

**ANALYSIS OF RAW POTATO SORTING
TECHNOLOGY ON A POTATO CHIP LINE**

By

AUDRA GEIGER

B.S, Kansas State University 2006

A THESIS

Submitted in partial fulfillment of the requirements

for the degree

MASTER OF AGRIBUSINESS

Department of Agricultural Economics

College of Agriculture

KANSAS STATE UNIVERSITY

Manhattan, Kansas

2011

Approved by:

Major Professor
Dr. Bryan Schurle

ABSTRACT

Frito-Lay is part of the PepsiCo Family which makes some of the best known and top selling snack foods around. Frito-Lay is the dominant player in the salty snack category in the United States, with a 65 percent share of the market. Frito-Lay brands include Lay's, Ruffles, Tostitos, Sunchips, Fritos, Cheetos, and Doritos.

The objective of the thesis is to analyze a potential project: installing a raw potato sorting system on a potato chip line. Part of the analysis will be to conduct a net present value analysis of the costs and benefits associated with the project. Currently the line runs with one full time employee that inspects the raw incoming potatoes for foreign matter and color. Recently, technology options are available that the company could add to the raw potato sorting function that could potentially reduce employee labor costs. This research project provides information regarding the system's investment cost, maintenance requirements, labor savings, and finished product quality impact.

As the business environment changes businesses must keep up with rapidly changing technology to be able to compete. A company that is able to compete will be able to survive in the market and sustain profitability. Capital expenditures need to be evaluated and adopted if they keep a company competitive or make a company more cost efficient.

The analysis concluded that the investment of installing a raw potato sorting system would be profitable, earning a positive NPV and internal rate of return

greater than Frito-lay's cost of capital. I would recommend that Frito-Lay move forward with this investment.

TABLE OF CONTENTS

List of Figures.....	vi
List of Tables	vii
Acknowledgments.....	viii
Chapter 1: Introduction.....	1
1.1 Company background	1
1.2 Project Objectives.....	6
1.3 Potato Chip Process Overview.....	6
Chapter 2: Literature Review	11
2.1 Potato Background	11
2.2 Acoustic Technology.....	15
2.3 Color Vision Systems.....	15
2.4 Ultraviolet Vision System	16
2.5 Business Environment.....	16
2.6 Company Change Plan Strategy	18
Chapter 3: Theoretical Model.....	21
3.1 Background Information	21
3.2 Net Present Value	21
3.2 Alternatives to Net Present Value.....	22
Chapter 4: Methods and Results	24
4.1 NPV Formula.....	24
4.2 Labor Savings Assumptions.....	25
4.3 System Maintenance and Operating Cost.....	26
4.4 Depreciation Schedule.....	27
4.5 Marginal Tax Rate	27
4.6 Project Financing and Discount Rate.....	27
4.7 NPV and Cash Flow Calculations	28
4.8 IRR Calculations	32

4.9 Quality Impact	32
Chapter 5: Summary and Conclusions	37
5.1 Research Summary and Recommendation	37
5.2 Limitations and Future Study	37
References	38

LIST OF FIGURES

Figure 1.1: Locations of Frito-Lay Plants..... 2
Figure 1.2: U.S. Market Share 4
Figure 1.3: Growth at the Topeka Facility 5
Figure 1.4: Potato Chip Line Process Flow 9
Figure 1.5: Whole Potato Inspection System 10
Figure 2.1: Whole Potato Inspection Detection 14
Figure 4.1: Wooster Customer Complaint Data..... 35

LIST OF TABLES

Table 4.1: Labor Savings	26
Table 4.2: Labor and Benefit Savings	26
Table 4.3: Maintenance Costs	27
Table 4.4: Depreciation	29
Table 4.5: Capital and Start-up Costs.....	30
Table 4.6: Net Cash Flows and Net Present Value	31
Table 4.7: Internal Rate of Return	34
Table 4.8: Customer Complaint Reduction Calculations.....	36

ACKNOWLEDGMENTS

The author wishes to dedicate this thesis to her parents, Kent and Karen Frick, who have always been there for her. Your support and guidance has made me the person I am today. Thank you so much for your support and love through the years. To my three older siblings, Christina, Melissa, and Kurtis, they have always given me someone to look up to and challenged me to always do my best.

To my MAB classmates that were willing to help no matter what time of day it was. To the faculty and staff in the Masters of Agribusiness program, especially Dr. Bryan Schurle, who helped me when I needed motivation to complete my thesis. To my friends at Frito-Lay that helped provide data, results, and information for all of my company related assignments throughout the MAB program.

Finally, to my wonderful husband Dustin. You always were there to read my assignments and papers. Thanks for your patience and support during this time.

