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Introduction

Roasting Innovation has prepared the following report for U.S. Roaster Corp to provide them with all information concerning the development, including building and purchasing of parts, of the 300 kilogram roaster. The team has also included the campaign and business plans to allow U.S. Roaster Corp to see how this product will need to be marketed and how it will affect their business.

Mission Statement

Roasting Innovations mission is to develop a 300 kilogram roaster that will be safe and reliable with the ability to be easily reproduced. The team will accomplish this by redesigning the drum and drive train components of the roaster. Materials used to build the roaster will be chosen to maintain optimal quality of the product being roasted.

The business plan will outline the economic prospects of the 300 kilogram roaster. Roasting Innovation will define and expand the market for an industrial sized roaster while remaining in the middle of the price market for similar products. Communication with the sponsor will be maintained throughout the entire designing and building process to be sure the team produces an optimal product. Communication with customers will be maintained through a series of surveys to evaluate satisfaction with the current product, as well as what changes they would suggest.

Problem Statement

Roasting Innovation needs to design and produce a drum and drive train for a 300 kilogram roaster that can withstand temperatures up to approximately 600^{o}F so as to reduce

destruction of the quality of the roaster due to thermal expansion. The 300 kilogram roaster needs to be able to roast exceptional coffee to the user's taste, be easily reproducible, and remain safe to operate.

Statement of Work

Scope

Roasting Innovation will complete the design, construction and marketing of a 300 kilogram roaster for U.S. Roaster Corp. Our work will include the construction of the drive train and the rotating drum, which will withstand heating up to 600^{o}F for roasting of 300 kilograms of coffee beans and prevent compromising the operating of the roaster. It will also include the marketing and promotion of the 300 kilogram industrial roaster to the company's future and current customers.

Location

The work for Roasting Innovation will be done mostly on the Oklahoma State University campus within the computer laboratories provided by the Biosystems and Agricultural Engineering department as well as the Agricultural Communications department. These labs include computer labs as well as machine shops where we will build and test different drums for the roaster. There will also be some machine work done by our client, U.S. Roaster Corp, in Oklahoma City.

Time Period

The design process for the 300 kilogram industrial coffee roaster began in late August of 2010 and the final product will be completed by April 28, 2011.

Schedule of Deliverables

Table 1: Schedule of Deliverable

Deliverable	Due Date
Mission Statement	September 27, 2010
Problem Statement	September 27, 2010
Detailed Report and Budget	October 18, 2010
Competitive Analysis, Research, and Investigation	October 22, 2010
Statement of Work	October 29, 2010
Work Breakdown Schedule	November 5, 2010
List of Tasks	November 8, 2010
Fall Report	December 7, 2010
Fall Presentation	December 7, 2010
Website Completed	December 15, 2010
Acceptance of Final Design	December 17, 2010
First Prototype Completed	February 28, 2011
Tests on Prototype Completed	March 14, 2011
Final Design Completed	March 21, 2011
Final Report	April 25, 2011
Final Presentation	April 28, 2011

Table 1: Schedule of deliverables

Standards

According to the Specialty Coffee Association of America (SCAA) when evaluating green coffee beans (unroasted) there are two grades, premium and specialty. Specialty green coffee beans should have a minimum of five secondary full defects. Secondary defects are imperfections in the hull/husk or shell of the bean and can be caused by insect and water damage. Other secondary defects include partially black, partially sour, or floating beans, and

if the bean samples contain small or sticks. The green coffee beans should have no more than 10-12% moisture content. The roasted coffee beans should also meet the SCAA's cup evaluation of 80 points or above. Points are earned using a SCAA standard 16 point scale which evaluates cups of coffee based on fragrance and aroma, flavor, aftertaste, acidity, body, balance, uniformity, clean cup, sweetness, defects, and overall. Roasted coffee beans should be roasted 8 to 24 hours of cupping. The entire roasting time for the coffee beans must be between eight and twelve minutes and should exclude scorching and tipping of the beans. Once the roasted coffee beans reach room temperature they should be sealed in air tight containers until it is time for them to be cupped.

Coffee roasters should be operated at maximum temperatures ranging between 370°F and 1000°C depending on the size of the load, and the beans are roasted for a period of time ranging from eight to twelve minutes. Roasters are typically horizontal rotating drums that tumble the coffee beans in a current of hot air. The coffee roasters usually operate a batch mode, but sometimes operate as continuous systems. The air inside of the roaster is heated either by a direct flame applied on the outside of the roaster or indirectly using a heater to pre-heat the air before it is circulated through the drum.

Particulate matter, volatile organic compounds, organic acids, and combustion products are the principle emissions from coffee processing. Particulate matter emissions from the receiving, storage, cleaning, roasting, cooling, and stoning operations are typically ducted to cyclones before being emitted into the atmosphere. Gaseous emissions from roasting operations are typically ducted to a thermal oxidizer following particulate matter removal. Some facilities use burners as thermal oxidizers to heat the roaster; however, separate thermal oxidizers are more efficient because the desired operating temperature is typically between

650°C and 816°C (1200°F and 1500°F), which is 93°C to 260°C (200°F to 500°F) more than the maximum temperature of most roasters. Emissions from spray dryers are typically controlled by a cyclone, which is used to cool emissions, followed by a wet scrubber, which removed particulates from exhaust.

Acceptance

To be considered acceptable, the 300 kilogram roaster should be able to roast at least 300 kilograms of coffee beans within eight to twelve minutes at the standard temperature, about 500^{o}F. The roaster should be able to do this with minimal safety risks. If the roaster contains excessive heat escape, hot spots, loose connections, or excessive pressure buildup it will be considered unacceptable. The aesthetic design should resemble the previously design roasters developed by U.S. Roaster Corp but may be altered with the consent of both U.S. Roaster Corp and Roasting Innovation in order to improve overall appearance. The coffee roaster must also meet all necessary industry standards.

Special Requirements

The first unique consideration is taste. Our group must consider the taste of the coffee beans after they come out of the roaster. Another requirement to which we must pay attention to is the relatively high temperatures. Our roaster will reach temperatures around 400 degrees Celsius for about 15 minutes. Fifteen minutes is the approximate roasting time for coffee beans to obtain the desired specialty roast. The next special requirement to be considered is the ability of the roaster to mix the beans thoroughly. This must be accomplished while also allowing for quick evacuation of the beans to prevent over cooking. We must also know how the heating elements will affect the steel. The heating of the barrel will cause thermal

expansion to occur and must be compensated for. If the expansion problem is not solved, the roaster might lose beans and the efficiency will decrease. Another requirement is noise. Our team will be evaluating different kinds of gears to decrease the noise. As is, the existing roasters make quite a bit of noise with their straight cut gears. Lastly, our team must follow air pollution standards in not only Oklahoma but the entire nation, specifically southern California, where the regulations are much greater than the rest of the nation.

Work Breakdown Structure

1. **300 Kilogram Coffee Roaster**

1.1 Drum

1.1.1 Calculate Dimensions

1.1.1.1 Volume

1.1.1.2 Thermal Expansion

1.1.2 Fin Design

1.1.2.1 Mixing Tests

1.1.3 Inlet and Outlet

1.1.3.1 Efficiency

1.1.3.2 Speed

1.1.4 Material

1.1.4.1 Safety Factor

1.2 Drive Train

1.2.1 Bearings

1.2.1.1 Size Bearings

1.2.2 Gear Set

1.2.2.1 Size Gears

1.2.3 Motor

1.2.3.1 Power Requirement

1.2.3.2 RPM Requirement

1.3 Marketing

1.3.1 Website

1.3.1.1 Design

1.3.2 Brochure

1.3.2.1 Photos

1.3.2.2 Information about Product

1.3.2.3 Design

1.3.2.4 Printing

1.3.3 Promotional Index Card

1.3.3.1 Information about Product

1.3.3.2 Design

1.3.3.3 Printing

1.3.4 User and Safety Manual

1.3.4.1 Photos

1.3.4.2 Information on Product Use

1.3.4.3 Design

1.3.4.4 Printing

1.3.4.5 Binding

1.4 Business

1.4.1 Executive Summary

1.4.1.1 Objectives

1.4.1.2 Mission

1.4.1.3 Keys to Success

Market Research

Introduction

Roasting Innovation has completed a competitive analysis of the coffee industry as part of our research for the development of the 300 kilogram coffee roaster. Within our analysis, Roasting Innovation discussed and addressed the issues of the industry analysis, technical analysis, customers and buyers of the product, competitors and their resources, and the client company as well as its resources. The analysis also shows many different patents that will be useful in the designing of the drum, as well as different marketing techniques that could be useful. Overall, the analysis shows the depth of the coffee industry and the variety of areas that could affect the project.

Patents

Coffee Roasting Apparatus and Method – Patent 7143686 describes an industry coffee roaster that includes a combustion chamber and roasting drum. The heating gases for the

coffee beans recirculate through the combustion chamber to remove the coffee bean chaff. Patent 7143686 is applicable to Roasting Innovation's design because it represents an alternative roasting drum design.

Coffee Roaster Drum Rocker Arm Roller Bearing System - Patent 7003897 describes an industry coffee roaster which includes a coffee roaster drum and coffee roaster casing. The casing is fitted with bearings journals to allow the drum to rotate horizontally. The invention also contains notch fittings to keep the drum in place with the casing. This patent is applicable to the design because it represents a way to control the thermal expansion. The patent specifies that industry roasters should use cast iron while designing roasters; however, Roasting Innovation will use stainless steel in its designs.

Method and Apparatus for Roasting Coffee Beans - Patent 6036988 presents a small coffee roaster that uses heated air flow and drum rotation to roast coffee. This patent is applicable to the design because air flow will be the preferred way to heat the coffee beans and also alternative design on a roasting drum.

Fluidized Bed Coffee Roaster – Patent 5394623 describes a self-controlled coffee roaster which monitors the coffee bean temperature. The roaster also injects water into the air stream to quench the coffee beans when the roasting process is complete. This patent is applicable to the design because it is offers a different perspective to roasting coffee beans. Fluidized bed systems allow for controlled mixing and heating because these systems insert small amounts of the product instead of heating the entire product all at once.

Coffee Roasting Process and Apparatus – Patent 5287633 presents an industry coffee roaster that includes drum fins, shaft bearings, and a gear motor. This patent is similar to the

client's current product line and is applicable to the design because it allows for insight into advantages and disadvantages of similar designs. This also would provide some insight on how to control the thermal expansion of high end industry coffee roasters.

Dual shaft pan mixer – Patent 4758095 uses dual shafts with attached paddle mixers. The shafts are connected to a worm gear which is then powered by a motor. The paddles also contain shovels which help mix the solids. The rotations of the shafts are opposite directions, while the areas of sweep overlap each other. This patent shows how dual shaft mixers can be used for food processing methods.

Coffee Roaster – Patent 4691447 presents a coffee roasting drum that rotates on a diagonal axis. The roaster uses air flow to heat the coffee beans. This patent is applicable to the design because a diagonal axis drum allows for easy outlet flow. However, the heating of the drum could be an issue for an industrial sized roaster.

Industrial Economy

The growth of coffee consumption around the world has caused an increase in the coffee industry and the demand for coffee by consumers ever since it was first discovered in Ethiopia around 600 AD. One of the main economic conditions that have directly affected the industry is the changing dietary patterns by consumers and the emphasis on living healthier (IBISWorld). Coffee is actually a healthy beverage for consumers and even can help lower the risks of certain kinds of cancer, Type 2 diabetes, Alzheimer's disease, and heart disease (IBISWorld). This has directly affected consumers within the age group of 18 to 24-years old because they are becoming more health conscious (IBISWorld).

The world price of crude oil is another economic condition that will affect the coffee industry. It impacts the price of transportation, which in turn will affect the profitability of the coffee industry (IBISWorld). This is a very important aspect of the industry because so many of the industry's inputs are from foreign markets (IBISWorld).

Also, the demand from grocery wholesalers, who form a crucial link to supermarkets, supermarkets and grocery stores play a significant role in the economic conditions. Wholesalers, who account for 73.2% of the market, are essential because they affect which products make it onto the store shelves (IBISWorld). The supermarkets and grocery stores are the direct link between producers and consumers; therefore, coffee producers need to establish relationships with the supermarkets and grocery stores to gain competitive advantages (IBISWorld).

The actual price of the green coffee bean crops is another important economic condition for the coffee industry. The green coffee beans are the primary input into coffee production (IBISWorld). This in turn also affects the profitability for producers, which has brought to light the unethical treatment of growers in developing countries, which can affect the price of the coffee beans. Sustainable and fair-trade production is a continuing issue within the coffee industry (IBISWorld).

The coffee industry is growing at a consistent rate despite the global recession and by 2009, over 54% of Americans reported to drink at least one cup of coffee per day (IBISWorld). The increase in the industry is expected to record an average annual growth of 1.8% and to reach a total worth of $6.54 billion in the United States by 2010 (IBISWorld). By 2015, the industry is predicted to grow at an average annualized rate of 2.0% while reaching a total

worth of $7.22 billion (IBISWorld). Part of the increase in the industry is the increase in consumption for health benefits but also there is a wider range of flavors available, which has stimulated demand.

The supply of coffee beans is the foremost concern for the industry and plays an important part in its current size and ability to grow. Coffee is grown in rich soil, primarily in high altitude, tropical climates near the equator. The main countries which grow coffee beans are Ivory Coast, Puerto Rico, Costa Rica, Mexico, Guatemala, Kenya, Colombia, Yemen, Ethiopia, Brazil, and Indonesia. The primary coffee producer in the United States is Hawaii.

Coffee bean prices can be very unpredictable due to weather conditions that play an important part in the profitability of the coffee industry (IBISWorld). For example, in 2007 production revenue fell 9.9% due to adverse weather conditions (IBISWorld). Ethical consumerism plays an important part in the production of coffee beans. Out of the world's coffee, 50% is grown by small family growers in developing countries (IBISWorld). Many coffee retailers and consumers today take into account the issue of fair-trade when buying or selling coffee including Dunkin' Donuts, Starbucks and McDonald's (IBISWorld).

Over the last five years, the coffee industry has witnessed a 1.6% increase in the number of coffee production establishments annually (IBISWorld). The employment increased at a slower rate of 1.1% over the same period of time (IBISWorld). Also, the consumption of coffee has grown from an average of 24.3 gallons of coffee per person per year in 2005 to 24.7 gallons per person per year in 2009 (IBISWorld). While this may not seem like an extreme increase, it is still enough to play a significant role in the industry. Gourmet and imported coffee

have also helped to increase the coffee industry. On average, 17% of the adult population consumed a gourmet beverage, including tea or coffee, on a daily basis (IBISWorld).

Standards

The industry standards for the coffee industry, especially for coffee roasters, can range into a variety of different categories and there are not any major or specific standards that are required for the coffee roasters. Most of the standards refer to the beans and their quality. There are two standard grades, premium and specialty (Specialty Coffee Association of America, SCAA). According to the SCAA, beans should not have any primary defects and a maximum of five secondary defects, which include parchment, hull or husk, broken or chipped beans, insect damage, partial black or sour, shell, small stones or sticks, or water damage to the beans (SCAA). The beans should have 10-12% moisture content. They should also meet the SCAA's cup evaluation of eighty points or above, which is based on a sixteen point scale which evaluates eleven different coffee characteristics (SCAA).

The ethical treatment of workers is becoming a growing standard within the industry. It is becoming more and more common for ethical treatment of workers, especially in developing countries, to be a deciding factor in the production or purchasing of coffee. Ethical coffee groups and lobby groups are developing and establishing new standards defining what is considered unethical treatment of workers within the coffee industry (IBISWorld).

Regulations

The government regulations for the coffee industry are still developing because the industry itself is still developing. However, some of the major regulations that could affect U.S. Roaster Corp are air quality regulations. Many of these are done on a state or county level and

there are not any on a federal level specifically for coffee roasters. Specifically in Sacramento County, California, there are regulations on air quality and emissions due to coffee roasting. Attached in Appendix B is the listing of all the specific regulations for this part of California that will be a possible restraint for U.S. Roaster Corp.

Also, the environmental impact from the Environmental Protection Agency regulates the food processing side of the industry. Many environmental regulations affect U.S. Roaster Corp including the Clean Water Act, Clean Air Act, Pollution Prevention Act and the Resource Conservation and Recovery Act (IBISWorld). However, these do apply more to the food processing side of the industry including the grinding as opposed to the roasting. However, the Pollution Prevention Act currently lacks the regulatory power need to encourage companies to implement pollution prevention practices (IBISWorld.)

The regulation of public health and product labeling also affect the coffee industry. The Food and Drug Administration (FDA) is the primary regulator of public health and product labeling. The FDA requires that all of the coffee have the proper labeling that includes the nutrition information and bears nutrient content claims as well as certain health messages available to the consumers (IBISWorld).

Competitors

U.S. Roaster Corp has many competitors and some of these competitors have resources that exceed those of US. One of the major competitors is Primo Roasting. Primo Roasting was founded 26 years ago by Marty Curtis, and specializes in roaster rebuilding and performance enhancement as well as afterburner design and fabrication. Primo Roasting is

located in Rose Bud, Arkansas. Primo's largest roaster is their PRI-265 which holds 310 pounds of green coffee beans. They use the Internet for their primary marketing strategy.

Another competitor that U.S. Roaster Corp faces is Has Garanti. Has Garanti is based out of Turkey, and sells in 15 different countries; America, Canada, England, Australia, New Zealand, South Africa, and Taiwan but most of their products are sent to Europe and African countries. They were founded by Remzi Aydin in 1954. Their largest roaster is the HSR 180 which is considered one of their industrial roasters and it holds 180 kilograms (396.83 lbs.) of green coffee beans. They use word of mouth and the Internet for marketing.

The third competitor is Ambex Roasters, and was founded by Terry Davis. Ambex sells roasters, controls, equipment, maintenance, and also provides training. They are based in Clearwater, Florida, and try to visit many trade shows. Their largest roaster is the Ambex YM-120 and it holds up to 240 pounds maximum. They rely solely on word of mouth and the Internet for their marketing.

Next is Diedrich Manufacturing. Diedrich is out of Idaho and is a family company. The actual company was founded in 1980 but they were around before then. Diedrich attends several industry events; four are on the schedule until September 2011. They rely heavily on the tradeshows for their marketing. They have two series of roasters, the IR and the CR. Of the IR series the largest is the IR-12 that holds 12 kilograms of beans. The CR series, on the other hand, is quite a bit bigger. The largest that they have a picture of on their website is the CR-350 which holds 350 kilograms but they do have drawings for up to the CR-490 which would hold 490 kilograms (1080.27 lbs.) of beans.

U.S. Roaster Corp's last competitor is Probat. They were established in 1868 but their first roaster did not come out until 1920. They are located primarily in Germany but also have companies in Italy, U.S. and Brazil. They advertise that they can process cocoa, nuts, malt, and coffee. Probat publishes a magazine that began in 2006 called LEONARDO, which is their major marketing strategy. They have even started to offer what they are calling environmental friendly exhaust gas treatment. But, even with this treatment their roasters do not pass air quality regulations in southern California. Probat has three different lines of roasters. First in their Saturn line, the largest they have made so far, is the Saturn 4000 and it holds between 350-550 kilograms of beans. Second is the Neptune line, where their largest is the Neptune 1500 and it is stated to hold between 240-320 kilograms. Lastly is the Jupiter line, the largest is the Jupiter 5000 which holds between 550-750 kilograms of beans.

Client Characteristics

Buying practices for US include purchasing metal from Boyd Metals, AF Co., Jorgensen, and Special Metal. While it is necessary to purchase some materials, U.S. Roaster Corp prefers to, and primarily builds all of their equipment in house.

The current market size for US is $2.5 million each year. However, assuming every job works out flawlessly, the potential market size could be up to $5 million each year. This means that this year they will sell $2.5 million worth of their coffee roasters and rebuilding services. After the finishing of the 300 kilogram roaster they expect their gross sales to expand to $5 million per year, therefore doubling their profit from sales.

U.S. Roaster Corp attends approximately two trade shows a year and has subscriptions to several coffee industry magazines. U.S Roaster Corp obtains many of its product and

rebuilding sales by going to trade shows but does not currently advertise in any of the coffee industry magazines. Currently, U.S. Roaster Corp is selling to average sized corporations and small startup companies, as well as to companies that are not directly associated with the coffee industry, such as to Lowe's corporate office. They plan to begin selling to big-name coffee corporations such as Folgers and Starbucks by building larger, industrial sized coffee roasters such as the 150 kilogram and 300 kilogram coffee roasters. The larger coffee roasters would be more desired by the larger coffee corporations because they roast large amounts of coffee every day to sell to their customers and a smaller sized coffee roaster would not be able to keep up with the demand.

The main customers for the 300 kilogram coffee roaster will be coffee professionals. They desire gourmet coffee and demand consistency in how their coffee tastes. They are food service professionals who sell their coffee to loyal customers. The buying firms that would purchase a 300 kilogram coffee roaster are companies such as Starbucks, Folgers, and some hotel chains. These companies are picky and need their coffee to taste perfect, or at least consistent. The owners and employees of the companies who would purchase a 300 kilogram tend to be more affluent people who demand consistent, high quality taste in their coffee. These companies often appeal to wealthier people, and sell their coffee as being the best.

The products produced by US are currently used solely to roast coffee beans. However, it could also be used to roast nuts, other beans, and almost any other grain type food. There are many different markets which a 300 kilogram coaster could be a part of, but US would prefer to stay solely within the coffee market.

There are online resources such as Coffee Universe at coffeeuniverse.com. On this site, coffee lovers can learn about coffee and they can also purchase coffee roasters and various other coffee related machines. There is also market research available in coffee houses and coffee providers' stores. Some of the companies that US could market with would be Java Dave's, Starbucks, Seattle Coffee, Folgers, and some hotel chains. Additional market research should be done with magazines. Roasting Innovation has already researched a list of potential magazines available for US to advertise and market in. Some magazines that could be used are Café Magazine, Coffee Explorer, Coffee Geek, and Coffee Review. These magazines are primarily viewed by others within the coffee industry. Many coffee producers, coffee roaster manufacturers, coffee retailers, and coffee consumers all look at these magazines.

Environmental, Societal and Global Impacts

Southern California has more strict air pollution emission regulations than any other area of the United States of America. Currently, there are not any roasters sold on the market that are allowed to be operated in southern California because they exceed the more strict air quality regulations. U.S. Roaster Corp plans to be the first company to build an industrial coffee roaster which can legally operate in this area of the United States of America. Comparisons of the Air Quality Standards can be seen in Appendix A.

Design Requirements

- Hold 300 kilograms worth of coffee beans
- Allow for a 30% volume clearance of open space in the drum after the coffee beans have been roasted

- Improve the exiting of the coffee beans from the roaster to the cooler
- Account for thermal expansion
- Maintain mixing standards so as to reduce over-, under-, and uneven roasting
- Needs to meet air quality standards in Southern California, the highest in the United States of America

Alternative Design Concepts

Design 1: Hook Rotating Drum

In this proposal, the typical fin design would be replaced with horizontal hooks which would be welded along the entire length of the drum. These hooks would pick up the beans and then throw them in the air during each rotation. This would create a semi-fluidized motion for the coffee beans and encourage even roasting of the coffee beans. On the back end of the drum would be a screen. When the roasting is completed the screen could be moved along the entire length of the drum, pushing all of the roasted coffee beans through the outlet of the drum. This allows for quick evacuation of the coffee bean, again allowing for a more even roasting.

Figure 1: Drum

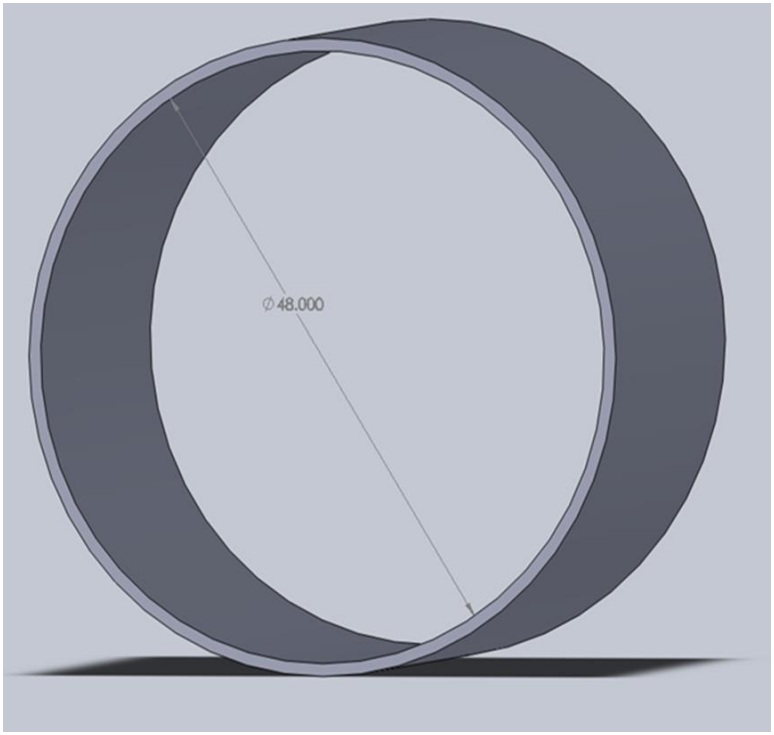


Figure 2: Drum with Hooks and Axel

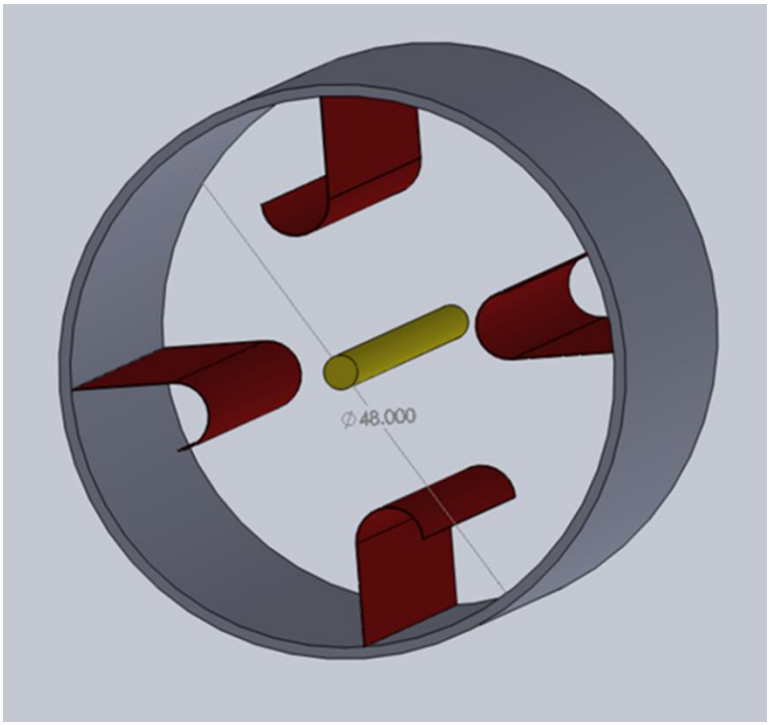
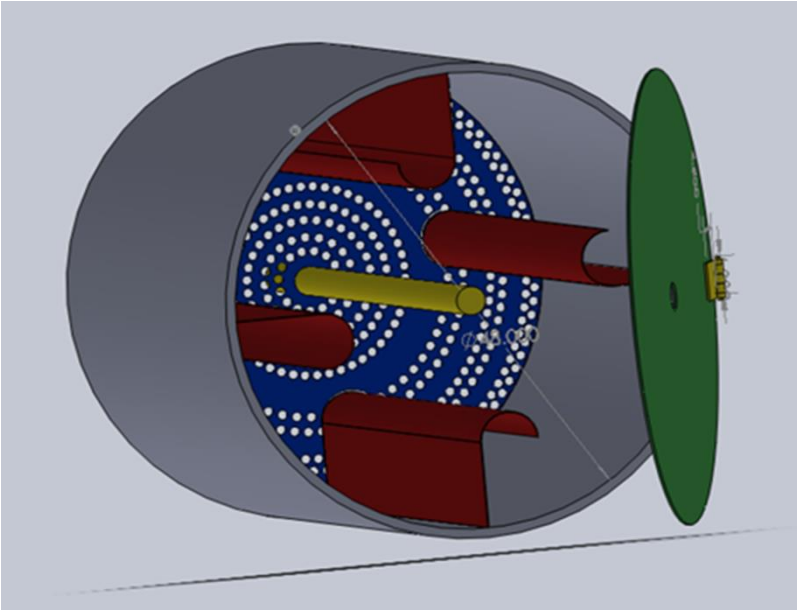


Figure 3: Assembly of Hook Rotating Drum Design



Design 2: Single Paddle Mixer

This design features the traditional roasting drum shape but it differs in mixing method it uses. This proposal uses a single rotating paddle to keep the beans mixing and roasting evenly. The paddle design will also be more efficient than the traditional rotating drum designs. It will accomplish this by requiring a smaller power source to rotate the paddles. This design will also feature a door at the bottom of the fixed drum. This allows for a faster exit for the coffee which interns permit a more even roast of the beans. The barrel would be heated one of two ways. The first possibility is to keep the current heating system in place. The second option consists of feeding the hot air into holes cut into the bottom or top of the drum. Either of these would be valuable options.

