555,120	59,736	768,920	49,089			10.76	6.38		1,324,040	108,825	8.22
4B	565,260	28,579	720,680	44,970			5.06	6.24		1,285,940	73,549	5.72
4C	559,600	49,761	777,760	77,305			8.89	9.94		1,337,360	127,066	9.50
4D	462,100	66,684	669,967	59,134			14.43	8.83		1,132,067	125,818	11.11
5A	530,480	62,185	746,260	55,825			11.72	7.48		1,276,740	118,010	9.24
5B	555,520	39,832	609,220	62,202			7.17	10.21		1,164,740	102,034	8.76
5C	504,360	47,789	838,240	58,843			9.48	7.02		1,342,600	106,632	7.94
5D	497,900	52,321	566,394	72,247			10.51	12.76		1,064,294	124,568	11.70
6A	551,220	62,159	756,360	51,722			11.28	6.84		1,307,580	113,881	8.71
6B	527,300	62,005	747,020	70,620			11.76	9.45		1,274,320	132,625	10.41
6C	504,360	57,389	804,140	56,506			11.38	7.03		1,308,500	113,895	8.70
6D	526,280	60,039	733,964	48,246			11.41	6.57		1,260,244	108,285	8.59
7A	685,240	85,699	708,980	57,034			12.51	8.04		1,394,220	142,733	10.24
7B	511,440	78,959	764,540	72,452			15.44	9.48		1,275,980	151,411	11.87
7C	774,200	118,988	1,046,340	101,098			15.37	9.66		1,820,540	220,086	12.09
7D	1,040,160	126,092	1,202,180	110,973			12.12	9.23		2,242,340	237,065	10.57
8A	824,660	126,564	1,089,040	57,749			15.35	5.30		1,913,700	184,313	9.63
8B	829,960	112,926	1,064,740	77,706			13.61	7.30		1,894,700	190,632	10.06
8C	789,220	106,400	1,046,880	80,598			13.48	7.70		1,836,100	186,998	10.18
8D	808,320	67,419	985,081	57,965			8.34	5.88		1,793,401	125,384	6.99
9A	829,060	72,748	1,110,800	64,777			8.77	5.83		1,939,860	137,525	7.09
9B	634,380	77,642	974,380	91,434			12.24	9.38		1,608,760	169,076	10.51
9C	799,000	81,884	985,000	104,036			10.25	10.56		1,784,000	185,920	10.42
9D	776,080	82,412	889,522	105,137			10.62	11.82		1,665,602	187,549	11.26
10A	806,720	82,400	1,050,480	80,964			10.21	7.71		1,857,200	163,364	8.80
10B	500,040	55,897	715,940	72,221			11.18	10.09		1,215,980	128,118	10.54
10C	733,720	105,351	904,892	142,152			14.36	15.71		1,638,612	247,503	15.10
10D	505,800	52,974	687,572	77,521			10.47	11.27		1,193,372	130,495	10.93
11A	779,940	64,561	1,039,620	81,614			8.28	7.85		1,819,560	146,175	8.03
11B	470,380	58,486	728,143	70,577			12.43	9.69		1,198,523	129,063	10.77
11C	538,180	37,821	739,080	89,261			7.03	12.08		1,277,260	127,082	9.95
11D	463,040	73,635	814,180	61,421			15.90	7.54		1,277,220	135,056	10.57
12A	283,340	18,170	769,880	85,658			6.41	11.13		1,053,220	103,828	9.86
12B	759,820	69,669	973,296	118,250			9.17	12.15		1,733,116	187,919	10.84
12C	785,220	68,862	1,045,160	86,728			8.77	8.30		1,830,380	155,590	8.50
12D	308,840	67,286	725,260	148,434			21.79	20.47		1,034,100	215,720	20.86
13A	543,860	44,156	637,308	94,142			8.12	14.77		1,181,168	138,298	11.71
13B	572,180	39,810	701,130	111,317			6.96	15.88		1,273,310	151,127	11.87
13C	567,240	42,319	820,440	68,066			7.46	8.30		1,387,680	110,385	7.95
13D	595,020	28,033	709,291	61,347			4.71	8.65		1,304,311	89,380	6.85

	A SHIFT	A SHIFT	A SHIFT	B SHIFT	B SHIFT	B SHIFT
	PROD #	# SAL	% SAL	PROD #	# SAL	% SAL
FY19	32,165,539	3,630,216	11.29%	43,473,070	4,117,040	9.47%
	total prod	total sal	total % sal			
FY19	75,638,609	7,747,256	10.24%			

Appendix C: Blender Scrape Down Tracking Sheet

Blender Operator Initials	Blender	Formula	Starting Weight (Pre-Scraping)	Ending Weight
	1			
	2			
	3			
	4			