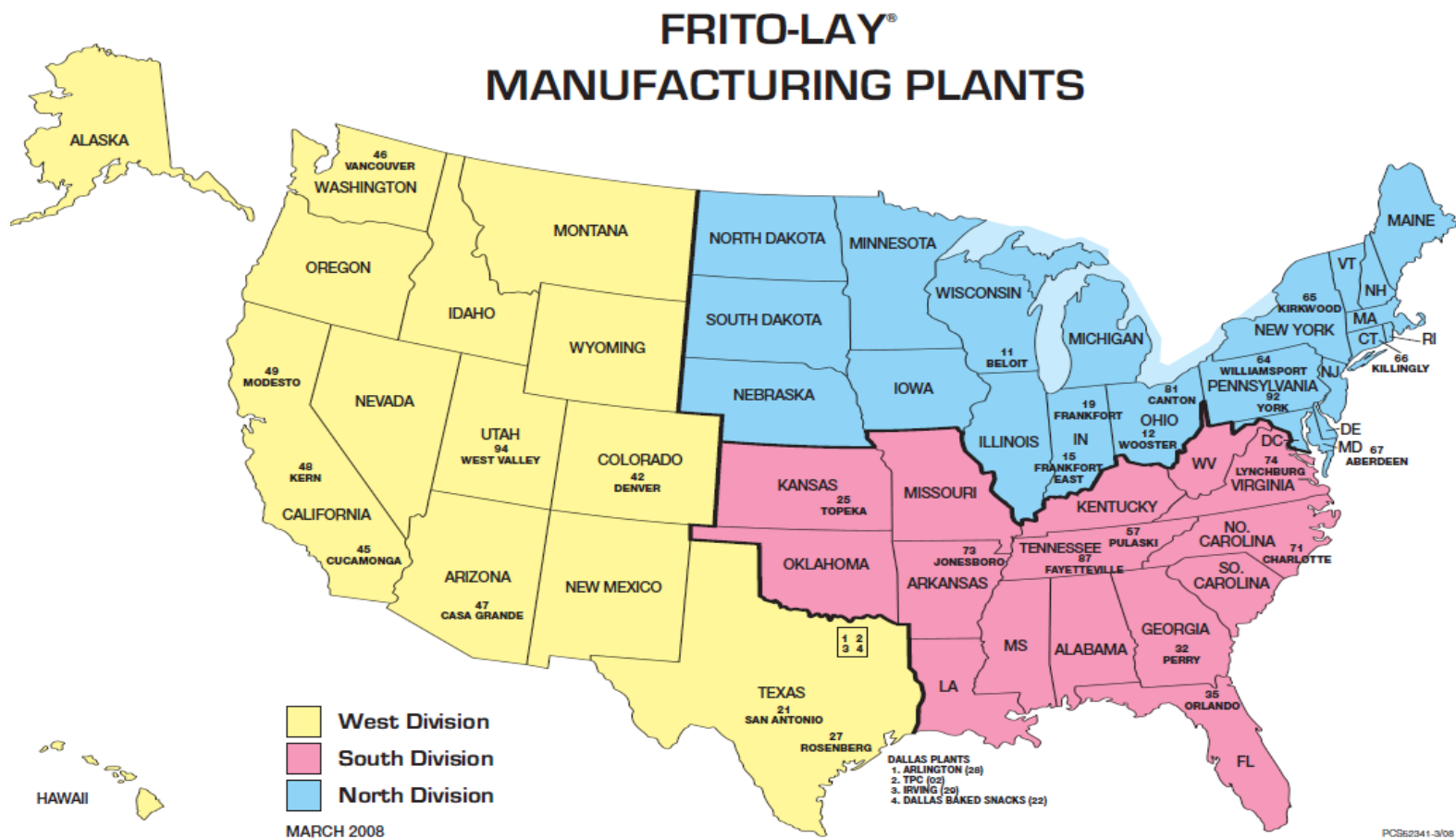
CHAPTER 1: INTRODUCTION

1.1 Company background

The H.W. Lays Company was started by Herman W. Lay. Lay began his career as a 24 year old delivery driver; he delivered potato chips to his customers in his Ford Model A. Eventually he expanded his profits and began to grow. In 1934 he founded the H.W. Lay distributing company based in Atlanta, Georgia. In 1937 he had 25 employees and had begun producing his own line of snack foods. The H.W. Lay Company merged with Frito Company in 1961, creating the largest selling snack food company in the United States. The company is now known as Frito-Lay Incorporated.

Today Frito-Lay is part of the PepsiCo Family which makes some of the best known and top selling snack foods around. Frito-Lay is the dominant player in the salty snack category in the United States, with a 65 percent share of the market. Frito-Lay brands include Lay's, Ruffles, Tostitos, Sunchips, Fritos, Cheetos, and Doritos. Frito-Lay North America has about 50 food manufacturing and processing plants and approximately 1,700 warehouses, distribution centers, and offices. Figure 1.1 shows the locations of plants in the United States. Of PepsiCo Inc.'s four operating divisions, Frito-Lay North America is the most profitable. The company generates 39 percent of the parent company's operating profit and Frito-Lay is also responsible for one-third of PepsiCo's overall revenues.

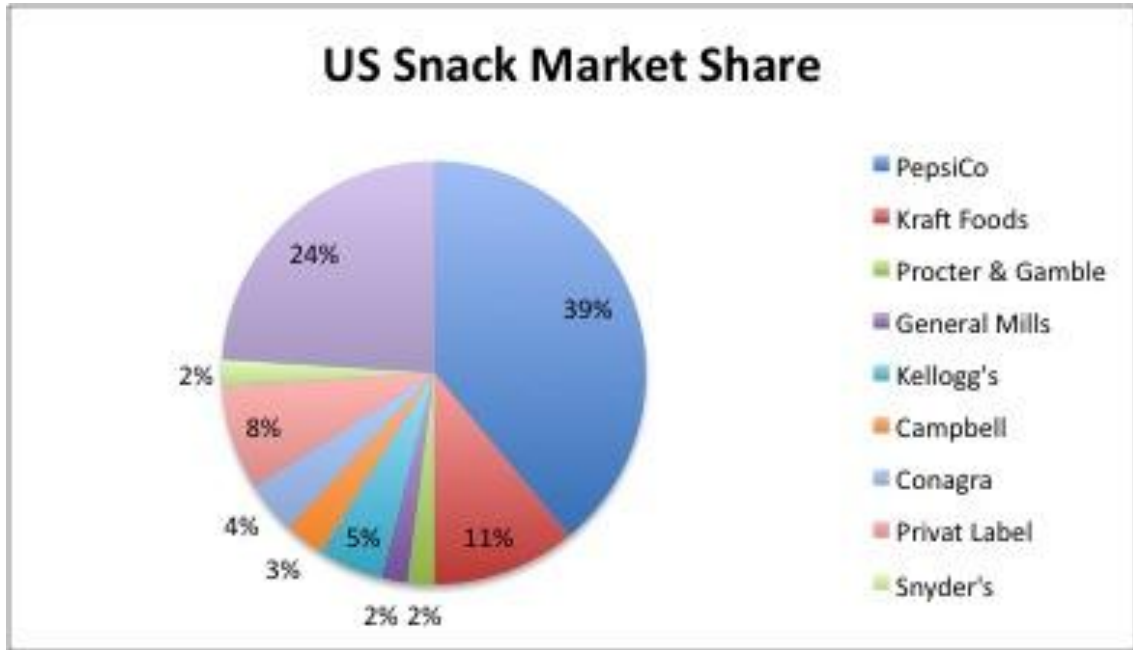
Figure 1.1: Locations of Frito-Lay Plants



Frito-Lay's company vision talks about continuously improving all aspects of the world we operate in: environment, social and economic. In addition, the company's vision is to put into action through programs focusing on environmental stewardship, activities to benefit society and build shareholder's value, making PepsiCo a truly sustainable long term company. Frito Lay is a leader in the snack food industry because the company has trustworthy brands for their consumers, has a strong and sound company for our stakeholders, is a forward-looking, and is an extraordinary place to work. The company's main competition is other salty snack food companies that have products in retail stores and restaurants. Some of the salty snack competitors include Kraft, Snyder's of Hanover, Utz's, and grocery store label brands. Figure 1.2 shows the market share of PepsiCo and its main snack competitors.

The Topeka Frito-Lay facility opened in 1956 in downtown Topeka. In 1966 the plant was destroyed by a tornado and a temporary plant was opened in the Forbes Field Warehouse district. In 1971 the Topeka plant opened its doors at its current location on Kirklawn Ave. Since that time there has been many expansions and growth at the site. Figure 1.3 shows the growth in Topeka from 2002-2010. The Topeka site ranks third behind Perry and Frankfott plant in pounds produced.