Figure4: Drum

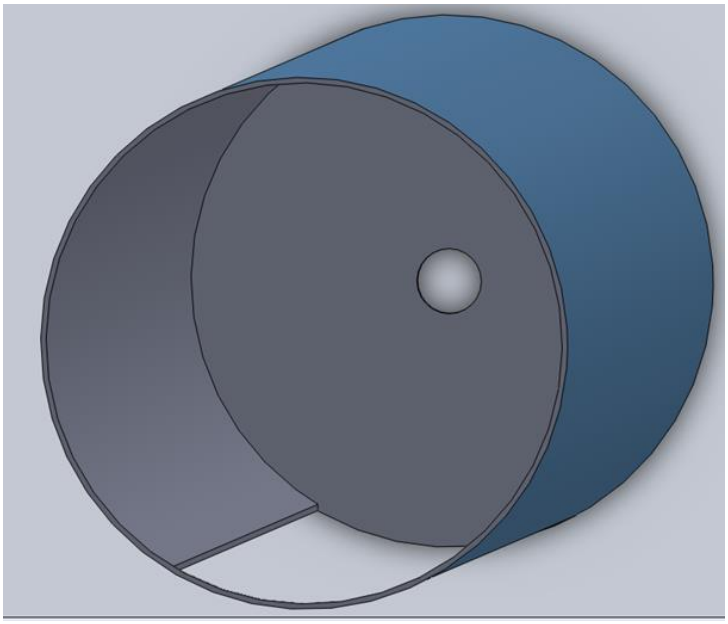


Figure 5: Drum with Paddles

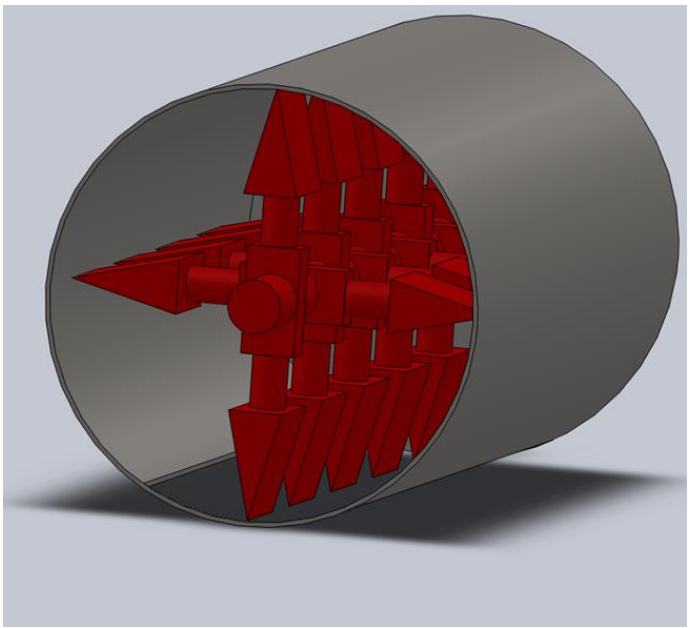
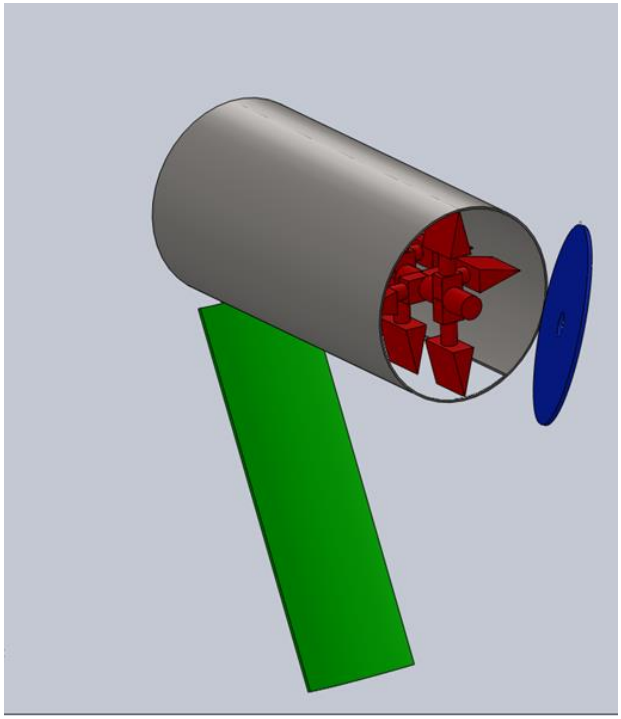


Figure 6: Assembly of the Single Paddle Mixer



Design3: Dual Paddle Fluidized Mixer

In order to offer optimal roasted coffee, the coffee must be evenly roasted through fluidized mixing. However, the traditional design of an industry coffee roaster could be changed slightly in order to accommodate for thermal expansion. Traditional roasters use coffee ovens or drums that rotate on a horizontal axis. The dual paddle fluidized mixer is designed to more efficiently mix the coffee beans while maintaining a similar aesthetic look to traditional roasters. The design no longer encompasses a roasting drum, but instead relies on two shafts with sweep paddles. The shafts are powered by gear sets and motors. The sweep paddles will be offset on the two shafts to efficiently move the coffee beans. The roaster will be heated through air flow coming from four nozzles that are placed at the top of the roaster. The coffee beans enter from the inlet situated on top of the roaster. The coffee beans will then land on the

sweep paddles. The sweep paddles will turn in opposite directions at 35 rpms. After the coffee beans are roasted, the roaster doors will swing open and allow the coffee beans to fall onto the cooler. This roaster will also contain a front face plate to allow for maintenance applications.

Figure7: Frame of Dual Paddle Mixer

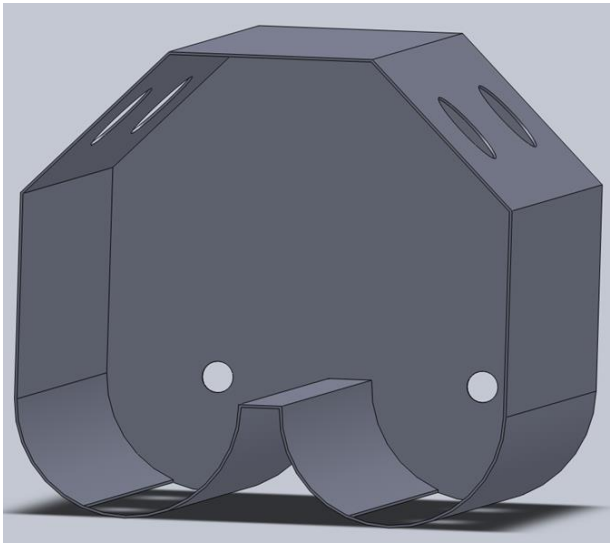


Figure 8: Frame with Paddles

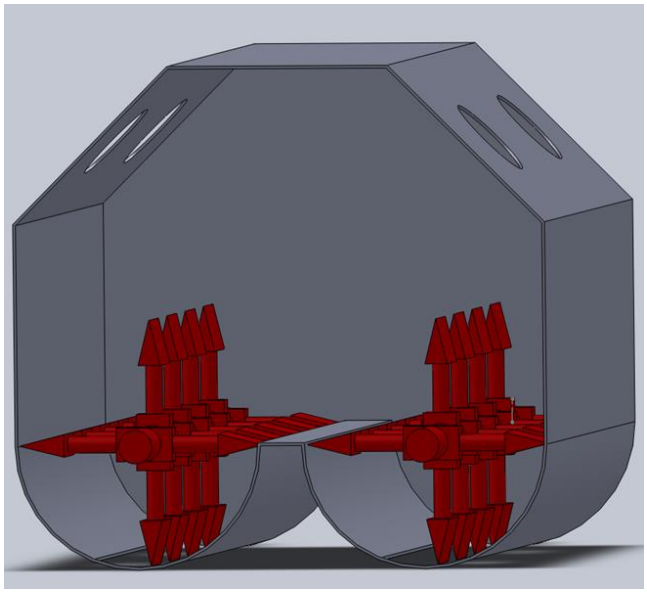
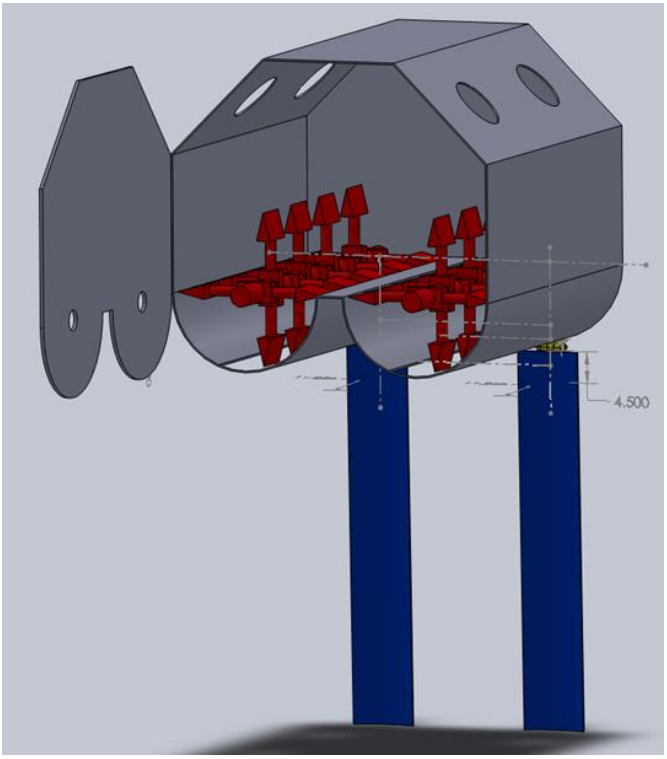


Figure 9: Assembly of Dual Paddle Mixer



Calculations and Testing

Calculations

Volume

Determining the volume, diameter, and length of the 300 kilogram drum are the first calculations that need to be completed in order to come up with a basic drum design. The drum's volume was calculated using *Equation 1*. Using the 150 kilogram drum already developed by U.S. Roaster, a rough estimate of the overall drum volume was determined. The

diameter and length of the drum were then calculated using the volume. *Equation 2* is to calculate the volume of the dual paddle fluidized mixer.

$$V = \frac{\pi}{4} * D^2 * L \qquad \textit{(Equation 1)}$$

Where: V = volume of the drum (feet^3)

D = diameter of the drum (feet)

L = length of the drum (feet)

Table 2. Diameter and length calculations based on the volume of the drum

Drum Volume Calculations			
Diameter (feet)	Length (feet)	Diameter: Length	Volume (feet^3)
4	5	1.250	62.8
4	4.5	1.125	56.52

$$V = \left((\pi * r^2) + (s * d) + \left(\frac{1}{2} * h * (s_T + d)\right)\right) * L \qquad \textit{(Equation 2)}$$

Where: V = volume of the drum (feet^3)

r = radius of the swing doors (inches)

s = side length of the drum (inches)

s_T = side length of the top (inches)

d= internal distance (from side to side) of drum (inches)

L = length of the drum (feet)

Table 3. Volume Calculations of the Dual Paddle Design

Drum Volume Calculations						
Side Length (in)	Length Top (in)	Radius (in)	Length (in)	Height (in)	Distance (in)	Volume (feet3)
19.5	19.5	12	54	13.8	51	60.8
20	21.5	12	54	14.1	51.3	78.3

The diameter: length ratio also needs to be considered. The design specifications require the length of the drum to be no greater than 25% of the diameter. Therefore, based on the calculations and specifications the proposed diameter and length of the drum is 4 feet and 4.5 feet, respectively. These results can be seen in Table 2. The dimension calculations for the dual paddle fluidized mixer can be seen in Table 3.

Thermal Expansion

Changes in temperature cause metal to contract and expand. The amount of expansion due to temperature increases is dependent upon what type of metal is subjected to the heat. When a metal such as stainless steel is heated it can expand considerably, while cast iron expands a relatively small amount. This can become a serious design issue with coffee roasters because they can reach temperatures up to 1000^{o}F. Special design requirements must be met in order to build a large, industrial coffee roaster which can function properly at these temperatures. In order to take in account the thermal expansion in the coffee roaster

design, the amount of expansion must first be calculated. The thermal expansion can be done using *Equation 3*.

$$\Delta L = c * L_i * (T_f - T_i) \qquad \textit{(Equation 3)}$$

Where: ΔL = the change in length due to thermal expansion (inches)

c = coefficient of thermal expansion (/Fahrenheit)

L_i = initial length of the drum before the temperature change (inches)

T_f = the final temperature (Fahrenheit)

T_i = the initial temperature (Fahrenheit)

Using Equation 3, the results for the amount of thermal expansion that is calculated when heating chromium stainless steel, alloy steel, stainless steel, and carbon steel up to 1000°F can be seen in Table 4.

Table 4. Change in length calculations based on the thermal expansion of different materials.

Thermal Expansion Calculations					
Material	Length$_i$ (in)	Temperature$_i$ (°F)	Temperature$_f$ (°F)	Coeff. (/°F)*	Change in Length (in)
Cr Stainless Steel	54	70	1100	0.00000663	0.382
Alloy Steel	54	70	1100	0.00000722	0.416
Stainless Steel	54	70	1100	0.0000103	0.594
Carbon Steel	54	70	1100	0.00000797	0.460

*Coefficients were obtained from Hose Master, LLC at http://www.hosemaster.com/products/technical/thermalexpansion.php.

Based on the information in Table 6, the material which provides the least amount of thermal expansion is the chromium stainless steel. The material which has the largest amount of expansion due to temperature change is stainless steel. A cost analysis must be done in order to determine whether the cost addition of reducing thermal expansion is necessary.

Tests to be Conducted

Test #1 Mixing

We will test the mixing of the beans once we develop a new fin design. We will paint the beans several different colors according to where they are placed in the drum. We then will rotate the drum to see if the beans mix well with the new fin design. Mixing is important to prevent under or over cooking and uneven cooking of the beans.

Test #2 Uniform Heating

We will test the uniformity of the heating of the coffee beans. Uniform heating is necessary for quality roasting in order to avoid uneven bean roasting. It also helps prevent under roasting and over roasting. We will test the heating by placing thermocouples around the drum and test to see how much the temperature varies.

Test #3 Pressure

We would like to increase the pressure inside the drum slightly in order to improve the overall efficiency of the roasting. This may be done by the addition of low levels of Nitrogen into the drum. Nitrogen would be used to create a more anaerobic environment for reasons discussed in *Test #8 Anaerobic*.

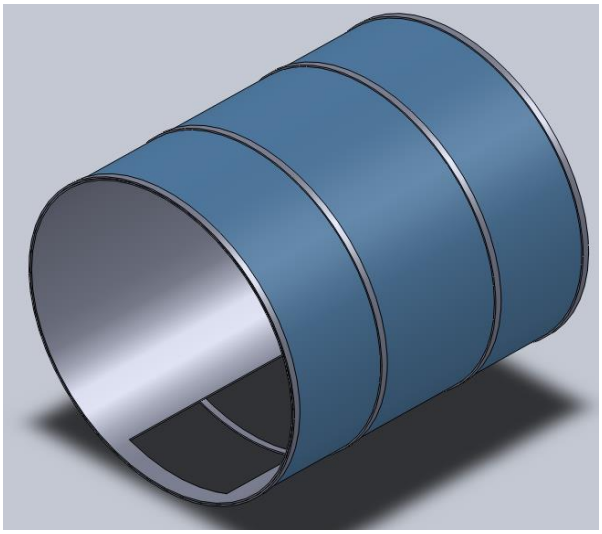
Final Prototype Design

After consulting with US Roaster Corp, Roasting Innovation decided to move forward with Design 2: Single Paddle Mixer.

Drum Specifications

One of the most important features of US Roaster Corp's roasters is their drum. However, in our design we decided to rotate the center shaft instead of the drum, which makes the drum in our design much less important. The drum is 54 inches long and has a 48 inch inside diameter. The design requirements for the drum include developing a way to keep the drum as close to round as possible, even after years of use. This was accounted for by manufacturing and attaching rings on the outside of the drum made of thick steel that will be resistant to bending for a long period of time. The second design requirement for the drum deals with creating an opening at the bottom for the belly dump style door. The door is further explained in detail later in this section of the report.

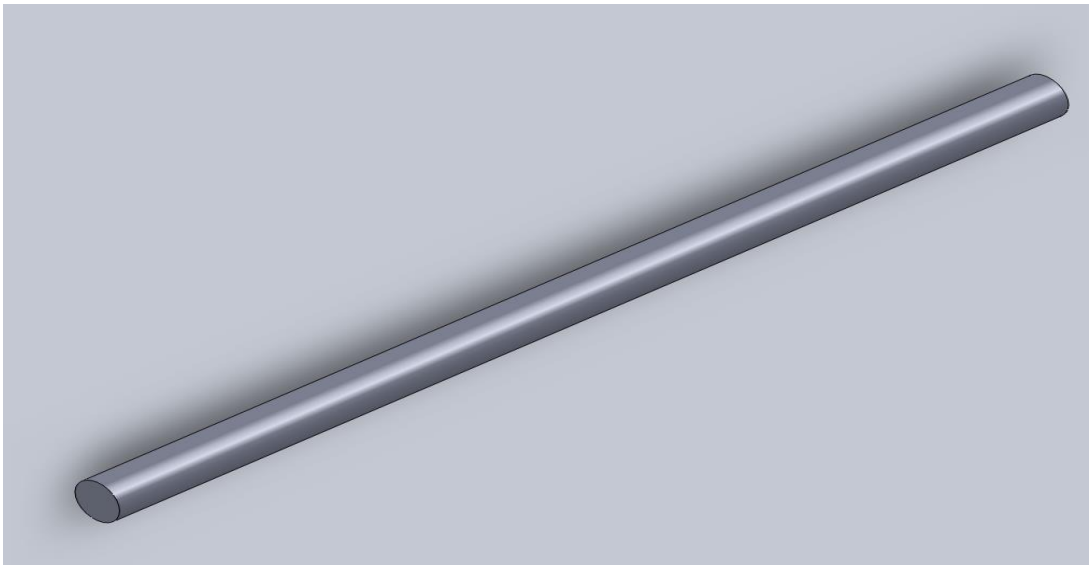
Figure 10. Solidworks Drawing of 300 Kilogram Drum



Shaft Specifications

The shaft consists of a circular rod. The length of the shaft will be 58 inches and the diameter of the shaft is 3 inches and the end being keyed to 2 inches to fit the gearbox. The paddles and gearbox will be connected to the shaft. The shaft will be inserted inside the drum and driven by an electric motor. The shaft will be made out of mild steel for the prototype, but will need to be made of stainless steel for the actual application. The shaft will rotate at a speed of 35 rpm to 44 rpm. The shaft had to be designed to be support the paddles and coffee beans.

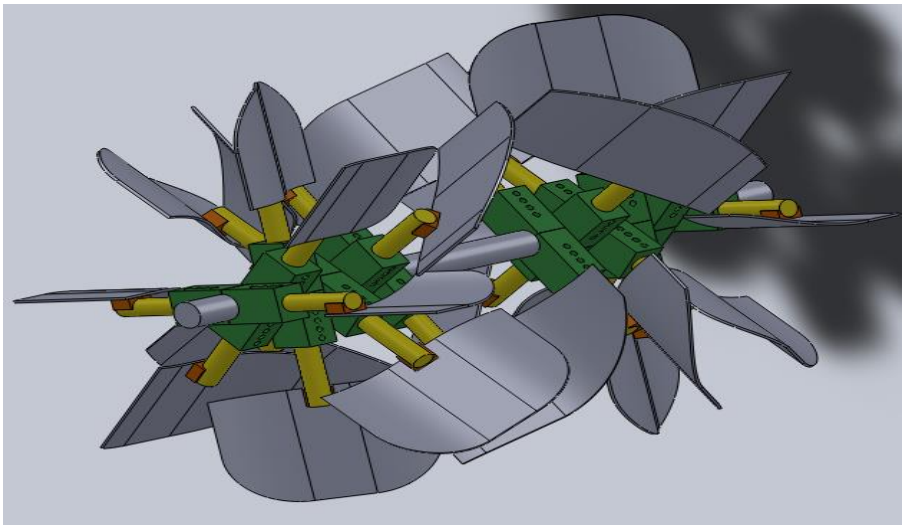
Figure 11. Solidworks Drawing of 300 Kilogram Roaster Center Shaft



Paddles Specifications

The paddles consist of an assembly of parts. The assembly consists of the fin, the fin rod, and the fin base. The fin is the end of the total assembly and constitutes all of the mixing. The fin rod connects the fin to the fin base. It also is machined with holes that make the overall paddle height adjustable. The fin base connects the fin and fin rod to the drive shaft. It also has holes machined to allow for the height adjustment. The holes in the fin base and rod had to be specifically located so that the height of the entire paddle assembly could be shortened and lengthened by a 1/8 in. The fin is made from thin sheet metal and has a much larger surface area that the other two paddle parts. Its surface area is larger to accomplish the appropriate bean mixing that was desired by our client. The fins are also curved; this curvature allows for the beans to be cycled from the outsides to the inside of the drum. Most of the fins, unlike the fin bases and rods, were designed in different shapes. This was done to permit the clearances needed for movement. The fins also have a rounded top, this feature allows for a smaller gap between the drum and paddle assembly.

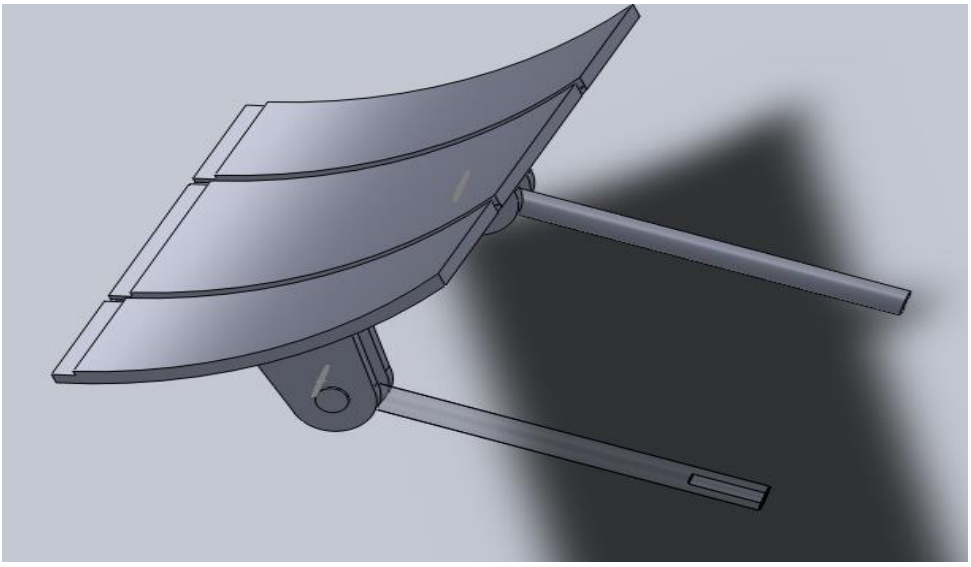
Figure 12. Solidworks Drawing of Paddle Design



Door Specifications

The door used to dump the beans in this roaster design is one of the major differences of this roaster from the other roasters the US Roaster typically builds. US Roaster usually has a door on the front face of the roaster which slowly dumps the beans into a cooler. This causes the beans in the back of the roaster to be roasted longer than the beans which exit first at the front of the roaster. The belly dump door design allows for all of the beans to exit the roaster at the same time, allowing for more even roasting. The door opens along the long side of the roaster and swings open with the assistance of hinges and pneumatic cylinders. The pneumatics allow for complete control of the closing and opening of the door.

Figure13. Solidworks Drawing of Belly Dump Door Design



Drive Train Specifications

The drive train consists of a variable speed drive (GS2-4010), electric C-Face motor (Baldor CEM3311T), and a gearbox (Quantis CUSTOM BB883CN210TC).

Automation Direct GS2-4010 specifications include:

CATALOG NUMBER	GS2-4010
MOTOR RATING [HP]	10
RATED OUTPUT CAPACITY [kVA]	13.7
RATED INPUT CURRENT [A]	23
RATED OUTPUT CURRENT [A]	18
WEIGHT [LB]	8.5

Figure 14. Automation Direct Variable Speed Drive

Quantis CUSTOM BB883CN210TC specifications include:

CATALOG NUMBER	BB883CN210TC
PRODUCT CATEGORY	RIGHT ANGLE HELICAL-BEVEL
PRODUCT TYPE	RHB
MOTOR TYPE	NEMA
MOTOR FRAME	210TC
INPUT SPEED [RPM]	1750
RATIO	34.4
OUTPUT SPEED [RPM]	51
OUTPUT MAX TORQUE [IN-LB]	14604
SERVICE FACTOR	1.00
MAX INPUT POWER [HP]	11.79
OUTPUT CONFIGURATION	FOOT MOUNTED
WEIGHT [LB]	169

Figure 15. Baldor Gear Reducer

Baldor CEM3311T specifications include:

CATALOG NUMBER	CEM3311T
SERVICE FACTOR	1.15
OUTPUT [HP]	7.5
SPEED [RPM]	1770
FRAME	213TC
FL EFFICIENCY [%]	91
WEIGHT [LB]	120

Figure 16. Baldor Electric Motor

Complete specifications tables are attached in Appendix E.

Pneumatic Specifications

Figure 17. Pneumatics System Connected to the Drum Door

The pneumatic system in the project was used to open and close the belly drop door. The system consisted of two pneumatic cylinders with a 2.5 in. bore and a 10 in. stroke, two mufflers, a directional control valve, ¼ in. plastic tubing, and several fittings to connect everything. The cylinders were used to do the actual work in open and closing the door. The directional control valve was used to control the motion of the cylinders. The mufflers control the speed at which the door opens and can be adjusted to allow the door to open faster or slower. The tubing and fittings are used to connect all of the pneumatic components together. We did not supply a compressor; rather we used the supplied shop air. The systems operating pressure is 100 psi.

Media and Communications

1. **Campaign Problem**

U.S. Roaster Corp needed a change in their marketing campaign to provide a more uniform and appealing campaign materials. Many of their current materials are outdated and have an overwhelming amount of information on one element.

2. **Previous Campaign Material**

U.S. Roaster Corp previously had promotional brochures, a logo, website, business card and a product label for their campaign materials. U.S. Roaster Corp was open to new promotional campaign materials such as a user manual and to all other campaign revisions besides altering its current logo. The company felt that they had already built up brand recognition with their current logo and did not want to lose that brand recognition.

After evaluating the company's previous campaign materials, many of them did not have a set color scheme that went along with the logo, differing text fonts, and unexplained graphics. The previous brochure was also outdated and contained information that needed to be updated. The information was also presented in an unorganized manner that made the brochure difficult to read and follow. Also, many of the pictures were of a poor quality and needed to be changed to provide a more professional appearance to potential customers. Ultimately, a decision was made to update, modernize and re-evaluate the brochure for the 300 kilogram roaster and to provide a new user manual, business card, and specifications sheet.

3. New Campaign Elements

We created a new campaign that had a specific color scheme to show cohesiveness between the company and all of their campaign materials, especially their current logo and website. We began this process initially by using the logo and a starting point and building the other materials around it.

Website

Roasting Innovation has developed a team website to promote the work done on the 300 kilogram roaster as well as the promote aspects of the marketing plan. This helps with the visibility of the product. This website was built for the purpose of promoting our team design, but U.S. Roaster Corp may use it in the future on their website.

Specifications Sheet

Roasting Innovation has developed a specifications sheet to be used to give the specifics of the coffee roaster. It allows U.S. Roaster Corp to adequately discuss the details of the roaster with their customers. It will include the same fonts and color scheme as the rest of the campaign materials to provide a uniform look to all campaign materials for the 300 kilogram roaster. We are not planning to have the specifications sheet specially printed so that U.S. Roaster Corp can easily print the sheet as they need it for their customers and clients. A copy of the specifications sheet can be seen in Appendix E.

Brochure

A promotional brochure was also developed for the marketing campaign. The brochure explains the new coffee roaster and the capabilities of the roaster, as well as how it can improve current roasting processes. Also in the brochure, we decided to include the product and services offered by the company as well as the history of the company. We also decided to make the promotional brochure a mailer so if our client chose to send the brochure to current customers, it would be more affordable to mail. The brochure will be sent out to customers, along with the specifications sheet. It will also be used at trade shows, conferences and other industry gatherings. The brochure was created to be 14 inches long and 8.5 inches wide, which allows the document to be printed on one sheet of standard legal size paper. The finalized promotional brochure can be seen in Appendix F.

User and Safety Manual

We decided to build all of the campaign materials and their color scheme off of the current logo that U.S. Roaster Corp is using. Also, we developed a user and safety manual on how to use the coffee roaster was developed for customers and purchasers of the 300 kilogram roaster of U.S. Roaster Corp. Our client's safety and user manual also goes along with the color scheme, texts, and design concept as the promotional brochure. We included the following information in the manual to provide general information to the customer on how to operate the roaster. We include operational requirements, general safety, pre-operations, operation, post operation, technical data, hazard analysis, applicable standards and applicable regulations. The user and safety manual will be standard paper size of 8.5 inches wide and 11 inches long. This will

allow our client to print the manual easily and will also make the manual to be bound like a book easily as well. The unbound version of the user and safety manual can be seen in Appendix G.

Business Card

Our final aspect of the campaign material is a business card that goes along with the color scheme, texts, and design concepts as well. The business card will be used along with the promotional brochure to present a united and uniform campaign for the 300 kilogram roaster and U.S. Roaster Corp. A copy of the business card can be seen in Appendix H.

4. Campaign Elements Cost

The communications and campaign plan consists of three elements that need to be printed. All elements can be printed from FedEx and prices were found at fedex.com. The promotional brochure can be printed for $199.99 for 250 brochures and can be mailed for $0.44 cents each, according to the United States Postal Service website.

The user and safety manual can be printed for $19.95 each. And the business card can be printed for $19.99 for 250 business cards.

Business Plan

1. Executive Summary

U.S Roaster Corp has been developing larger roasters to appeal to an increased market. They have encountered a few problems with thermodynamics which they have asked Roasting Innovation to help with. Roasting Innovation needs to design and produce a drum and drive train for a 300 kg roaster that can withstand high temperatures. The 300 kg roaster needs to be reliable, easily reproducible, and remain safe to operate.

1.1. Objectives

U.S. Roaster Corp expects that this product will raise approximately 3 million dollars per year for their company.

