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March 2011

# Production and Engineering Aspects of Manufacturing Ice Cream

Dillon T. O'Toole

*Worcester Polytechnic Institute*

Marc Andrew MacDougall

*Worcester Polytechnic Institute*

Mark T. Caulfield

*Worcester Polytechnic Institute*

Michael Edward Scanlon

*Worcester Polytechnic Institute*

Tyler M. Lapierre

*Worcester Polytechnic Institute*

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Project Number:

# **Production and Engineering Aspects of Manufacturing Ice Cream**

An Interactive Qualifying Project Report

Submitted to the Faculty of

WORCESTER POLYTECHNIC INSTITUTE

In partial fulfillment of the requirement for the

Degree of Bachelor of Science

By

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**Mark Caulfield**

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**Tyler Lapierre**

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**Marc MacDougall**

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**Dillon O'Toole**

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**Michael Scanlon**

**Date: March 3, 2010**

**Advisor:**

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**Professor Satya Shivkumar**

## **Abstract**

The purpose of this study is to develop an informative website that details the production of ice cream. The types of ingredients and the steps associated with the making of homemade and commercial ice cream are outlined. The effects of the processing steps used to make the ice cream on the mechanical properties have been studied. It is anticipated that the web site will improve the public understanding of the engineering principles necessary to make this unique treat.

# Acknowledgements

## **Nona's Homemade**

The Melt Review group would like to acknowledge Nona's Homemade, in Hingham, MA, for their patience and willingness to help our cause. Without the video and the hands on guidance from Krissy and Tom our group would not have had the practical experience needed to complete this project. We would like to send our sincerest thanks to the Donahue's at Nona's Homemade where we have been constantly reminded to "Eat Your Dessert First" – Kristin Donahue.

## **Biology and Biotechnology Department**

The Melt Review group would like to thank Abbie White and the rest of the WPI Biology and Biotechnology Department. Everyone was very helpful and courteous as we continued to need liquid nitrogen to complete our project. Our group really appreciates all patience that you had with us.

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# Chapter 1: Introduction

Since 2007, when the economy went into a recession, most industries have been in a decline. However, that is not the case with the ice cream industry. It has been nearly “recession proof” and has even grown by about 2 percent each year. In 2009 alone, there was 1.52 billion gallons of ice cream produced in the United States, which represented about 26.2 percent of the entire frozen dairy product market. In the United States, more than 90 percent of households consumed ice cream in 2009 (WC 14). So this begs the question: What exactly is ice cream? And what makes it so delicious?

There are several different types of frozen treats. There is dairy ice cream, non-dairy ice cream, gelato, frozen yogurt, milk ice, sorbet, sherbet, water ice, and fruit ice. This study focuses on dairy ice cream. According to “The Science of Ice Cream”, by C. Clarke, dairy ice cream is a frozen, aerated mixture of dairy ingredients, sugars, and flavors (WC 2 p.1). This is the product that most people are referring to when they speak about ice cream. There are several different methods and ingredients used to produce ice cream. These different methods and ingredients are what distinguish ice creams from each other and make some very unique.

This study aims to create an informative website detailing the production of ice cream. The production methods that are studied include continuous freezing (commercial), batch freezing (homemade), bag method (individual), pot freezing method (individual), and liquid nitrogen method (individual). The website includes instructional videos detailing the process to produce ice cream through the individual methods. Nona’s Homemade, based out of Hingham MA, helped create a video that outlines the process to make their delicious ice cream. Another goal for the website is to explain the structure of the ice cream in a unique way to help people understand each ingredient’s purpose in the structure. Additionally, an experiment was conducted on several different processes of making ice cream. The purpose of the experiment was to show scientific and structural differences between the production methods.

## Chapter 2: Objectives

This project aims to accomplish the following objectives:

1. Create a unique website detailing the industrial processes of producing ice cream
  - a. Do It Yourself Videos
  - b. Commercial versus Homemade Ice Cream Production
  - c. Interactive Timeline of the history of ice cream
  - d. Interactive map of local homemade ice cream parlors
  - e. Provide FDA guidelines for different types of ice cream
  - f. Provide nutritional facts for ice cream
  - g. Create an analogy between the structure of ice cream and a building structure
2. Visit homemade ice cream parlors in Massachusetts
  - a. Create and establish a working relationship with homemade parlor owners
  - b. Use questionnaire to establish a basis for popular and unique ice creams
3. Create a business plan that will provide us with a great foundation for the ongoing maintenance of the website.

## Chapter 3: Background

### 3.1 History of Ice Cream

Although the actual history of ice cream is not well documented, the following account appears to be well known and has been passed down through generations as a wide spread belief.

The history of ice cream begins in China. About 3,000 years ago the Chinese the invented the first type of ice cream which is now referred to as snow ice cream. However, what they really invented was closer to water ice, frozen sugar syrup with flavor and color, or fruit ice, similar to water ice, but made with real fruit juice (WC 2 p. 1). Ice cream did not evolve into what it is today until it was brought to Europe by Marco Polo in 1295. The recipe for ice cream was given as a gift to royalty throughout Europe. The recipe changed as it went from country to country. Therefore, it is impossible to determine which country is responsible for the modern recipe for ice cream. Since the discovery of the modern recipe for ice cream, there have been advances in the production of ice cream and the creation of hundreds, if not thousands, of different flavors.

### 3.2 Ice Cream on the Internet

Part of the study was to create a website that was unique and helpful. Therefore, research was performed on the existing websites regarding ice cream. Two things were evident while analyzing these other sites; first, there were many websites dedicated to ice cream. Second, all the information on the internet appeared to be disorganized or scattered. Most of the websites focus on one aspect of ice cream, and did not provide all the information sought by viewers. This wastes time and causes frustration for viewers. Along with information being scattered over the internet, videos on how to make ice cream were not on any of these informative websites. Most of the videos were only on YouTube. This shows the necessity for a website that compiles all the data in one place.



Home » [Ice Cream Recipes](#) » [Commercial Ice Cream Recipes](#) » [Ice Cream vs. Gelato](#) » [Ice Cream FAQ](#) » [Contact](#)

**BASE FOR GELATO**

White Base  
Chocolate Base  
Hazelnut Base

**GELATO**

Basil  
Chocolate Pear  
Caramel  
Cream of Lemon  
Cream of Orange  
Cream of Strawberry  
Fruit de Lait  
Mint  
Peach  
Rose Petal  
Sage  
Stracciatella  
"Newest" "Newest"

**WHITE BASE:** [Basic White Base](#) - [White Base using Danloy](#) - [White Base using Ice Cream 100](#)

**Basic White base recipes**

Milkcream	Hot process use with milk	Base 100	Cold Process use with milk
100 gr.	Milkcream	100 gr.	Base 100
250 gr.	Sugar	250 gr.	Sugar
1 liter	Milk	1 liter	Milk

Base Univerzale	Hot or Cold Process use with milk	Danloy	Hot or cold Process use with milk or water
50 gr.	Base Univerzale	250 gr.	Danloy
250 gr.	Sugar	250 gr.	Sugar
1 liter	Milk	1 liter	Milk

Ice Cream 100	Hot or Cold Process use with milk
100 gr.	Ice Cream 100

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- Business
- Government & Policy
- Science/Technology
- Career & Employment
- ACS News
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**Science & Technology**

November 8, 2004  
Volume 82, Number 45  
p. 51

**WHAT'S THAT STUFF?**


**ICE CREAM**

The finer points of physical chemistry and flavor release make this favorite treat so sweet

[BETHANY HALFOPO](#)

I scream; you scream; we all scream for ice cream. The reason is simple: Ice cream is an excellent example of the whole tasting better than the sum of its parts.

By weight, ice cream is composed primarily of water (from milk and cream) with sweeteners such as corn syrup or sugar, flavorings, ...



Home » [Science](#) » [The Structure of Ice Cream - Emulsions and Foams](#)

**The Structure of Ice Cream - Emulsions and Foams**

Article Summary: [View](#) | [Original Article PDF Download](#) | [PDF](#) | [Rating](#) | [Views](#): 1003 | [Words](#): 900

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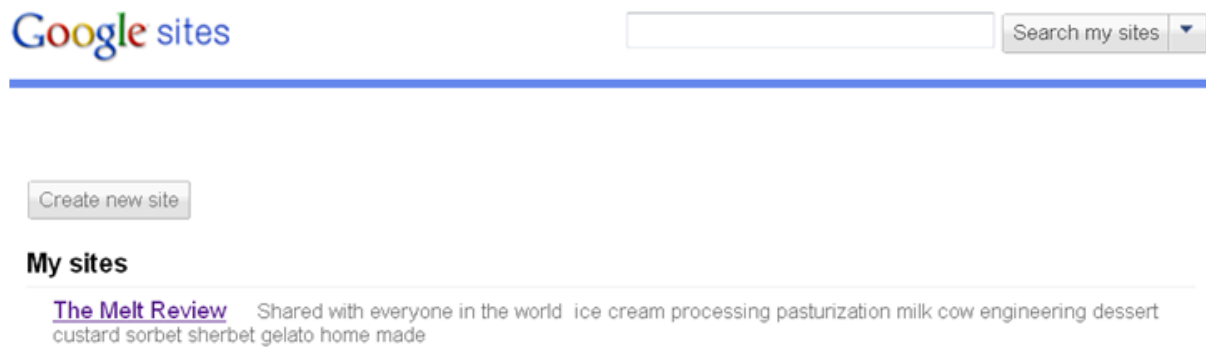
An emulsion is defined as liquid droplets dispersed in another immiscible liquid. The dispersed phase droplet size ranges from 0.1-10 µm. Important oil-in-water food emulsions, ones in which oil or fat is the dispersed phase and water is the continuous phase, include milk, cream, ice cream, salad dressings, cake batters, flavour emulsions, meat emulsions, and cream liqueurs. Examples of food water-in-oil emulsions are butter or margarine. Emulsions are inherently unstable because free energy is associated with the interface between the two phases. As the interfacial area increases, either through a decrease in particle or the addition of more dispersed phase material, i.e. higher fat, more energy is needed to keep the emulsion from coalescing. Some molecules act as surface active agents (called surfactants or emulsifiers) and can reduce this energy needed to keep th

Another noticeable trend was the lack of creativity. This means that all the websites were bland and only contained text. A bland website may be ignored or skimmed, which could lead the reader to miss important information. The website for this project has been created to stand out from other ice cream websites and the presentation will be central for the website.

# Methodologies

## 4.1 Website

Google Sites was used to host “The Melt Review”. Google offered a very speedy and user friendly website creator. Also, Google has many web friendly applications that are in sync. On top of these benefits, the main reason Google Sites was chosen as the host was because of their zero dollar cost.



Naming the site was difficult to agree on. After several attempts choosing a host name the idea settled upon was a forum style site in which a homemade ice cream parlor would be visited each week and a review would be written. As a result, “The Melt Review” was chosen as the name. After a few more weeks of work, the site took on a new style and weaned away from the original idea, however the name stuck.