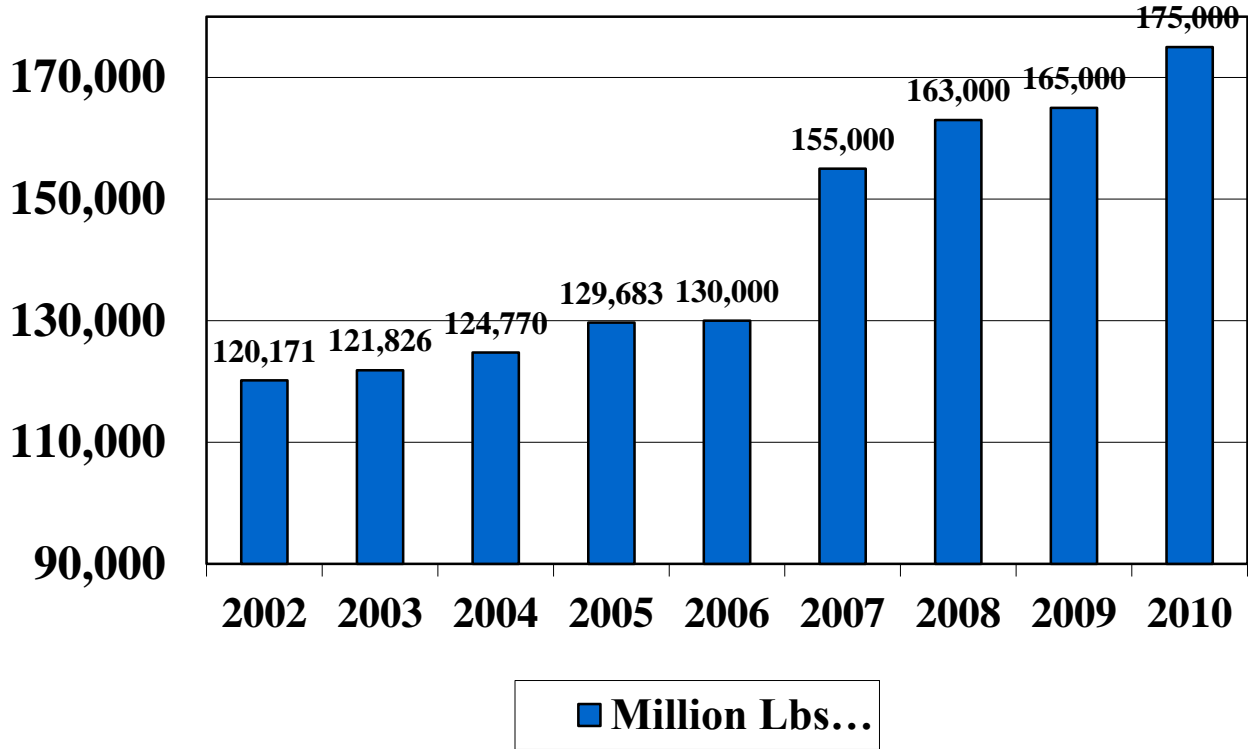
Figure 1.2: U.S. Market Share



2008 U.S. Snack Market by volume

Source: [http://www.wikinvest.com/stock/Pepsico.\(PEP\)](http://www.wikinvest.com/stock/Pepsico.(PEP))

Figure 1.3: Growth at the Topeka Facility



1.2 Project Objectives

The objective of the thesis is to analyze a potential project: installing an automated raw potato sorting system on a potato chip line. Part of the analysis will be to conduct a net present value analysis of the costs and benefits associated with the project. Currently, the line requires one full time employee to inspect the raw incoming potatoes for foreign matter and color. Recently, technology options are available that the company could add to the raw potato sorting function that could potentially reduce employee labor costs. This research project will provide information regarding the system's investment cost, maintenance requirements, labor savings, and finished product quality impact. The investment cost includes the cost of the equipment, installation, and ongoing operating costs. The final objective is to create a change plan to minimize impact to affected employees. An automated raw potato inspection system will provide the ability to remove foreign matter from product flow. Additionally, it will provide the capability to remove damaged potatoes and color defect potatoes. Removing foreign matter is important to protect our consumer from harmful objects and also to protect our processing line equipment. Removing damaged potatoes can help reduce finished product waste and also improve quality to the consumer. Installing the system enables the reduction of three full time employees which would have been utilized to remove damage potatoes and potato defects.

1.3 Potato Chip Process Overview

The quality of potatoes coming into the plant influences many downstream operations and also may affect manufacturing costs to the company. The first operation in the potato chip making process is destoning and peeling. The potatoes are first loaded

on a screw conveyor which allows stones to fall to the bottom to remove debris and pushes the potatoes up the conveyor belt to the peeler. See figure 1.4 letter E.

The next step is to go through the peeler. See Figure 1.4 letter F. Every load of potatoes can be very different to process based on a number of factors like % solids, defects, variety, potato size, and storage conditions. When the potato goes through the peeler process you can start to see the true quality of the potato. Storage potatoes must be peeled at a higher rate due to these potatoes having a thicker skin while fresh crop has a thinner skin. The customer does not like the characteristics of the finished chip when there is a large amount of peel on the potato, so it is important to ensure proper peeling. From a cost standpoint the company would start to lose money in potato inventory if too much peel was taken off of the potato.

The next step in the operation is inspecting, trimming, and autohalving. See figure 1.4 letter H. In this process large potatoes are automatically autohalved so that they do not cause product breakage and to help remove the chance for a bottleneck in the process at the slicers. In this step the defective potatoes are trimmed or removed and undersized potatoes are removed. All of the waste at this step is a loss in potato inventory for the manufacturing plant. The potato waste is then transferred to a starch recovery system. The starch recovery system allows the plant to sell the potato starch as livestock feed. In retrospect if defective or undersize potatoes are not removed they can contribute to wasted oil, waste of salt and seasoning, and an increase in customer complaints. This step in the process is where I am looking at adding raw potato sorting technology.

The Titan Odenburg sorter will allow the plant to achieve reduction in labor, sustain food quality and safety, and sustain potato yield. Letter H in Figure 1.4 shows an employee

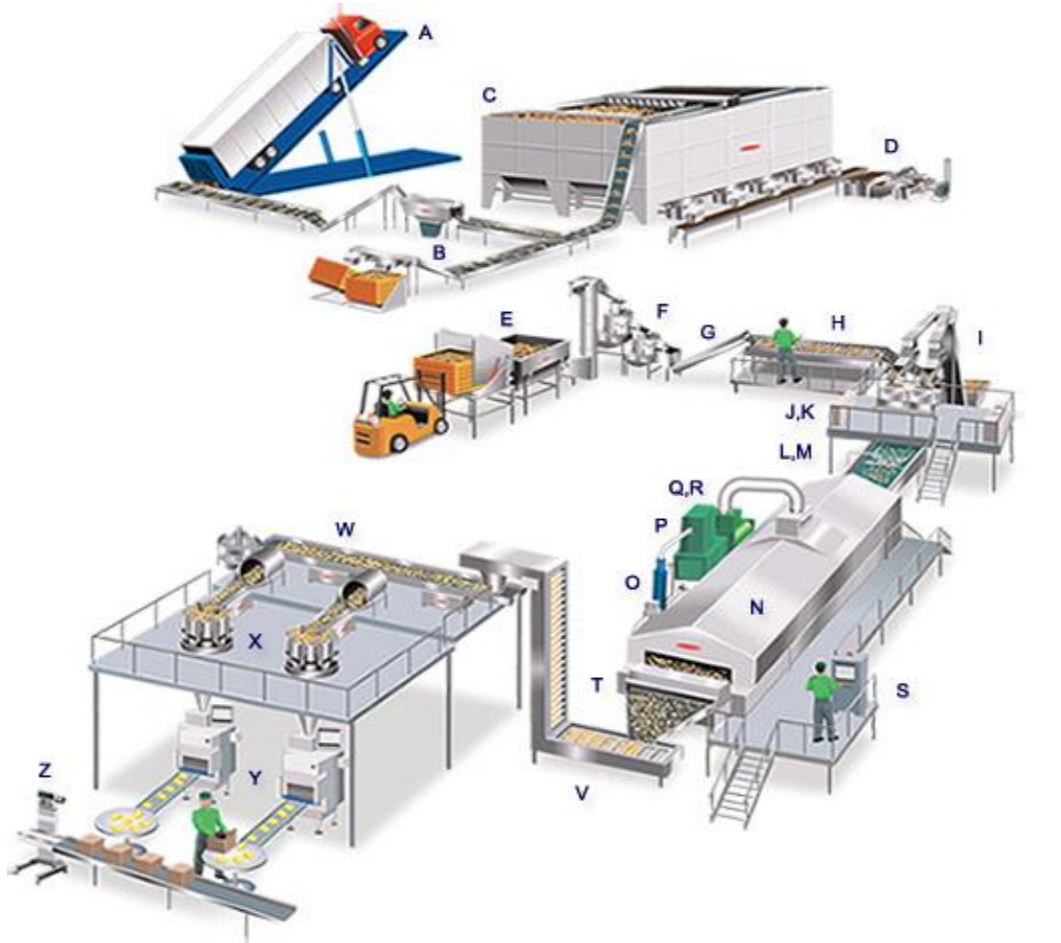
standing by the conveyor inspecting potatoes. The Titan Odenburg would allow the reduction of that position. The sorter provides a three way product sort; accept, re-peel, and waste stream. The optical potato sorter uses a combination of pulsed lighting, image processing software and advance microprocessors to separate the good potatoes from those with defects. Figure 1.5 shows the Titan sorter and a picture of the accept and reject waste stream.