1.2. Target Customers and Market Analysis

Currently, U.S. Roaster is selling to middle income and wealthy corporations. These companies are not always associated with the coffee industry. They plan to begin selling to big-name coffee corporations. In order to attract the bigger companies into buying their products they are beginning to move away from the smaller roasters on their line, and trying to build bigger roasters which the big name coffee companies would be more interested in buying. The customers for the 300 kilogram coffee roaster will be coffee professionals. They desire gourmet coffee and demand consistency in how their coffee tastes. They are food service professionals who sell their coffee to loyal customers.

1.3. Positioning, Value Proposition (Benefits)

Since the roaster is going to be twice the size of U.S. Roaster Corp's largest current roaster the clients that use this roaster will be able to roast twice as much in the same amount of time. This will be very beneficial for growing companies. We hope that the 300 kilogram roaster will be consistent with the roasters that our clients have currently. This will in able an ease of transition from the current roaster to the new 300 kilogram roaster.

1.4. Features

- Superior Mixing
- Belly Dump for quick evacuation of beans
- Front door for easy cleaning
- Available for Revelation upgrade
- Easy to follow user manual

1.5. Sales and Marketing Strategy

Our target audience will be reached in a variety of ways. There is a fully functioning website that will include ordering information. Representatives from U.S. Roaster Corp will be attending many trade shows throughout the year to give demonstrations and provide advertising. There will be a brochure dedicated to the 300 kilogram roaster specifically. Customers can also call the U.S. Roaster Corp office to obtain information about the different roasters and services that they offer.

1.6. Financial/Business Case

Rough estimates show that we could sell approximately 5 roasters per year. This is a conservative estimate. At $ 300,000 we would be forecasting approximately $1,500,000 in revenue per year.

1.7. Competitive Products

U.S. Roaster Corp is completely American made unlike most other coffee roaster manufacturers. They also have very quality products for the price customers pay. Their knowledge of the industry and the experience rebuilding other company's roasters put them above the competition.

Competitors:

1. Primo Roasting- PRI-265 holds 310 lbs. of green beans
2. Has Garanti- HSR-180 holds 390 lbs. of green beans
3. Ambex- YM-120 holds of 240 lbs. of green beans
4. Diedrich Manufacturing- CR-490 holds 1080 lbs. of green beans
5. Probat- Jupiter 5000 holds 1650 lbs. of green beans

2. Target Customers

U.S. Roaster Corp targets their previous customers for return business. For secondary customers U.S. Roaster Corp relies on word of mouth and the internet to refer people to them. Roasting Innovation has compiled a list of U.S. Roaster Corporation customers whom were contacted to complete a survey on their preferences including their current roasters (Table 5).

Customers	Contact Person	Roaster Purchased	Contact Number	When Contacted	What do you value most about your current roaster?	What is somehting that you wouldn't change about your roaster?	Would you buy another roaster from U.S. Roaster Corp? Why?	If you had to change one thing what would it be?
Broadway Café	Jon Cates	Sample Roaster	816-679-5897	11/17/2010	Mostly roasts with Deidrich roaster ease of maintenance	Likes to be able to roast and cool at the same time and likes to roast smaller batches than what the max is.	Yeah, if they could be up to the standards of Deidrich	Temperature readout, wants as many probes as possible
Charlie Bean	Charles Mangus	5 Killogram Roaster	405-642-5964	11/29/2010	Druability	Way its fabricated- out of solid steel	Yes, good service and very reliable	More user friendly computer screen
Down East Coffee	Terry Montague	12 Killogram Roaster	506-576-9292	11/29/2010	Looks nice and roasts good tasting coffee	Energy efficient	Yes, nice people	Needs to mix better
First Light Coffee Roasters	Walt Manchester	12 Killogram Roaster	207-655-1196	11/17/2010	automation (PLC)	Anything	Yes, very good quality and really nice people	Improve the software and automation. The roaster software is supposed to be able to monitor temperature and adjust the gas to the profile but it doesn't really work
Forestdale Coffee	David Edwards	3 Killogram Roaster	423-677-1473	11/17/2010 Left Message	Energy efficient	Looks nice	Yes, good people there	Easier maintenance entry points, mixing could be better
Mystic Coffee Roasters	Sharon Hepburn	5 Killogram Roaster	781-420-2344	11/29/2010	They get lots of use out of it.	the fuel is gas	Yes, they are nice and easy going	Maintenance is a little difficult. Getting to certain places is not easy.
Red Rooster Coffee Co.	B. Osborn & H. Polseno	3 Killogram Roaster	540-797-3746	11/17/2010	Looks really nice, and energy efficient	airflow monitor	Yeah, they are easy to deal with, low cost for what you get and American made	The entry and exit panels get gummed up and are hard to clean. There is not good access to under the drum, there are 2 bolts and they get really hot. Basically have to wait to the next day.
Roastmeisters Coffee	David Fullerton	12 Killogram Roaster	508-756-9446	11/17/2010	Recirculating air, all electric	environmentally friendly	Yes, they have good services	Make it easier to clean the catalyst without big machinery
Serenus Coffee & Tea	Steve Souphanthoung	5 Killogram Roaster	416-727-7209	11/17/2010	Don't use it right now	any change that is for the better	Depending on the future product, if good then yes	Better bean mixing

Table 5: List of customers, contact information, and questions they were asked.

3. Target Users

The primary users of this product will be larger coffee houses and roasting factories. The people who will use the machine will monitor the temperature and capacity throughout the roasting process. This product will help smaller coffee houses grow tremendously

through the exponentially larger capacity of the roaster. Being more energy efficient and cost efficient will also help the smaller business grow when they use this product.

4. Product Description & Positioning Statement

For the owner of coffee houses who would like to grow their business with a larger roaster, U.S. Roaster Corp with their 300 kilogram coffee roaster is a roasting product that is highly energy efficient, cost efficient, American made, and comes with a company that has a high level of expertise in the rebuilding/manufacturing coffee roasters. Unlike Probat or Deidrich, we are the only roaster company that is able to pass air quality standards in Southern California.

4.1. Business Problem, Product Concept and History

U.S. Roaster Corp's customers value the fact that the roaster is American made and energy efficient, but they have been experiencing a few problems with the mixing of the beans. U.S. Roaster Corp currently uses fins inside of their roasting drums to facilitate mixing but Roasting Innovation feels like these can be vastly improved with a few different designs which were presented to U.S. Roaster Corp. The outcome of this meeting was that U.S. Roaster Corp felt the changes were unnecessary and too different than their current line of roasters. This prompted Roasting Innovation to rethink the designs and come up with a design that stayed consistent with U.S. Roaster Corp's current roasters but also would benefit the mixing of the coffee beans.

4.2. Key Messages & Main Benefits:

The new roaster design will facilitate greater mixing and a more even roast of the coffee beans. A new method for emptying the beans will also be implemented. The effect of this will be increased precision in timing of the roasting. The empting or "belly

dump” method will allow for all of the beans to exit at one time instead of in short waves or bursts. This aspect is something that no other roaster manufacturing company has implemented. Although this will be new to the market after marketing and sales descriptions this method will be used in increasing numbers throughout the industry.

4.3. Features, Functions, & Benefits:

Feature	**Function**
Mixing Fins	This feature will facilitate increased mixing and a more fluidized motion of the beans for an even mixing
Belly Dump	This will allow for expedient release of the beans to prevent burning
Front Door	The front door will help with the cleaning process and any maintenance that needs to be done
Revelation style	This is the most energy efficient and environment friendly roaster on the market
User Manual	The user manual will have easy to follow instructions for first time users.

Table 6. Description of functions of each of the design features.

5. Market Data, Competitive Products, and Analysis

U.S. Roaster Corp has examined the current market and its competitors and feel as though this is the opportune time introduce a larger roaster. Most of their competitors have larger roasters that have been very profitable for each company. U.S. Roaster Corp knows that their new 300 kilogram roaster will be welcomed into the market and

increase profits for the company. Roasting Innovation has already analyzed our competitors (Table 7)

5.1. Competitive Strengths, Weaknesses & Response Statements

Primo Roasting

Strength- Low Cost

Weakness- Poor Quality

Has Garanti

Strength- Nice Looking Equipment

Weakness- Based in Turkey so maintenance is difficult

Ambex

Strength- Attractive website and training courses available

Weakness- Small company with not well developed marketing

Deidrich

Strength- Have some very large roasters

Weakness- Don't have any roasters that can pass air quality standards in California

Probat

Strength- Years of experience and brand loyalty

Weakness- Cast iron fronts are very expensive to replace if cracked

Companies vs. Criteria	Accessed on and from	Located	Years manufacturing	Largest Roaster	Industry Events per year	Focus	Marketing Stragegies	Strengths	Weaknesses	Opportunities
Primo Roasting	10-6-2010 from www.primoroasting.com	Rose Bud, Arkansas	26 years	PRI-265 holds 310 lbs of green beans	0	Rebuilding and performance enhancement	Internet and word of mouth	Low cost	Poor Quality	Most opportunitites are related with rebuilding
Has Garanti	10-6-10 from www.hasgaranti.com.tr	Turkey	54 years	HSR-180 holds 390 lbs of green beans	6	Coffee grinders, roasters, and afterburners	Attend trade shows, internet, and word of mouth	Nice looking equipment	Foreign company so maintenance is complicated	Europe and countries that are closer
Ambex	10-6-10 from www.ambexroasters.com	Clearwater, Florida		YM-120 holds of 240 lbs of green beans	3	Smaller roasters and maintenance	Attend trade shows, internet, and word of mouth	Attractive website and training courses available	Small company with not well developed marketing	With marketing they could get more business
Diedrich Manufacturing	10-6-10 from www.diedrichroasters.com	Ponderay, Idaho	30 years	CR-490 holds 1080 lbs of green beans	5	Roasters and also coffee production	Attend trade shows, internet, and word of mouth	Have some very large roasters	Don't have any roasters that can pass air quality standards in CA	Once they catch up with the PLC control system they can expand
Probat	10-6-10 from www.probat.com	Hamburg, Germany	100 years	Jupiter 5000 holds 1650 lbs of green beans	10	Roasters and training courses	Produce own magazine, attend trade shows, internet	Years of experience; brand loyalty	Cast iron fronts are very expensive to replace if cracked	They have already expanded
U. S. Roaster Corp.	10-8-10 from Dan Jolliff	Oklahoma City, Oklahoma	6 years	Revelation 300 holds 660 lbs of green beans	3	Rebuilding and manufacturing	Word of mouth and internet	Quality products and maintenance, knowledge of industry	Not very long manufacturing	Expanding into the larger market. Revelation in South California.

Table 7: Competitors and comparisons

6. Financial Data/Business Model

6.1. Pricing

The 300 kilogram roaster will be priced at $300,000. This price will include installation.

6.2. Financial Projections

Projected costs were derived from rough pricing of the inputs needed to manufacture the roaster (Tables 8-11). Costs do not include labor and wages. The sales projection is based on the current sales of the other large roasters (Table 12).

Machine Materials List				
Component of Machine	**Material**	**Price per Unit**	**Number of Units**	**Total**
Drum				
	Stainless Steel	$ 1.51	150.6	$ 227.63
	Bearing	$ 48.75	1	$ 48.75
	Welding	$ 49.00	1	$ 49.00
	Hinges	$ 18.00	4	$ 72.00
Front Plate				
	Stainless Steel	$ 1.51	267.21	$ 403.89
Back Plate				
	Stainless Steel	$ 1.51	267.12	$ 403.75
Rings				
	Stainless Steel	$ 1.51	5.52	$ 8.34
Drive Train				
	Engine	$ 1,500.00	1	$ 1,500.00
	Variable Speed Drive	$ 279.00	1	$ 279.00
	Gear Drive	$ 2,500.00	1	$ 2,500.00
	Pneumatics	$ 450.00	1	$ 450.00
Paddles				
	Stainless Steel	$ 1.51	123	$ 185.91
	Bolts	$ 1.39	50	$ 69.50
Drive Shaft				
	Stainless Steel	$ 720.90	1	$ 720.90
Stand				
	Square Tubing	4.68/2ft	41	$ 191.88
Total				$ 7,110.56

Table 8: Engineering Costs

Testing Materials List				
Test	**Material**	**Price per Unit**	**Number of Units**	**Total**
Mixing Test				
	Paint or Dye	$ 5.00	4 colors	$ 20.00
Total				$ 20.00

Table 9: Testing Cost

Maketing Materials List				
Component of Maketing	**Unit**	**Price per Unit**	**Number of Units**	**Total**
Brochure				
	Printing	199.99/250	1	$ 199.99
User Manual				
	Printing	$ 19.95	250	$ 4,987.50
Business Cards				
	Printing	19.99/250	1	$ 19.99
Total				$ 5,207.48

Table 10: Marketing Costs

Total Cost of Materials	
Materials	**Cost**
Machine Materials	$ 7,110.56
Testing	$ 20.00
Marketing	$ 5,207.48
Total	$ 12,338.04

Table 11: Total projected costs of production

Sales Projections											
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Coffee Roaster	Unit	1	2	3	4	5	5	5	5	5	5
		1	2	3	4	5	5	5	5	5	5
Gross Sales Projection											
		Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
Coffee Roaster											
Total Volume		1	2	3	4	5	5	5	5	5	5
Price/Unit		$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000	$300,000
Gross Sales		$300,000	$600,000	$900,000	$1,200,000	$1,500,000	$1,507,500	$1,515,038	$1,522,613	$1,530,226	$1,537,877
TOTAL GROSS SALES		$300,000	$600,000	$900,000	$1,200,000	$1,500,000	$1,507,500	$1,515,038	$1,522,613	$1,530,226	$1,537,877
Production Expense											
Coffee Roaster		$8,363	$16,726	$25,089	$33,452	$41,815	$42,024	$42,234	$42,446	$42,658	$42,871
TOTAL VARIABLE EXP.		$8,363	$16,726	$25,089	$33,452	$41,815	$42,024	$42,234	$42,446	$42,658	$42,871

Table 12: Sales Projections

7. Product Team (Roles and Responsibilities)

Faculty Advisors

Dr. Tim Bowser	FAP-C	bowser@okstate.edu
Dr. Rodney Holcomb	FAP-C	rodney.holcomb@okstate.edu

Team Leader

Brittany Looke	Engineer	brittany.looke@okstate.edu

Team

Karolyn Bolay	Communications	karolyn.bolay@okstate.edu
Kelsey Hubbard	Business	kelsey.hubbard@okstate.edu
Mark Marshall	Engineer	mark.marshall@okstate.edu
Nathan Moyer	Engineer	nmoyer@okstate.edu

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Appendix A – Solid Work Drawings

Appendix B – Scientific Literature

Appendix C – Patents

Appendix D – Gantt Chart

300 Kilogram Coffee Drum	390.44d	Mon 8/23/10		Thu 7/7/11
Drum	21d	Fri 1/21/11	Fri 2/4/11	
Calculate Dimensions	2d	Fri 1/21/11		Mon 1/24/11
Volume	1d	Fri 1/21/11	Sat 1/22/11	
Thermal Expansion	1d	Sun 1/23/11		Mon 1/24/11
Fin Design	7d	Tue 2/1/11		Fri 2/4/11
Fin Tolerances	7d	Tue 2/1/11		Fri 2/4/11
Fin Style	7d	Tue 2/1/11	Fri 2/4/11	
Mixing Tests	1d	Tue 2/1/11		Tue 2/1/11
Inlet and Outlet	7d	Wed 1/26/11		Tue 2/1/11
Effeciency Tests	7d	Wed 1/26/11		Tue 2/1/11
Speed Tests	7d	Wed 1/26/11		Tue 2/1/11
Material	7d	Fri 1/21/11	Wed 1/26/11	
Safety Factor	7d	Fri 1/21/11		Wed 1/26/11
Drive Train	188.44d	Mon 8/23/10		Fri 1/21/11
Berings	7d	Mon 8/23/10	Thu 8/26/10	
Size Berrings	7d	Mon 8/23/10		Thu 8/26/10
Gear Set	7d	Mon 8/23/10	Thu 8/26/10	
Size Gears	7d	Mon 8/23/10		Thu 8/26/10
Motor	188.44d	Mon 8/23/10	Fri 1/21/11	
Power Requirements	7d	Tue 1/18/11		Fri 1/21/11
RPM Requirement	7d	Mon 8/23/10		Thu 8/26/10
Marketing	181d	Fri 2/4/11	Thu 7/7/11	
Website	70d	Fri 2/4/11	Thu 3/31/11	
Design	70d	Fri 2/4/11	Thu 3/31/11	
Brochure	32d	Thu 3/31/11	Thu 4/21/11	
Photos	4d	Thu 3/31/11	Mon 4/4/11	
Information about Product	7d	Mon 4/4/11		Thu 4/7/11
Design	14d	Thu 4/7/11	Mon 4/18/11	
Printing	7d	Mon 4/18/11	Thu 4/21/11	
Promotional Index Card	28d	Thu 4/21/11		Fri 6/3/11
Information about Product	7d	Thu 4/21/11		Tue 4/26/11
Design	14d	Tue 4/26/11	Thu 5/5/11	
Printing	7d	Thu 5/5/11	Fri 6/3/11	
Pictoral User Manual	51d	Fri 6/3/11	Thu 7/7/11	
Photos	4d	Fri 6/3/11	Mon 6/6/11	
Information on Product Use	7d	Mon 6/6/11		Fri 6/10/11
Design	30d	Fri 6/10/11	Thu 6/30/11	
Printing	7d	Thu 6/30/11	Wed 7/6/11	
Binding	3d	Wed 7/6/11	Thu 7/7/11	
Business	65d	Fri 2/4/11	Mon 3/28/11	
Executive Summary	6d	Fri 2/4/11	Wed 2/9/11	
Objectives	2d	Fri 2/4/11	Mon 2/7/11	
Mission	2d	Mon 2/7/11	Tue 2/8/11	
Keys to Success	2d	Tue 2/8/11		Wed 2/9/11
Company Description	3d	Wed 2/9/11		Thu 2/10/11
Company Locations	3d	Wed 2/9/11		Thu 2/10/11
Product	28d	Thu 2/10/11	Wed 3/2/11	
Description	7d	Thu 2/10/11		Wed 2/16/11
Competitive comparison	7d	Wed 2/16/11		Mon 2/21/11
Sales Literature	14d	Mon 2/21/11		Wed 3/2/11
Financial Analysis	28d	Wed 3/2/11		Mon 3/28/11
Financial Indicators	14d	Wed 3/2/11		Thu 3/10/11
Break Even Analysis	14d	Thu 3/10/11		Mon 3/28/11

Appendix E – Specification Sheet

Specifications: 300 Kilogram Coffee Roaster		
Drum		
	Material	Stainless Steel
	Diameter	48 inches
	Length	52 inches
	Thermal Expansion	0.6 inches
	Volume	56 cubic feet
	Material Thickness	1/10 inch
Paddles		
	Material	Stainless Steel
	Tolerance	__ inches
Shaft		
	Material	Stainless Steel
	Diameter	2 inches
	Length	60 inches
Motor: CEM3311T		
	Horsepower	7.5 HP
	Service Factor	1.15
	Speed	1770 rpm
	Frame	213TC
	Efficiency	91%
	Weight	120 lb
Gear Reducer: BB883CN210TC		
	Category	Right Angle Helical-Bevel
	Type	RHB
	Input Speed	1750 rpm
	Ratio	34.4:1
	Output Speed	51
	Max Output Torque	1464 in-lb
	Service Factor	1
	Max Input Power	11.79 HP
	Weight	169 lb
Variable Speed Drive: GS2-4010		
	Motor Rating	10 HP
	Rated Output Capacity	13.7 kVA
	Rated Input Current	23 A
	Rated Output Current	18 A
	Weight	8.5 lb
Pneumatic Cylinders: 3-DP-A		
	Stroke	10 inch
	Bore Size	2.5 inch
	Pressure Range	0-200 psig
	Mounting	Rod End: Threaded, Blind End: Clevis
Directional Control Valve: VBL4303		
	Number of Paths	4
	Number of Positions	3
	Normal Position	Closed
	Actuation	Manual

Appendix F – Brochure

Appendix G – User and Safety Manual

Appendix H – Business Card

Appendix I – Final Presentation

Roasting Innovation

The Design and Marketing of a 300 Kilogram Coffee Roaster

Our Team

Marketing:
Karolyn Bolay

Business:
Kelsey Hubbard

Team Leader/Engineer:
Brittany Looke

Engineer:
Mark Marshall

Engineer:
Nathan Moyer

Our Client

- US Roaster Corp
  - Owned and operated by Dan Joliff
  - Located in Oklahoma City, Oklahoma
  - Manufactures coffee roasters
    - 3 kilo sample roaster - 150 kilo industrial roaster
  - Refurbishes old coffee roasters

Mission Statement

Roasting Innovations' mission was to develop a 300 kilogram roaster that would be safe and reliable with the ability to be easily reproduced. The team accomplished this by redesigning the drum and drive train components of the roaster. Materials used to build the roaster were chosen to maintain optimal quality of the product being roasted.

Problem Statement

Roasting Innovation needed to design and produce a drum and drive train for a 300 kilogram roaster that could withstand temperatures up to approximately 600°F so as to reduce destruction of the quality of the roaster due to thermal expansion. The 300 kilogram roaster needed to be able to roast exceptional coffee to the user's taste, be easily reproducible, remain safe to operate, and environmentally friendly.

Thermal Expansion

$$\Delta L = c * L_i * (T_f - T_i)$$

ΔL = the change in length due to thermal expansion (in)

c = coefficient of thermal expansion (°F)

L_i = initial length of the drum (in)

T_f = the final temperature (°F)

T_i = the initial temperature (°F)

Thermal Expansion of 300 Kilogram Roaster: 0.6 inches

Target Industry

- Large scale coffee companies
  - Folgers
  - Maxwell House
- Southern California
  - Air Pollution Standards

Competitors

- Probat
  - Entire drum rotates
  - Exit door is a small hole in front
  - Mixes comparable to other machines

Competitors

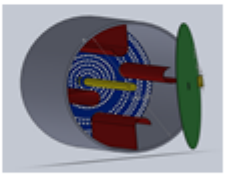
- Diedrich Manufacturing
  - Full drum rotates
  - Mixes comparable to other machines
  - Small front bean removal

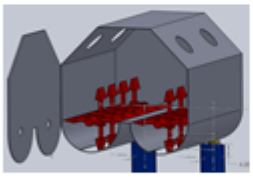
Important Design Requirements

- Quick bean exit
  - Even Roasting
- Minimizing power consumption
  - Cost
- Improved mixing
  - Customer Survey
- Thermal expansion
  - Minimize Friction

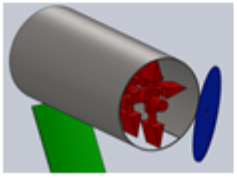
Fall Semester

- Completed competitive and industrial analysis
- Developed three alternatives to be chosen from by our client based on cost and design preferences



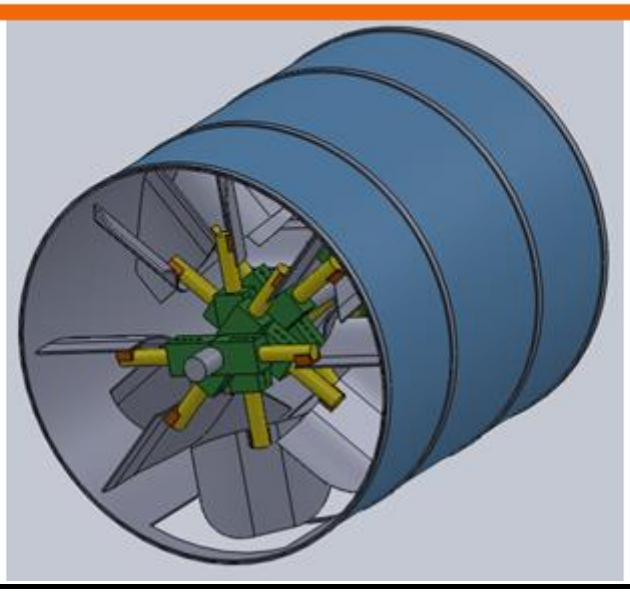


- Chose a design and began calculating specific requirements and details



Final Design

Final Design



Final Design

- Quick bean exit
  - Belly dump door
- Minimizing power consumption
  - Rotating shaft
- Improved mixing
  - Rotating shaft
  - Fin Design
- Thermal Expansion
  - Rotating shaft

Final Design – Drive Train

Motor

- CEM 3311T
- Baldor C-faced
- 7.5 HP
- 1770 rpm
- 3 Phase

Horsepower Calculations

Assumptions

- No Friction
- All beans are lifted from bottom to top

$P = WhN$

P = power (hp)
W = weight (lb)
h = max. height beans need to be lifted (ft)
N = Speed of shaft rotation (rpm)

Final Design – Drive Train

Gear Reducer

- Dodge Quantis RHB
- Gear Ratio = 34.4 : 1
- Output Speed = 51 rpm
- Input HP = 10 HP
- Safety Factor = 1.53

Final Design – Drive Train

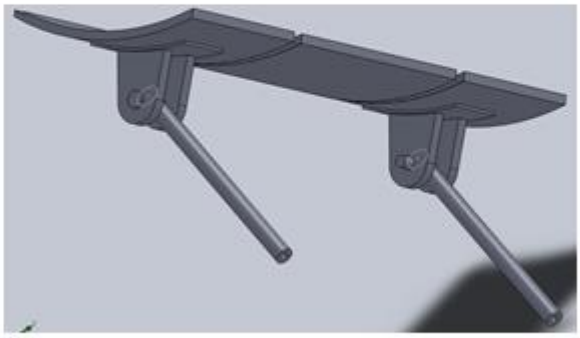
Variable Speed Drive

- GS2-4010
- Automation Direct
- 380 – 480 Volts
- Three phase
- Start and stop the drive
- Set the speed
- Command direction of motor shaft

GS2-4010

Final Design – Door Design

- Belly Dump
- Single door
- Pneumatically controlled



Final Design – Door Design

Pneumatics

- System pressure at 100 psi
- 2 Humphrey Cylinders
  - 2.5 in bore
  - Force = 630 lbs.
- Versa Valve
  - 3 position
  - Normally Closed
- 2 Norgren Mufflers

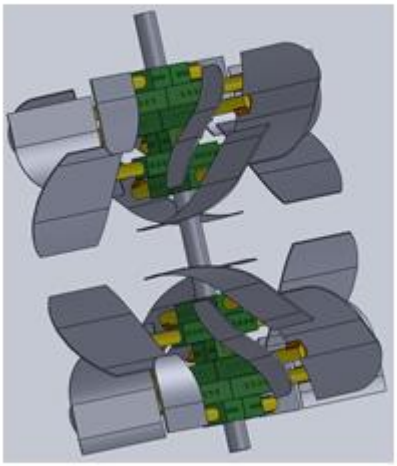
Final Design - Rotating shaft Design

Rotating Shaft

- Smaller rotating mass
- Less HP loss due to rubbing
- Less load on bearings
- Allows for basic belly dump design
- No dead zones
- Allows for thermal expansion

Final Design – Fin Design

- Curved fins increases bean movement
- Large surface area of fins
- Fin placement for elimination of dead zones

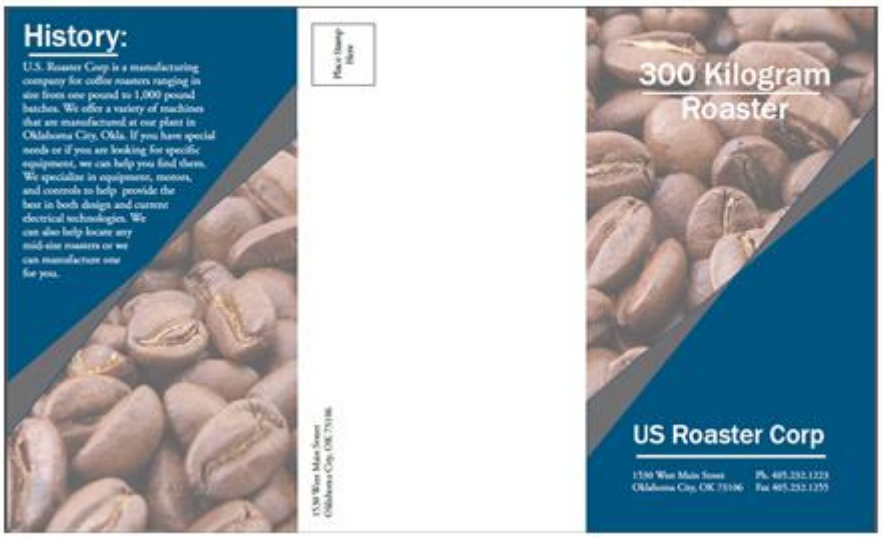


Final Design: Video

Marketing Overview

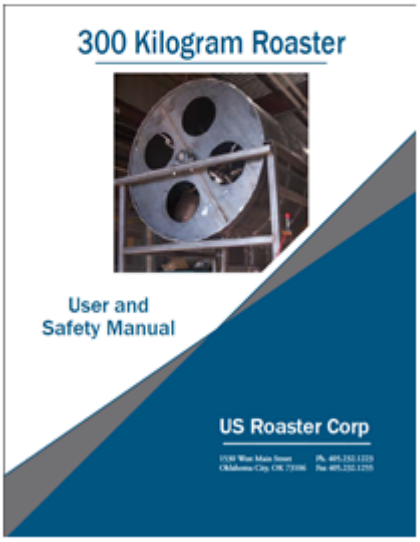
- Consistent color scheme to provide a uniform look
- Used previous logo and website as a base
- This allowed previous customers to recognize new marketing materials
- Trade show must-haves
  - Business card
  - Brochure
- Consumer must-haves
  - User and safety manual
  - Specifications sheet

Brochure



Brochure

User and Safety Manual



US Roaster Corp
1530 West Main Street
Oklahoma City, OK 73106
Ph. 405.232.1223
Fax 405.232.1255

Specification Sheet

Business Plan Overview

- Appeal to a larger market including large coffee houses and roasting factories

- Highly energy efficient
- Cost efficient
- American made

- Improved mixing of the coffee beans
- Quick bean evacuation

Top Features

- Pictorial user and safety manual
  - Walk-through for first time users
- Belly dump
  - Quick bean evacuation
  - More even roast
- Shaft rotation
  - Cuts down on horsepower requirements

Financial Overview

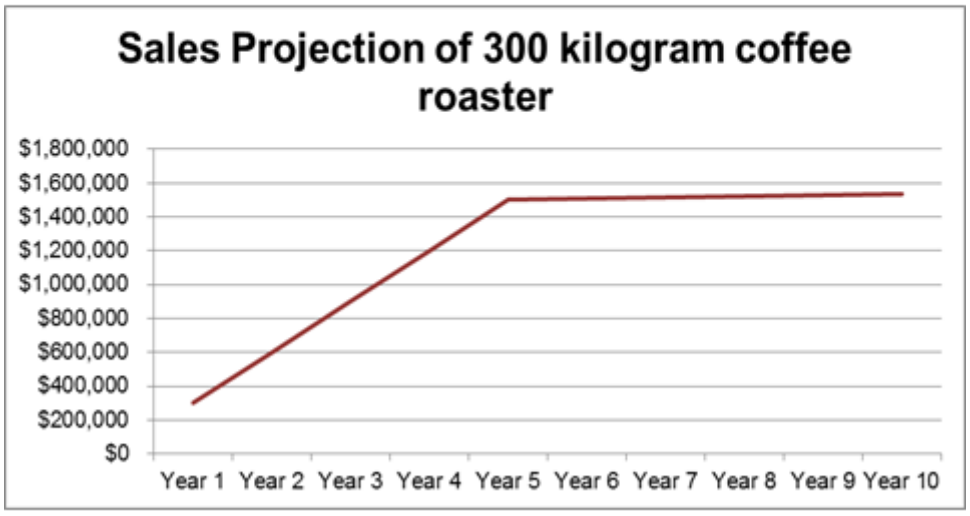
- Projected income after 5 years = $1,500,000
- Cost to manufacture and promote = $10,000
- Price of the finished product = $300,000

- From communications with U.S. Roaster we are assuming that they can market, sell, and produce up to 5 per year.
- Our calculations only include the drum and drive mechanism.