## Home

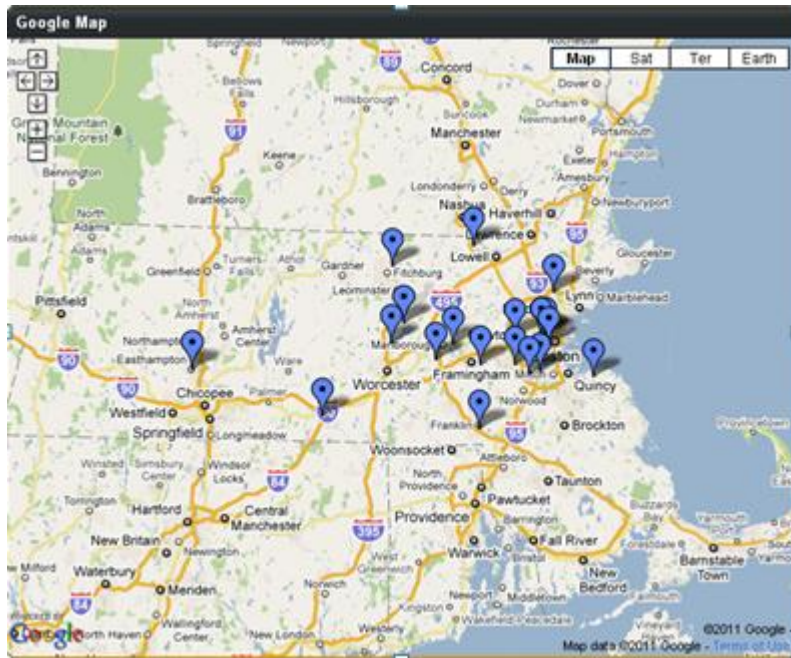
### Mission Statement:

The Melt Review was created by five undergraduate students from Worcester Polytechnic Institute in order to complete their Interactive Qualifying Project. The purpose of the website is to gather all the information on ice cream and bring it to one website, thus creating a unique website on ice cream. The website contains an interactive timeline detailing the history of ice cream, an interactive map containing homemade ice cream parlors in Massachusetts, FDA guidelines for making ice cream, and nutritional facts about ice cream. However, the main focus of the site is to detail several different processes of making ice cream. We have posted videos of ourselves making ice cream in a variety of ways. We hope that you find the videos to be informational and enjoyable and that you had no problems trying to find anything on the Melt Review.

If having trouble viewing any web page "refresh" and click "no" on pop-up.



The map on the website was created using Google maps. To insert a parlor onto the map it was necessary to search for the parlor on Google. If the parlor was available it could be added to the embedded map along with a picture and street view. These features are part of the Google Maps program and are available for custom maps. If the parlor could not be found, the location was manually entered, thus creating information for that parlor.

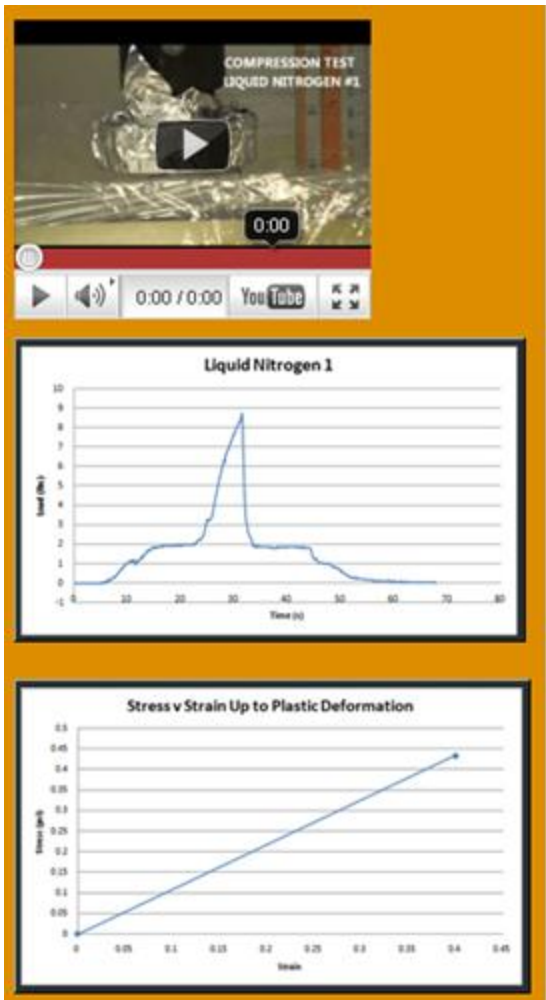


For the timeline on the website, timeglider.com was used. With a simple to use interface and nice sleek look, it was a nice addition to the website. The timeline has bubbles that pop up for every new instance with a picture and text explaining the instance.



The videos on “The Melt Review” were uploaded for free using Youtube.com. YouTube was chosen because a member had already personally used it, and knew it was exactly what was needed. The biggest problem with any the videos was the Nona’s video. Due to the lengthy run time, YouTube would not accept it. As a result, the video was split it into two halves then uploaded. Creating the make it yourself videos were quite easy; the end result was fun to watch and informative.

The “Science!” page on the site has the engineering information for ice cream. The texture measurement tests were captured on video. Also included on this page were graphs and tables along with text to further explain the texture measurement tests.



## 4.2 Videos

A large part of the project was creating videos to place on the website. Videos were needed to add a multimedia aspect to the website, which would improve the overall experience. All filming equipment was supplied by the WPI Academic Technology Center. The videos were first uploaded to YouTube, and then embedded onto the website. They were then broken into two different categories, the first on creating ice cream, and the second on ice cream in a different context.

The videos detailed different processes of creating ice cream from hand. Each video began with pre-measuring all the ingredients. The second step was to follow the recipes available in the

“Do It Yourself” page of the website. Each video contains a gap in time during which the mixing of ingredients was performed. The videos ended with a shot of the created ice cream. This same basic framework was used for the Bag method, Pot Freezer method, and Liquid Nitrogen method.



Another video was shot in Nona's Homemade in Hingham, MA. The ice cream making machinery consisted of one batch freezer and two large walk in freezers. One freezer was set to a lower temperature for a quick freeze. A storage freezer was set at a higher temperature, allowing the ice cream to be workable when removed. The co-owner of the establishment was initially filmed creating a batch of ice cream. Afterward, a group member was filmed making a batch while being instructed by the co-owner. Filming ended with a quick interview in the front of the store. Another video was the filming of an ice cream eating contest. The contest was at WPI and sponsored by Hershey's.



### **4.3 Parlor Visits**

The beginning of this project entailed finding parlors, and since most are family owned and operated, many would not have their own websites or on-line addresses. After sifting through the hundreds of Google links and utilizing Google maps to help locate these parlors, it was necessary to expand the search to friends and family. In the end asking grandparents and elder relatives proved more helpful than Google.

After collecting this list of owners, phone numbers, and addresses, interviews were arranged. This began completely wrong with an attempt to walk up to the owners without a prior phone call. The first man believed this was an attempt to steal his family recipes and refused to respond. After that embarrassment it became a unanimous decision to call the owners before showing up.

During the summer it was tough to get the five man group together and between work and driving distances it became impossible to interview parlor owners so most of the interviewing was conducted by Mike Scanlon. The questionnaire was kept relatively short because these owners were taking time out of their workday. The questionnaire consisted of fifteen questions covering the owners background, the shops background, their most unique and common recipes, along with a couple manufacturing questions (Appendix C). The basic purpose of the questionnaire is to get to know the owners better and help understand the products and services they provide. After five in person interviews it was decided this approach was not the best and not the most financially sound because it was too expensive to drive to these parlors. The list needed to be cut down to specific parlors. One parlor chosen was Nona's Homemade out of Hingham Massachusetts, and they agreed to let the group film and make ice cream.

#### **4.4 Business Plan**

The purpose of the business plan was to analyze what it would take to make the website profitable. The first part of the business plan was an in depth description of what the website provides for the public. This gives the investor a good idea of the purpose and benefits of the website. The next part of the business plan is the marketing plan. The marketing plan gives a detailed explanation of how the group plans to sell advertising spots on the website. The next part of the business plan is the operations plan, which describes the physical necessities required to run the business. These parts of the business plan are straight forward and do not require extensive research in order to complete.



The next part of the business plan is the financial plan. The financial plan contains multiple parts. The first part is a projection of sales. This includes projected revenue, variable costs, fixed costs, contribution margin, and net income. There are multiple scenarios; one can view how the business will do in different situations. The next part of the financial plan is a break-even analysis. The break-even analysis shows how many advertisements the website would need to sell in order to break-even. This business plan will provide a great foundation for the ongoing maintenance of the website. See Appendix D to view the business plan.

#### **4.5 Texture Measurement Tests**

The texture measurement tests were performed on different ice cream samples giving scientific data to interpret. Vanilla ice cream was made in three different ways. A commercial brand of vanilla was also tested as a control. To keep tests consistent the samples were frozen in the same freezer for the same amount of time to eliminate discrepancies between the samples. Ice cream was made using the three homemade processes posted on the website, under the “Do It Yourself” page. The three processes include the Bag method, Pot Freezer method, and Liquid Nitrogen method. In order to get the ice cream in the shape needed for testing, the ice cream was placed in aluminum cans with the top cut off. By placing the ice cream in the aluminum cans, it took the shape of the can and therefore gave a uniform shape for all the molds. By using this method for creating samples the cross sectional area was kept constant at 4.43 in<sup>2</sup>. The ice cream was then cut using a band saw one at a time as they were needed for testing. When the ice cream was not being tested it was kept in a freezer.

Steps were taken to prevent damage to the testing apparatus. The most significant danger was the dripping of the liquid ice cream into the machine. This occurs because the ice cream is viscoelastic and when a force is applied the friction inside the ice cream increases; thus the heat increases causing the ice cream to melt. To protect the machine an acrylic box was constructed and the top of the box was lined with saran wrap. This system helps keep the potentially damaging liquid out of the electronics inside the machine. Also the sides of the machine were

coated with aluminum foil to help keep possible splatter out of the gears inside the upright beams. Once the machine had been properly prepared testing began.



The testing apparatus is capable of recording a 0.01 Newton force at a 100 millisecond interval. This is useful information for detailing the connections between internal structure and taste texture experienced by the consumer. The data found from these tests can be used to calculate various significant mechanical properties such as yield stress, strain, elastic modulus, and collapsing force.

## Chapter 5: Texture Measurement Test Results

From the texture measurement tests, results were compiled for each type of ice cream. The first step in obtaining certain properties of the ice cream was to plot the data, time on the x axis and the load applied on the y axis. From this graph the collapsing force of the ice cream was found. The collapsing force is defined as the amount of force needed to compress all the air bubbles inside the ice cream. When looking at this graph, there is a clear plateau near the beginning. The first points on this plateau, as well as the last point on this plateau, were used in calculating the collapsing force. The collapsing force was calculated by finding the average force between these two points. The beginning of this graph shows the elastic deformation of the ice cream, which is the recoverable deformation. In contrast, the rise after the plateau represents the plastic deformation of the ice cream. This is the non-recoverable or permanent deformation.

The next property that was determined was the yield stress for each individual test. To calculate the yield stress, the collapsing force was divided by the cross sectional area of the sample. The reason it was calculated in this fashion was because stress is defined as load divided by area. The term yield stress is used because this is the point where elastic deformation ends and plastic deformation begins.

Another mechanical property found for each compression test was the Elastic Modulus (E). The Elastic Modulus of a specimen is the relationship between stress and strain in the elastic region of the stress versus strain graph. The higher the Elastic Modulus, the more resilient the specimen is. The elastic modulus was calculated for each test by dividing the yield stress by the yield strain; these values were used because this region is linear.

Another interesting relationship was the time it took each sample to reach the collapsing force. To calculate this value the final point of the first plateau on the time versus load graph was taken and then the time value where the load was first applied was subtracted. This value was not always zero because it took time for the testing apparatus to first apply a load to the ice cream.

To see the final calculations, including tables and graphs, view the “SCIENCE” page on the website or Appendix A.

## Chapter 6: Conclusions

Ice cream is a marvel of modern engineering and will continue to evolve as time goes on. Using the developing knowledge of structural engineering, and the ever growing demand for this delicious treat, companies have had to mass produce while keeping recipes traditional and increasing profits. The ice crystal structure has been broken down, studied, and turned into a science. Everything known about how ice freezes and how ingredients react with it has become formulated, graphed, maximized, and minimized, producing a product that not only has a long shelf life but tastes fresh out of the freezer. The matrix structure of ice cream is comparable to a tightly woven web containing everything needed to make ice cream. The fats, stabilizers, emulsifiers, sugars, and proteins are trapped inside the matrix. However, the most important part of the structure is the types of bonds formed between these molecules and how they break. In modern science bond breaking and forming is crucial; the types of bonds and how they react determine what physical and mechanical properties the substance exhibits. For ice cream, the scientists needed a substance that was structurally stable at low temperatures, but would not be brittle. Although scientists and engineers have been working at this for decades, they will continue to do so for decades to come. Ice cream's humble icy origins in the mountains of China and now the modern day factory ice cream man has made and remade simple fruit ice hundreds of times to reach what it is today.