The most critical step in the process is the slicing process. Potato infeed into slicers must be continuous and cut to specifications. If chips are not sliced to specifications, chips may have soft centers, chips may be scorched, and chips may absorb more oil.

The frying step is the next step in the process. In this step the hot oil provides much of the flavor that will be enhanced with salt and seasoning later in the process. Frying cooks the interior of the chip, allowing oil to replace much of the moisture removed.

The Vision System is how the company sorts finished defective potato chips. The purpose of the Vision System is to allow the best product to reach the consumer. The Vision system identifies chip appearance defects and rejects bad chips before they reach packaging. The Vision system has a camera that identifies if the chip is defective and uses a short blast of air to remove the chip from the product stream.

Figure 1.4: Potato Chip Line Process Flow



- | | |
|---------------------------------------|--|
| A Truck dumping & hydro-unloading | N Potato chip fryers |
| B Dirt removal, sizing, crate filling | O Oil filtration systems |
| C Gentle-Flo® potato storage bins | P Heat exchangers |
| D Potato pumping & debris removal | Q Pollution controls |
| E Crate dumping, metering, de-stoning | R Heat recovery systems |
| F Continuous or batch peeling | S Control systems |
| G Transfer conveyors | T Salt & seasoning applicators |
| H Inspection/trim conveyors | U Inspection & transfer conveyors |
| I Slicer feeders | V Varilift® bucket conveyors |
| J Singulating feed systems | W FastBack® conveyors for distribution, chip sizing & accumulation |
| K Slicer service platforms | X Ishida weighers |
| L Slice washers & conditioners | Y Ishida APEX® bagmakers |
| M AirSweep® water removal | Z Ishida checkweighers |

Source: Heat and Control: Potato Chips System Tour

Figure 1.5: Whole Potato Inspection System

Reject: 10% Good in Reject Stream

Accept: Directly through machine



CHAPTER 2: LITERATURE REVIEW

2.1 Potato Background

Contrary to popular belief, a potato is not a root, but an underground stem. A potato furnishes its own food supply using the starch it stores during the growing season. An average potato is approximately 85% water and 15% solid matter; the solid matter of the potato supplies the potato plant with nutrients. After the potato sprouts, the young sprout manufactures its own food supply. It is important to remember that as long as a potato is intact it is a living organism, so it needs a good supply of air to breathe. A potato breathes much like a person, by taking in oxygen from the air and giving off carbon dioxide; this process is called diffusion (Frito-Lay, Potato Receiving Manual 2008).

Potatoes break down and become diseased for many different reasons. One example includes insufficient diffusion; this is usually a slow process. At times the diffusion process can't supply enough oxygen. For example, a potato gets so hot that oxygen demand increases or when the potato is large in size and insufficient air is available, the result can be potato breakdown, black heart, or rot. Potatoes put into storage are usually in sound condition with reasonably low sugar content. An adverse environment such as extreme low or high temperatures, excessive handling or exposure to gases can cause the potato to convert into sugar. If the conversion is carried too far, the potato will attempt to reproduce itself resulting in aerial tubers and sprouting (Frito-Lay, Potato Receiving Manual 2008).

Frito-Lay Topeka transports raw potatoes from the potato farm in Nebraska to Topeka, Kansas during the storage crop season. Frito-Lay Topeka does not keep more than one day's inventory of potatoes on hand due to quality storage issues. In turn, if the

carrier's trucking fleet incurs problems in the transportation process this will cause downtime to the manufacturing operation and potential cut case opportunity to the consumer. This means that the customer would not receive all the cases of product that they ordered (Heitman 2009).

Every year Frito-Lay has contracts with each of its growers. There are specific quality guidelines that the growers must follow to be able to produce potatoes for the company. The Frito-Lay company can accept exceptions, but charges the grower back based on the percentage of non-quality "defect" potatoes in each load. Every year the grower plants the potatoes and harvests them at different times depending on the region of the country. Fresh crop potatoes are grown mainly in warm, southern regions of the country. They are harvested and usually shipped between May and October. Storage crop potatoes are grown mainly in cool, northern climates and are harvested and shipped between October and May. The grower must store these potatoes in a conducive environment to minimize defects.

Potatoes are received into the plant on a tractor trailer. One of the goals of potato receiving at the Topeka site is to provide a consistent flow of quality potatoes to downstream operations because inconsistent flow causes problems to operations such as defects, oil degradation, and downtime. Another goal of potato receiving is to remove foreign matter from the potato lot because if not removed it may harm the consumer, increase customer complaints, and can cause potential equipment damage. The last goal is to maintain potato condition while holding the potatoes. Frito-Lay receiving employees must fill out a potato inspection data form for every load of potatoes coming into the plant. A half dozen or more buckets are randomly filled with potatoes. Some loads can be

punched with holes in their cores so they can be tracked through the cooking process. The potatoes are examined for green edges and blemishes. The pile of defective potatoes is weighed; if the weight exceeds Frito-Lay preset allowance, a truckload can be rejected. (Frito-Lay, Potato Receiving Manual 2008). Figure 2.1 shows the potato defects and foreign matter that the Titan Odenburg sorter will remove from the product line.

Figure 2.1: Whole Potato Inspection Detection



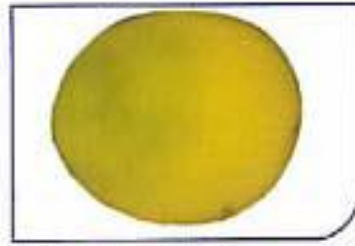
Major Defects



Bruised potato



Green potato



Slight green potato



Potato rot



Potato scab



Black potato



Foreign Material



Peel remaining

2.2 Acoustic Technology

Elbatawi discusses utilizing acoustic technology to detect hollow heart in raw potatoes. Hollow heart is a discolored hole in the middle of a potato. Elbatawi states that the system utilizes a microphone, digital signal processing hardware, and material handling equipment. The system is designed to detect the sound signal as the potato drops onto a steel impact surface. The study found that the solid potatoes emit a higher magnitude sound than potatoes that have hollow heart. The signal data upon impact then diverts the potatoes into two different streams based on hollow heart or those without hollow heart. The system study's had a 98% classification accuracy rate, thus the study concluded that the internal quality of potatoes can be adequately detected by the acoustic impact method (Elbatawi 2008).

2.3 Color Vision Systems

Noordam discusses potato grading and inspection based on a color vision system. The HIQUIP vision system sorts potatoes based on size, shape, and external defects, such as greening, mechanical damage, and most external diseases. An online scan camera inspects the potatoes in flight as they pass under the camera. The system utilizes 11 SHARC digital signal processors to perform the image processing and classification. Linear discriminant analysis and Mahalanobis distance are used to classify the pixels. The complete system utilizes a conveyor unit, a vision unit, and rejection unit. The study indicates that the system performs well on rhizoctonia and crack detection. Rhizoctonia is a fungus that can attack a potato plant in cool or wet soils. Noordam suggests that further research will need to be completed to evaluate the performance for other defects. The

reported classification results in this study indicate that the HIQUIP system can meet the demands of the potato industry (Noordam 1997).