Cost of Production

Machine Materials List				
Component of Machine	Material	Price per Unit	Number of Units	Total
Drum				
	Stainless Steel	$ 1.51	150.6	$ 227.63
	Bearing	$ 48.75	1	$ 48.75
	Welding	$ 49.00	1	$ 49.00
	Hinges	$ 18.00	4	$ 72.00
Front Plate				
	Stainless Steel	$ 1.51	267.21	$ 403.89
Back Plate				
	Stainless Steel	$ 1.51	267.12	$ 403.75
Rings				
	Stainless Steel	$ 1.51	5.52	$ 8.34
Drive Train				
	Engine	$ 1,500.00	1	$ 1,500.00
	Variable Speed Drive	$ 279.00	1	$ 279.00
	Gear Drive	$ 2,500.00	1	$ 2,500.00
	Pneumatics	$ 450.00	1	$ 450.00
Paddles				
	Stainless Steel	$ 1.51	123	$ 185.91
	Bolts	$ 1.39	50	$ 69.50
Drive Shaft				
	Stainless Steel	$ 720.90	1	$ 720.90
Stand				
	Square Tubing	4.68/2ft	41	$ 191.88
Total				$ 7,110.56

Financial Analysis



Thank You to Our Supporters...

- US Roaster Corp
- Dr. Tim Bowser
- Baldor Electric Co.
- Hydraquip
- BAE Lab Staff
- Innovations Faculty
  - Dr. Blackwell
  - Dr. Holcomb
  - Dr. Tilley
  - Dr. Weckler


Roasting
Innovation

Roasting Innovation

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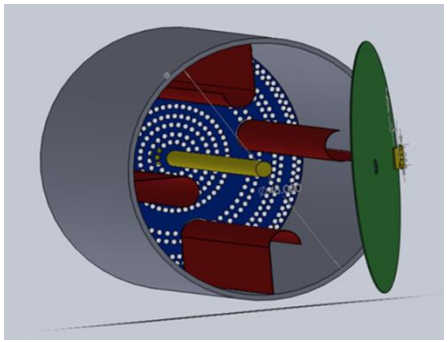

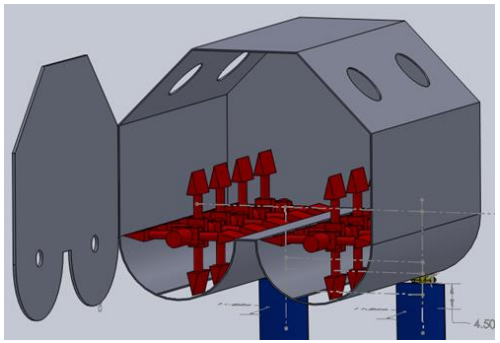

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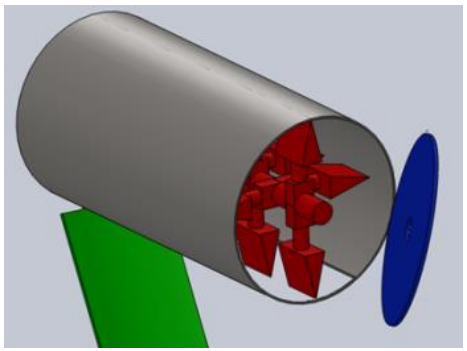
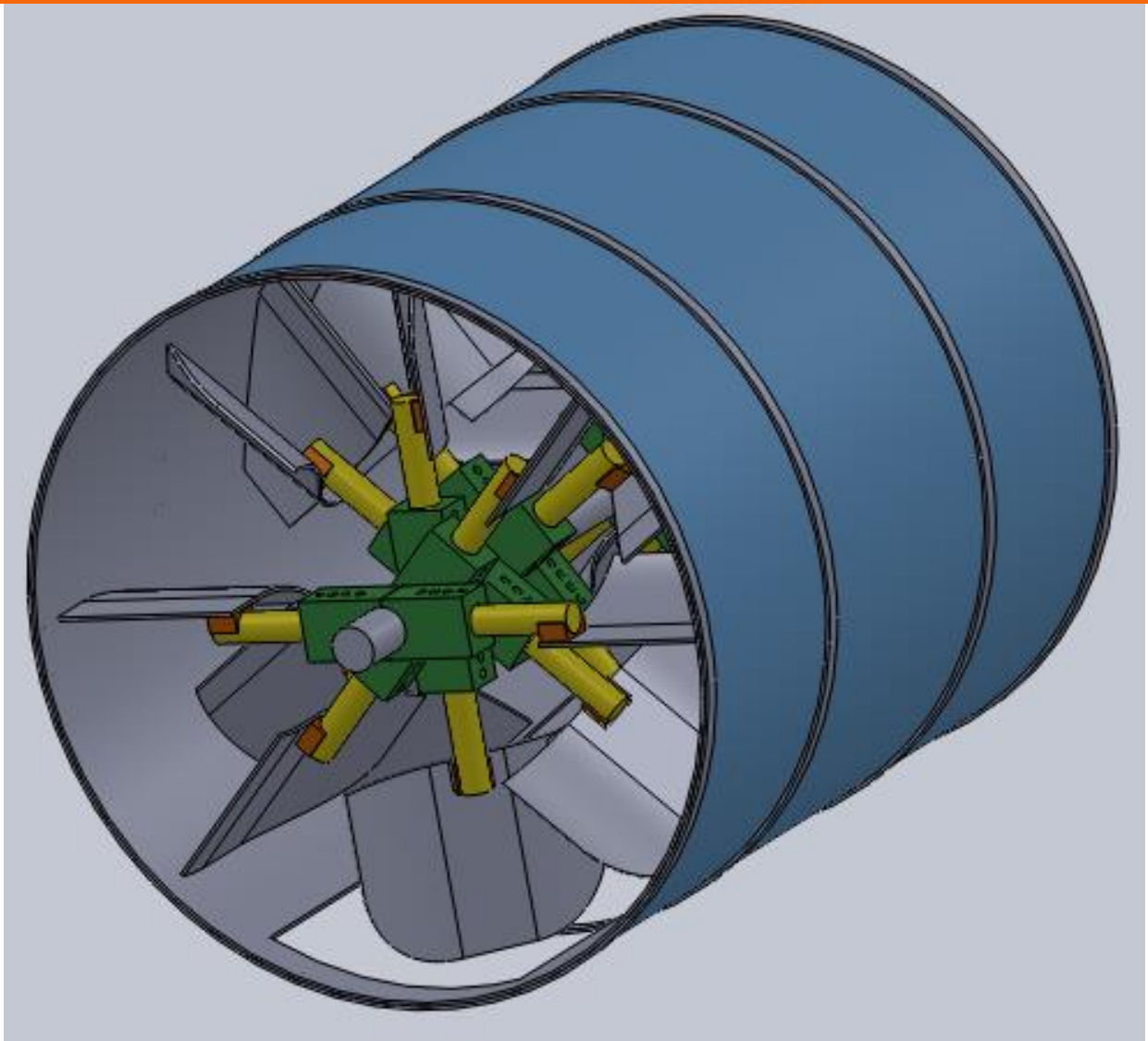


Roasting Innovation

Final Design

Roasting Innovation

Final Design



Roasting Innovation

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Roasting Innovation

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Roasting Innovation

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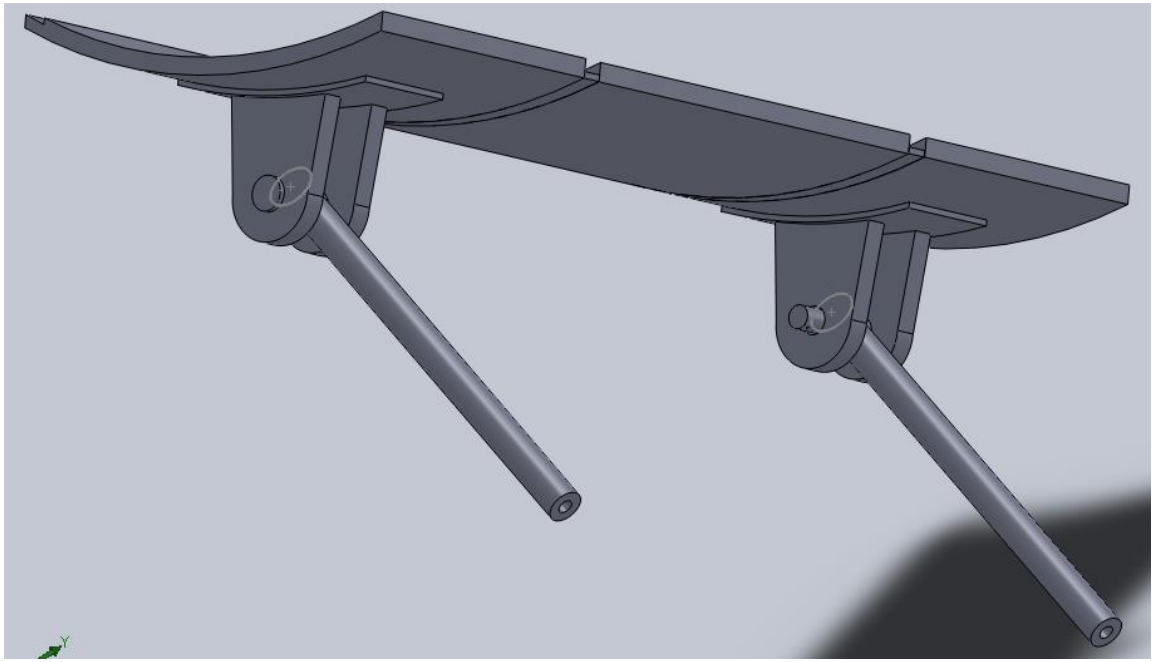

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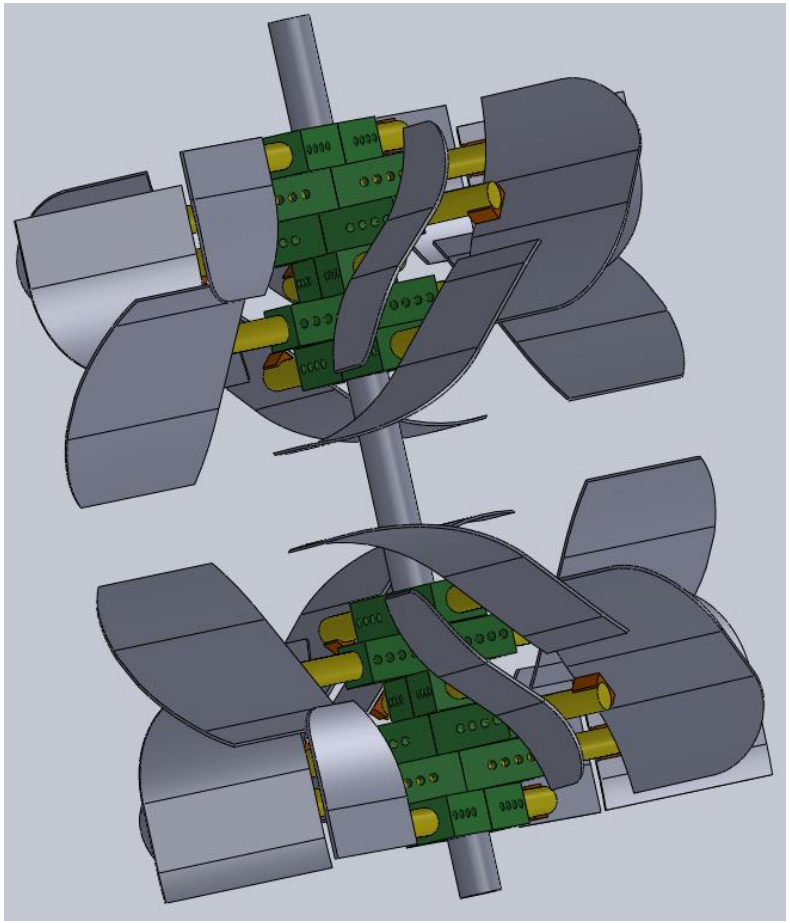
- Large surface area of fins
- Fin placement for elimination of dead zones



Roasting Innovation

Final Design: Video

Roasting Innovation

Marketing Overview

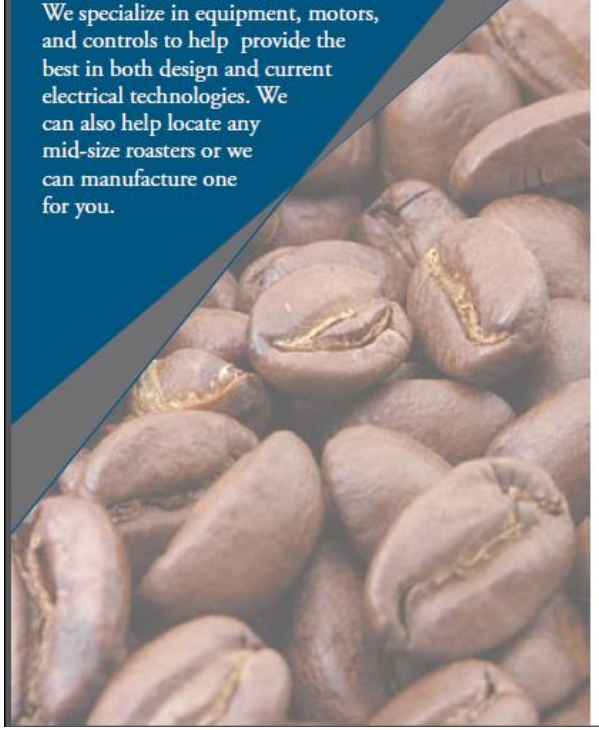
- Consistent color scheme to provide a uniform look
- Used previous logo and website as a base
- This allowed previous customers to recognize new marketing materials
- Trade show must-haves
  - Business card
  - Brochure
- Consumer must-haves
  - User and safety manual
  - Specifications sheet

Roasting Innovation

Brochure

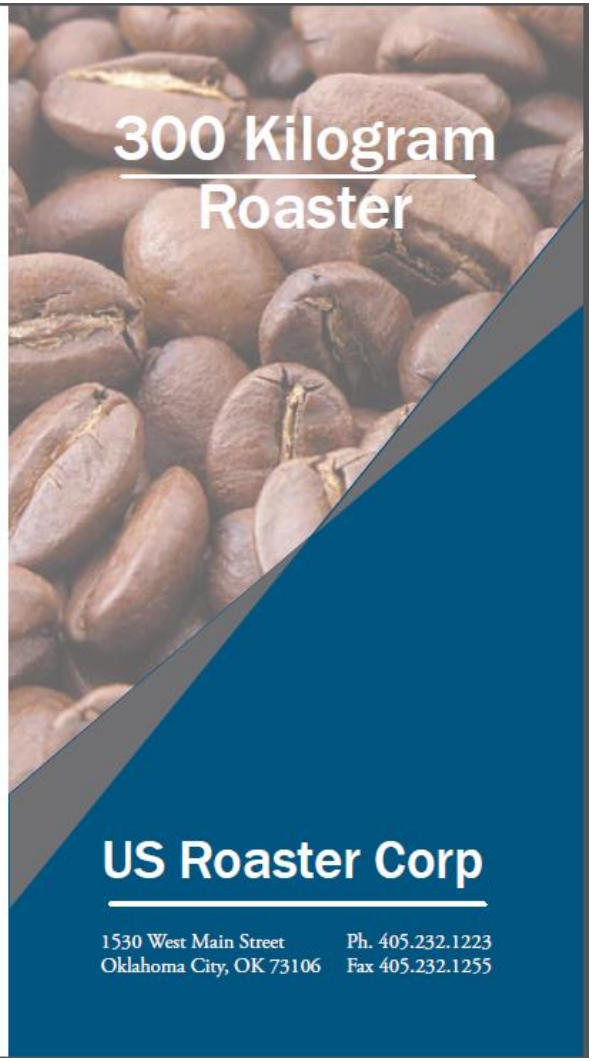
History:

U.S. Roaster Corp is a manufacturing company for coffee roasters ranging in size from one pound to 1,000 pound batches. We offer a variety of machines that are manufactured at our plant in Oklahoma City, Okla. If you have special needs or if you are looking for specific equipment, we can help you find them. We specialize in equipment, motors, and controls to help provide the best in both design and current electrical technologies. We can also help locate any mid-size roasters or we can manufacture one for you.



Place Stamp Here

1530 West Main Street
Oklahoma City, OK 73106



300 Kilogram Roaster

US Roaster Corp

1530 West Main Street
Oklahoma City, OK 73106

Ph. 405.232.1223
Fax 405.232.1255

Brochure

Specifications:

- Stainless steel drum - 48 inches diameter and 52 inches long
- Rotates at a speed of 35 rpm to 44 rpm
- Stainless steel adjustable paddles
- Stainless steel shaft - 2 inches in diameter and 60 inches long
- 7.5 HP motor - 120 lbs
- Right angle helical-bevel gear reducer - 169 lbs
- 10 HP variable speed drive - 8.5 lbs
- 3-DP-A Pneumatic cylinders
- Manual directional control valve

300 Kilogram Roaster

Features:

- Center rotating shaft
- Driven by an electric motor
- Paddles with a larger surface area
- Curved fins and adjustable paddles
- Belly dump doors

Why should you get a 300 kilogram roaster?

- The 300 kilogram roaster provides a more even roast of the beans.
- The center rotating shaft is unique and is a safer option for the user.
- The curved fin design and adjustable paddles allow for a smaller gap between the drum and the paddles.
- The belly dump doors allow for a faster exit time of the beans.

User and Safety Manual

300 Kilogram Roaster

User and
Safety Manual

US Roaster Corp

1530 West Main Street
Oklahoma City, OK 73106

Ph. 405.232.1223
Fax 405.232.1255

US Roaster Corp

1530 West Main Street
Oklahoma City, OK 73106

Ph. 405.232.1223
Fax 405.232.1255

Roasting Innovation

Specification Sheet

Specifications: 300 Kilogram Coffee Roaster		
Drum		
	Material	Stainless Steel
	Diameter	48 inches
	Length	52 inches
	Thermal Expansion	0.6 inches
	Volume	56 cubic feet
	Material Thickness	1/10 inch
Paddles		
	Material	Stainless Steel
	Tolerance	__ inches
Shaft		
	Material	Stainless Steel
	Diameter	2 inches
	Length	60 inches
Motor: CEM3311T		
	Horsepower	7.5 HP
	Service Factor	1.15
	Speed	1770 rpm
	Frame	213TC
	Efficiency	91%
	Weight	120 lb
Gear Reducer: BB883CN210TC		
	Category	Right Angle Helical-Bevel
	Type	RHB
	Input Speed	1750 rpm
	Ratio	34.4:1
	Output Speed	51
	Max Output Torque	1464 in-lb
	Service Factor	1
	Max Input Power	11.79 HP
	Weight	169 lb
Variable Speed Drive: GS2-4010		
	Motor Rating	10 HP
	Rated Output Capacity	13.7 kVA
	Rated Input Current	23 A
	Rated Output Current	18 A
	Weight	8.5 lb
Pneumatic Cylinders: 3-DP-A		
	Stroke	10 inch
	Bore Size	2.5 inch
	Pressure Range	0-200 psig
	Mounting	Rod End: Threaded, Blind End: Clevis
Directional Control Valve: VBL4303		
	Number of Paths	4
	Number of Positions	3
	Normal Position	Closed
	Actuation	Manual

Roasting Innovation

Business Plan Overview

- Appeal to a larger market including large coffee houses and roasting factories

- Highly energy efficient
- Cost efficient
- American made

- Improved mixing of the coffee beans
- Quick bean evacuation

Roasting Innovation

Top Features

- Pictorial user and safety manual
  - Walk-through for first time users
- Belly dump
  - Quick bean evacuation
  - More even roast
- Shaft rotation
  - Cuts down on horsepower requirements

Roasting Innovation

Financial Overview

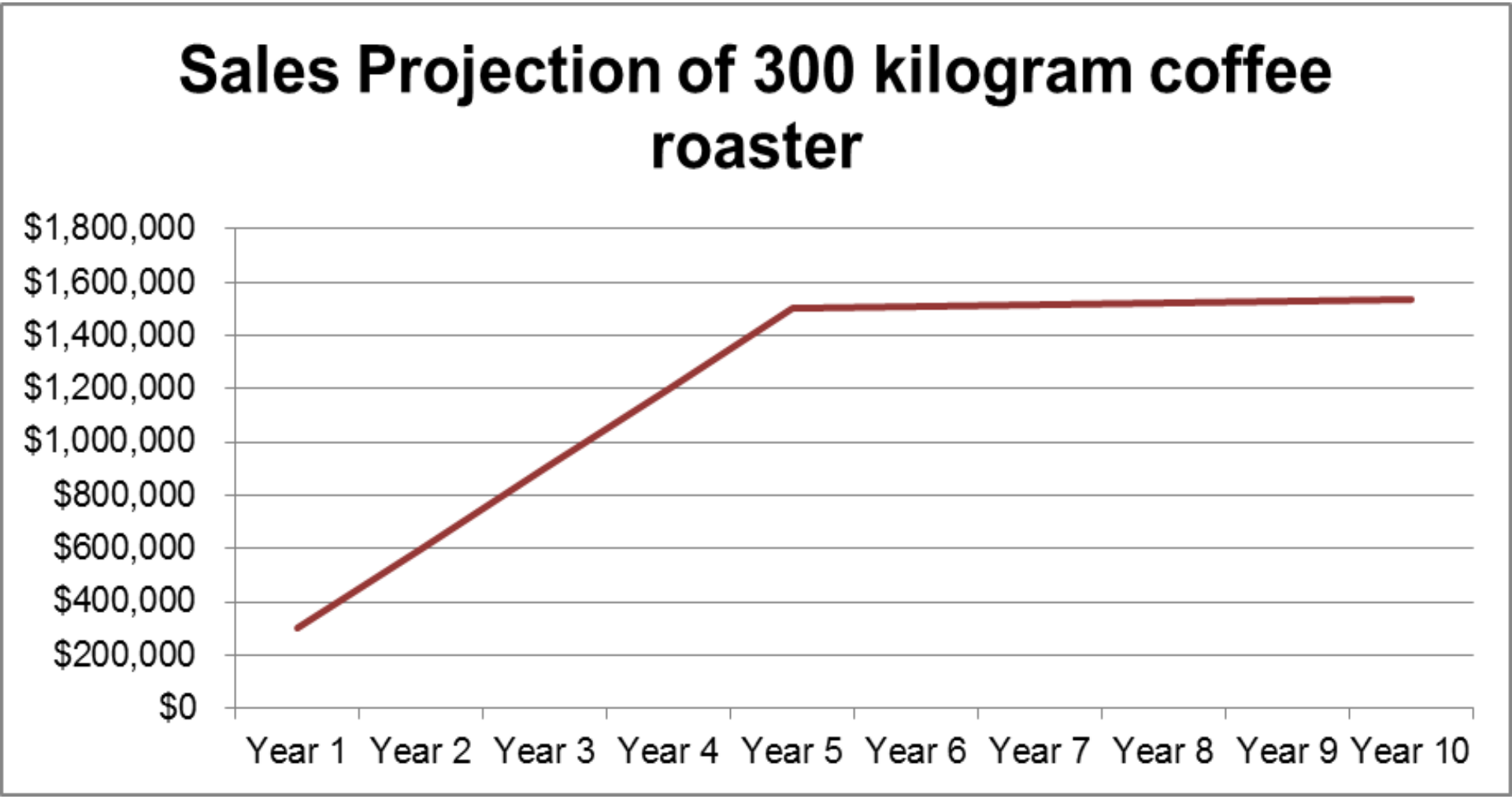
- Projected income after 5 years = $1,500,000
- Cost to manufacture and promote = $10,000
- Price of the finished product = $300,000

- From communications with U.S. Roaster we are assuming that they can market, sell, and produce up to 5 per year.
- Our calculations only include the drum and drive mechanism.

Cost of Production

Machine Materials List				
Component of Machine	**Material**	**Price per Unit**	**Number of Units**	**Total**
Drum				
	Stainless Steel	$ 1.51	150.6	$ 227.63
	Bearing	$ 48.75	1	$ 48.75
	Welding	$ 49.00	1	$ 49.00
	Hinges	$ 18.00	4	$ 72.00
Front Plate				
	Stainless Steel	$ 1.51	267.21	$ 403.89
Back Plate				
	Stainless Steel	$ 1.51	267.12	$ 403.75
Rings				
	Stainless Steel	$ 1.51	5.52	$ 8.34
Drive Train				
	Engine	$ 1,500.00	1	$ 1,500.00
	Variable Speed Drive	$ 279.00	1	$ 279.00
	Gear Drive	$ 2,500.00	1	$ 2,500.00
	Pneumatics	$ 450.00	1	$ 450.00
Paddles				
	Stainless Steel	$ 1.51	123	$ 185.91
	Bolts	$ 1.39	50	$ 69.50
Drive Shaft				
	Stainless Steel	$ 720.90	1	$ 720.90
Stand				
	Square Tubing	4.68/2ft	41	$ 191.88
Total				$ 7,110.56

Financial Analysis



Thank You to Our Supporters...

- US Roaster Corp
- Dr. Tim Bowser
- Baldor Electric Co.
- Hydraquip
- BAE Lab Staff
- Innovations Faculty
  - Dr. Blackwell
  - Dr. Holcomb
  - Dr. Tilley
  - Dr. Weckler

Roasting Innovation

Roasting

Innovation

Design of a 300 Kilogram Coffee Roaster

Karolyn Bolay

Kelsey Hubbard

Brittany Looke

Mark Marshall

Nathan Moyer

Prepared for US RoasterCorp

Team Advisor: Dr. Tim Bowser

Fall 2010

Table of Contents

Appendices

Mission Statement

Roasting Innovations mission is to develop a 300 kilogram roaster that will be safe and reliable with the ability to be easily reproduced. The team will accomplish this by redesigning the drum and drive train components of the roaster. Materials used to build the roaster will be chosen to maintain optimal quality of the product being roasted.

The business plan will outline the economic prospects of the 300 kilogram roaster. Roasting Innovation will define and expand the market for an industrial sized roaster while remaining in the middle of the price market for similar products. Communication with the sponsor will be maintained throughout the entire designing and building process to be sure the team produces an optimal product. Communication with customers will be maintained through a series of surveys to evaluate satisfaction with the current product, as well as what changes they would suggest.

Problem Statement

Roasting Innovation needs to design and produce a drum and drive train for a 300 kilogram roaster that can withstand temperatures up to approximately $600^{o}F$ so as to reduce destruction of the quality of the roaster due to thermal expansion. The 300 kilogram roaster needs to be able to roast exceptional coffee to the user's taste, be easily reproducible, and remain safe to operate.

Statement of Work

Scope

Roasting Innovation will complete the design, construction and marketing of a 300 kilogram roaster for US RoasterCorp. Our work will include the construction of the drive train and the rotating drum, which will withstand heating up to 600^{o}F for roasting of 300 kilograms of coffee beans and prevent compromising the operating of the roaster. It will also include the marketing and promotion of the 300 kilogram industrial roaster to the company's future and current customers.

Location

The work for Roasting Innovation will be done mostly on the Oklahoma State University campus within the computer laboratories provided by the Biosystems and Agricultural Engineering department as well as the Agricultural Communications department. These labs include computer labs as well as machine shops where we will build and test different drums for the roaster. There will also be some machine work done by our client, US RoasterCorp, in Oklahoma City.

Time Period

The design process for the 300 kilogram industrial coffee roaster began in late August of 2010 and the final product will be completed by April 22, 2011.