The project resulted in a few key findings. When a taste test was performed between homemade ice cream from Nona's and commercially made ice cream, the homemade was widely preferred. When texture tests were performed to the homemade ice cream samples, they were nearly twice as strong as the commercial brand. This difference in strength can be attributed to the inability to aerate the ice cream properly as it froze. As a result, the homemade samples had fewer air bubbles. The lack of air bubbles created a brittle and icy texture, unlike the smooth and creamy texture of the commercial brand.

Throughout the project, the group learned not only about ice cream, but group dynamics and web design. The group was able to not only learn about mechanical properties of ice cream,

but also the opinions and preferences of individuals regarding ice cream. For scientific data, homemade ice cream was compared to commercial ice cream in categories such as collapsing force and elastic modulus. When it came to working together and scheduling mutually agreeable meeting times, many obstacles had to be overcome. Some of these obstacles were extracurricular such as varsity sports and jobs. Along with these extracurricular activities schoolwork had to be factored in as well. A solution to this was to separate and delegate the workload and combine the work during group meeting times. The web design of the project was accomplished by using Google Sites.

Interesting challenges were presented to the group. Ice cream is a very seasonal item; this caused difficulties in both scheduling and availability. Most shops are closed for the colder months, so scheduling a meeting with proprietors was difficult. Another unforeseen challenge came when texture measurements had to be taken. Elaborate canisters were created to house the samples until it was time to perform the tests. However the canisters were not leak-proof so a new solution was necessary. The low tech option of using a tin can was found to be the best choice. Choosing the right webpage host created a challenge as well. After doing enough research, Google was chosen, due to its cost and availability.

The hope for the website is that it will organize and present the information available on homemade ice cream. Most of the information found on the website can be found in other places. What sets “The Melt Review” apart is the availability of information in one place, as well as the approach taken in presenting the information. “The Melt Review” presents information in interactive ways, including an interactive timeline and step by step video directions on multiple approaches to creating homemade ice cream. The creators of “The Melt Review” feel a precedent has been set in creating a centralized location for information regarding a single subject. In the future “The Melt Review” can provide a template for similar projects.

To view the website offline go to “Themeltreview.zip” folder associated with this paper.

To view The Melt Review online follow this link: <https://sites.google.com/site/themeltreview/>

## Chapter 7: Resources

### Works Cited

1. Bellis, Mary. "History of Ice Cream." *Inventors*. Web. 28 Feb. 2011. <[http://inventors.about.com/od/foodrelatedinventions/a/ice\\_cream.htm](http://inventors.about.com/od/foodrelatedinventions/a/ice_cream.htm)>.
2. Clarke, Chris. *The Science of Ice Cream*. Cambridge: RSC Publ., 2006. Print.
3. "Commercial Ice Cream White Base." *Ice Cream, Gelato and Sorbet Recipes*. Web. 28 Feb. 2011. <[http://www.worldoficecream.com/Commercial\\_white\\_base.htm](http://www.worldoficecream.com/Commercial_white_base.htm)>.
4. "Dairy Science and Technology Home Page." *Food Science | University of Guelph*. Web. 28 Feb. 2011. <<http://www.foodscience.uoguelph.ca/dairyedu/home.html>>.
5. "The Food Timeline: History Notes--ice Cream." *Food Timeline: Food History & Vintage Recipes*. Web. 28 Feb. 2011. <<http://www.foodtimeline.org/foodicecream.html>>.
6. HALFORD, BETHANY. "ICE CREAM The Finer Points of Physical Chemistry and Flavor Release Make This Favorite Treat so Sweet." *Science and Technology*. Web.
7. "History of Ice Cream, Ices, Sorbets, Granitas, Ice Cream History." *What's Cooking America, Mardi Gras, New Orleans Mardi Gras, New Orleans Foods, New Orleans Recipes, History of New Orleans Food, Fat Tuesday*. Web. 28 Feb. 2011. <<http://whatscookingamerica.net/History/IceCream/IceCreamHistory.htm>>.
8. "The History of Ice Cream." *MakeIceCream.com - Ice Cream Makers , Ice Cream Maker Supplies, and Ice Cream Recipes*. Web. 28 Feb. 2011. <<http://www.makeicecream.com/hisoficecrea.html>>.
9. "How Do You Avoid Ice Cream Crystallization? - Discuss Cooking - Cooking Forums." *Cooking Forums & Community*. Web. 28 Feb. 2011.

<<http://www.discusscooking.com/forums/f17/how-do-you-avoid-ice-cream-crystallization-59566.html>>.

10. "How Does an Ice Cream Maker Work?" *WiseGEEK: Clear Answers for Common Questions*. Web. 28 Feb. 2011. <<http://www.wisegeek.com/how-does-an-ice-cream-maker-work.htm>>.
11. "Ice Cream Maker." *Wikipedia, the Free Encyclopedia*. Web. 28 Feb. 2011. <[http://en.wikipedia.org/wiki/Ice\\_cream\\_maker](http://en.wikipedia.org/wiki/Ice_cream_maker)>.\
12. "Is Ice Cream Still Ice Cream If It Doesn't Melt, Isn't Cold, or Tastes Like a Bagel? -- New York Magazine." *New York Magazine -- NYC Guide to Restaurants, Fashion, Nightlife, Shopping, Politics, Movies*. Web. 28 Feb. 2011. <<http://nymag.com/restaurants/features/58059/>>.
13. "Making An Ice Cream Custard Base or Cream Base." *Ice Cream Maker Recipes - Ice-cream-recipes.com*. Web. 28 Feb. 2011. <[http://www.ice-cream-recipes.com/custard\\_cream\\_base.htm](http://www.ice-cream-recipes.com/custard_cream_base.htm)>.
14. Mallare, Cathy. "History of Ice Cream." *WIT Home Page REDIRECT*. Web. 28 Feb. 2011. <<http://webinstituteforteachers.org/~cbmallare/History1.htm>>.
15. "News & Views - Media Kits - Ice Cream - Ice Cream Sales and Trends." *International Dairy Foods Association*. Web. 03 Mar. 2011. <<http://www.idfa.org/news--views/media-kits/ice-cream/ice-cream-sales-and-trends/>>.
16. "Peaceful Meadows Ice Cream." *Insider Pages - Restaurant Reviews, Beauty Salons, Dentists, Preschools, Spas and More*. Web. 28 Feb. 2011. <<http://www.insiderpages.com/b/3715399170/peaceful-meadows-ice-cream-whitman>>.



17. Ray, Crystal. "How to Prevent Ice Crystals on Ice Cream." *Associated Content from Yahoo!* - *Associatedcontent.com*. Web. 28 Feb. 2011.  
<[http://www.associatedcontent.com/article/631657/how\\_to\\_prevent\\_ice\\_crystals\\_on\\_ice.html](http://www.associatedcontent.com/article/631657/how_to_prevent_ice_crystals_on_ice.html)>.
  
18. "The Scoop in Abington, MA | 201 N Quincy St, Abington, MA." *Yellow Pages: Superpages Yellow Pages, Maps, Driving Directions, Weather...* Web. 28 Feb. 2011.  
<<http://www.superpages.com/bp/Abington-MA/Scoop-The-L2137438343.htm#BPinfoContainer>>.
  
19. "The Structure of Ice Cream - Emulsions and Foams." *Free Book Reviews / Book Summaries / Shvoong - Summaries & Reviews*. Web. 28 Feb. 2011.  
<<http://www.shvoong.com/exact-sciences/1861910-structure-ice-cream-emulsions-foams/>>.

# Chapter 8: Appendences

## 8.1 Appendix A

### Texture Measurement Results

The following is a table summarizing the results of our compression testing.

Table 1: Summary of Compression Testing Results

Test	Collapsing Force (lbs)	Collapsing Range (s)	Time to Plastic Deformation (s)	Yield Stress (psi)	E (psi)
Bag 1	1.95	15.7 - 22.9	22.9	0.441	1.102
Bag 2	1.8996	7.1 - 12.6	12.6	0.4288	1.072
Average Bag	1.9248	11.4 - 17.75	17.75	0.4349	1.087
Commercial 1	1.099	22.1 - 25.7	20.1	0.248145	0.62
Commercial 2	1.072	19.7 - 24.3	16.6	0.24206	0.605
Average Commercial	1.0855	20.9 - 25	18.35	0.2451025	0.613
Liquid Nitrogen 1	1.9199	14.6 - 22	16.4	0.43338	1.083
Liquid Nitrogen 2	1.8974	20 - 31.1	23.9	0.4283	1.071
Average Liquid Notrogen	1.90865	17.3 - 26.55	20.15	0.43084	1.077
Pot Freezer 1	1.928	17.7 - 27.5	18.5	0.43521	1.088
Pot Freezer 2	1.919	13.1 - 17.1	11.7	0.43318	1.083
Average Pot Freezer	1.9235	15.4 - 22.3	15.1	0.434195	1.086
All Average	1.7106125	16.25 - 22.9	17.8375	0.386259375	0.966

Each compression test was used to calculate the properties in table 1 above. From the compression test data we were able to generate two graphs for each test. The first graph represented the “Time versus Load Applied” graph. From this graph we are able to determine the collapsing force for each sample. The second graph for each test displays the “Stress versus Strain” relationship for each ice cream. The “Stress versus Strain” graph was created through calculated data including the yield stress as well as yield strain (yield strain a constant .4). This graph was then used to calculate the Elastic Modulus (E) for each sample. All graphs are located below and labeled according to graph type and test.