2.4 Ultraviolet Vision System

Al-Mallahi analyzed the sorting of potatoes using an ultraviolet imaging-based machine vision system. This system removes clods and unwanted potatoes including small potatoes. The detection unit utilizes ultraviolet reflectance of the potatoes compared to their background including pieces of clods. An algorithm was developed to detect threshold value between the potatoes by smoothing the original intensity histogram until the ultimate peak was found. This procedure could overcome the difference in lighting conditions and the water content of the potatoes. Sorting the potatoes by size was accomplished by estimating their size through a calculation of their maximum length and width using the ultraviolet camera. Testing was completed by taking a video of potatoes and clods using the ultraviolet camera. One video frame from the video taken each second and the potatoes within the frame used the algorithm developed to detect tubers and clods. The results of the research showed that 98.79% of tubers and 98.28% of the clods were accurately detected. The research also indicated the system would be able to keep up with the speed of the current conveyor in use. (Al-Mallahi 2010, Al-Mallahi 2010).

2.5 Business Environment

A research survey was conducted by the Area Development Company to determine a company's number one factor for making site selection decisions. The number one factor identified was the cost of labor. The study states, in order to be competitive, companies must be able to deliver the quality and productivity at a given level of process technology. When a technology is developed, a highly trained workforce is needed and the product

requires high margins. The study states “As the product matures and profit margins are reduced, the company relies on more automated production techniques, and skill requirements from highly trained technicians to moderately trained labor. In contrast, an industry such as food processing may start with simple processes and lower skilled labor and seek to achieve a higher productivity over time through process automation and upgrade of labor skills.” To stay competitive, there must be constant improvement and increased productivity. Labor continues to be a high proportion of a company’s operating budget in today’s world. Productivity and technology will ultimately help a company succeed (Rhodes 2007).

Frost and Sullivan (2008) researched the machine vision industry in developing countries. They found that the industry is beginning to see growth in these countries, but due to the low labor costs not at the rate of developed countries. Large scale manufacturing operations that are able to afford this technology usually see a good return on investment so they can afford these systems and reduce labor costs. The research concludes by stating “there is a necessity to minimize human error, and thereby, decrease the cost of quality incurred” (Sullivan 2008).

The literature reviewed provides a brief overview of some of the current technology that has been developed and provided reasons why a company would want to consider investing in this technology. There has been some new technology and development in the economy since some of these works have been written. As Frito-Lay consumers are looking to save money it is important to consider what consumer’s are willing to pay for our product. The Frito-Lay Company needs to continue to make quality product when their products are at a premium price. The quality of Frito-Lay’s products can be a major

competitive advantage. When Frito-Lay achieves a competitive advantage they can attract more customers, gain market share, and increase profits. Then Frito-Lay can reinvest its profits to improve quality, expand their offerings, and improve their processes, which further improves its competitive advantage. Frito-Lay's continued exploration of technology within the manufacturing will help the company stay ahead of the competition and ultimately keep lower prices for the consumer.

2.6 Company Change Plan Strategy

One of the most difficult processes is to roll-out new changes to front line employees. In today's rapidly changing business environment, businesses that cannot change to meet new challenges or seize new opportunities are destined to be left behind. The necessary changes can be rapid and overwhelming if we do not have strategies to implement them. Change leadership is a key skill that can be applied to any level (Frito-Lay, Peer Coaching 2007). No matter what the cause, executing a successful change is not easy. According to the Harvard Business Review, 70% of all change efforts fail for the following reasons:

- Complacency
- Lack of Guidance
- Lack of Clear Vision
- Poorly communicated vision
- Needless obstacles
- Failure to gain momentum early on
- Declaring victory too soon
- Failure of change to take hold in the culture

(Nohria 2000)

The statement by Charles Koch, “Even successful companies struggle to keep up because, given human nature, we tend to become complacent, self protective and less innovative as we become successful,” really relates to all businesses (Koch 2007, p. 29). Change Leadership Model is a business model that Frito-Lay needs to consider as the company makes changes to the processing line. The Pepsico Change Leadership Model will guide the managers through the change process as outlined:

Stage 1: Increase Urgency: to overcome complacency in those who must execute and live with unplanned change, you must convey a sense of urgency.

Stage 2: Build a Guiding Team: Even great ideas or change initiatives need the right stewards to execute them well.

Stage 3: Get the Vision Right: Make sure to create a vision that people can buy in to

Stage 4: Communicate for Buy-in: Setting the vision is the first stage in overcoming resistance in change. You must continue to carefully communicate to get buy-in for the change.

Stage 5: Empower Action: Empowerment puts people into a position to succeed by making sure they have what they need and removing barriers.

Stage 6: Create Short-Term Wins: Short term wins should be built into the change plan to enhance momentum and success.

Stage 7: Don't Let Up: Be careful with short-term victories. A false sense of completion can cause the change effort to stall.

Stage 8: Make Change Stick: Even when the objectives of the change plan are accomplished, there is more to do. Follow-up to be sure the change remains in place until

it becomes part of the culture (Frito-Lay, 2007). Change needs to be part of any successful business culture. Individually, I must embrace change to lead it. Leading change is one of the biggest challenges for a manager.

Installing a raw potato sorting system this will eliminate three employees on the potato chip line. A change leadership strategy has been developed to roll out to the employees involved in this change. The plan includes the company change plan's objectives above to make sure that the transition will go smoothly.

The plant union steward will also be involved in the change. The last five years the Topeka site has transitioned to transformational packaging in some departments which has reduced the need for packers to be crewed for these production lines. The facility has not had to lay off employees due to retirements and attrition. The transition should be smooth with the proper facilitation of the change plan strategy.

CHAPTER 3: THEORETICAL MODEL

3.1 Background Information

As the business environment changes businesses must keep up with rapidly changing technology to be able to compete. A company that is able to compete will be able to survive in the market and sustain profitability. Capital expenditure projects need to be evaluated and adopted if they keep a company competitive or make a company more cost efficient. Having zero investment in new technology may lead to inefficiencies and thus competitors gaining control of the market. Consequently, organizations should venture into projects that will give a sustainable competitive advantage to the organization. Capital expenditures carry huge risks including cash inflows and outflows. They can also influence the quality and potential profit of a product. Therefore, it is important that the manager evaluates the project before carrying out the project. Managers can apply many tools to evaluate investment decisions to ensure to maximize shareholder's wealth as discussed below.

3.2 Net Present Value

Net present value (NPV) is a tool that is used to make financial decisions to help determine whether a project will increase or decrease the shareholder's wealth and by how much. The goal of every company is to increase shareholder's wealth and NPV is a useful way to help a company decide the feasibility of a project. This can help a company that may be considering multiple projects make a decision especially when capital is limited. The discounted value of cash inflows minus the discounted cash outflows over the projects projected lifespan is its net present value. Companies should invest in projects with a

positive NPV and reject projects with a negative NPV to ensure shareholder profit (Brealey, Myers, Allen 2008).

Companies must make a decision whether to return cash on hand to its shareholders or to reinvest back into the business. A key feature of NPV analysis is that it is able to recognize that a dollar held today has a greater value than a dollar tomorrow because the dollar today can work towards earning interest immediately. Opportunity cost is the income forgone due to investing the dollar. Every dollar spend has an opportunity costs, and NPV captures this cost in the discount rate. Forecasted cash flows can be utilized when considering a project to make a comparison of the two alternatives in the value of today's dollar (Brealey, Myers, Allen 2008).