Schedule of Deliverables

Table 1: Schedule of Deliverable

Deliverable	Due Date
Mission Statement	September 27, 2010
Problem Statement	September 27, 2010
Detailed Report and Budget	October 18, 2010
Competitive Analysis, Research, and Investigation	October 22, 2010
Statement of Work	October 29, 2010
Work Breakdown Schedule	November 5, 2010
List of Tasks	November 8, 2010
Fall Report	December 7, 2010
Fall Presentation	December 7, 2010
Website Completed	December 15, 2010
Acceptance of Final Design	December 17, 2010
First Prototype Completed	February 28, 2011
Tests on Prototype Completed	March 14, 2011
Final Design Completed	March 21, 2011
Final Report	April 25, 2011
Final Presentation	April 25, 2011

Standards

According to the Specialty Coffee Association of America (SCAA) when evaluating green coffee beans (unroasted) there are two grades, premium and specialty. Specialty green coffee beans should have a minimum of five secondary full defects. Secondary defects are imperfections in the hull/husk or shell of the bean and can be caused by insect and water

damage. Other secondary defects include partially black, partially sour, or floating beans, and if the bean samples contain small or sticks. The green coffee beans should have no more than 10-12% moisture content. The roasted coffee beans should also meet the SCAA's cup evaluation of 80 points or above. Points are earned using a SCAA standard 16 point scale which evaluates cups of coffee based on fragrance and aroma, flavor, aftertaste, acidity, body, balance, uniformity, clean cup, sweetness, defects, and overall. Roasted coffee beans should be roasted 8 to 24 hours of cupping. The entire roasting time for the coffee beans must be between eight and twelve minutes and should exclude scorching and tipping of the beans. Once the roasted coffee beans reach room temperature they should be sealed in air tight containers until it is time for them to be cupped.

Coffee roasters should be operated at maximum temperatures ranging between 370°F and 1000°C depending on the size of the load, and the beans are roasted for a period of time ranging from eight to twelve minutes. Roasters are typically horizontal rotating drums that tumble the coffee beans in a current of hot air. The coffee roasters usually operate a batch mode, but sometimes operate as continuous systems. The air inside of the roaster is heated either by a direct flame applied on the outside of the roaster or indirectly using a heater to pre-heat the air before it is circulated through the drum.

Particulate matter, volatile organic compounds, organic acids, and combustion products are the principle emissions from coffee processing. Particulate matter emissions from the receiving, storage, cleaning, roasting, cooling, and stoning operations are typically ducted to cyclones before being emitted into the atmosphere. Gaseous emissions from roasting

operations are typically ducted to a thermal oxidizer following particulate matter removal. Some facilities use burners as thermal oxidizers to heat the roaster; however, separate thermal oxidizers are more efficient because the desired operating temperature is typically between 650°C and 816°C (1200°F and 1500°F), which is 93°C to 260°C (200°F to 500°F) more than the maximum temperature of most roasters. Emissions from spray dryers are typically controlled by a cyclone, which is used to cool emissions, followed by a wet scrubber, which removed particulates from exhaust.

Acceptance

To be considered acceptable, the 300 kilogram roaster should be able to roast at least 300 kilograms of coffee beans within eight to twelve minutes at the standard temperature, about 500^{o}F. The roaster should be able to do this with minimal safety risks. If the roaster contains excessive heat escape, hot spots, loose connections, or excessive pressure buildup it will be considered unacceptable. The aesthetic design should resemble the previously design roasters developed by US RoasterCorp but may be altered with the consent of both US RoasterCorp and Roasting Innovation in order to improve overall appearance. The coffee roaster must also meet all necessary industry standards.

Special Requirements

The first unique consideration is taste. Our group must consider the taste of the coffee beans after they come out of the roaster. Another requirement to which we must pay attention to is the relatively high temperatures. Our roaster will reach temperatures around 400 degrees Celsius for about 15 minutes. Fifteen minutes is the approximate roasting time for coffee beans

to obtain the desired specialty roast. The next special requirement to be considered is the ability of the roaster to mix the beans thoroughly. This must be accomplished while also allowing for quick evacuation of the beans to prevent over cooking. We must also know how the heating elements will affect the steel. The heating of the barrel will cause thermal expansion to occur and must be compensated for. If the expansion problem is not solved, the roaster might lose beans and the efficiency will decrease. Another requirement is noise. Our team will be evaluating different kinds of gears to decrease the noise. As is, the existing roasters make quite a bit of noise with their straight cut gears. Lastly, our team must follow air pollution standards in not only Oklahoma but the entire nation, specifically southern California, where the regulations are much greater than the rest of the nation.

Task List

The following is a list of all tasks to be completed in order to define a final design for the 300 kilogram industrial coffee roaster. It encompasses all engineering, marketing, and economic tasks which Roasting Innovation will accomplish by the completion of this project.

Engineering

1. Calculate the volume and thermal expansion of the drum
2. Perform Tests: Mixing, Fin, Inlet, Outlet, Uniform Heating, Pressure, Airflow, and Anaerobic Conditions/Taste
3. Determine speed and horsepower requirements
4. Size mechanical equipment: gears, bearings

Communications

1. Website
2. Brochure
3. Pictorial User Manual
4. Specifications Sheet

Economics

1. Write a Product Plan
2. Competitive Analysis
3. Market Analysis

Work Breakdown Structure

1. 300 Kilogram Coffee Roaster

1.1 Drum

1.1.1 Calculate Dimensions

1.1.1.1 Volume

1.1.1.2 Thermal Expansion

1.1.2 Fin Design

1.1.2.1 Mixing Tests

1.1.3 Inlet and Outlet

1.1.3.1 Efficiency

1.1.3.2 Speed

1.1.4 Material

1.1.4.1 Safety Factor

1.2 Drive Train

1.2.1 Bearings

1.2.1.1 Size Bearings

1.2.2 Gear Set

1.2.2.1 Size Gears

1.2.3 Motor

1.2.3.1 Power Requirement

1.2.3.2 RPM Requirement

1.3 Marketing

1.3.1 Website

1.3.1.1 Design

1.3.2 Brochure

1.3.2.1 Photos

1.3.2.2 Information about Product

1.3.2.3 Design

1.3.2.4 Printing

1.3.3 Promotional Index Card

1.3.3.1 Information about Product

1.3.3.2 Design

1.3.3.3 Printing

1.3.4 Pictorial User Manual

1.3.4.1 Photos

Market Research

Introduction

Roasting Innovation has completed a competitive analysis of the coffee industry as part of our research for the development of the 300 kilogram coffee roaster. Within our analysis,

Roasting Innovation discussed and addressed the issues of the industry analysis, technical analysis, customers and buyers of the product, competitors and their resources, and the client company as well as its resources. The analysis also shows many different patents that will be useful in the designing of the drum, as well as different marketing techniques that could be useful. Overall, the analysis shows the depth of the coffee industry and the variety of areas that could affect the project.

Patents

Coffee Roasting Apparatus and Method – Patent 7143686 describes an industry coffee roaster that includes a combustion chamber and roasting drum. The heating gases for the coffee beans recirculate through the combustion chamber to remove the coffee bean chaff. Patent 7143686 is applicable to Roasting Innovation's design because it represents an alternative roasting drum design.

Coffee Roaster Drum Rocker Arm Roller Bearing System - Patent 7003897 describes an industry coffee roaster which includes a coffee roaster drum and coffee roaster casing. The casing is fitted with bearings journals to allow the drum to rotate horizontally. The invention also contains notch fittings to keep the drum in place with the casing. This patent is applicable to the design because it represents a way to control the thermal expansion. The patent specifies that industry roasters should use cast iron while designing roasters; however, Roasting Innovation will use stainless steel in its designs.

Method and Apparatus for Roasting Coffee Beans - Patent 6036988 presents a small coffee roaster that uses heated air flow and drum rotation to roast coffee. This patent is

applicable to the design because air flow will be the preferred way to heat the coffee beans and also alternative design on a roasting drum.

Fluidized Bed Coffee Roaster – Patent 5394623 describes a self-controlled coffee roaster which monitors the coffee bean temperature. The roaster also injects water into the air stream to quench the coffee beans when the roasting process is complete. This patent is applicable to the design because it is offers a different perspective to roasting coffee beans. Fluidized bed systems allow for controlled mixing and heating because these systems insert small amounts of the product instead of heating the entire product all at once.

Coffee Roasting Process and Apparatus – Patent 5287633 presents an industry coffee roaster that includes drum fins, shaft bearings, and a gear motor. This patent is similar to the client's current product line and is applicable to the design because it allows for insight into advantages and disadvantages of similar designs. This also would provide some insight on how to control the thermal expansion of high end industry coffee roasters.

Dual shaft pan mixer – Patent 4758095 uses dual shafts with attached paddle mixers. The shafts are connected to a worm gear which is then powered by a motor. The paddles also contain shovels which help mix the solids. The rotations of the shafts are opposite directions, while the areas of sweep overlap each other. This patent shows how dual shaft mixers can be used for food processing methods.

Coffee Roaster – Patent 4691447 presents a coffee roasting drum that rotates on a diagonal axis. The roaster uses air flow to heat the coffee beans. This patent is applicable to the

design because a diagonal axis drum allows for easy outlet flow. However, the heating of the drum could be an issue for an industrial sized roaster.

Industrial Economy

The growth of coffee consumption around the world has caused an increase in the coffee industry and the demand for coffee by consumers ever since it was first discovered in Ethiopia around 600 AD. One of the main economic conditions that have directly affected the industry is the changing dietary patterns by consumers and the emphasis on living healthier (IBISWorld). Coffee is actually a healthy beverage for consumers and even can help lower the risks of certain kinds of cancer, Type 2 diabetes, Alzheimer's disease, and heart disease (IBISWorld). This has directly affected consumers within the age group of 18 to 24-years old because they are becoming more health conscious (IBISWorld).

The world price of crude oil is another economic condition that will affect the coffee industry. It impacts the price of transportation, which in turn will affect the profitability of the coffee industry (IBISWorld). This is a very important aspect of the industry because so many of the industry's inputs are from foreign markets (IBISWorld).

Also, the demand from grocery wholesalers, who form a crucial link to supermarkets, supermarkets and grocery stores play a significant role in the economic conditions. Wholesalers, who account for 73.2% of the market, are essential because they affect which products make it onto the store shelves (IBISWorld). The supermarkets and grocery stores are the direct link between producers and consumers; therefore, coffee producers need to

establish relationships with the supermarkets and grocery stores to gain competitive advantages (IBISWorld).

The actual price of the green coffee bean crops is another important economic condition for the coffee industry. The green coffee beans are the primary input into coffee production (IBISWorld). This in turn also affects the profitability for producers, which has brought to light the unethical treatment of growers in developing countries, which can affect the price of the coffee beans. Sustainable and fair-trade production is a continuing issue within the coffee industry (IBISWorld).

The coffee industry is growing at a consistent rate despite the global recession and by 2009, over 54% of Americans reported to drink at least one cup of coffee per day (IBISWorld). The increase in the industry is expected to record an average annual growth of 1.8% and to reach a total worth of $6.54 billion in the United States by 2010 (IBISWorld). By 2015, the industry is predicted to grow at an average annualized rate of 2.0% while reaching a total worth of $7.22 billion (IBISWorld). Part of the increase in the industry is the increase in consumption for health benefits but also there is a wider range of flavors available, which has stimulated demand.

The supply of coffee beans is the foremost concern for the industry and plays an important part in its current size and ability to grow. Coffee is grown in rich soil, primarily in high altitude, tropical climates near the equator. The main countries which grow coffee beans are Ivory Coast, Puerto Rico, Costa Rica, Mexico, Guatemala, Kenya, Colombia, Yemen, Ethiopia, Brazil, and Indonesia. The primary coffee producer in the United States is Hawaii.

Coffee bean prices can be very unpredictable due to weather conditions that play an important part in the profitability of the coffee industry (IBISWorld). For example, in 2007 production revenue fell 9.9% due to adverse weather conditions (IBISWorld). Ethical consumerism plays an important part in the production of coffee beans. Out of the world's coffee, 50% is grown by small family growers in developing countries (IBISWorld). Many coffee retailers and consumers today take into account the issue of fair-trade when buying or selling coffee including Dunkin' Donuts, Starbucks and McDonald's (IBISWorld).

Over the last five years, the coffee industry has witnessed a 1.6% increase in the number of coffee production establishments annually (IBISWorld). The employment increased at a slower rate of 1.1% over the same period of time (IBISWorld). Also, the consumption of coffee has grown from an average of 24.3 gallons of coffee per person per year in 2005 to 24.7 gallons per person per year in 2009 (IBISWorld). While this may not seem like an extreme increase, it is still enough to play a significant role in the industry. Gourmet and imported coffee have also helped to increase the coffee industry. On average, 17% of the adult population consumed a gourmet beverage, including tea or coffee, on a daily basis (IBISWorld).

Standards

The industry standards for the coffee industry, especially for coffee roasters, can range into a variety of different categories and there are not any major or specific standards that are required for the coffee roasters. Most of the standards refer to the beans and their quality. There are two standard grades, premium and specialty (Specialty Coffee Association of America, SCAA). According to the SCAA, beans should not have any primary defects and a

maximum of five secondary defects, which include parchment, hull or husk, broken or chipped beans, insect damage, partial black or sour, shell, small stones or sticks, or water damage to the beans (SCAA). The beans should have 10-12% moisture content. They should also meet the SCAA's cup evaluation of eighty points or above, which is based on a sixteen point scale which evaluates eleven different coffee characteristics (SCAA).

The ethical treatment of workers is becoming a growing standard within the industry. It is becoming more and more common for ethical treatment of workers, especially in developing countries, to be a deciding factor in the production or purchasing of coffee. Ethical coffee groups and lobby groups are developing and establishing new standards defining what is considered unethical treatment of workers within the coffee industry (IBISWorld).

Regulations

The government regulations for the coffee industry are still developing because the industry itself is still developing. However, some of the major regulations that could affect US RoasterCorp are air quality regulations. Many of these are done on a state or county level and there are not any on a federal level specifically for coffee roasters. Specifically in Sacramento County, California, there are regulations on air quality and emissions due to coffee roasting. Attached in Appendix B is the listing of all the specific regulations for this part of California that will be a possible restraint for US RoasterCorp.

Also, the environmental impact from the Environmental Protection Agency regulates the food processing side of the industry. Many environmental regulations affect US RoasterCorp including the Clean Water Act, Clean Air Act, Pollution Prevention Act and the

Resource Conservation and Recovery Act (IBISWorld). However, these do apply more to the food processing side of the industry including the grinding as opposed to the roasting. However, the Pollution Prevention Act currently lacks the regulatory power need to encourage companies to implement pollution prevention practices (IBISWorld.)

The regulation of public health and product labeling also affect the coffee industry. The Food and Drug Administration (FDA) is the primary regulator of public health and product labeling. The FDA requires that all of the coffee have the proper labeling that includes the nutrition information and bears nutrient content claims as well as certain health messages available to the consumers (IBISWorld).

Competitors

US RoasterCorp has many competitors and some of these competitors have resources that exceed those of US RoasterCorp. One of the major competitors is Primo Roasting. Primo Roasting was founded 26 years ago by Marty Curtis, and specializes in roaster rebuilding and performance enhancement as well as afterburner design and fabrication. Primo Roasting is located in Rose Bud, Arkansas. Primo's largest roaster is their PRI-265 which holds 310 pounds of green coffee beans. They use the Internet for their primary marketing strategy.

Another competitor that US RoasterCorp faces is Has Garanti. Has Garanti is based out of Turkey, and sells in 15 different countries; America, Canada, England, Australia, New Zealand, South Africa, and Taiwan but most of their products are sent to Europe and African countries. They were founded by Remzi Aydin in 1954. Their largest roaster is the HSR 180 which is

considered one of their industrial roasters and it holds 180 kilograms (396.83 lbs) of green coffee beans. They use word of mouth and the Internet for marketing.

The third competitor is Ambex Roasters, and was founded by Terry Davis. Ambex sells roasters, controls, equipment, maintenance, and also provides training. They are based in Clearwater, Florida, and try to visit many trade shows. Their largest roaster is the Ambex YM-120 and it holds up to 240 pounds maximum. They rely solely on word of mouth and the Internet for their marketing.

Next is Diedrich Manufacturing. Diedrich is out of Idaho and is a family company. The actual company was founded in 1980 but they were around before then. Diedrich attends several industry events; four are on the schedule until September 2011. They rely heavily on the tradeshows for their marketing. They have two series of roasters, the IR and the CR. Of the IR series the largest is the IR-12 that holds 12 kilograms of beans. The CR series, on the other hand, is quite a bit bigger. The largest that they have a picture of on their website is the CR-350 which holds 350 kilograms but they do have drawings for up to the CR-490 which would hold 490 kilograms (1080.27 lbs) of beans.

US RoasterCorp's last competitor is Probat. They were established in 1868 but their first roaster did not come out until 1920. They are located primarily in Germany but also have companies in Italy, U.S. and Brazil. They advertise that they can process cocoa, nuts, malt, and coffee. Probat publishes a magazine that began in 2006 called LEONARDO, which is their major marketing strategy. They have even started to offer what they are calling environmental friendly exhaust gas treatment. But, even with this treatment their roasters do not pass air

quality regulations in southern California. Probat has three different lines of roasters. First in their Saturn line, the largest they have made so far, is the Saturn 4000 and it holds between 350-550 kilograms of beans. Second is the Neptune line, where their largest is the Neptune 1500 and it is stated to hold between 240-320 kilograms. Lastly is the Jupiter line, the largest is the Jupiter 5000 which holds between 550-750 kilograms of beans.

Client Characteristics

Buying practices for US RoasterCorp include purchasing metal from Boyd Metals, AF Co., Jorgensen, and Special Metal. While it is necessary to purchase some materials, US RoasterCorp prefers to and primarily builds all of their equipment in house.

The current market size for US RoasterCorp is $2.5 million each year. However, assuming every job works out flawlessly, the potential market size could be up to $5 million each year. This means that this year they will sell $2.5 million worth of their coffee roasters and rebuilding services. After the finishing of the 300 kilogram roaster they expect their gross sales to expand to $5 million per year, therefore doubling their profit from sales.

US RoasterCorp attends approximately two trade shows a year and has subscriptions to several coffee industry magazines. U.S Roaster Corp obtains many of its product and rebuilding sales by going to trade shows but does not currently advertise in any of the coffee industry magazines. Currently, US RoasterCorp is selling to average sized corporations and small startup companies, as well as to companies that are not directly associated with the coffee industry, such as to Lowe's corporate office. They plan to begin selling to big-name coffee corporations such as Folgers and Starbucks by building larger, industrial sized coffee roasters such as the 150

kilogram and 300 kilogram coffee roasters. The larger coffee roasters would be more desired by the larger coffee corporations because they roast large amounts of coffee every day to sell to their customers and a smaller sized coffee roaster would not be able to keep up with the demand.

The main customers for the 300 kilogram coffee roaster will be coffee professionals. They desire gourmet coffee and demand consistency in how their coffee tastes. They are food service professionals who sell their coffee to loyal customers. The buying firms that would purchase a 300 kilogram coffee roaster are companies such as Starbucks, Folgers, and some hotel chains. These companies are picky and need their coffee to taste perfect, or at least consistent. The owners and employees of the companies who would purchase a 300 kilogram tend to be more affluent people who demand consistent, high quality taste in their coffee. These companies often appeal to wealthier people, and sell their coffee as being the best.

The products produced by US RoasterCorp are currently used solely to roast coffee beans. However, it could also be used to roast nuts, other beans, and almost any other grain type food. There are many different markets which a 300 kilogram coaster could be a part of, but US RoasterCorp would prefer to stay solely within the coffee market.

There are online resources such as Coffee Universe at coffeeuniverse.com. On this site, coffee lovers can learn about coffee and they can also purchase coffee roasters and various other coffee related machines. There is also market research available in coffee houses and coffee providers' stores. Some of the companies that US RoasterCorp could market with would be Java Daves, Starbucks, Seattle Coffee, Folgers, and some hotel chains. Additional market

research should be done with magazines. Roasting Innovation has already researched a list of potential magazines available for US RoasterCorp to advertise and market in. Some magazines that could be used are Café Magazine, Coffee Explorer, Coffee Geek, and Coffee Review. These magazines are primarily viewed by others within the coffee industry. Many coffee producers, coffee roaster manufacturers, coffee retailers, and coffee consumers all look at these magazines.

Environmental, Societal and Global Impacts

Southern California has more strict air pollution emission regulations than any other area of the United States of America. Currently, there are not any roasters sold on the market that are allowed to be operated in southern California because they exceed the more strict air quality regulations. US RoasterCorp plans to be the first company to build an industrial coffee roaster which can legally operate in this area of the United States of America. Comparisons of the Air Quality Standards can be seen in Appendix A.

Media and Communications

Website

Roasting Innovation will develop a team website to promote the work done on the 300 kilogram roaster as well as the promotional aspects of the marketing plan. Also, this will help with the visibility of the product. This website will be built for the purpose of promoting our team design, but US RoasterCorp may use it in the future on their website. Roasting Innovation

will also include a video of our design from SolidWorks on the website showing the details and specifications of the 300 kilogram roaster.

Specifications Sheet

Roasting Innovation will also develop a specifications sheet to be used to give the specifics of the coffee roaster. It will allow US RoasterCorp to adequately discuss the details of the roaster with their customers.

Brochure

A promotional brochure will also be developed for the marketing campaign. The brochure will explain the new coffee roaster and the capabilities of the roaster, as well as how it can improve current roasting processes. The brochure will be sent out to customers, along with the specifications sheet. It will also be used at trade shows, conferences and other industry gatherings.

Pictorial User Manual

Also, a pictorial user manual on how to use the coffee roaster will be developed for customers of US RoasterCorp. The manual will include pictures of different stages of the roasting process, including pictures of the beans throughout the process as well as differences in roasting times and how that affects the beans.

Business Plan

1. Executive Summary

U.S Roaster Corp has been developing larger roasters to appeal to an increased market. They have encountered a few problems with thermodynamics which is why they have asked Roasting Innovation to help. Roasting Innovation needs to design and produce a drum and drive train for a 300 kilogram roaster that can withstand high temperatures. The 300 kilogram roaster needs to be reliable, easily reproducible, and remain safe to operate.

1.1. Objectives

US RoasterCorp expects that this product will raise approximately 3 million dollars per year for their company.

1.2. Target Customers and Market Analysis

Currently, US RoasterCorp is selling to average and wealthy corporations, not always associated with the coffee industry. They plan to begin selling to big-name coffee corporations. In order to attract the bigger companies into buying their products they are beginning to move away from the smaller roasters on their line, and trying to build bigger roasters which the big name coffee companies would be more interested in buying. The customers for the 300 kilogram coffee roaster will be coffee professionals. They desire gourmet coffee and demand consistency in how their coffee tastes. They are food service professionals who sell their coffee to loyal customers.

1.3. Competitive Products

US RoasterCorp is completely American made unlike most other coffee roaster manufacturers. They also have very quality products for the price customers pay. Their knowledge of the industry and the experience rebuilding other company's roasters places them above the competition.

Competitors:

1. Primo Roasting- PRI-265 holds 310 lbs of green beans
2. Has Garanti- HSR-180 holds 390 lbs of green beans
3. Ambex- YM-120 holds of 240 lbs of green beans
4. Diedrich Manufacturing- CR-490 holds 1080 lbs of green beans
5. Probat- Jupiter 5000 holds 1650 lbs of green beans

2. Target Customers

US RoasterCorp targets their previous customers for return business. For secondary customers, US RoasterCorp relies on word of mouth and the Internet to refer people to them. Roasting Innovation has compiled a list of US RoasterCorp customers whom were contacted and asked to complete a survey on their preferences, including their current roasters (Table 2).

Table 2: List of customers, their contact information, and survey

Customers	Contact Person	Roaster Purchased	Contact Number	When Contacted	What do you value most about your current roaster?	What is somehting that you wouldn't change about your roaster?	Would you buy another roaster from U.S. Roaster Corp? Why?	If you had to change one thing what would it be?
Broadway Café	Jon Cates	Sample Roaster	816-679-5897	11/17/2010	Mostly roasts with Deidrich roaster ease of maintenance	Likes to be able to roast and cool at the same time and likes to roast smaller batches than what the max is.	Yeah, if they could be up to the standards of Deidrich	Temperature readout, wants as many probes as possible
Charlie Bean	Charles Mangus	5 Killogram Roaster	405-642-5964	11/29/2010	Druability	Way its fabricated- out of solid steel	Yes, good service and very reliable	More user friendly computer screen
Down East Coffee	Terry Montague	12 Killogram Roaster	506-576-9292	11/29/2010	Looks nice and roasts good tasting coffee	Energy efficient	Yes, nice people	Needs to mix better
First Light Coffee Roasters	Walt Manchester	12 Killogram Roaster	207-655-1196	11/17/2010	automation (PLC)	Anything	Yes, very good quality and really nice people	Improve the software and automation. The roaster software is supposed to be able to monitor temperature and adjust the gas to the profile but it doesn't really work
Forestdale Coffee	David Edwards	3 Killogram Roaster	423-677-1473	11/17/2010 Left Message	Energy efficient	Looks nice	Yes, good people there	Easier maintenance entry points, mixing could be better
Mystic Coffee Roasters	Sharon Hepburn	5 Killogram Roaster	781-420-2344	11/29/2010	They get lots of use out of it.	the fuel is gas	Yes, they are nice and easy going	Maintenance is a little difficult. Getting to certain places is not easy.
Red Rooster Coffee Co.	B. Osborn & H. Polseno	3 Killogram Roaster	540-797-3746	11/17/2010	Looks really nice, and energy efficient	airflow monitor	Yeah, they are easy to deal with, low cost for what you get and American made	The entry and exit panels get gummed up and are hard to clean. There is not good access to under the drum, there are 2 bolts and they get really hot. Basically have to wait to the next day.
Roastmeisters Coffee	David Fullerton	12 Killogram Roaster	508-756-9446	11/17/2010	Recirculating air, all electric	environmentally friendly	Yes, they have good services	Make it easier to clean the catalyst without big machinery
Serenus Coffee & Tea	Steve Souphanthoung	5 Killogram Roaster	416-727-7209	11/17/2010	Don't use it right now	any change that is for the better	Depending on the future product, if good then yes	Better bean mixing

3. Target Users

The primary users of this product will be larger coffee houses and roasting factories. The people who will use the machine will monitor the temperature and capacity throughout the roasting process. This product will help smaller coffee houses grow tremendously

throughout the exponentially larger capacity of the roaster. Being more energy efficient and cost efficient will also help the smaller business grow when they use this product.

4. Product Description & Positioning Statement

For the owner of coffee houses who would like to grow their business with a larger roaster, US RoasterCorp with their 300 kilogram coffee roaster is a roasting product that is highly energy efficient, cost efficient, American made, and comes with a company that has a high level of expertise in the rebuilding/manufacturing coffee roasters. Unlike Probat or Deidrich, US RoasterCorp is the only coffee roaster that is able to pass air quality standards in Southern California.

4.1. Business Problem, Product Concept and History

US RoasterCorp's customers value the fact that the roaster is American made and energy efficient, but they have been experiencing a few problems with the mixing of the beans. US RoasterCorp currently uses fins inside of their roasting drums to facilitate mixing but Roasting Innovation feels like these can be vastly improved with a few different designs which were presented to US RoasterCorp. The outcome of this meeting was that US RoasterCorp felt the changes were unnecessary and too different than their current line of roasters. This prompted Roasting Innovation to rethink the designs and come up with a design that stayed consistent with US RoasterCorp's current roasters but also would benefit the mixing of the coffee beans.

4.2. Key Messages & Main Benefits:

The new roaster design will facilitate greater mixing and a more even roast of the coffee beans. A new method for emptying the beans will also be implemented. The effect of this will be increased precision in timing of the roasting. The empting or "belly dump" method will allow for all of the beans to exit at one time instead of in short waves or bursts. This aspect is something that no other roaster manufacturing company has implemented. Although this will be new to the market after marketing and sales descriptions this method will be used in increasing numbers throughout the industry.

5. Market Data, Competitive Products, and Analysis

US RoasterCorp has examined the current market and its competitors and feel as though this is the opportune time introduce a larger roaster. Most of their competitors have larger roasters that have been very profitable for each company. US RoasterCorp knows that their new 300 kilogram roaster will be welcomed into the market and increase profits for the company. Roasting Innovation has already analyzed the competitors (Table 3).

5.1. Competitive Strengths, Weaknesses & Response Statements

Primo Roasting

Strength- Low Cost

Weakness- Poor Quality

Has Garanti

Strength- Nice Looking Equipment

Weakness- Based in Turkey so maintenance is difficult

Ambex

Strength- Attractive website and training courses available

Weakness- Small company with not well developed marketing

Deidrich

Strength- Have some very large roasters

Weakness- Does not have any roasters that can pass air quality standards in California

Probat

Strength- Years of experience and brand loyalty

Weakness- Cast iron fronts are very expensive to replace if cracked

Table 3: Competitors and comparisons

Companies vs. Criteria	Accessed on and from	Located	Years manufacturing	Largest Roaster	Industry Events per year	Focus	Marketing Stragegies	Strengths	Weaknesses	Opportunities
Primo Roasting	10-6-2010 from www.primoroasting.com	Rose Bud, Arkansas	26 years	PRI-265 holds 310 lbs of green beans	0	Rebuilding and performance enhancement	Internet and word of mouth	Low cost	Poor Quality	Most opportunitites are related with rebuilding
Has Garanti	10-6-10 from www.hasgaranti.com.tr	Turkey	54 years	HSR-180 holds 390 lbs of green beans	6	Coffee grinders, roasters, and afterburners	Attend trade shows, internet, and word of mouth	Nice looking equipment	Foreign company so maintenance is complicated	Europe and countries that are closer
Ambex	10-6-10 from www.ambexroasters.com	Clearwater, Florida		YM-120 holds of 240 lbs of green beans	3	Smaller roasters and maintenance	Attend trade shows, internet, and word of mouth	Attractive website and training courses available	Small company with not well developed marketing	With marketing they could get more business
Diedrich Manufacturing	10-6-10 from www.diedrichroasters.com	Ponderay, Idaho	30 years	CR-490 holds 1080 lbs of green beans	5	Roasters and also coffee production	Attend trade shows, internet, and word of mouth	Have some very large roasters	Don't have any roasters that can pass air quality standards in CA	Once they catch up with the PLC control system they can expand
Probat	10-6-10 from www.probat.com	Hamburg, Germany	100 years	Jupiter 5000 holds 1650 lbs of green beans	10	Roasters and training courses	Produce own magazine, attend trade shows, internet	Years of experience; brand loyalty	Cast iron fronts are very expensive to replace if cracked	They have already expanded
U. S. Roaster Corp.	10-8-10 from Dan Jolliff	Oklahoma City, Oklahoma	6 years	Revelation 300 holds 660 lbs of green beans	3	Rebuilding and manufacturing	Word of mouth and internet	Quality products and maintenance, knowledge of industry	Not very long manufacturing	Expanding into the larger market. Revelation in South California.