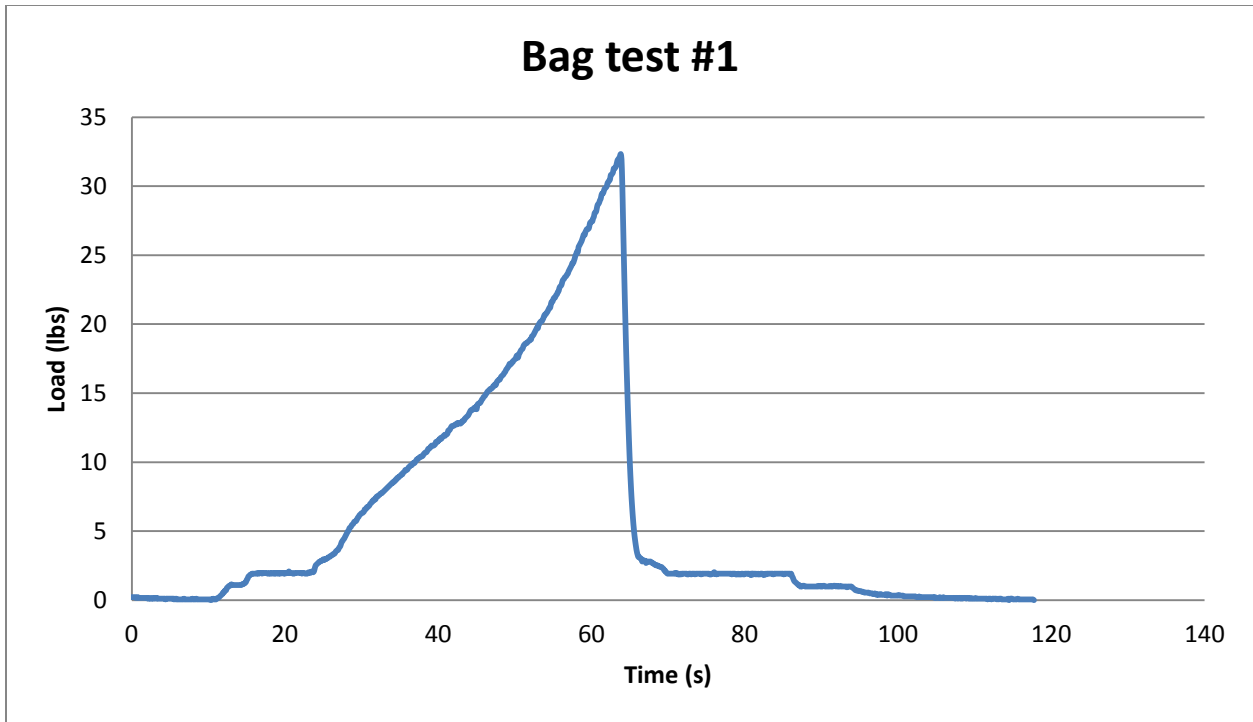


Figure 1: "Time versus Load Applied"; Bag test 1

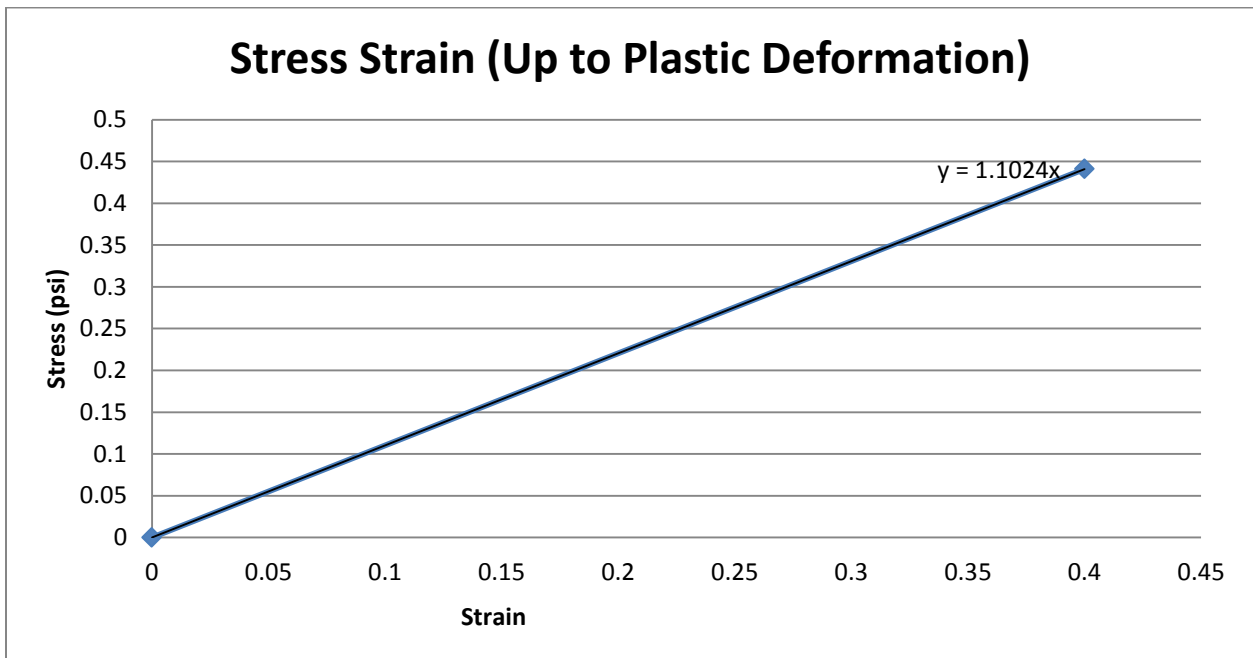


Figure 2: "Stress versus Strain"; Bag Test 1

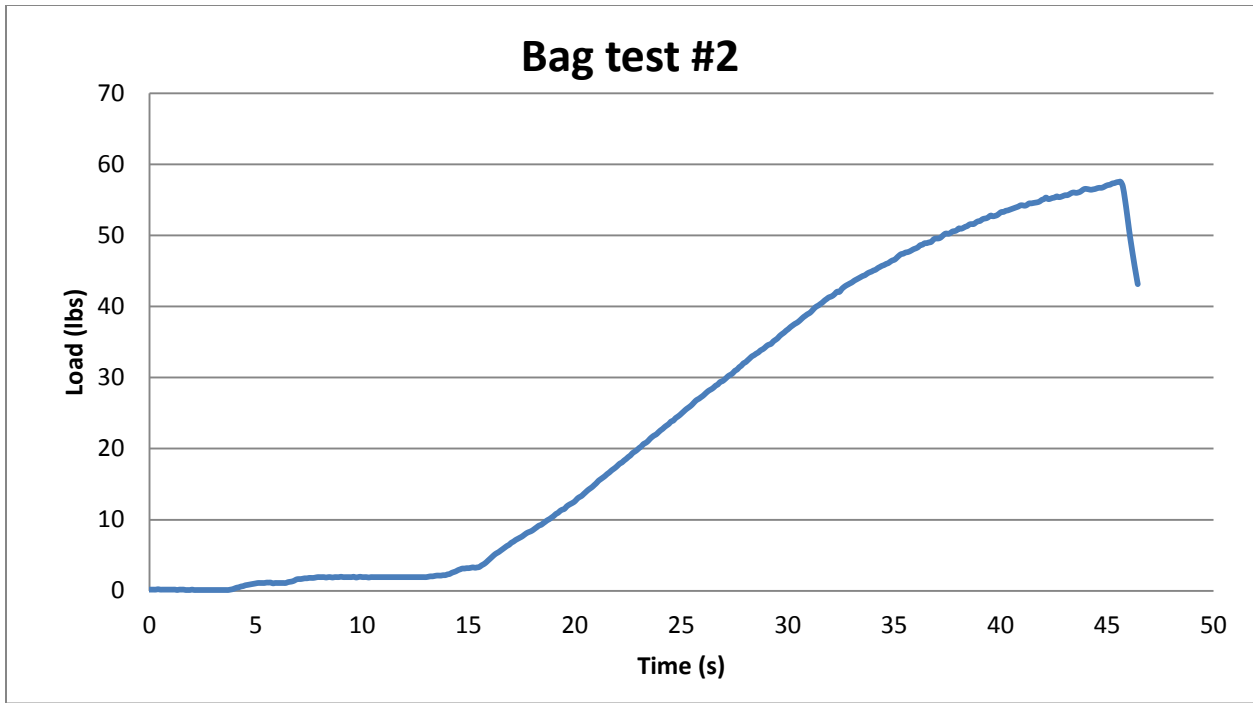


Figure 3: Figure 1: "Time versus Load Applied"; Bag test 2

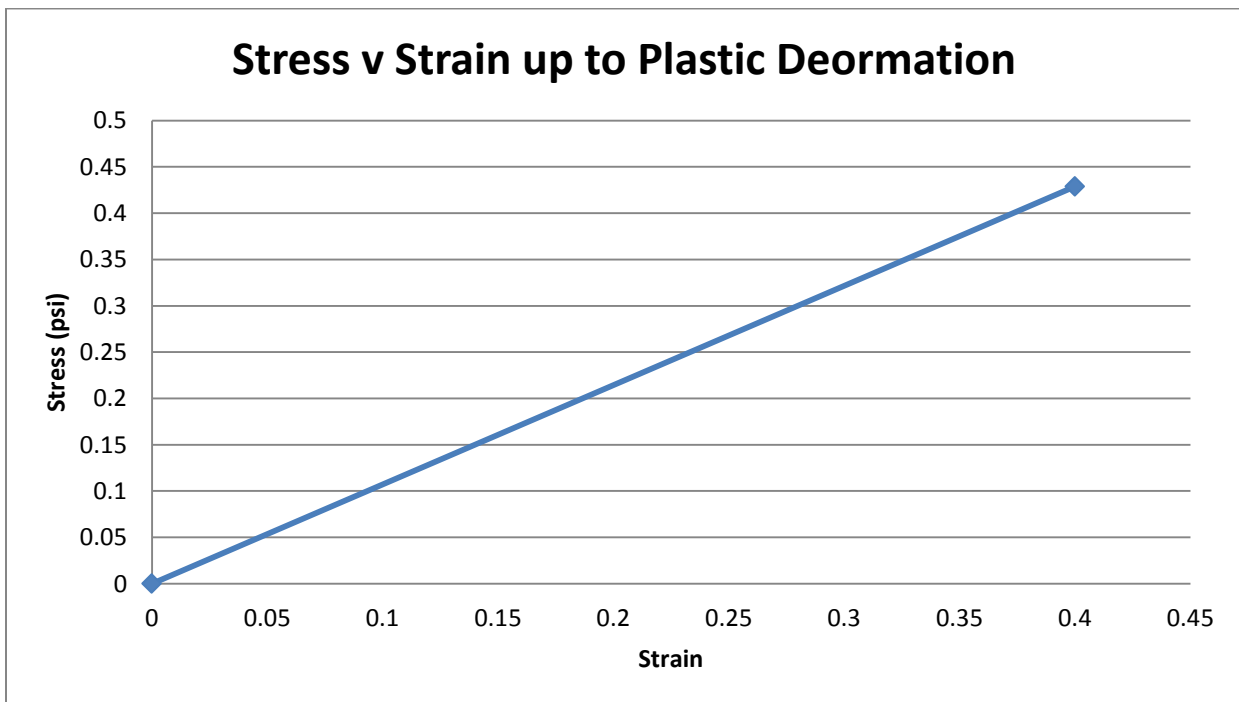


Figure 4: Figure 2: "Stress versus Strain"; Bag Test 2

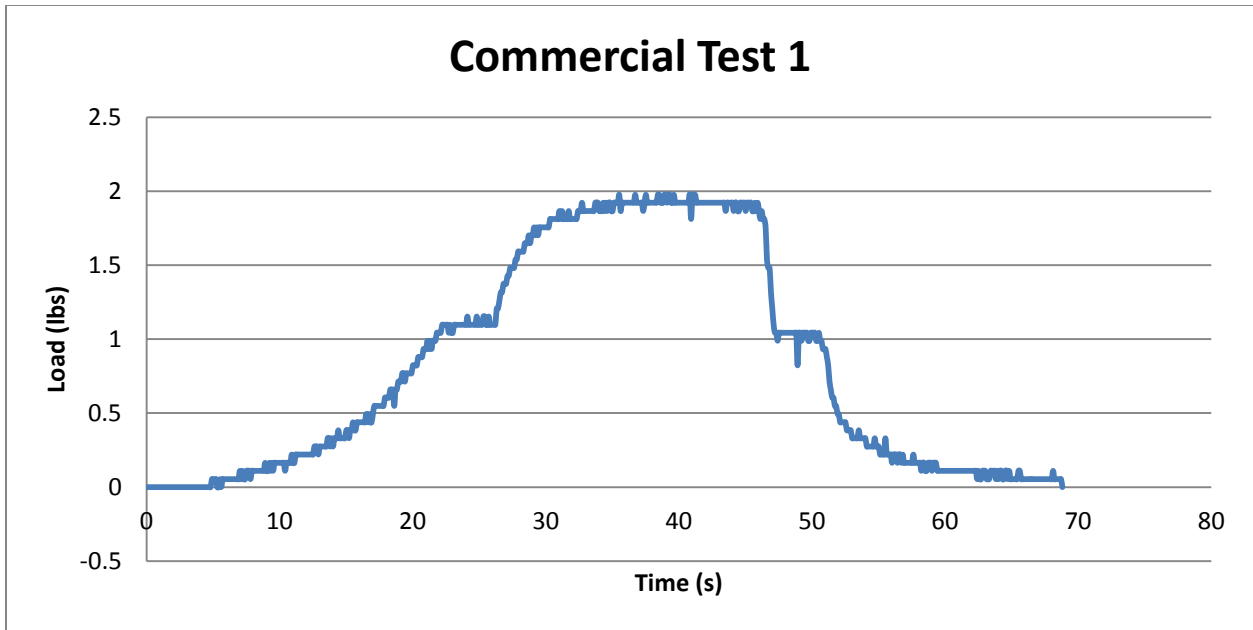


Figure 5: Figure 3: Figure 1: "Time versus Load Applied"; Commercial Test 1

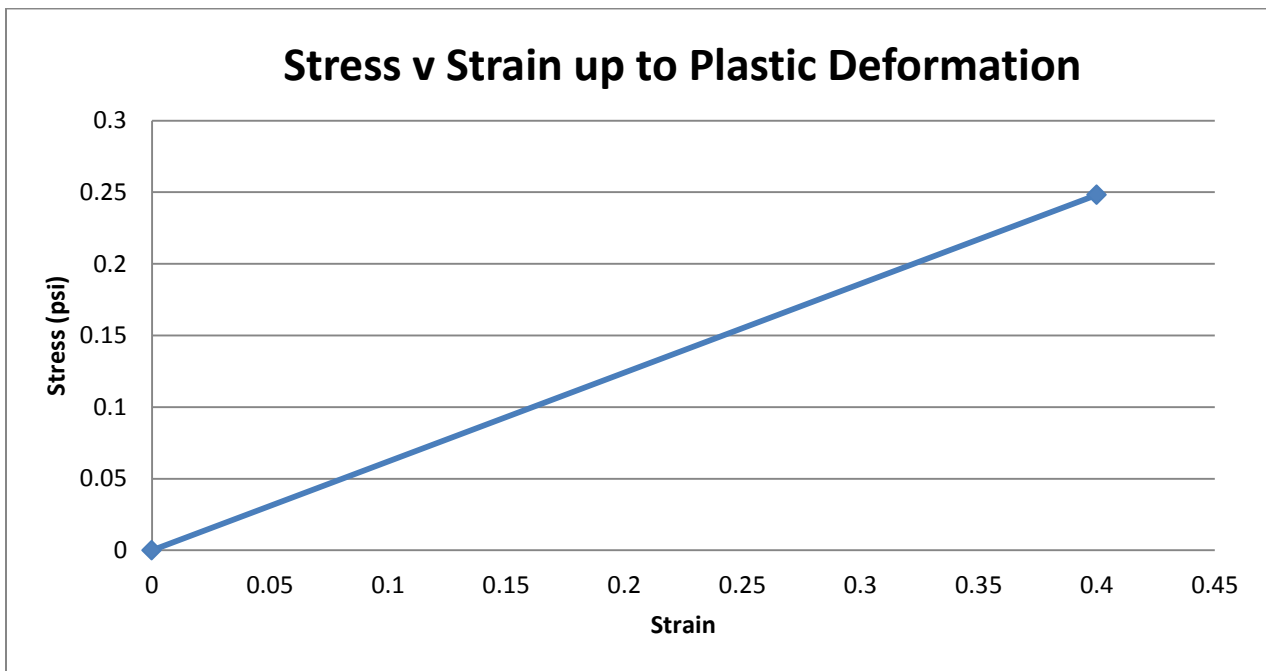


Figure 6: Figure 4: Figure 2: "Stress versus Strain"; Commercial test 1

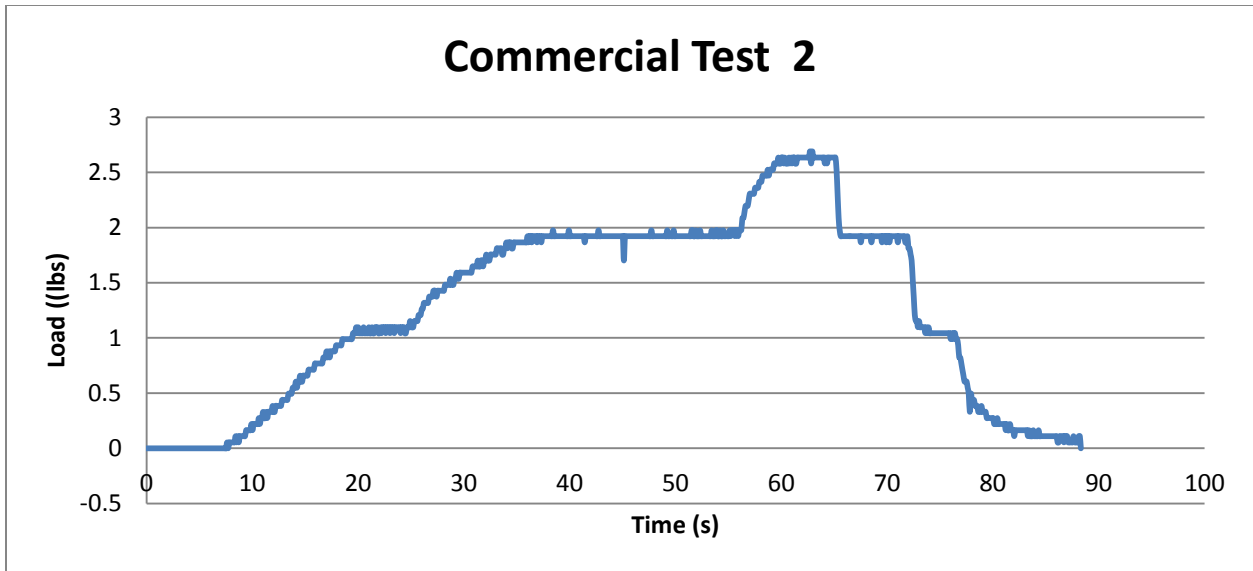


Figure 7: Figure 3: Figure 1: “Time versus Load Applied”; Commercial Test 2