3.2 Alternatives to Net Present Value

Some alternatives to net present value are book rate of return, payback period, and internal rate of return (IRR). The book rate of return uses the book income divided by book assets to calculate the accounting rate of return. A shortfall of this tool is that it can be deceiving due to accounting practices that firms use to classify either capital expenses or an operating expense. Capital expenses are depreciated over time and this can distort the book rate of return. Book rate of return does not consider the opportunity cost of money used for the potential investment and NPV does.

The payback period tool uses the numbers of years it takes to recoup the initial investment by adding the projected discounted cash flow from each year over a period of time. The payback period tool does not take into account what happens in the years following the initial payback period. In contrast, net present value analysis takes into account the entire life of the project to determine feasibility.

Another alternative to NPV is the internal rate of return (IRR). IRR is defined as the rate at which a project would have a zero NPV. IRR is like NPV in that it is a technique based on discounted cash flows (Brealey, Myers, Allen 2008). IRR can give you a good assessment of a potential project, but NPV will give much more consistent results. When a firm is deciding where to allocate project money for multiple projects and both projects have positive IRR, NPV is a much more accurate tool to use due to project size issues. In addition, calculating the profitability index of each project can allow the firm to select the best project when investment funds are limited. The profitability index can be calculated by dividing the NPV by the initial investment cost. Profitability index can lead to incorrect decision when comparing mutually exclusive investments (Brealey, Myers, Allen 2008).

CHAPTER 4: METHODS AND RESULTS

The objective is to evaluate the investment using net present value (NPV) and internal rate of return (IRR) methods. The analysis uses discounted cash flows to determine if installing a whole potato inspection unit outweighs the capital and operating costs. The cash flows are estimated over a 10 year period and discounted after taxes to present dollars.

4.1 NPV Formula

The following formula is used to calculate the NPV

$$\text{NPV} = -C_0 + C_N (1 + r)^{-N} + (1 - T) \left[\sum_{k=1}^N L_k (1 + r)^{-k} \right] + T \left[\sum_{k=1}^N D_k (1 + r)^{-k} \right] - (1 - T) \left[\sum_{k=1}^N M_k (1 + r)^{-k} \right]$$

NPV= Net Present value of whole potato system investment

C_0 = The original investment required for equipment and installation of the whole potato inspection system.

C_N = The salvage value of the system at the end of the N^{th} year. This term is discounted to present value by $(1+r)^{-N}$.

r = An after-tax discount rate.

T = The combined federal and state marginal income tax rate.

L_k = Labor savings in k^{th} year. This is the savings in labor from using the technology. This term is discounted and multiplied by $(1 - T)$ to arrive at the actual after-tax savings..

M_k = Maintenance cost of the k^{th} year.

D_k = Depreciation in k^{th} year. This term is discounted and then multiplied by the tax rate to arrive at the effective tax deduction for depreciation.

N = Lifespan of the project

4.2 Labor Savings Assumptions

Table 4.1 shows the labor savings from installing the whole potato inspection unit. 2009 Plant Production Tracking Efficiency Hours are used for the line. Plant Production Tracking is a software program that figures how much labor should be used based on the runtime and pounds produced on the line. 2010 plant standard labor rates will be used. Standard labor rate for a potato chip line operator is \$19.27 an hour. \$5800 a year is added for allocation of an employee to break the employee that would have been crewed on the pare and trim platform. \$21,000 a year is allocated for the sanitation labor to clean the line. The projection is that we utilize 75% of unplanned downtime for hours and assume that 25% of the time employee would have been productively deployed elsewhere in the plant. 4.5% wage and benefit inflation will be used which is a standard used for Frito-Lay automation productivity projects. Table 4.2 shows the labor savings with the wage and benefit inflation for 10 years. All of year one savings assumed to be in 2011 due to schedule of installation at year end of 2010. Assume all volume remains constant across the life of the equipment.

Table 4.1: Labor Savings

Annual Savings	\$ K
1 Full Time Employee/Shift	41.1
Overtime (Total overtime/Total FTE)	4.2
Benefits	18.6
Workers Compensation	0.4
Total Savings per FTE	64.3
Plus 0.1 Breaker per FTE	5.8
Subtotal	70.1
<hr/>	
FTE Savings @ 3 shifts	210.3
Less (Sanitation) @ 3% of Capital	-21
Net Labor Savings	189.3

Table 4.2: Labor and Benefit Savings

Year	Savings
1	\$189,300.00
2	\$197,818.50
3	\$206,720.33
4	\$216,022.75
5	\$225,743.77
6	\$235,902.24
7	\$246,517.84
8	\$257,611.14
9	\$269,203.65
10	\$281,317.81

4.3 System Maintenance and Operating Cost

The whole potato inspection system requires monthly maintenance cost. A yearly average of 4 hours per month has been allocated for the maintenance. Table 4.3 below shows the total labor costs per hour and benefit cost per hour. Replacement parts and maintaining the whole potato inspection system is an estimate from the Odenburg

manufacturer. The benefits cost is calculated using 43% of the hourly wage rate. Energy costs were not included in NPV equation because the energy costs are not significantly different from the old conveyor that is in place currently.

Table 4.3: Maintenance Costs

Year	Hours Used	Hourly Rate	Benefit Cost per Hour	Yearly Cost
1	48	\$23.47	\$10.09	\$1,610.98
2	48	\$24.53	\$10.55	\$1,683.47
3	48	\$25.63	\$11.02	\$1,759.23
4	48	\$26.78	\$11.52	\$1,838.40
5	48	\$27.99	\$12.04	\$1,921.12
6	48	\$29.25	\$12.58	\$2,007.58
7	48	\$30.56	\$13.14	\$2,097.92
8	48	\$31.94	\$13.73	\$2,192.32
9	48	\$33.38	\$14.35	\$2,290.98
10	48	\$34.88	\$15.00	\$2,394.07
Total	480			\$19,796.07

4.4 Depreciation Schedule

The depreciation amount assumes a 0% salvage value. This term is discounted and then multiplied by the tax rate to arrive at the effective tax deduction for depreciation.

Table 4.4 shows the depreciation of the system.

4.5 Marginal Tax Rate

A marginal tax rate of 37.18% percent is used in this evaluation taking into account federal and Kansas state taxes.

4.6 Project Financing and Discount Rate

Funding for this project will not require borrowed funds. Each year capital projects are paid out of a capital expenditure account allocated for facility improvements. A

discount rate of 9% was provided by the capital projects team. Table 4.5 shows the initial investment costs provided by the manufacture and also the Fluor engineering team.

4.7 NPV and Cash Flow Calculations

The assessment uses an after tax discounted cash flow analysis. Table 4.6 shows the cash flows and the net present value of the Investment. The NPV for this investment is \$239,317.89. A positive NPV means that the project is expected to add value to the company and therefore will increase the wealth of the shareholders by that amount. Based on the NPV this is a good investment.