Design Requirements

- Hold 300 kilograms worth of coffee beans
- Allow for a 30% volume clearance of open space in the drum after the coffee beans have been roasted
- Improve the exiting of the coffee beans from the roaster to the cooler
- Account for thermal expansion
- Maintain mixing standards so as to reduce over-, under-, and uneven roasting
- Needs to meet air quality standards in Southern California, the highest in the United States of America

Calculations and Testing

Calculations

Volume

Determining the volume, diameter, and length of the 300 kilogram drum are the first calculations that need to be completed in order to come up with a basic drum design. The drum's volume was calculated using *Equation 1*. Using the 150 kilogram drum already developed by U.S. Roaster, a rough estimate of the overall drum volume was determined. The diameter and length of the drum were then calculated using the volume. *Equation 2* is to calculate the volume of the dual paddle fluidized mixer.

$$V = \pi * \left(\frac{D}{2}\right)^2 * L \qquad \text{(Equation 1)}$$

Where: V = volume of the drum (feet^3)

D = diameter of the drum (feet)

L = length of the drum (feet)

Table 4. Diameter and length calculations based on the volume of the drum

Drum Volume Calculations			
Diameter (feet)	Length (feet)	Diameter:Length	Volume (feet^3)
4	5	1.250	62.8
4	4.5	1.125	56.52

$$V = s * s * 2 + s * d + 12 * h * s_T + s * L \qquad \text{(Equation 2)}$$

Where: V = volume of the drum (feet^3)

r = radius of the swing doors (inches)

s = side length of the drum (inches)

s_T = side length of the top (inches)

d= internal distance (from side to side) of drum (inches)

L = length of the drum (feet)

Table 5. Volume Calculations of the Dual Paddle Design

Drum Volume Calculations						
Side Length (in)	Length Top (in)	Radius (in)	Length (in)	Height (in)	Distance (in)	Volume (feet3)
19.5	19.5	12	54	13.8	51	60.8
20	21.5	12	54	14.1	51.3	78.3

The diameter: length ratio also needs to be considered. The design specifications require the length of the drum to be no greater than 25% of the diameter. Therefore, based on the calculations and specifications the proposed diameter and length of the drum is 4 feet and 4.5 feet, respectively. These results can be seen in Table 4. The dimension calculations for the dual paddle fluidized mixer can be seen in Table 5.

Thermal Expansion

Changes in temperature cause metal to contract and expand. The amount of expansion due to temperature increases is dependent upon what type of metal is subjected to the heat. When a metal such as stainless steel is heated it can expand considerably, while cast iron expands a relatively small amount. This can become a serious design issue with coffee roasters because they can reach temperatures up to 1000^{o}F. Special design requirements must be met in order to build a large, industrial coffee roaster which can function properly at these temperatures. In order to take in account the thermal expansion in the coffee roaster design, the amount of expansion must first be calculated. The thermal expansion can be done using *Equation 3*.

$\Delta L = c * L_i * (T_f - T_i)$ *(Equation 3)*

Where: ΔL = the change in length due to thermal expansion (inches)

c = coefficient of thermal expansion (/^{o}Fahrenheit)

L_i = initial length of the drum before the temperature change (inches)

T_f = the final temperature (^{o}Fahrenheit)

T_i = the initial temperature (^{o}Fahrenheit)

Using Equation 3, the results for the amount of thermal expansion that is calculated when heating chromium stainless steel, alloy steel, stainless steel, and carbon steel up to 1000^{o}F can be seen in Table 6.

Table 6. Change in length calculations based on the thermal expansion of different materials.

Thermal Expansion Calculations					
Material	Length$_i$ (in)	Temperature$_i$ (^{o}F)	Temperature$_f$ (^{o}F)	Coeff. of Thermal Expansion (/^{o}F)*	Change in Length (in)
Cr Stainless Steel	54	70	1100	0.00000663	0.382
Alloy Steel	54	70	1100	0.00000722	0.416
Stainless Steel	54	70	1100	0.0000103	0.594
Carbon Steel	54	70	1100	0.00000797	0.460

*Coefficients were obtained from Hose Master, LLC at http://www.hosemaster.com/products/technical/thermalexpansion.php.

Based on the information in Table 6, the material which provides the least amount of thermal expansion is the chromium stainless steel. The material which has the largest amount of expansion due to temperature change is stainless steel. A cost analysis must be done in order to determine whether the cost addition of reducing thermal expansion is necessary.

Tests to be Conducted

Test #1 Mixing

We will test the mixing of the beans once we develop a new fin design. We will paint the beans several different colors according to where they are placed in the drum. We then will rotate the drum to see if the beans mix well with the new fin design. Mixing is important to prevent under or over cooking and uneven cooking of the beans.

Test #2 Uniform Heating

We will test the uniformity of the heating of the coffee beans. Uniform heating is necessary for quality roasting in order to avoid uneven bean roasting. It also helps prevent under roasting and over roasting. We will test the heating by placing thermocouples around the drum and test to see how much the temperature varies.

Test #3 Pressure

We would like to increase the pressure inside the drum slightly in order to improve the overall efficiency of the roasting. This may be done by the addition of low levels of Nitrogen into the drum. Nitrogen would be used to create a more anaerobic environment for reasons discussed in *Test #8 Anaerobic*.

Test #4 Airflow

In order to have even roasting the airflow within the drum should be steady and uniform. This will help reduce hot spots and keep the roasting of the coffee beans even.

Alternative Design Concepts

Design 1: Hook Rotating Drum

In this proposal, the typical fin design would be replaced with horizontal hooks which would be welded along the entire length of the drum. These hooks would pick up the beans and then throw them in the air during each rotation. This would create a semi-fluidized motion for the coffee beans and encourage even roasting of the coffee beans. On the back end of the drum would be a screen. When the roasting is completed the screen could be moved along the entire length of the drum, pushing all of the roasted coffee beans through the outlet of the drum. This allows for quick evacuation of the coffee bean, again allowing for a more even roasting.

Figure 1: Drum

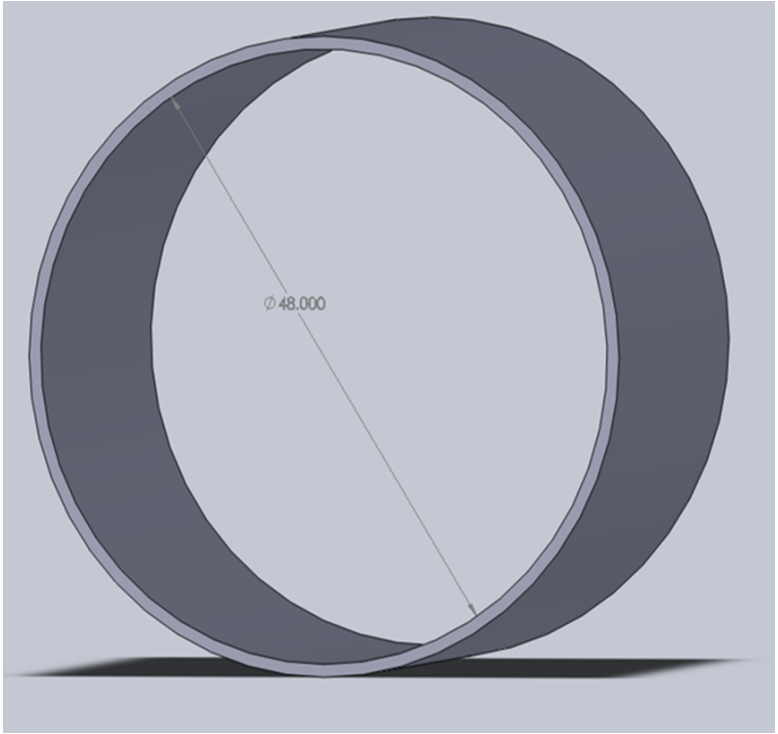


Figure 2: Drum with Hooks and Axel

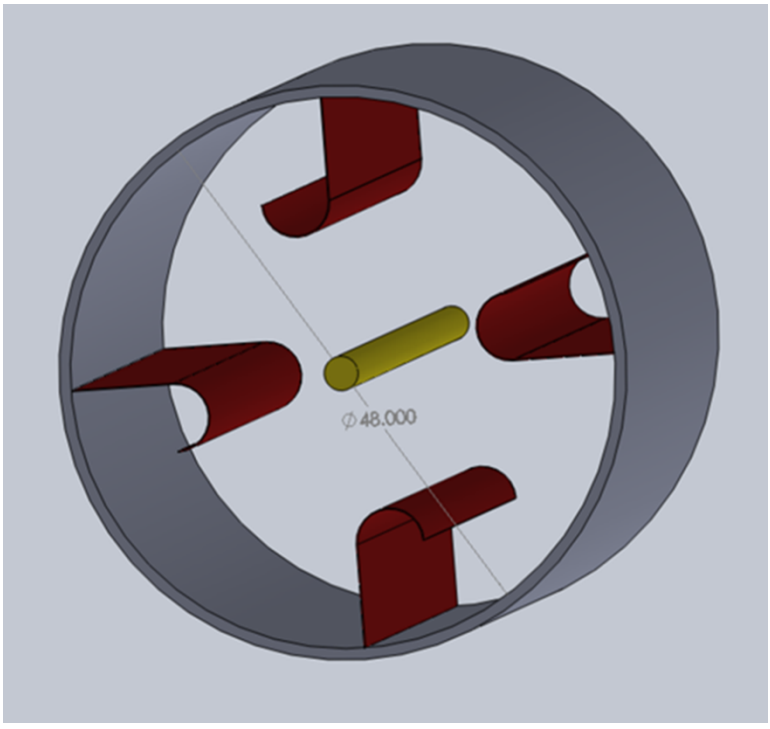
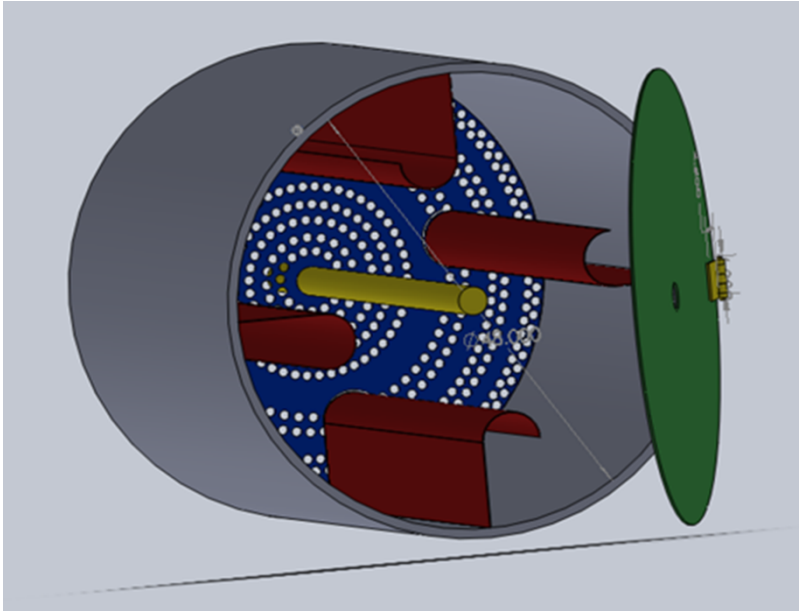


Figure 3: Assembly of Hook Rotating Drum Design



Design 2: Single Paddle Mixer

This design features the traditional roasting drum shape but it differs in mixing method it uses. This proposal uses a single rotating paddle to keep the beans mixing and roasting evenly. The paddle design will also be more efficient than the traditional rotating drum designs. It will accomplish this by requiring a smaller power source to rotate the paddles. This design will also feature a door at the bottom of the fixed drum. This allows for a faster exit for the coffee which interns permit a more even roast of the beans. The barrel would be heated one of two ways. The first possibility is to keep the current heating system in place. The second option consists of feeding the hot air into holes cut into the bottom or top of the drum. Either of these would be valuable options.

Figure4: Drum

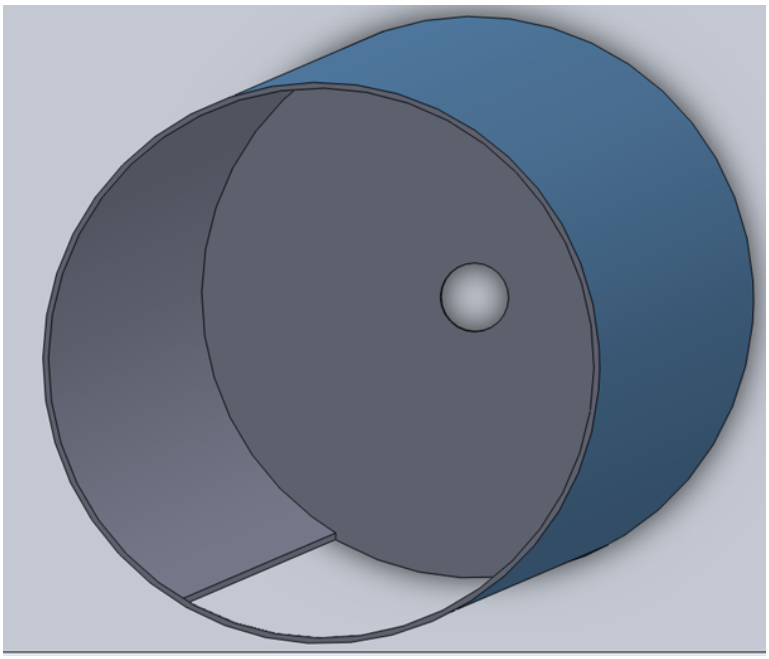


Figure 5: Drum with Paddles

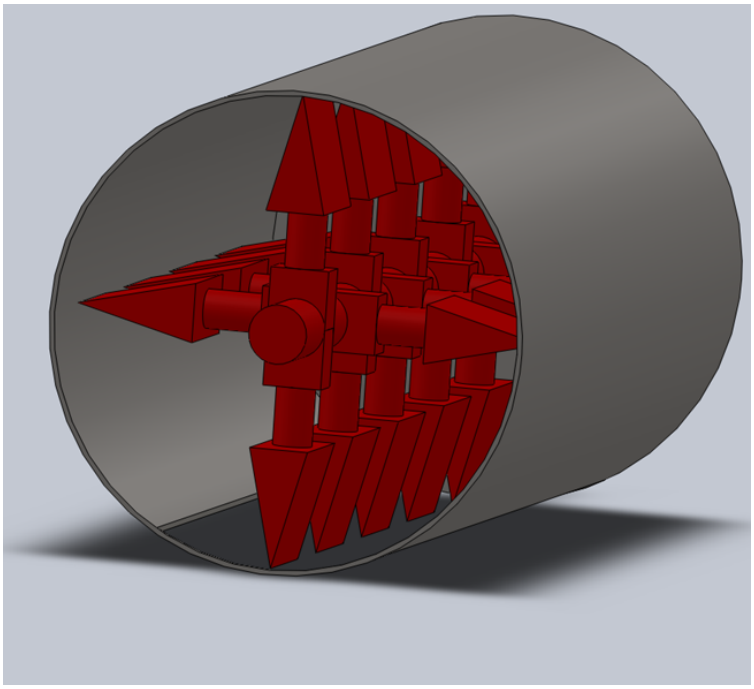
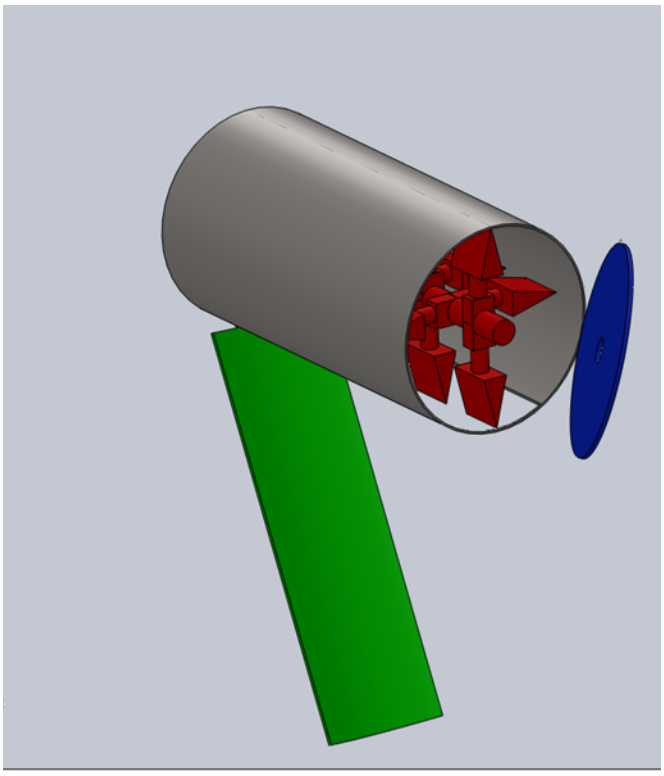


Figure 6: Assembly of the Single Paddle Mixer



Design3: Dual Paddle Fluidized Mixer

In order to offer optimal roasted coffee, the coffee must be evenly roasted through fluidized mixing. However, the traditional design of an industry coffee roaster could be changed slightly in order to accommodate for thermal expansion. Traditional roasters use coffee ovens or drums that rotate on a horizontal axis. The dual paddle fluidized mixer is designed to more efficiently mix the coffee beans while maintaining a similar aesthetic look to traditional roasters. The design no longer encompasses a roasting drum, but instead relies on two shafts with sweep paddles. The shafts are powered by gear sets and motors. The sweep paddles will be offset on the two shafts to efficiently move the coffee beans. The roaster will be heated through air flow coming from four nozzles that are placed at the top of the roaster. The coffee

beans enter from the inlet situated on top of the roaster. The coffee beans will then land on the sweep paddles. The sweep paddles will turn in opposite directions at 35 rpms. After the coffee beans are roasted, the roaster doors will swing open and allow the coffee beans to fall onto the cooler. This roaster will also contain a front face plate to allow for maintenance applications.

Figure7: Frame of Dual Paddle Mixer

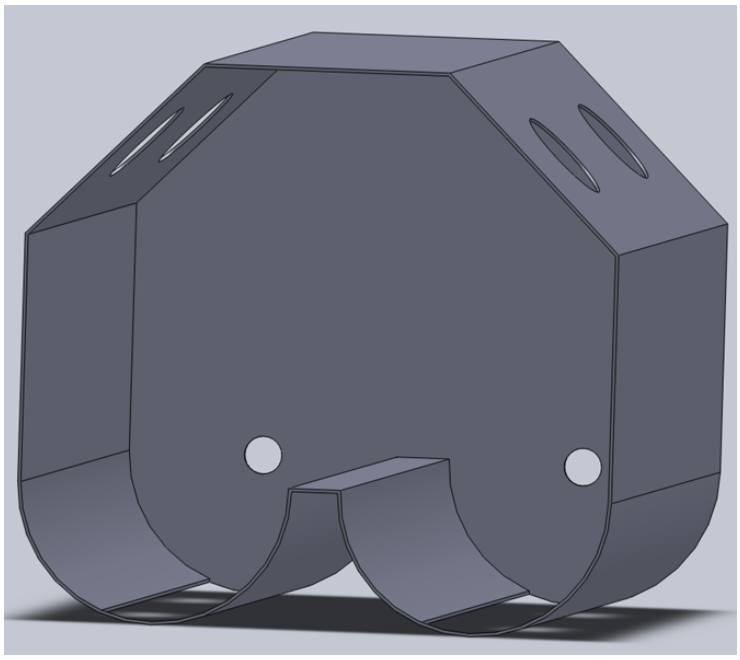


Figure 8: Frame with Paddles

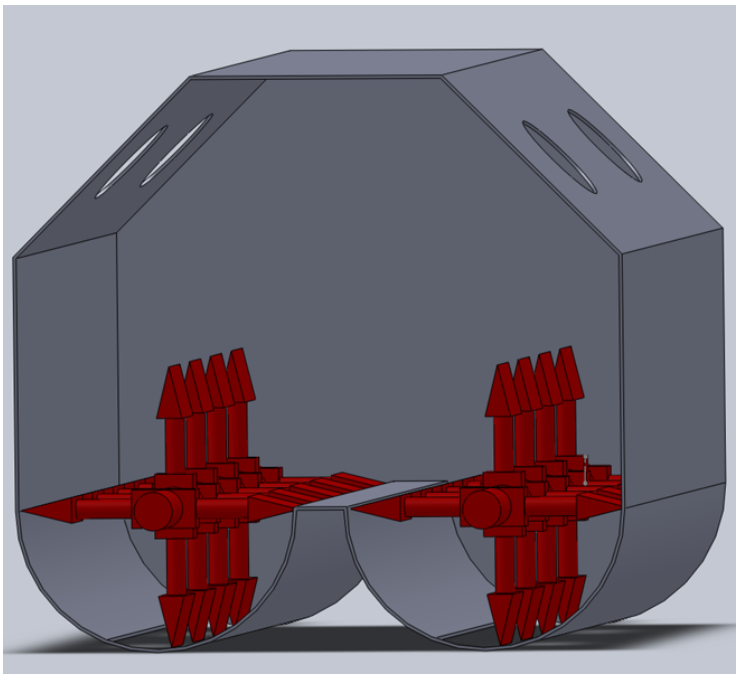
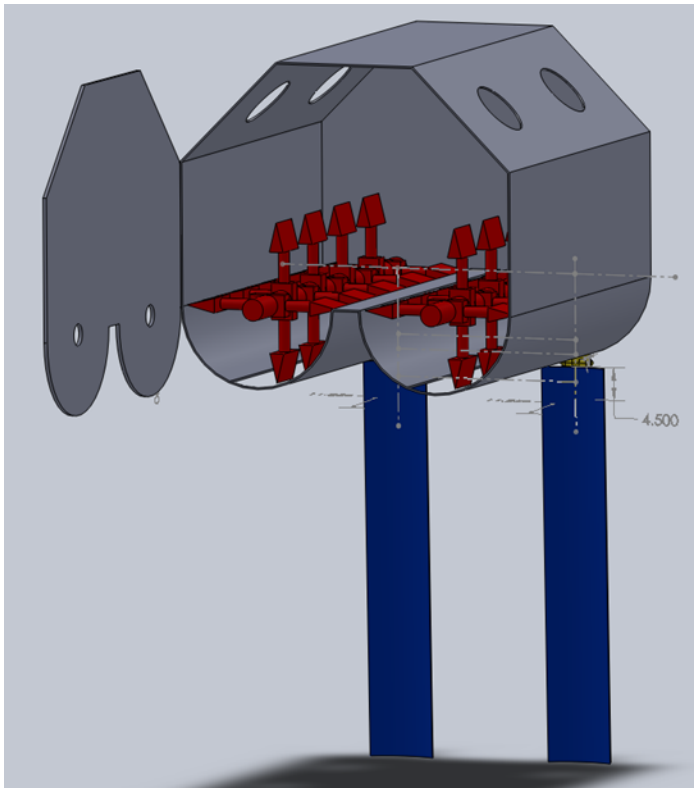


Figure 9: Assembly of Dual Paddle Mixer



Financial Analysis

Table 7: Testing and Miscellaneous Requirements

Product	Amount	Price per Unit	Cost
Sprockets (#35, #40)	1	$200	$200
Plastic sheeting for Testing	1 .25x12x24	$65	$65
Metal sheeting for Testing	2 .008x4x10	$15	$30
Fittings/bolts	--	--	$10
5 gallon plastic bucket	1	$15	$15
Thermocouples	3	$30	$90
Gear Motor	1	$300	$300
Pressure Gage	1	$15	$15
Dye/Paint	4 colors	$5	$20
Drive shaft	1	$10	$10
Total			$755.00

Table 8: Design 1 Hook Rotating Drum

Product	Amount	Price per Unit	Cost
Stainless Steel Drum 12.5 x 4.5 feet (600lbs)	1	1.635 ($/lb.)	$981
Welding	1	$49	$49
Shaft	1	$720.90	$720.90
Hooks (28lb)	4	$1.635 ($/lb)	$183.12
Bearings	1	$89.80	$89.80
Total			$2023.82

Table 9: Design 2 Single Paddle Mixer

Product	Amount	Price per Unit	Cost
Stainless Steel Drum 12.5 x 4.5 feet (600lbs)	1	1.635 ($/lb.)	$981
Welding	1	$49	$49
Hinges	4	$18	$72
Paddles (18 lb)	--	--	--
Shaft	1	$720.90	$720.90
Bearings	1	$48.75	$48.75
Total			$1871.65

Table 10: Design 3 Dual Paddle Mixer

Product	Amount	Price per Unit	Cost
Stainless Steel Drum 12.5 x 4.5 feet (600lbs)	1	1.635 ($/lb.)	$981
Welding	1	$49	$49
Hinges	4	$18	$72
Shafts	2	$720.90	$1441.80
Paddles (36 lb)	--	--	--
Bearings	2	$48.75	$97.50
Total			$2641.30

Table 11: Total Cost of Each Design

Design	Cost
Testing, Miscellaneous, and Design 1Hook Rotating Drum	$2778.82
Testing, Miscellaneous, and Design 2 Single Paddle Mixer	$2626.65
Testing, Miscellaneous, and Design 3 Dual Paddle Mixer	$3396.30

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Appendix A – Scientific Literature

Appendix B – Patents

Karolyn Bolay, Kelsey Hubbard, Brittany Looke,
Mark Marshall and Nathan Moyer

The Team

The Client

U.S. Roaster Corp
Oklahoma City, Oklahoma

Owned by Dan Jolliff

Have been manufacturing coffee roasters since 2004.