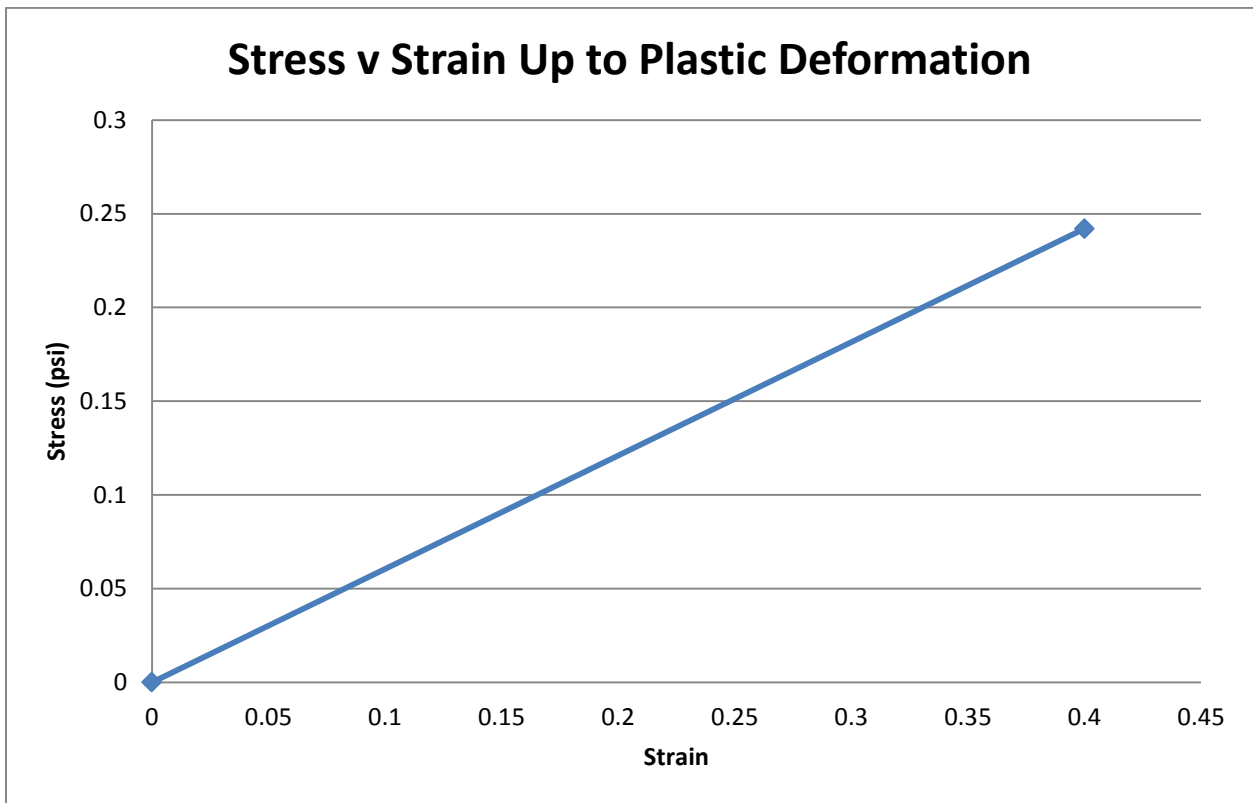


Figure 8: “Stress versus Strain”; Commercial test 2

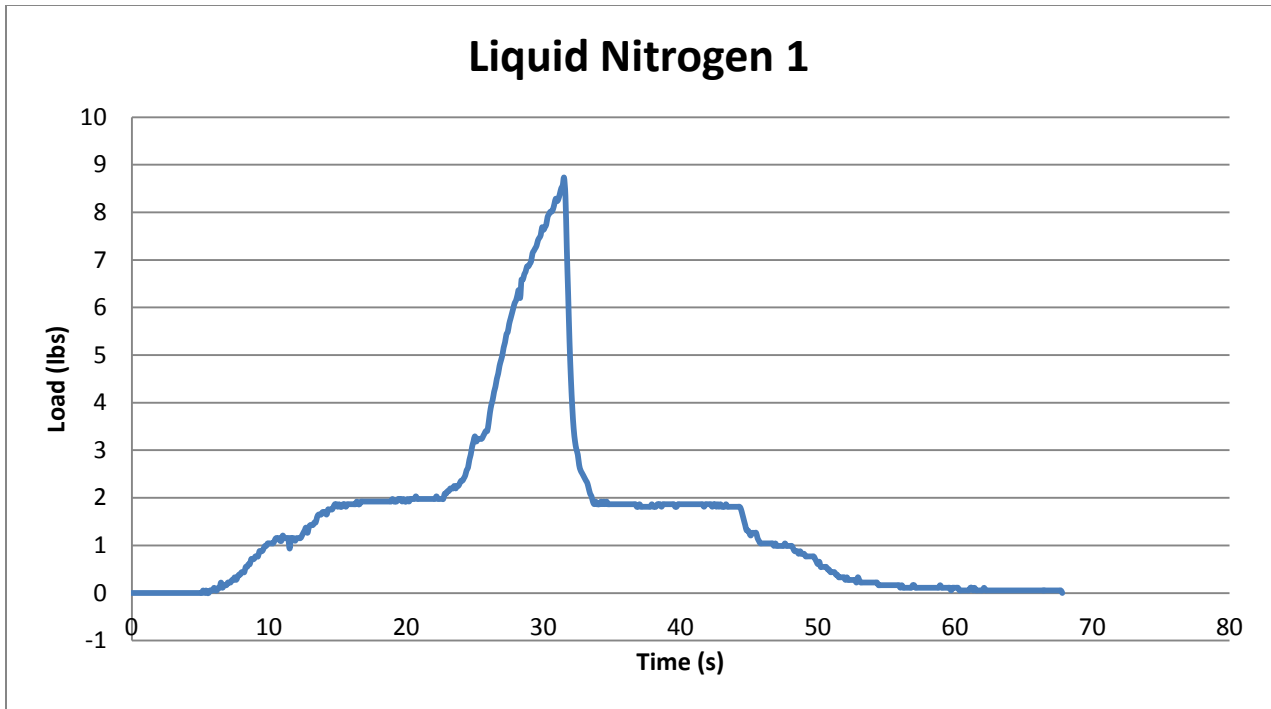


Figure 9: “Time versus Load Applied”; Liquid Nitrogen test 1

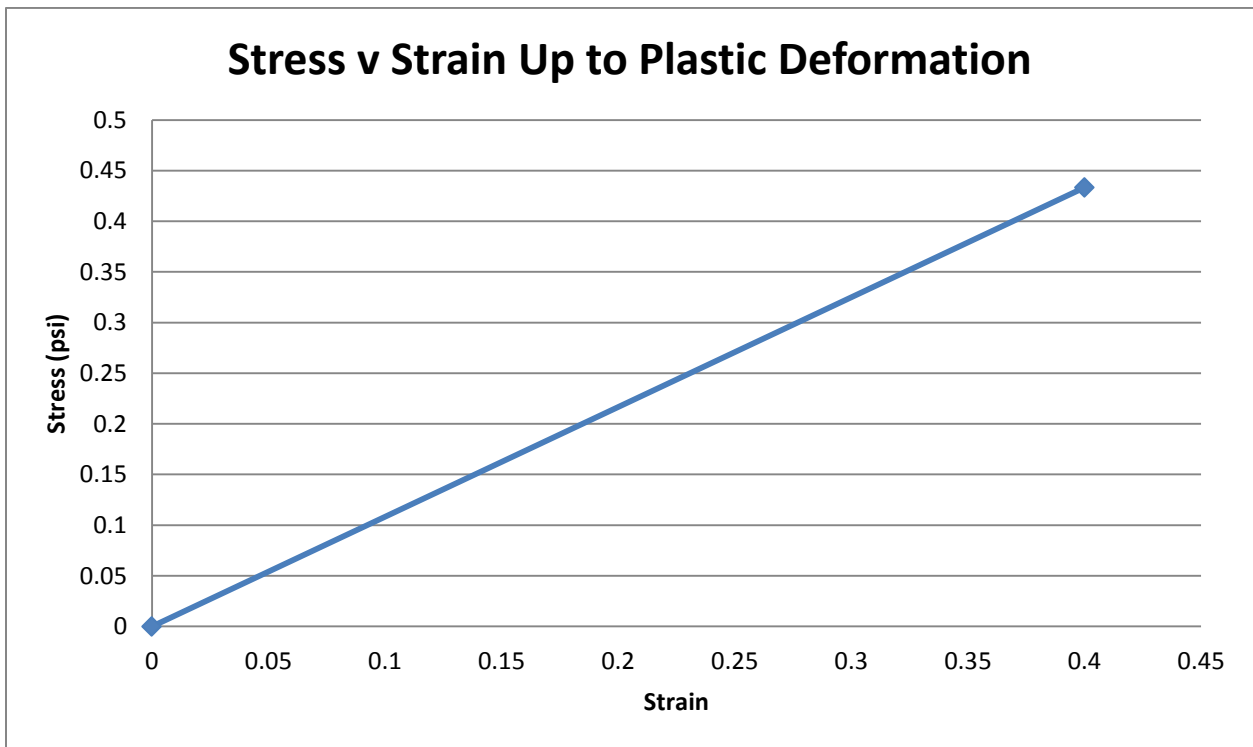


Figure 10: “Stress versus Strain”; Liquid Nitrogen test 1

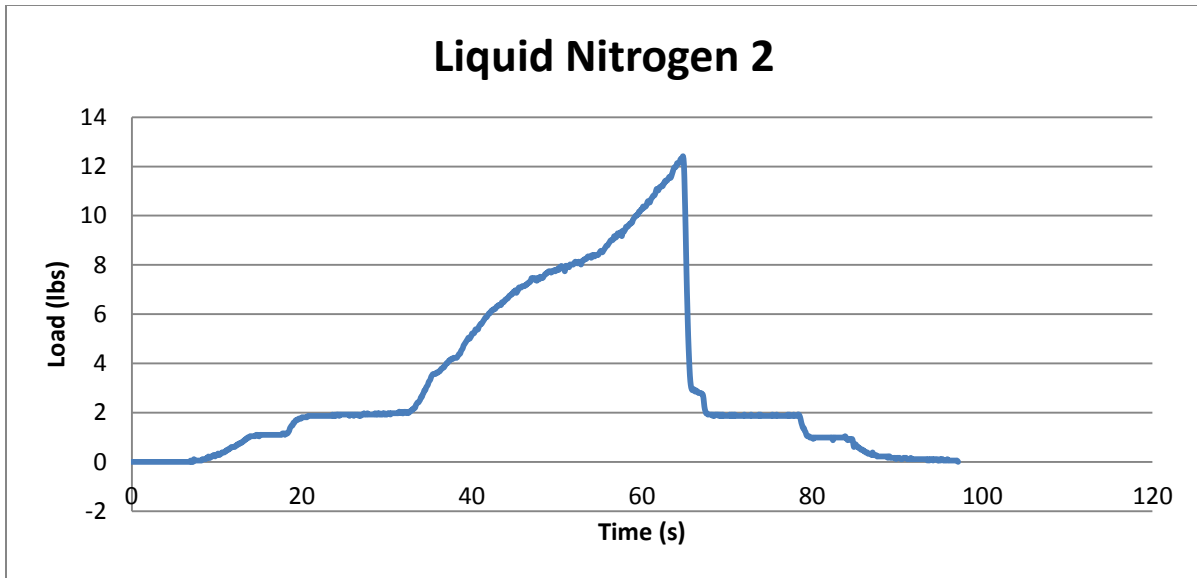


Figure 11: "Time versus Load Applied"; Liquid Nitrogen test 2

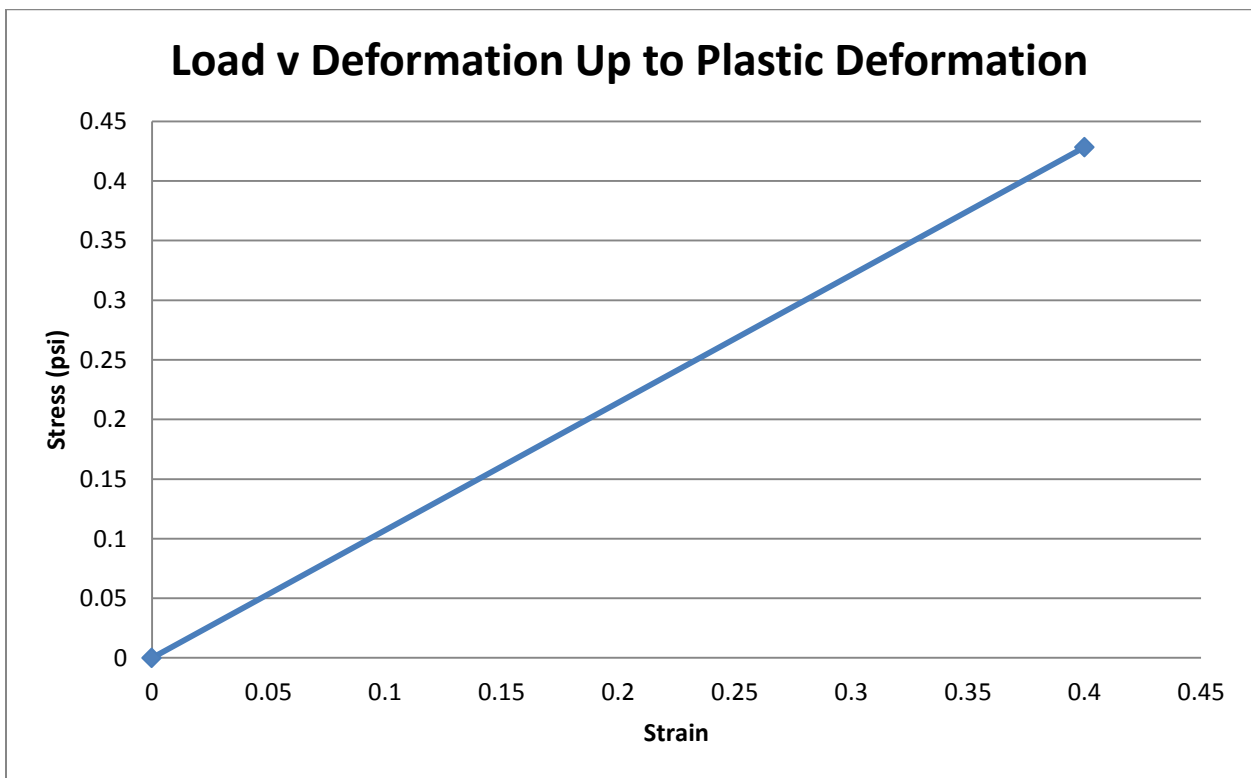


Figure 12: "Stress versus Strain"; Liquid Nitrogen test 2



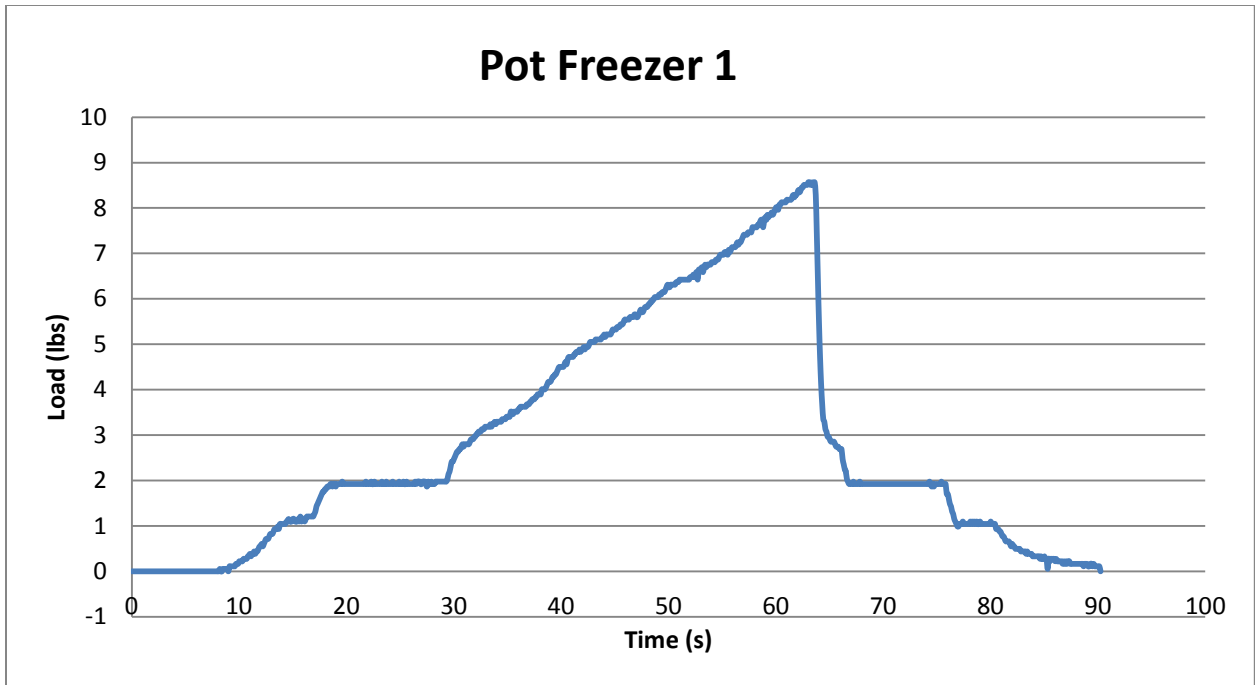


Figure 13: "Time versus Load Applied"; Pot Freezer test 1

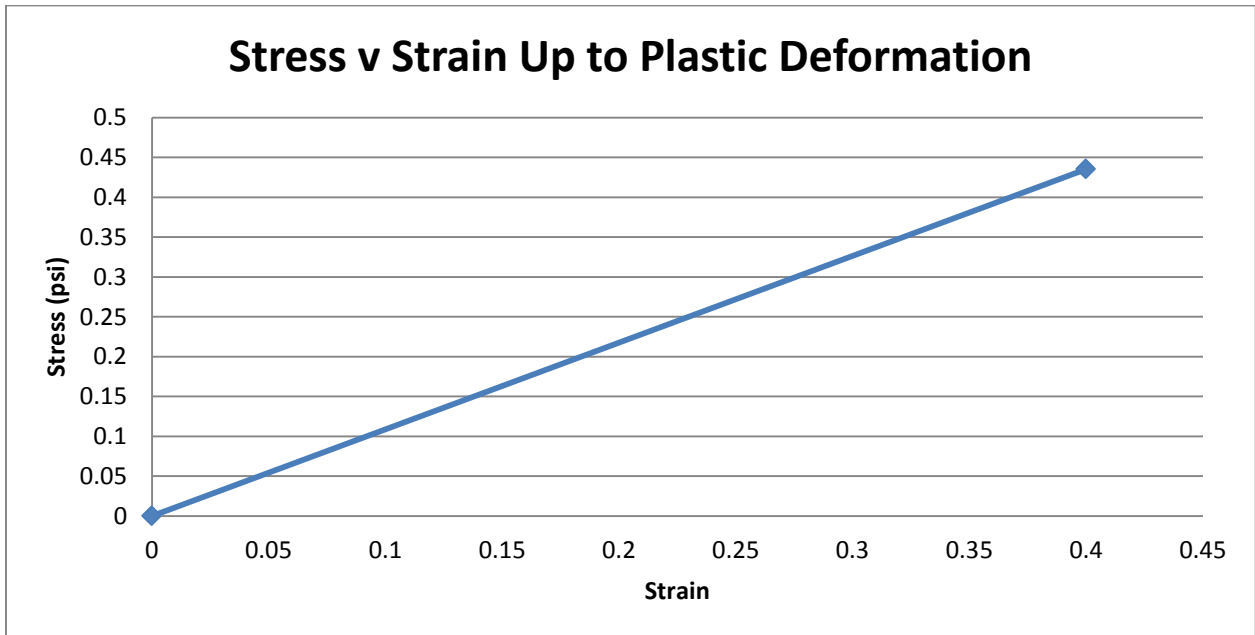