Table 4.4: Depreciation

Initial Investment	815000								
Tax Depreciation	0	1	2	3	4	5	6	7	8
14.29%		\$116,463.50							
24.49%			\$199,593.50						
17.49%				\$142,543.50					
12.49%					\$101,793.50				
8.93%						\$72,779.50			
8.92%							\$72,698.00		
8.93%								\$72,779.50	
4.46%									\$36,349.00
Total		\$116,463.50	\$199,593.50	\$142,543.50	\$101,793.50	\$72,779.50	\$72,698.00	\$72,779.50	\$36,349.00

Table 4.5: Capital and Start-up Costs

Capital Cost	\$K
Whole Potato Inspection Unit	250
Infeed/Discharge Conveyor	150
Engineering	50
Controls	50
Installation and Start-up	200
Total	700
Expenses	\$K
Training	10
Spare Parts	20
Write Off	50
Commissioning	20
Demolition	15
Total	115

Table 4.6: Net Cash Flows and Net Present Value

Year	Initial Investment	Cash Outflow	Cash Inflow	Taxes	Operating Cash Flow After Tax	Net CF	DCF	Cumm. DCF
0	\$815,000.00	\$115,000.00		-\$42,757.00	-\$72,243.00	-\$887,243.00	-\$887,243.00	-\$815,000.00
1		\$1,610.98	\$189,300.00	\$26,481.65	\$161,207.37	\$161,207.37	\$147,896.67	-\$667,103.33
2		\$1,683.47	\$197,818.50	-\$1,285.86	\$197,420.89	\$197,420.89	\$166,165.21	-\$500,938.12
3		\$1,759.23	\$206,720.33	\$23,206.86	\$181,754.24	\$181,754.24	\$140,347.62	-\$360,590.50
4		\$1,838.40	\$216,022.75	\$41,786.92	\$172,397.43	\$172,397.43	\$122,130.69	-\$238,459.81
5		\$1,921.12	\$225,743.77	\$56,157.84	\$167,664.81	\$167,664.81	\$108,970.62	-\$129,489.19
6		\$2,007.58	\$235,902.24	\$59,932.92	\$173,961.74	\$173,961.74	\$103,727.70	-\$25,761.49
7		\$2,097.92	\$246,517.84	\$63,815.91	\$180,604.01	\$180,604.01	\$98,796.58	\$73,035.09
8		\$2,192.32	\$257,611.14	\$81,450.16	\$173,968.66	\$173,968.66	\$87,309.01	\$160,344.10
9		\$2,290.98	\$269,203.65	\$99,238.13	\$167,674.54	\$167,674.54	\$77,202.01	\$237,546.11
10		\$2,394.07	\$281,317.81	\$103,703.85	\$175,219.89	\$175,219.89	\$74,014.78	\$311,560.89
		NPV	\$239,317.89					

4.8 IRR Calculations

The internal rate of return in this investment is the discount rate at which the NPV is equal to zero. The internal rate of return is 14.8%. Table 4.7 outlines the internal rate of return. IRR also shows that this project is a promising investment.

4.9 Quality Impact

The quality of Frito-Lay's products can be a major competitive advantage. When Frito-Lay achieves a competitive advantage it can attract more customers, gain market share, and increase profits. Then Frito-Lay can reinvest its profits to improve quality, expand their offerings, and improve their processes, which further improves its competitive advantage (Stalk 2009).

“Providing a premium product at a premium price” says Chip Dudine, Frito-Lay Quality Enabler for the Midwest South Region. This statement has become part of Topeka's site vision through the recent years. Each year as raw commodity prices have increased Frito-Lay has had to pass this cost on to the consumer by either increasing the price for each bag or taking weight out of the bag. Brand loyalty has always been a very important goal of the Frito-Lay Business. “Studies show that as brand loyalty increases, consumers are less sensitive to price change” (Giddens 2002, p. 1). Frito-Lay consumers see a unique value in our brands over other competitors and are willing to pay a higher price for our brands.

A facility in Wooster, Ohio installed a similar Whole Potato Inspection System, Period 3 of 2010. Figure 4.1 shows a chart of customer complaints for potential foreign matter that the system would remove from the product flow. Overall from 2009 to 2010 foreign matter customer complaints were reduced 12.75%. Table 4.8 shows the combined

complaint totals and units produced total for each year. Production units are the number of total bags produced on the production line. Frequency is figured by dividing total complaints by number of units. Overall the system seems to be delivering improved quality results compared to having a person crewed to remove foreign material.

Table 4.7: Internal Rate of Return

Year	Initial Investment	Cash Outflow	Cash Inflow	Taxes	Operating Cash Flow After Tax	Net CF	DCF	Cumm. DCF
0	\$815,000.00	\$115,000.00		-\$42,757.00	-\$72,243.00	-\$887,243.00	-\$887,243.00	-\$815,000.00
1		\$1,610.98	\$189,300.00	\$26,481.65	\$161,207.37	\$161,207.37	\$147,896.67	-\$667,103.33
2		\$1,683.47	\$197,818.50	-\$1,285.86	\$197,420.89	\$197,420.89	\$166,165.21	-\$500,938.12
3		\$1,759.23	\$206,720.33	\$23,206.86	\$181,754.24	\$181,754.24	\$140,347.62	-\$360,590.50
4		\$1,838.40	\$216,022.75	\$41,786.92	\$172,397.43	\$172,397.43	\$122,130.69	-\$238,459.81
5		\$1,921.12	\$225,743.77	\$56,157.84	\$167,664.81	\$167,664.81	\$108,970.62	-\$129,489.19
6		\$2,007.58	\$235,902.24	\$59,932.92	\$173,961.74	\$173,961.74	\$103,727.70	-\$25,761.49
7		\$2,097.92	\$246,517.84	\$63,815.91	\$180,604.01	\$180,604.01	\$98,796.58	\$73,035.09
8		\$2,192.32	\$257,611.14	\$81,450.16	\$173,968.66	\$173,968.66	\$87,309.01	\$160,344.10
9		\$2,290.98	\$269,203.65	\$99,238.13	\$167,674.54	\$167,674.54	\$77,202.01	\$237,546.11
10		\$2,394.07	\$281,317.81	\$103,703.85	\$175,219.89	\$175,219.89	\$74,014.78	\$311,560.89
		IRR	14.8%					