Mission Statement

- Roasting Innovations mission will develop a 300 kilogram coffee roaster that will be safe and reliable with the ability to be easily reproduced
- The team will redesign the drum and drive train components of the roaster
- Materials used to build the roaster will be chosen to maintain optimal quality of the product being roasted

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Problem Statement

- Roasting Innovation needs to design and produce a drum and drive train for a 300 kilogram roaster that can withstand temperatures up to approximately 600 degree Fahrenheit so as to reduce destruction of the quality of the roaster due to thermal expansion

- The 300 kilogram roaster needs to be able to roast exceptional coffee to the user's taste, be easily reproducible, and remain safe to operate

Roasting Innovation

Fall Semester Schedule

- September
  - Mission Statement and Problem Statement due 9/27
- October
  - Detailed Report and Budget due 10/18
  - Competitive Analysis, Research, and Investigation due 10/22
  - Statement of Work due 10/29
- November
  - Work Breakdown Structure and List of Tasks due 11/5
- December
  - Fall Report and Presentation due 12/7

Competitors and products

- Ambex – 240lbs of green coffee beans

http://www.ambexroasters.com/art/equipment/roasters/ym120/lrg/ym_120_main.jpg

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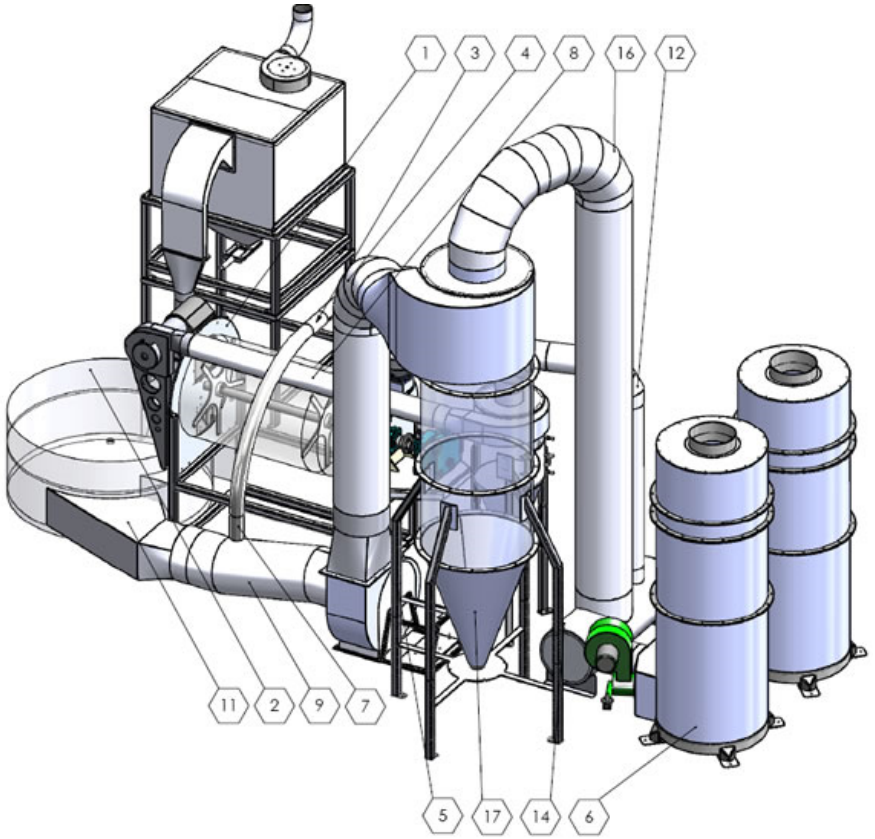
Competitors Continued

- Has Garanti – 390lbs of green coffee beans

http://www.hasgaranti.com.tr/components/com_virtuemart/shop_image/product/0acb6e7bf3752a9175f2eac295b2f44d.jpg

Competitors Continued

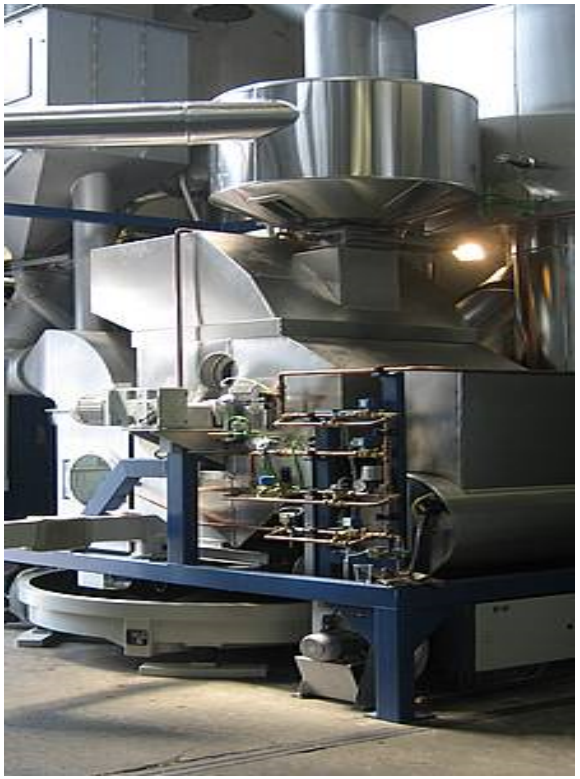
- Deidrich – 1080lbs of green coffee beans



http://www.diedrichroasters.com/images/JPG/CR-490-2008.jpg

Competitors Continued

- Probat – 1650lbs of green coffee beans



http://www.probat.com/typo3temp/pics/6c95847e0d.jpg

Competitors Continued

- Primo Roasting – 310lbs of green coffee beans

http://www.primoroasting.com/images/primo/articles/16/PRI135lg.jpg

Existing Technology

- Fluidization
- Rotating Drum
- Curved Fins
- Belly Dump

Common Designs

- Horizontal Rotating Drum
- Indirect Heating
- Curved Fins

Roasting Innovation

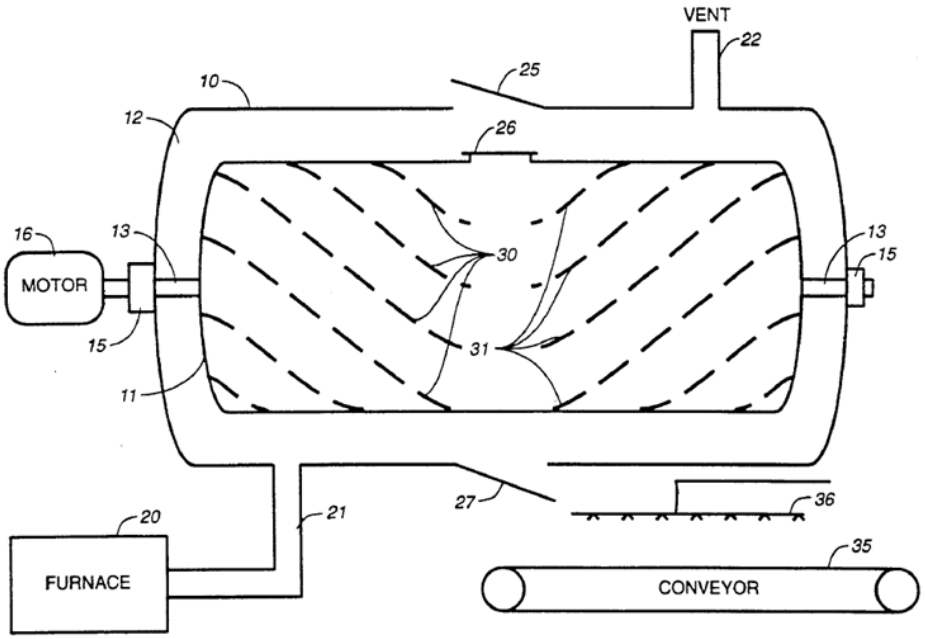
Analysis of the Coffee Industry

- Roaster Patents
- Effects on the Industry
- Standards
- Regulations
- Client Characteristics
- Environmental Concerns

Patents

- Coffee Roasting Process and Apparatus – Patent 5287633 presents an industry coffee roaster that includes drum fins, shaft bearings, and a gear motor

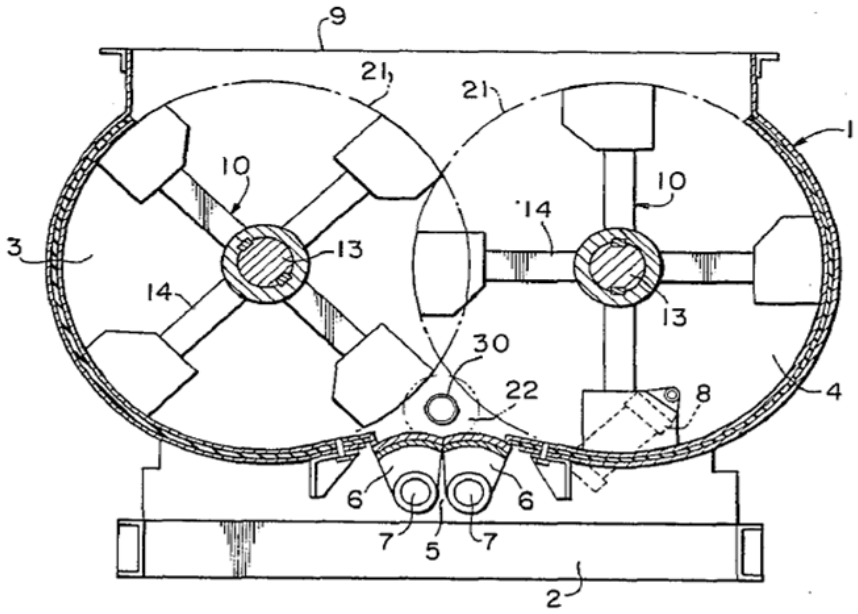
- How to control the thermal expansion of high end industry coffee roasters.



Patents

- Dual shaft pan mixer ¬– Patent 4758095 uses dual shafts with attached paddle mixers. The shafts are connected to a worm gear which is then powered by a motor

- Shows how dual shaft mixers can be used for food processing



Where Does Coffee Come From?

- The main countries which grow coffee beans are:
  - Ivory Coast
  - Puerto Rico
  - Costa Rica
  - Mexico
  - Guatemala
  - Kenya
  - Colombia
  - Yemen
  - Ethiopia
  - Brazil
  - Indonesia
- The primary coffee producer in the United States is Hawaii.

Effects on the Industry

- Health benefits
  - Lowers the risks of certain kinds of cancer, Type 2 diabetes, Alzheimer's disease, and heart disease
- World price of crude oil
- Demand from grocery wholesalers
- Supermarkets and grocery stores

Effects on the Industry

- Price of the green coffee bean
  - Coffee bean prices can be very unpredictable due to weather conditions
- Sustainable and fair-trade production
  - Many coffee retailers and consumers today take into account the issue of fair-trade when buying or selling coffee
- Gourmet and imported coffee have increased the growth of the coffee industry

Standards

- Ethical treatment of workers
  - a deciding factor in the production or purchasing of coffee
  - Ethical coffee groups and lobby groups are developing and establishing new standards
- Quality of beans
  - 10-12% moisture content
  - No primary defects
  - Maximum five secondary defects
    - parchment, hull or husk, broken or chipped beans, insect damage, partial black or sour, shell, small stones or sticks, or water damage

Regulations

- Air quality regulations
- Public health and product labeling regulations
  - Food and Drug Administration (FDA)
    - CFR 21: Reference Amount Customarily Consumed Per Eating Occasion: 240 mL (8 fl. Oz.)
  - nutrition information and health messages available to the consumers

Regulations

- Food processing regulations
  - Clean Water Act
  - Clean Air Act
  - Pollution Prevention Act
  - Resource Conservation and Recovery Act
- International Coffee Organization
  - Development and funding of projects
  - Certificates of origin
  - Sustainable management of coffee resources and processing

Client Characteristics

- Potentially can double U.S. Roaster Corp's market size with the 300 kilogram roaster

- Currently selling to:
  - average sized coffee corporations
  - startup companies
- Want to sell to big-name coffee corporations
  - Folgers and Maxwell House
  - Larger coffee roasters such as the 150 kilogram and 300 kilogram coffee roasters

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Environmental Concerns

- Southern California has more strict air pollution emission regulations than any other area of the United States of America.
- Currently, there are not any roasters sold on the market that are allowed to be operated in southern California because they exceed the more strict air quality regulations.

Customer Survey

- 9 U.S. Roaster Corp customers were contacted
- All 9 said that they would buy another coffee roaster from U.S. Roaster Corp

- Most Important Change: the mixing of the beans
- Additional Improvements: PLC controls
- Most Important Value: the roasters are environment friendly and look appealing

Business Plan

- The product will be manufactured on site
- Materials from local shops will be purchased
- Total cost of production will approximately be between $2700 and $3500, depending on the chosen design

Experiments and Testing

- *Test #1 Mixing*
  - test the mixing of the beans once a new fin design is developed
  - Mixing is important to prevent uneven cooking of the beans
- *Test #2 Uniform Heating*
  - Test by placing thermocouples around the drum to observe temperature variance
  - Uniform heating is necessary for quality roasting in order to avoid uneven bean roasting

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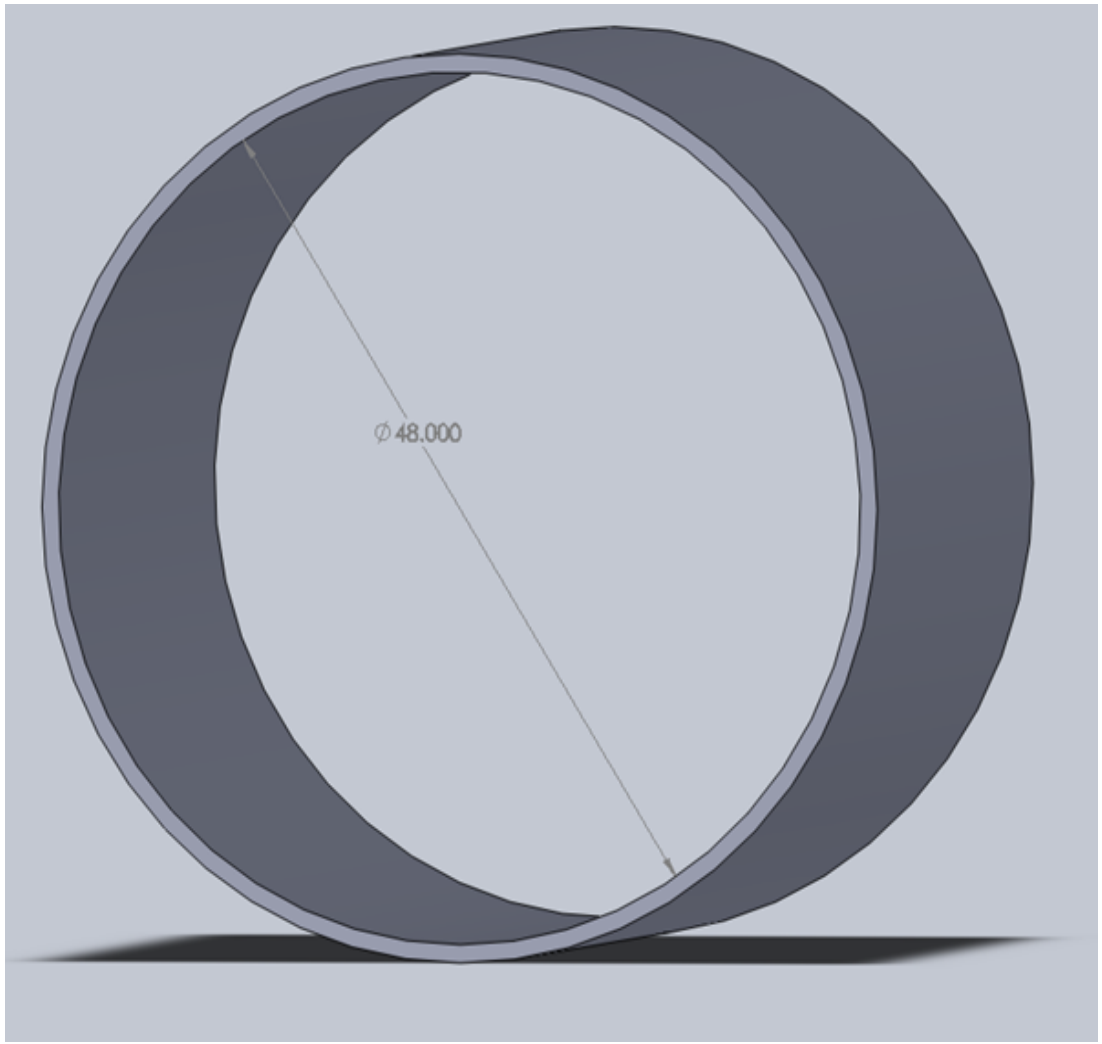
Experiments Continued

- *Test #3 Pressure*
  - increase the pressure inside the drum slightly in order to improve the overall efficiency of the roasting
- *Test #4 Airflow*
  - airflow within the drum should be steady and uniform to reduce hot spots and keep the roasting even

Roasting Innovation

Design 1: Hook Rotating Drum



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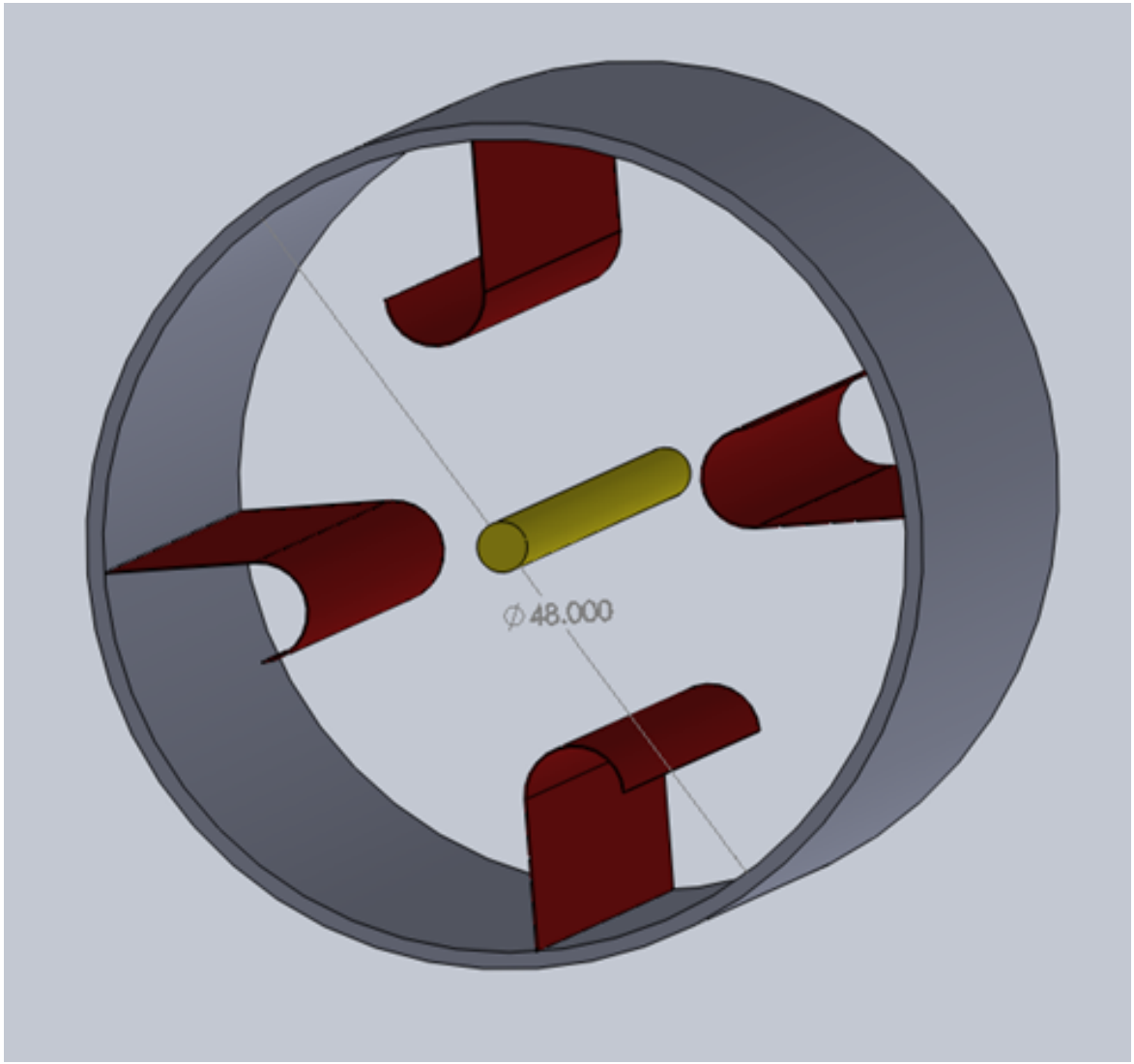

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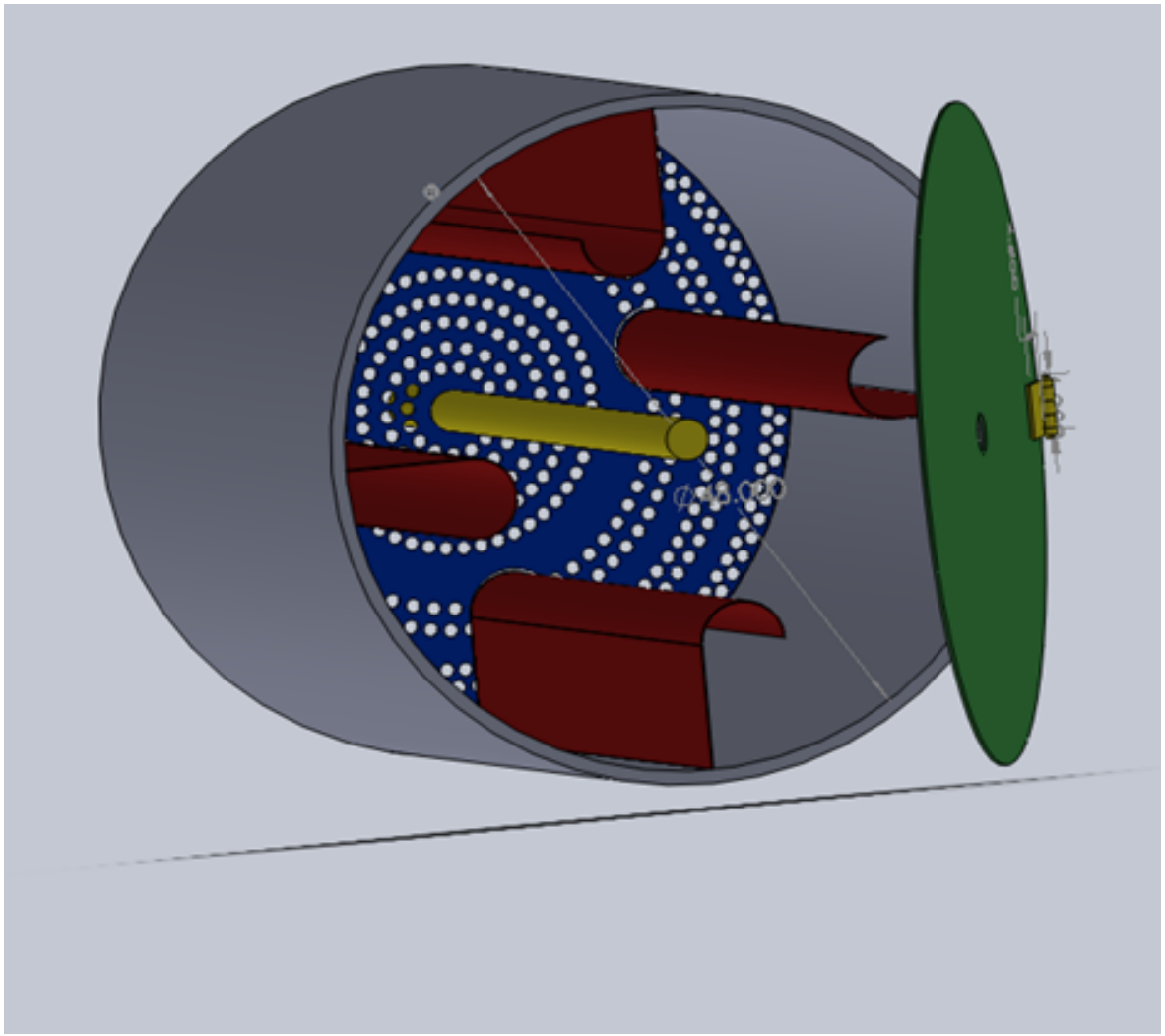
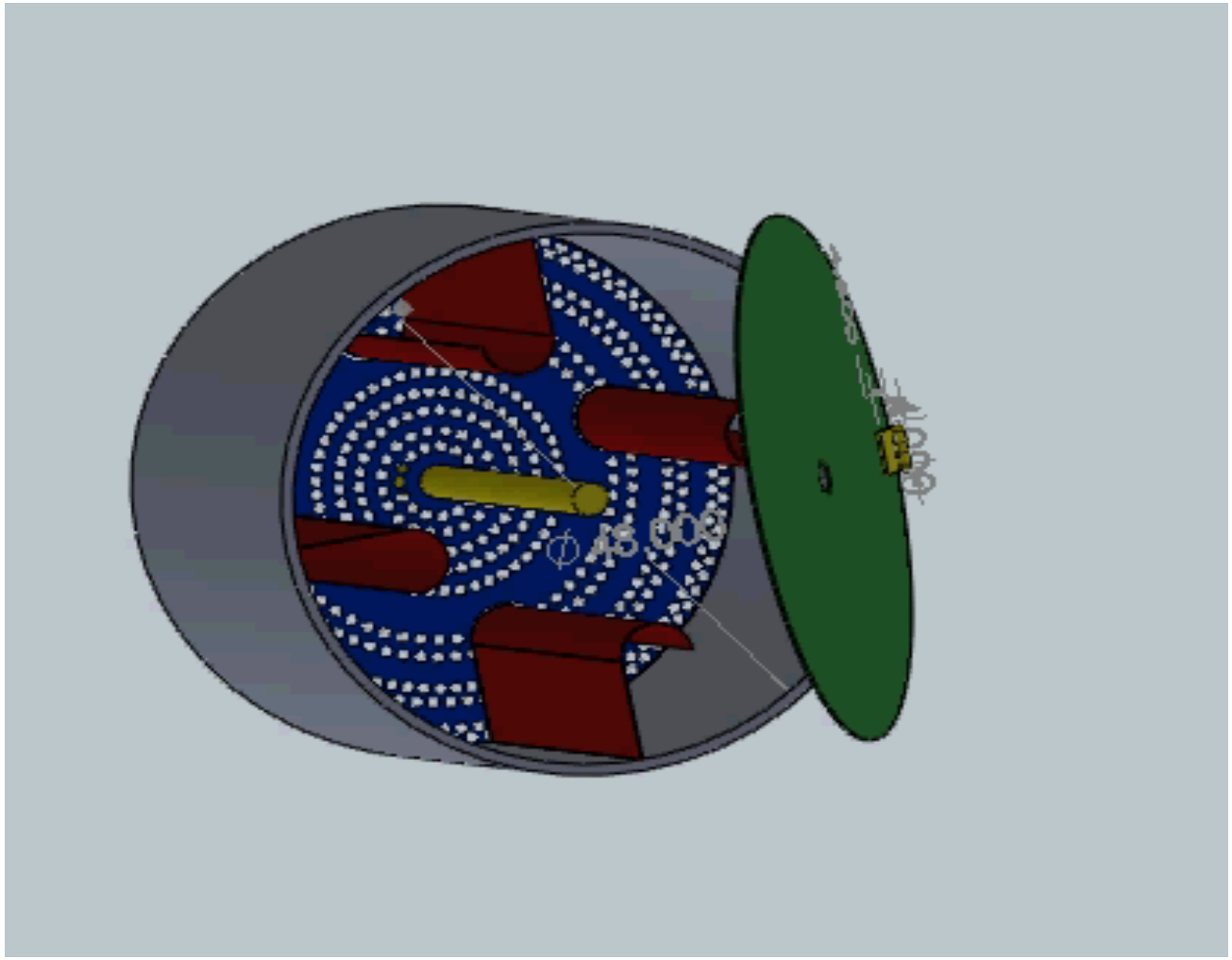
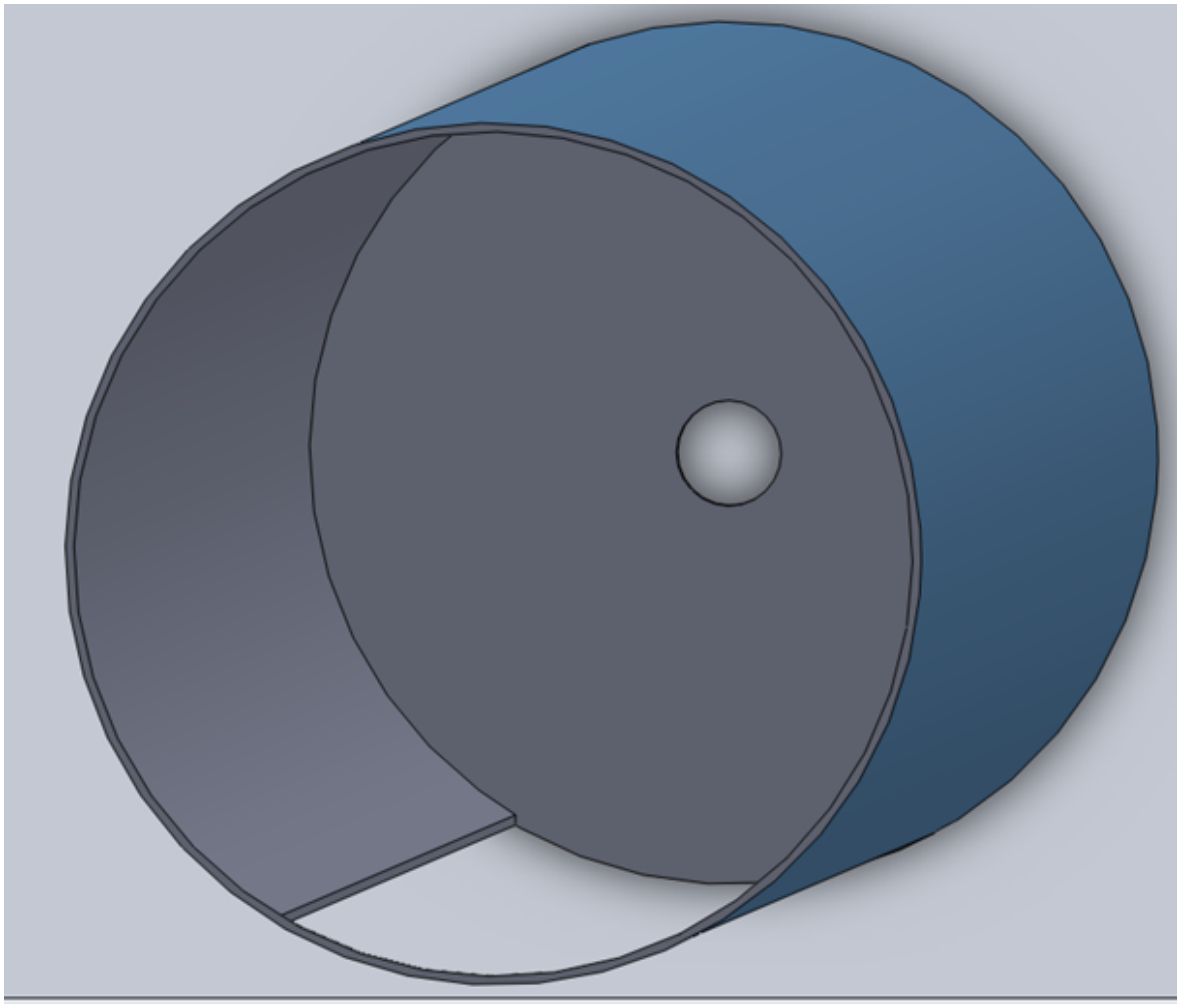