Figure 14: "Stress versus Strain"; Pot Freezer test 1

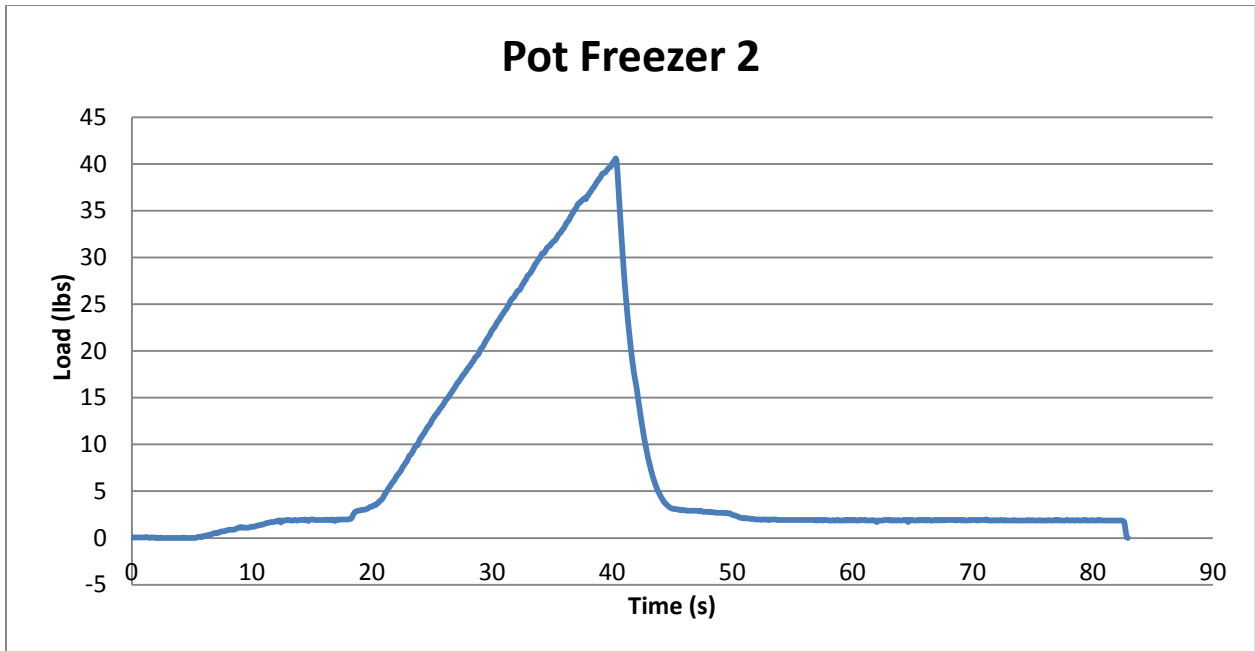


Figure 15: "Time versus Load Applied"; Pot Freezer test 2

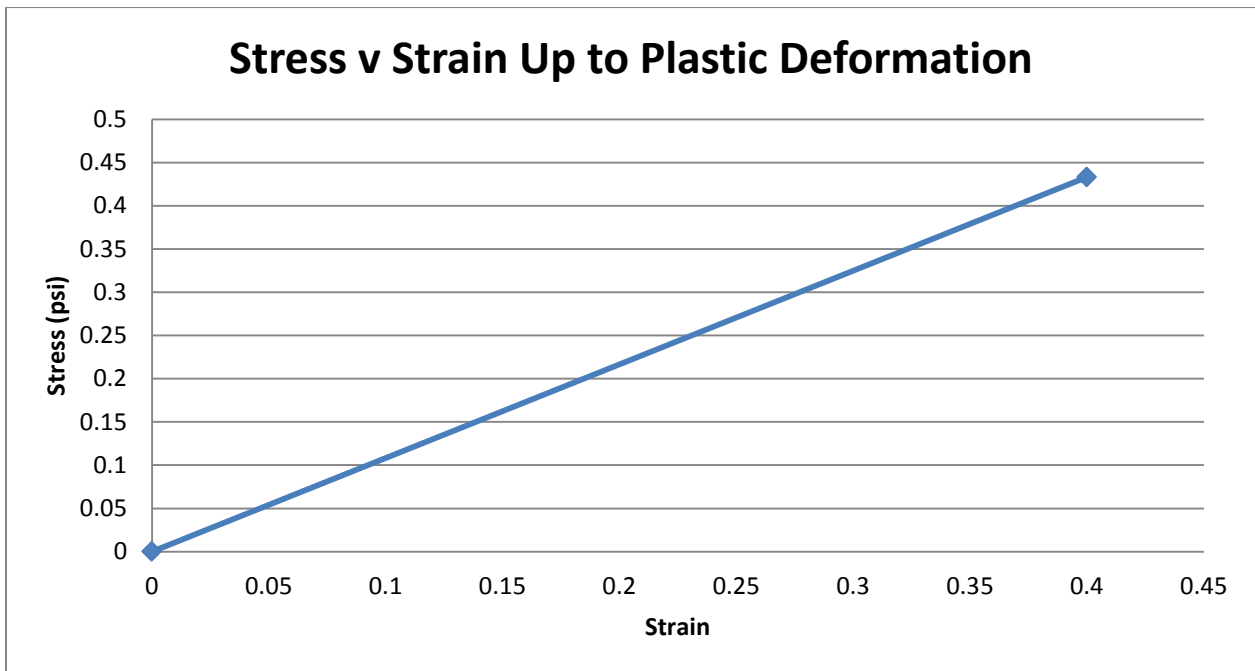


Figure 16: "Stress versus Strain"; Pot Freezer test 1

## 8.2 Appendix B

### Consumer Surveys

#### Food Engineering: Ice Cream

1. How often do you eat ice cream?
  - a. Every Day
  - b. Couple time a week
  - c. Couple times a month
  - d. Couple times a year
  - e. Only during the summer
  - f. Never
2. Do you prefer to eat at homemade ice cream parlors or commercial ice cream?
  - a. Homemade
  - b. Commercial
3. What is your favorite flavor of ice cream?

---

4. What is the most unique flavor of ice cream that you have ever had?