Figure 4.1: Wooster Customer Complaint Data

Page 1 of 1

Wooster Plant: Frequency of Whole Potato Inspection Foreign Matter

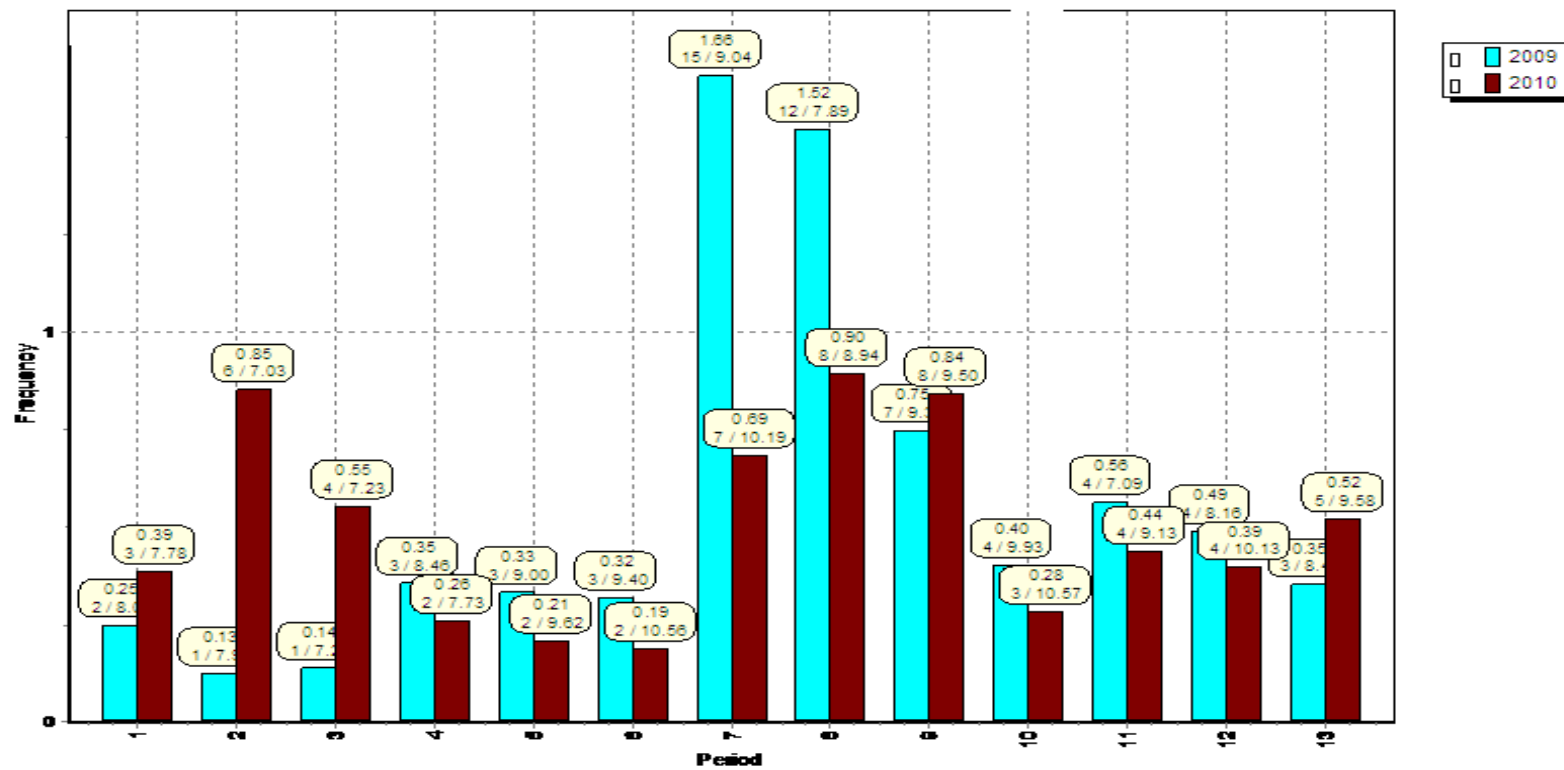


Table 4.8: Customer Complaint Reduction Calculations

COMPLAINT YEAR	COMPLAINT PERIOD	FREQUENCY	COMPLAINTS	PRODUCTION UNITS
2009	1	0.25	2	8.014
2009	2	0.125	1	7.979
2009	3	0.137	1	7.276
2009	4	0.355	3	8.46
2009	5	0.334	3	8.995
2009	6	0.319	3	9.403
2009	7	1.66	15	9.037
2009	8	1.521	12	7.89
2009	9	0.75	7	9.331
2009	10	0.403	4	9.935
2009	11	0.564	4	7.09
2009	12	0.49	4	8.156
2009	13	0.354	3	8.476
Total			62	110.042
Year Frequency				0.56
2010	1	0.386	3	7.779
2010	2	0.853	6	7.03
2010	3	0.554	4	7.226
2010	4	0.259	2	7.733
2010	5	0.208	2	9.621
2010	6	0.189	2	10.555
2010	7	0.687	7	10.188
2010	8	0.895	8	8.938
2010	9	0.842	8	9.504
2010	10	0.284	3	10.572
2010	11	0.438	4	9.132
2010	12	0.395	4	10.129
2010	13	0.522	5	9.582
Total			58	117.989
Year Frequency				0.49
% Improvement				12.75%

CHAPTER 5: SUMMARY AND CONCLUSIONS

5.1 Research Summary and Recommendation

The thesis analyzed adding a raw potato inspection sorting system to a potato chip line. Net cash flows were determined and used to calculate NPV and IRR. The Odenburg whole raw potato inspection system would provide the ability to remove foreign matter and damaged potatoes from product flow.

Installing the system will replace one full time employee on all three shifts of production. Capital investment is \$700,000, which includes machines, conveyors, engineering, controls, and installation. The project requires \$115,000 in additional expenses. Additional expenses include training, spare parts, commissioning, and demolition. The analysis found that Frito-Lay would save \$189,300 annually at the current volume of the potato chip line. Based on the NPV and IRR my recommendation would be to go forward with the project. While the decision to proceed with the investment could be potentially influenced by internal investment funds for the year, but management should note the high NPV and IRR for this project.

5.2 Limitations and Future Study

Future research opportunities could focus on technology with energy savings and the increased quality impacts. Another opportunity would be to look into the ability for the system to sort potatoes based on peel removal. Peel removal is an important aspect of an emerging health concern known as Acrylamides. It also has an important flavor quality impact. As the business environment changes Frito-Lay must keep up with rapidly changing technology to be able to compete. Ultimately, companies who are able to compete will be able to survive in the market and sustain profitability.

REFERENCES

- Al-Mallahi, T. Kataoka, H. Okamoto. "Detection of potato tubers using an ultraviolet imaging based machine vision system." *Biosystems Engineering*, 2010: 257-265.
- Brealey, Myers, Allen. *Principles of Corporate Finance*. McGraw Hill, 2008.
- Brown, Bill. "The History of Economics." *Economics Journal of History*, 2009: 4-12.
- Doe, John B. "Financial Impact of US Economic Crisis." *Agribusiness Worldwide* June/July, no. 1 (2009): 4-12.
- Dudine, Chip, interview by Audra Geiger. *Quality* (March 4, 2009).
- Elbatawi, I.E. "An acoustic impact method to detect hollow heart of potato tubers." *Biosystems Engineering*, 2008: 206-213.
- Frito-Lay. "Peer Coaching." Frito-Lay, 2007.
- "Potato Receiving Manual." 2008.
- Giddens, Nancy. *Iowa State University Extension*. August 2002.
<http://www.extension.iastate.edu/agdm/wholefarm/html/c5-54.html> (accessed March 10, 2009).
- Heat and Control*. <http://www.heatandcontrol.com/potato%chip%20systems%20tour2.asp> (accessed March 10, 2009).
- Heitman, Ken, interview by Audra Geiger. *Potato Chip Receiving* (February 23, 2009).
- John K. Smith, Bill C. Jones. "The Impact of Subsidy Funding." *Agricultural Economics* 2, no. 4 (May 2007): 65-68.
- Koch, Charles. *The Science of Success*. John Wiley and Sons Inc., 2007.
- Nohria, M. Beer and C. ""Cracking the Code of CHange." *Harvard Business Review*, 2000.
- Noordam, J.C., G.W Otten, A.J.M Timmermans, B.H. van Zwol. *High speed potato grading and quality inspection based on a color vision system*. Wageningen, the Netherlands: Department Production and Control Sysytems, ATO, 1997.

Rhodes, John M. "Labor Cost Ranked #1." *Area of Development Online*. Feb/March 2007. <http://www.areadevelopment.com/corpSurveyResults/feb07/laborcosts07.shtml> (accessed November 14, 2010).

Stalk, George. "Google Books." *Hardball*. 2009. http://books.google.com/books?id=nAQ5B15U3WEC&pg=PA28&lpg=PA28&dq=frito-lay+quality&source=bl&ots=pFMO49V5nj&sig=ITKRRqV2_wCVCW5EApIsobL1wLY&hl=en&ei=m8euSYK3OoSGngf-7bHDBg&sa=X&oi=book_result&resnum=3&ct=result#PPA1,M1 (accessed March 10, 2009).

Sullivan, Frost and. "Emergence of machine vision systems in developing economies." *Advanced Manufacturing Technology*, 2008: 8.

USDA. 2010. <http://www.ers.usda.gov/StateFacts/> (accessed April 10, 2011).

Wyant, Robert. "Personal Communication." Minneapolis, February 12, 2011.