Design 1 Video



Design 2: Single Paddle Mixer



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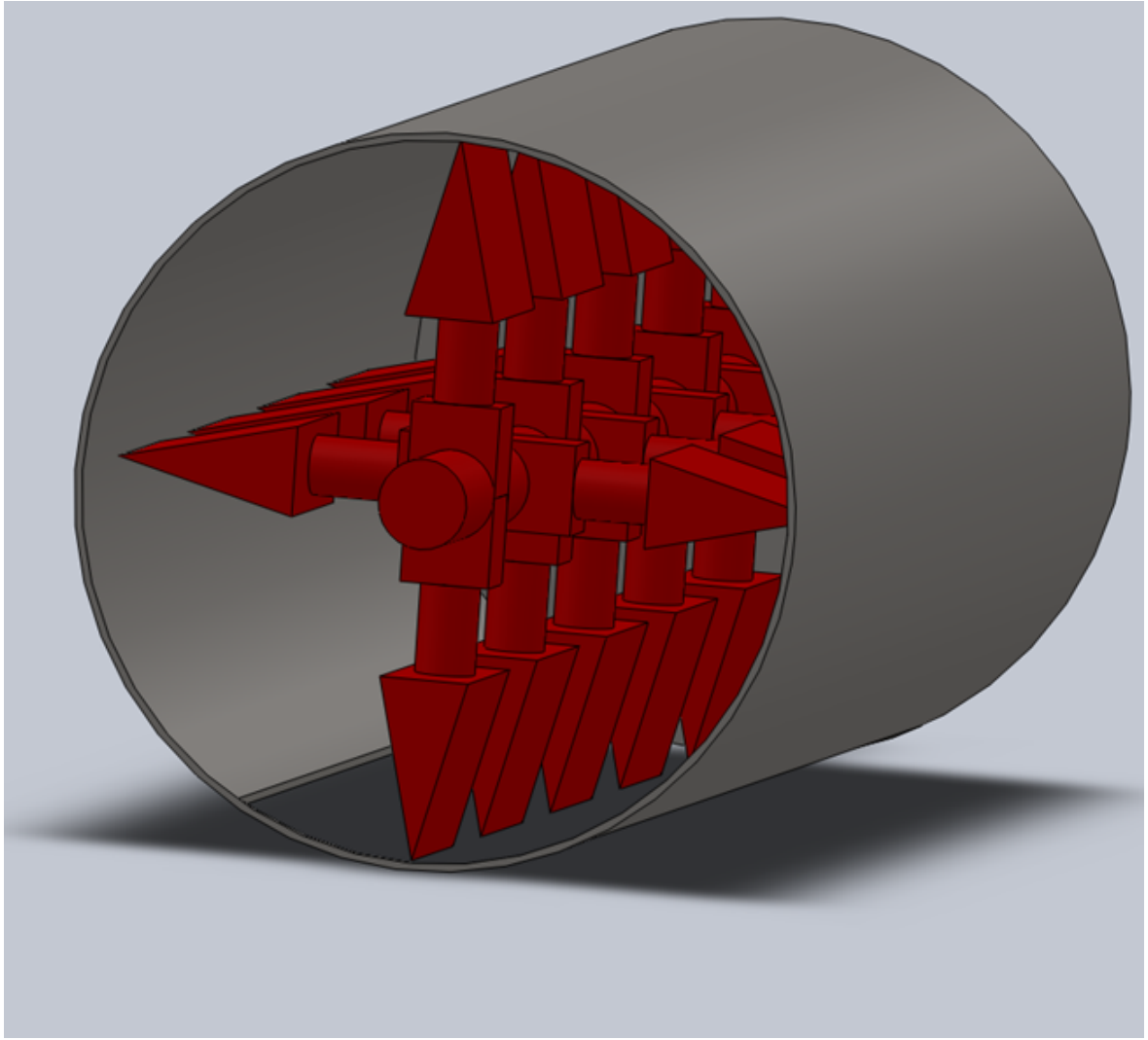

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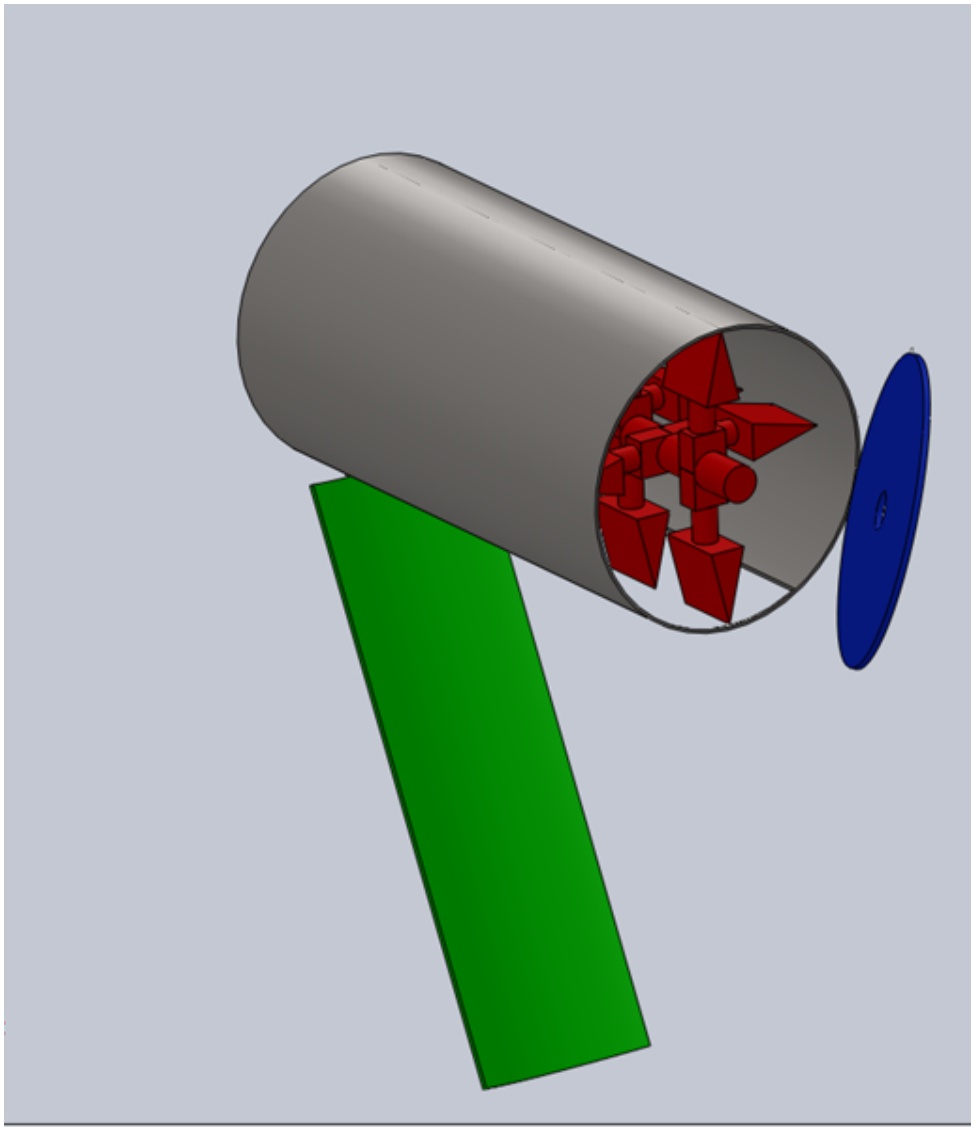
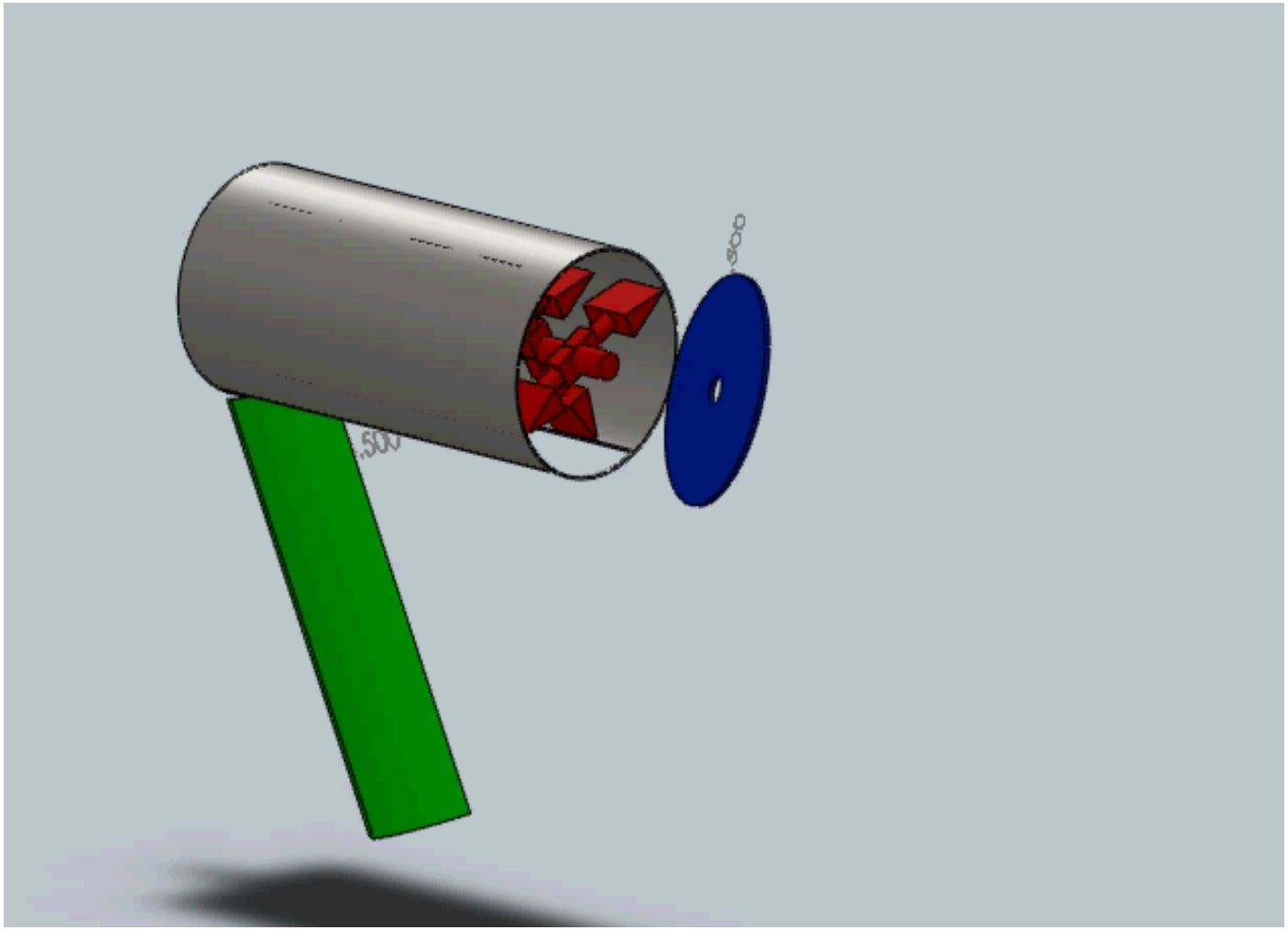
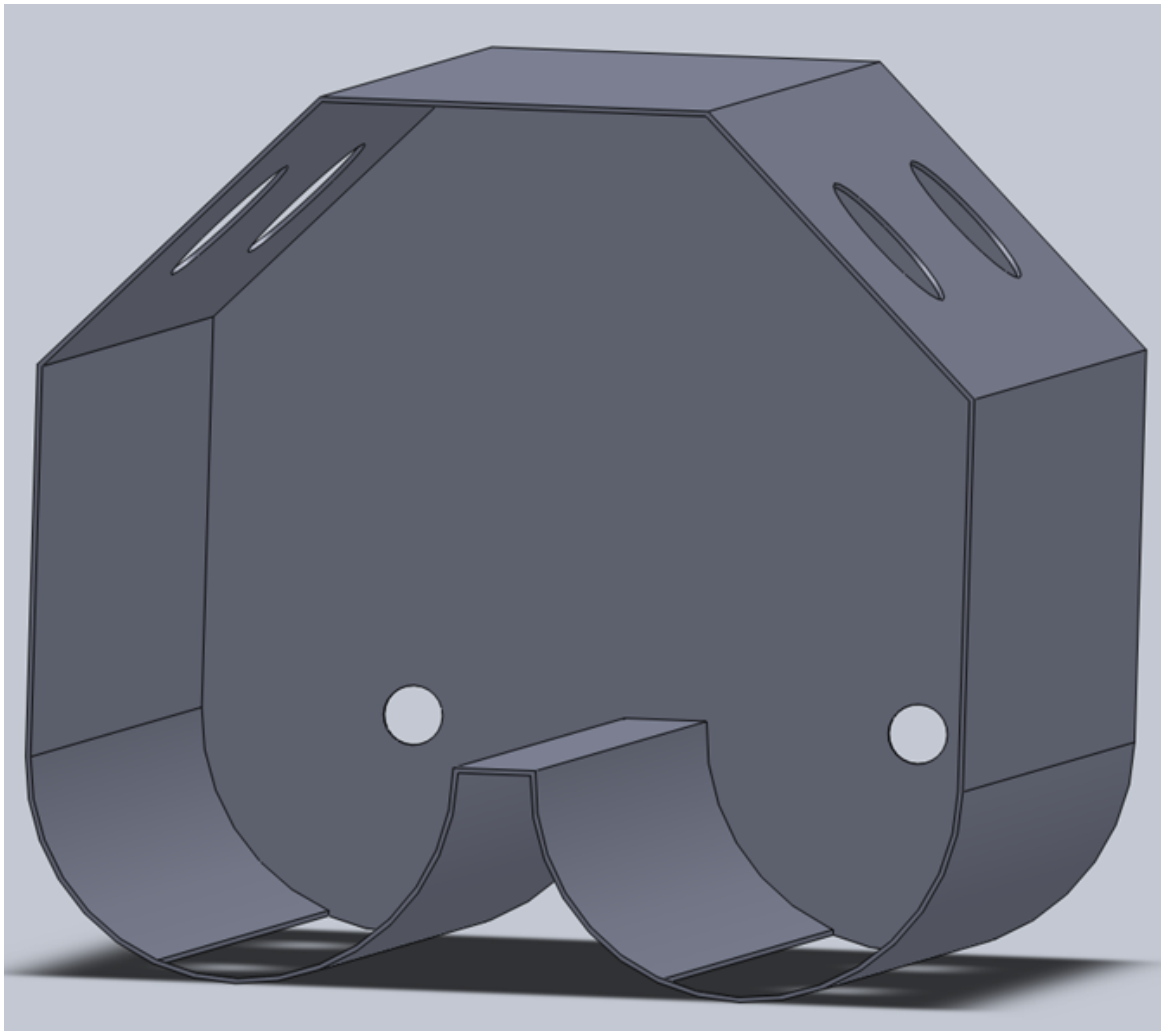


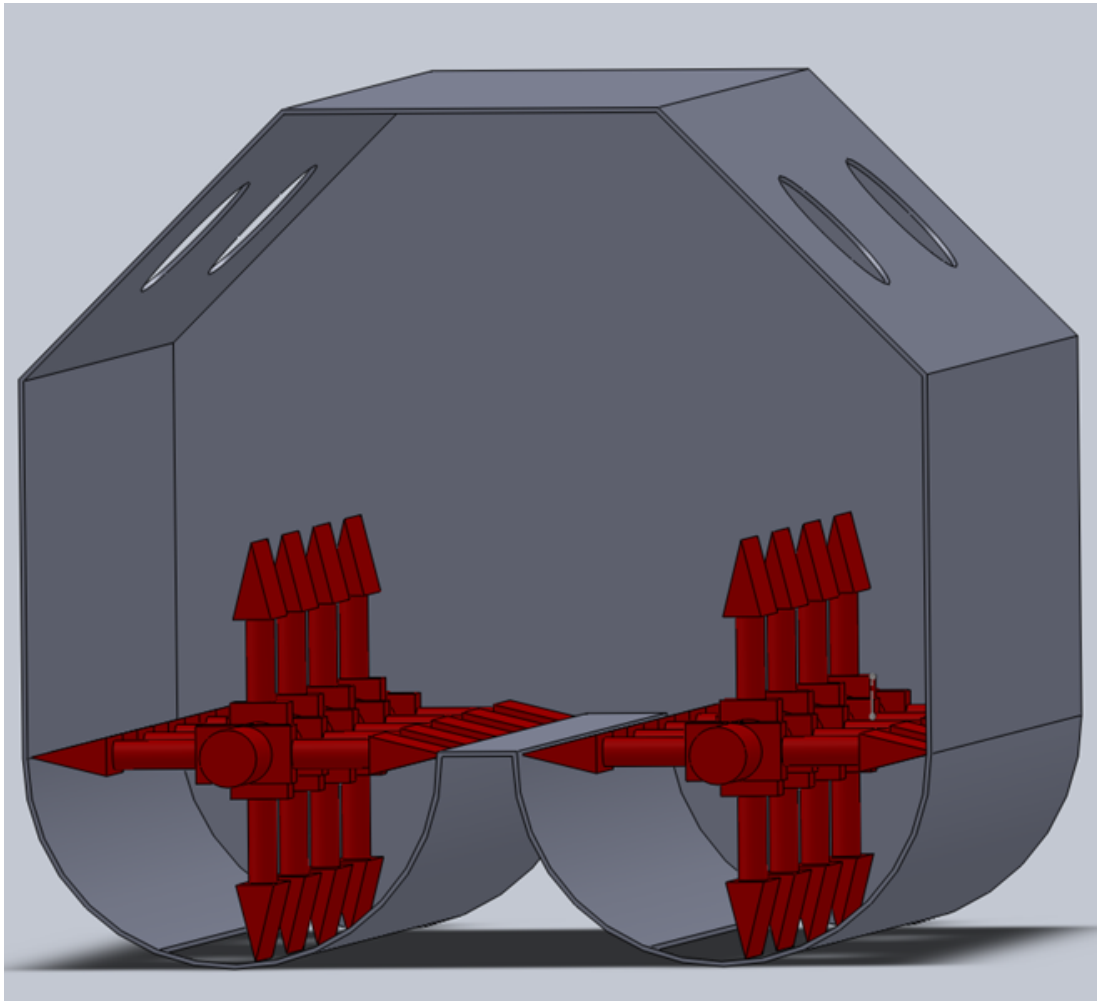
Design 2 Video



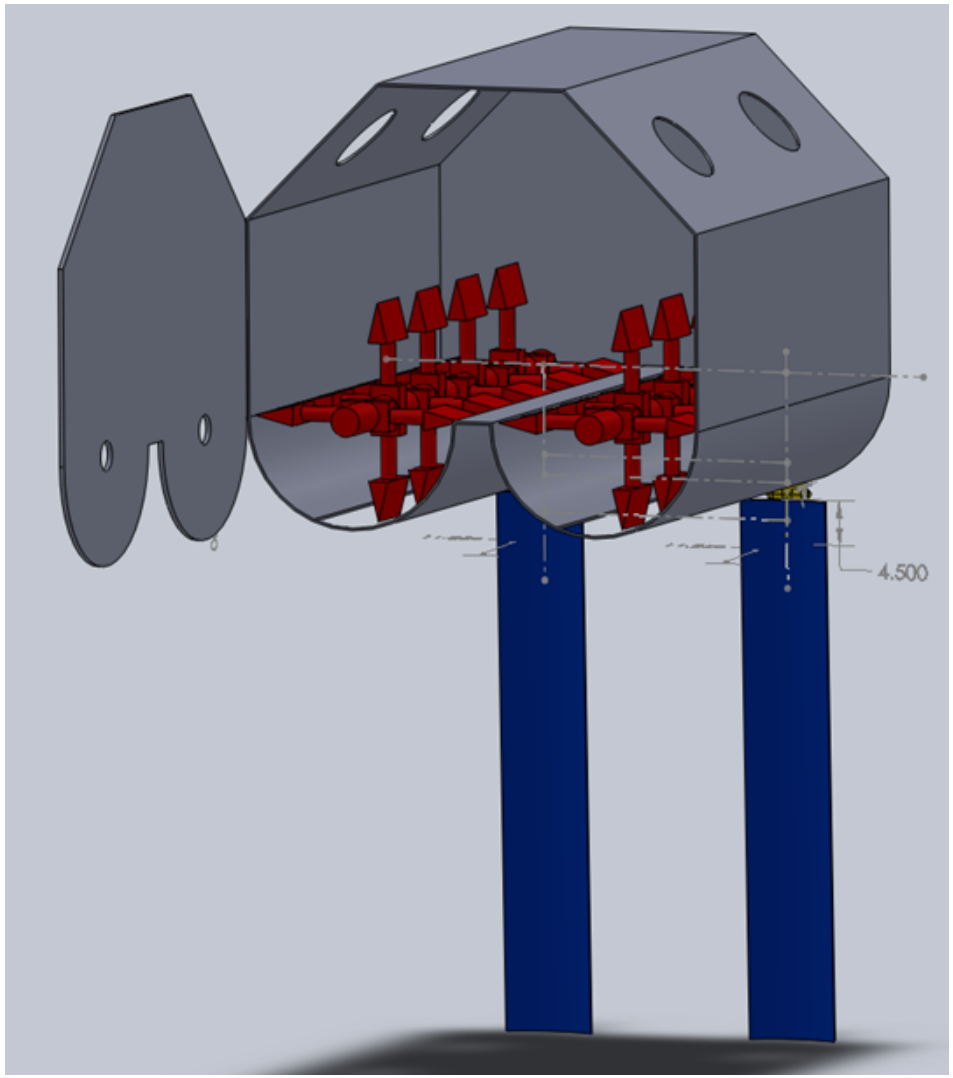
Design 3: Dual Paddle Mixer



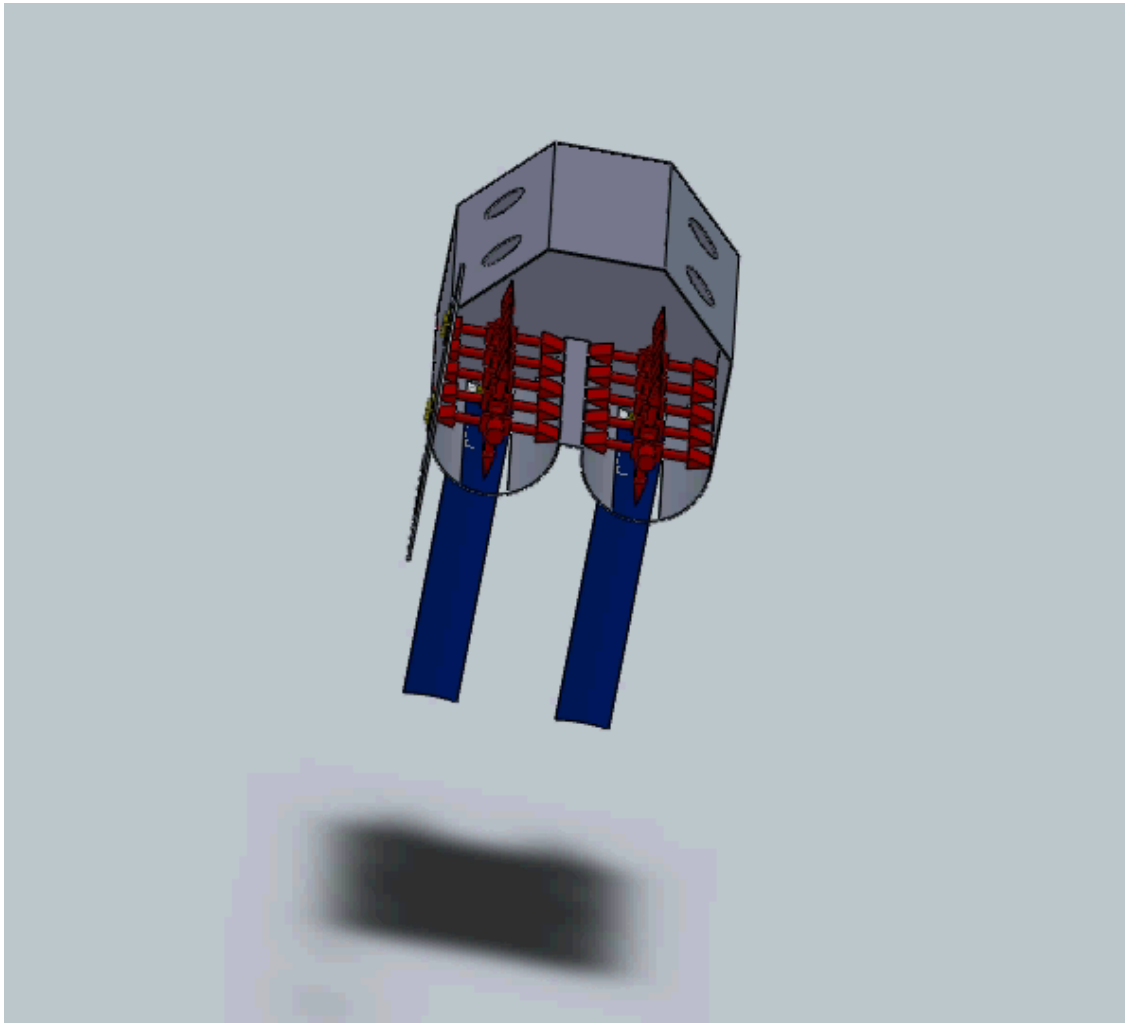
Design 3: Dual Paddle Mixer



Design 3: Dual Paddle Mixer



Design 3 Video



Calculations: Volume

- Requirements:
  - Length of the drum should be about 125% the width of the diameter
    - Diameter:Length = 1.25
  - Must account for about 30% clearance volume

- Once taking into account all of the requirements we determined that the desired volume should be at least 56 cubic feet

Volume: Design 1 and 2

- The volume of a single drum was calculated using the following equation

$$V = \frac{\pi}{4} * D^2 * L$$

Where: V = volume of the drum (feet^3)

D = diameter of the drum (feet)

L = length of the drum (feet)

Drum Volume Calculations			
Diameter (feet)	Length (feet)	Diameter:Length	Volume (feet^3)
4	5	1.250	62.8
4	4.5	1.125	56.52

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Volume: Design 3

- The volume of the Dual Paddle Drum was calculated using the following equation

$$V = \left((\pi * r^2) + (s * d) + \left(\frac{1}{2} * h * (s + d) \right) \right) * L$$

Where: V = volume of the drum (feet^3)

r = radius of the swing doors (inches)

s = side length of the drum (inches)

d= internal distance (from side to side) of drum (inches)

L = length of the drum (feet)

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Volume: Design 3

Drum Volume Calculations						
Side Length (in)	Length Top (in)	Radius (in)	Length (in)	Height (in)	Distance (in)	Volume (cubic ft)
19.5	19.5	12	54	13.8	51	60.8
20	21.5	12	54	14.1	51.3	78.3

Calculations: Thermal Expansion

- Using the following equation, the amount of expansion due to heat application was determined

$$\Delta L = c * L_i * (T_f - T_i)$$

Where: ΔL = the change in length due to thermal expansion (inches)

c = coefficient of thermal expansion (/°Fahrenheit)

L_i = initial length of the drum (inches)

T_f = the final temperature (°Fahrenheit)

T_i = the initial temperature (°Fahrenheit)

Thermal Expansion Calculations

Material	Length$_i$ (in)	Temp$_i$ (^{o}F)	Temp$_f$ (^{o}F)	Coeff. of Thermal Expansion (/^{o}F)	Δ Length (in)
Cr Stainless Steel	54	70	1000	0.00000663	0.382
Alloy Steel	54	70	1000	0.00000722	0.416
Stainless Steel	54	70	1000	0.0000103	0.594
Carbon Steel	54	70	1000	0.00000797	0.460

*Coefficients were obtained from Hose Master, LLC at http://www.hosemaster.com/products/technical/thermalexpansion.php

- Chromium Stainless Steel had the least amount of expansion
- Stainless Steel had the greatest amount of expansion

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Financial Analysis: Testing

Product	Amount	Price per Unit	Cost
Sprockets (#35, #40)	1	$200	$200
Plastic sheeting for Testing	1 .25x12x24	$65	$65
Metal sheeting for Testing	2 .008x4x10	$15	$30
Fittings/bolts	--	--	$10
5 gallon plastic bucket	1	$15	$15
Thermocouples	3	$30	$90
Gear Motor	1	$300	$300
Pressure Gage	1	$15	$15
Dye/Paint	4 colors	$5	$20
Drive shaft	1	$10	$10
Total			$755.00

Financial Analysis: Design 1

Product	Amount	Price per Unit	Cost
Stainless Steel Drum 12.5 x 4.5 feet (600lbs)	1	1.635 ($/lb.)	$981
Welding	1	$49	$49
Shaft	1	$720.90	$720.90
Hooks (28lb)	4	$1.635 ($/lb)	$183.12
Bearings	1	$89.80	$89.80
Total			$2023.82

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Financial Analysis: Design 2

Product	Amount	Price per Unit	Cost
Stainless Steel Drum 12.5 x 4.5 feet (600lbs)	1	1.635 ($/lb.)	$981
Welding	1	$49	$49
Hinges	4	$18	$72
Paddles (18 lb)	--	--	--
Shaft	1	$720.90	$720.90
Bearings	1	$48.75	$48.75
Total			$1871.65

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Financial Analysis: Design 3

Product	Amount	Price per Unit	Cost
Stainless Steel Drum 12.5 x 4.5 feet (600lbs)	1	1.635 ($/lb.)	$981
Welding	1	$49	$49
Hinges	4	$18	$72
Shafts	2	$720.90	$1441.80
Paddles (36 lb)	--	--	--
Bearings	2	$48.75	$97.50
Total			$2641.30

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Financial Overview

Design	Cost
Testing and Design 1Hook Rotating Drum	$2778.82
Testing and Design 2 Single Paddle Mixer	$2626.65
Testing and Design 3 Dual Paddle Mixer	$3396.30

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Marketing Plan

- Website
  - Team website to explain our purpose
- Specifications Sheet
  - Will allow customers to see the specifications of the roaster and compare to others
- Brochure
  - To be used at conferences, trade shows and taste testing events to promote the roaster
- Pictorial User Manual
  - Will be given to the customer upon purchase to show how to use the roaster and obtain prime results

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Spring Project Schedule

- January
  - Begin Working on building of the Prototype
- February
  - First Prototype Completed by 2/28
- March
  - Test on Prototype Completed 3/14
  - Final Design Completed 3/21
- April
  - Final Report and Presentation due 4/21