---

5. What type of ice cream do you prefer?
  - a. Regular
  - b. Light
  - c. Low Fat
  - d. Reduced Fat
6. What is something that you would like to know about ice cream?

---

7. Are there any funny videos that you would like to see with ice cream?

---

8. Which ice cream sample did you prefer?

- a. Sample A (Homemade)
- b. Sample B (Commercial)

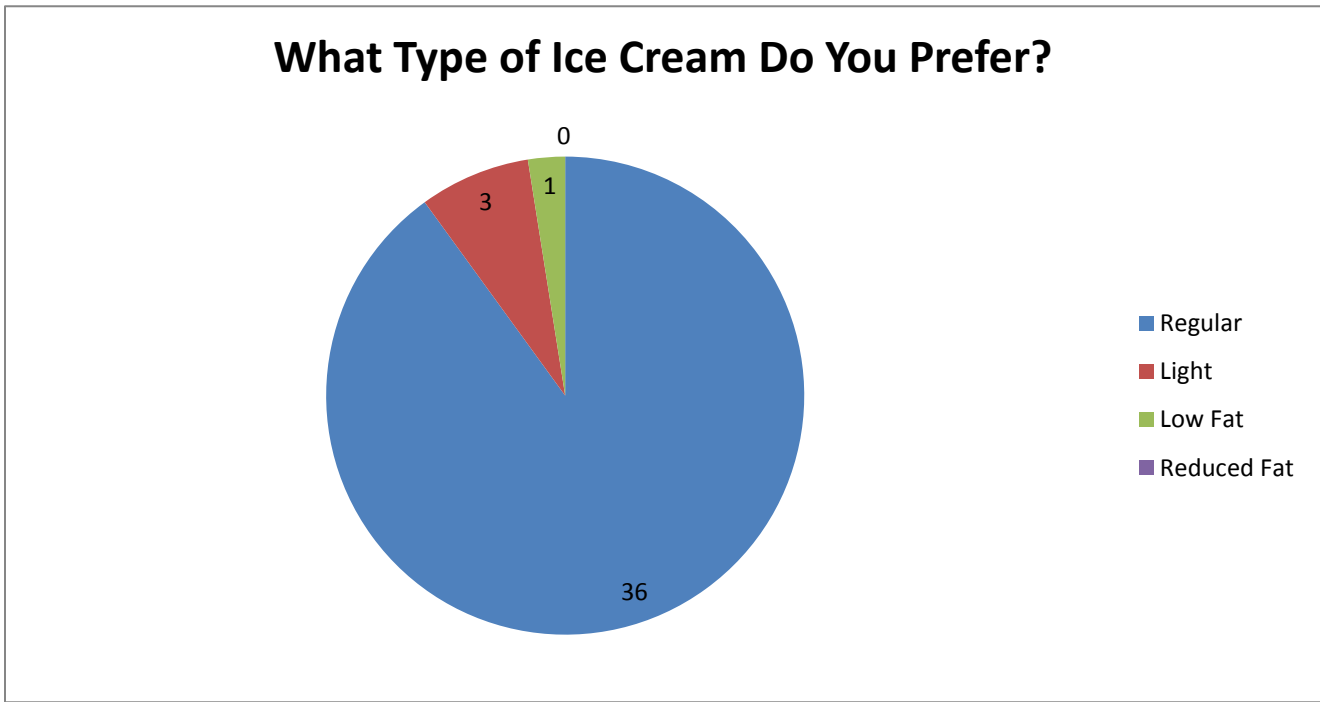


Figure 17: Pie Chart of the data from the survey detailing different types of ice cream that is preferred

### How Often Do You Eat Ice Cream?

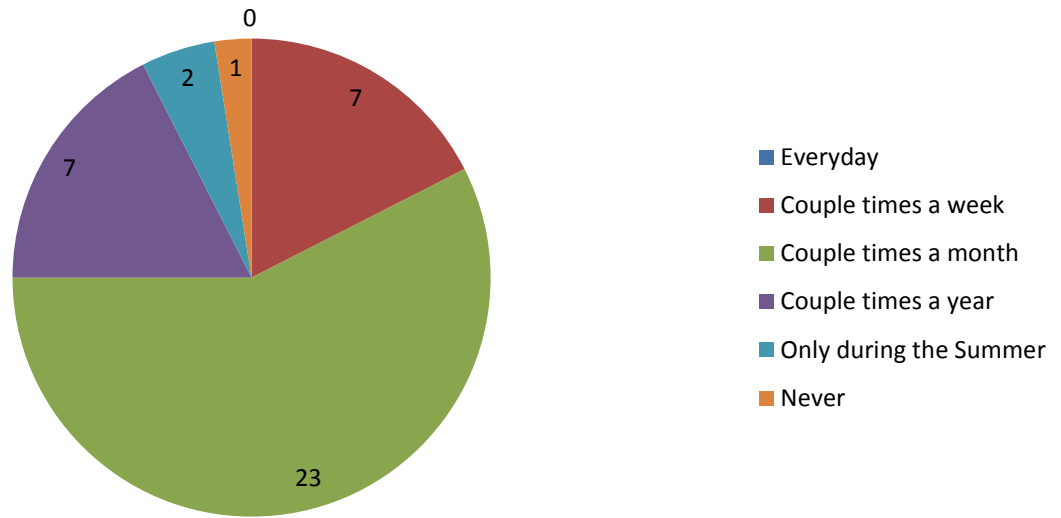


Figure 18: Pie chart of the data from the survey on how often people eat ice cream

## Homemade Ice Cream Parlors vs. Commercial Ice Cream

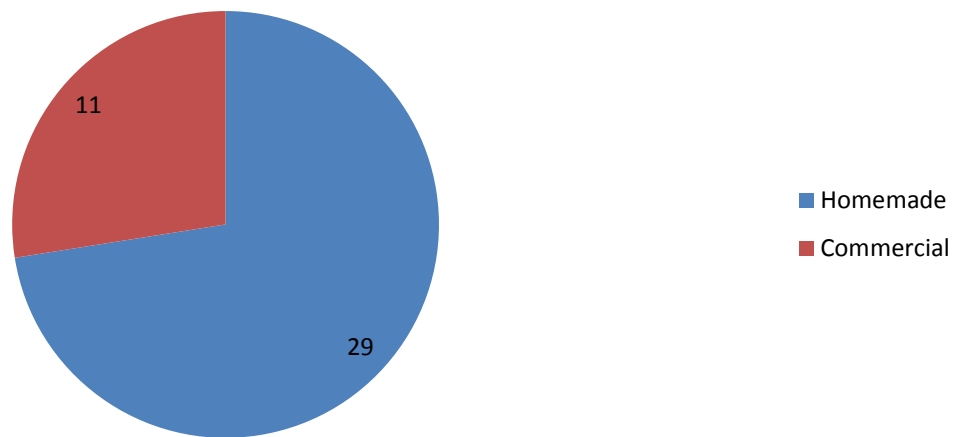


Figure 19: Pie chart of the data from the survey detailing the preference between homemade ice cream and commercial ice cream

## Blind Taste Test Results

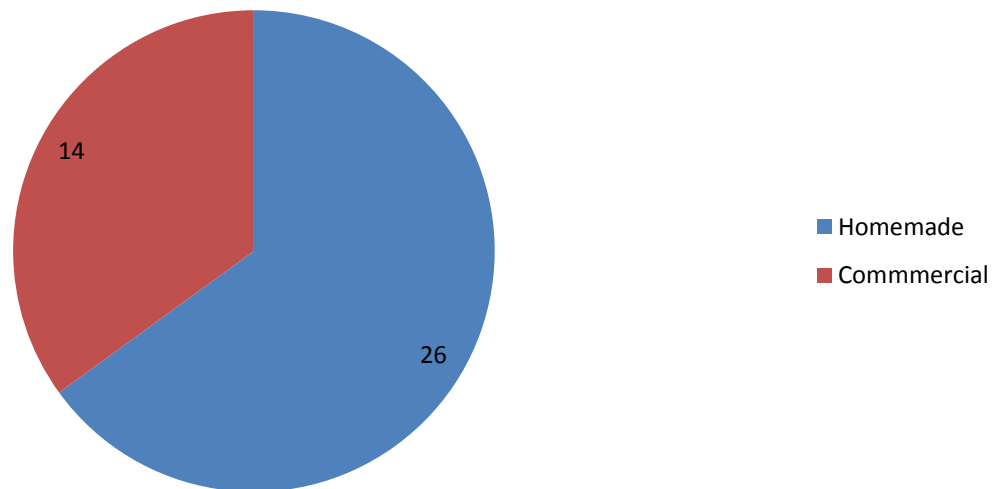


Figure 20: Pie chart of the data from the survey detailing the result from the blind taste test.

## 8.3 Appendix C

### Homemade Parlor Interview/Survey

#### Food Engineering IQP (Homemade Ice Cream)

##### Contact Information:

Parlor Name: \_\_\_\_\_

Parlor Location: \_\_\_\_\_  
\_\_\_\_\_

Parlor Phone Number: (\_\_\_\_) - \_\_\_\_\_

Owners Name(s): \_\_\_\_\_

Personal Contact Information (If Necessary):

Address: \_\_\_\_\_  
\_\_\_\_\_

Daytime Phone Number: (\_\_\_\_) - \_\_\_\_\_

##### Background:

Are you the original owner of the business? If not, who is and can we get some information on him so we can speak to him.

\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

How long have you been making ice cream?

---

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How did you get started?

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When did you open this business?

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Why did you start producing ice cream?

---

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Where was your first location?

---

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---

Originally how many flavors did you start off with?

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---

---

---

How many flavors do you have now?

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---

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---

What is your most unique flavor?

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---

What is your most popular flavor?

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**Manufacturing:**

What tools/ machinery do you use? Can I take a look at them?

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Do you produce organic ice cream?

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Where do you get your ingredients from? In-House? Local? Commercial?

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Do you have any ties to major companies? Which Ones?

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---

Has your business gone green?

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**Remarks:**

Do you have anything that you would like to add to this interview or possibly a selling point that we could put on our web site?

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Do you give \_\_\_\_\_ and/or any group members associated with the Food Engineering Interactive Qualifying Project (Ice Cream) conducted under the permission of Worcester Polytechnic Institute and the attending professor Satya Shivkumar permission to publish any information given on this questionnaire or pictures taken during the course of this interview on a web site and/or article and/ or research paper that will be produced as a result of this project.

Signature (Client): \_\_\_\_\_

Date: \_\_\_\_\_

Signature (Witness): \_\_\_\_\_

Date: \_\_\_\_\_

## **8.4 Appendix D**

### **Business Plan**

#### Website Description:

The goal for our group is to make gather all the information on ice cream and bring it to one website, thus creating a unique website on ice cream. The websites name will be called “The Melt Review.” This website includes an interactive timeline, an interactive map with as many homemade ice cream parlors as possible, FDA guidelines to making ice cream, nutritional facts for ice cream. However, the main focus of the site is to detail several different processes of making ice cream. We have posted videos of ourselves making ice cream in a variety of ways so viewers can make their own ice cream. The group plans to expand the website further in the future in order to make it a central hub style website on ice cream.

#### Marketing Plan:

The group needs to continue to search for more homemade ice cream parlors in Massachusetts. The goal is to incorporate the homemade parlors in our interactive map and offer them advertising on our website. The recognition and increased business that the ice cream parlors would receive would be the only thing that they would need. We would offer them advertising space for \$10 a month (\$120 a year). As the traffic on the website increases, we could increase the cost for advertising. Each parlor that would like to buy advertisement would start to pay April 2011. Once we have finished the Massachusetts map, we would then move on to another state and offer our services. We expect that we will need to spend 2 hours a week on site maintenance. We would pay Tyler \$10 to make sure the website is running smoothly. We expect that the cost of buying a domain name will be \$10 per month.

#### Operations Plan:

For us to smoothly run our website, we only need a few things in order to succeed. The first thing would be a computer with editing capabilities. Next we would need a fast internet connect. Also, we would need a camera in order to create more videos.

Financial Plan:

Budget (Yearly)							
	Scenarios	1	2	3	4	5	6
		10 ads	10 ads	30 ads	30 ads	50 ads	50 ads
		2 hours / week	4 hours / week	2 hours / week	4 hours / week	2 hours / week	4 hours / week
Revenue							
Advertisement							
180\$ per year		\$1,800.00	\$1,800.00	\$5,400.00	\$5,400.00	\$9,000.00	\$9,000.00
Total Revenue		\$1,800.00	\$1,800.00	\$5,400.00	\$5,400.00	\$9,000.00	\$9,000.00
Variable Costs							
Site maintnence		\$1,040.00	\$2,080.00	\$1,040.00	\$2,080.00	\$1,040.00	\$2,080.00
\$ 10 per hour							
Total Variable Costs		\$1,040.00	\$2,080.00	\$1,040.00	\$2,080.00	\$1,040.00	\$2,080.00
Contribution Margin		\$760.00	-\$280.00	\$4,360.00	\$3,320.00	\$7,960.00	\$6,920.00
Fixed Costs							
Yearly website cost		\$100.00	\$100.00	\$100.00	\$100.00	\$100.00	\$100.00
Domain Name Fee		\$120.00	\$120.00	\$120.00	\$120.00	\$120.00	\$120.00
Total Fixed Costs		\$220.00	\$220.00	\$220.00	\$220.00	\$220.00	\$220.00
Total Costs		\$1,260.00	\$2,300.00	\$1,260.00	\$2,300.00	\$1,260.00	\$2,300.00
Net Income		\$540.00	-\$500.00	\$4,140.00	\$3,100.00	\$7,740.00	\$6,700.00

Above is our projected earning over several scenarios.

## CVP Analysis

### Break-even analysis

For our break-even analysis we used the fact that we think that we will need to have 2 hours a week for website maintenance. Even though we consider the amount of hours worked to be a variable cost, it is not related to our source of revenue. Therefore our graph and analysis will be a little different. First we calculated our fixed cost which was only the cost for our domain name. That was \$120. Then we calculated the cost for our website maintenance. That came out to be \$1040. We added the two together to get \$1260. Finally we divide the total costs by the revenue on one advertisement (\$120).

$\$1260 / \$120 = 7$  advertisements.

It will take 7 advertisements for the website to break-even.

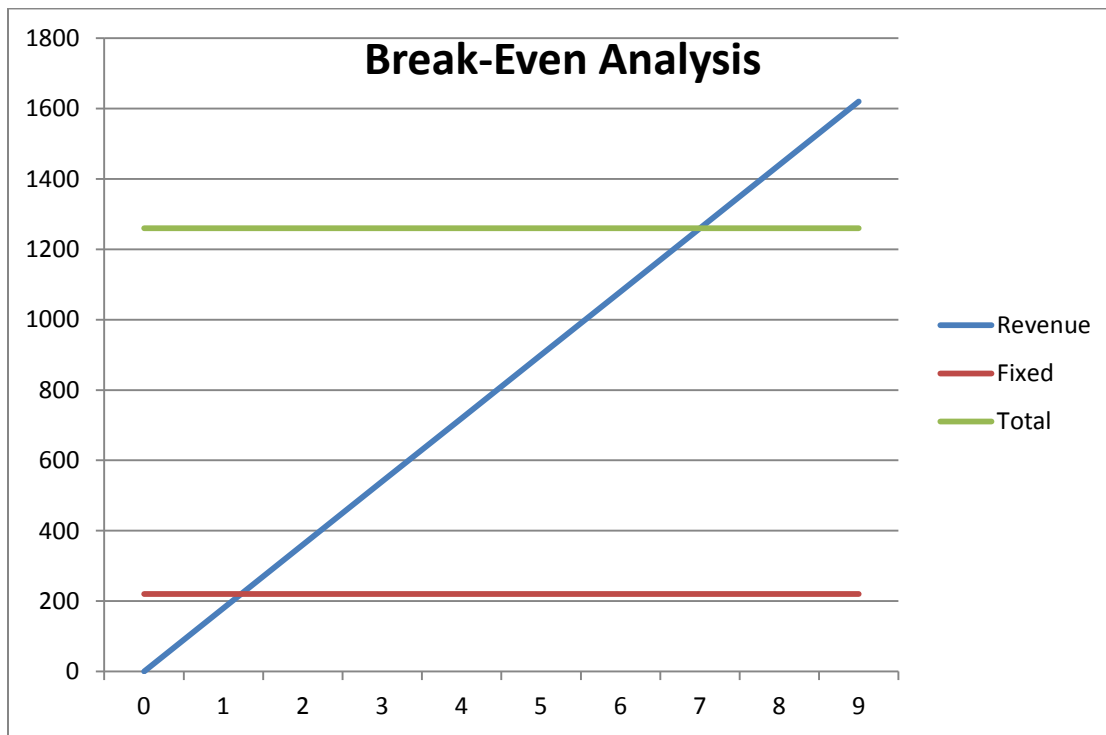


Figure 21: Break-Even Analysis for The Melt Review