EML 4551 Senior Design Project

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PREPARED IN PARTIAL FULFILLMENT OF THE
REQUIREMENT FOR THE DEGREE OF
BACHELOR OF SCIENCE
IN
MECHANICAL ENGINEERING

"SUB-AUTOMATIC"

25% Report

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This B.S. thesis is written in partial fulfillment of the requirements in EML 4551. The contents represent the opinion of the authors and not the Department of Mechanical and Materials Engineering.

Ethics Statement and Signatures

The work submitted in this B.S. thesis is solely prepared by a team consisting of Carlos Bonilla, Omar Tavarez, and Daniel Pijeira and it is original. Excerpts from others' work have been clearly identified, their work acknowledged within the text and listed in the list of references. All of the engineering drawings, computer programs, formulations, design work, prototype development and testing reported in this document are also original and prepared by the same team of students.

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Abstract

With the increase of fast food restaurants, particularly the sandwich style eateries, a growing inefficiency in the preparation of the meal has become apparent. Our task is to design a small, inexpensive, safe, efficient and practical machine that will significantly reduce the time it takes to complete assembly of a sub. This type of approach has never been implemented in a high output commercial setting, but with the FDA and ISO regulations

(more will be written when the project is near completion)

1. Introduction

2. Problem Statement

Design and build a sub folding machine that meets all governmental regulations and requirements while being a safe, efficient, practical and cost effective solution.

3. Motivation

A good portion of machines that are fabricated in today's society are generally created to fulfill a need. This project is not an exception to this statement. One of the main purposes of designing this system is to reduce a tedious, time consuming task that is nonetheless necessary in the workplace today. In doing so, our hope is that this improvement will allow employees of these various businesses to instead focus their attention to other tasks that could make them more efficient. In addition to easing the process, we aim to utilize technology to expand the life of the end product.

This project is multi-faceted in that it has business challenges in addition to the engineering and governmental challenges presented. This added complexity is brought on by the product's marketability and interaction with the consumer public. Meaning, the ultimate design and development of the solution must take into account aesthetics as well as ease-of-use, all the while remaining compliant with governmental regulations. In completing this project, we are also gaining valuable knowledge in how engineering problems are approached and how various solutions are presented and ultimately marketed.

4. Literature Survey

4.1 ISO 22,000 – Requirements for Certification

4.2 ISO 9,000 - Requirements

4.3 Patent Law

4.3.1 National

4.3.2 International

Check European union patent office

4.4 Machine Size Restrictions

4.5 Heat Sealing

When sealing an object inside of two or more pieces of plastic, the method used to weld them together is known as heat-sealing. This is achieved by pressing two sheets together using a punch press machine that is equipped with a heating sealing die. This is accomplished by using a lower and upper platen. Each platen normally consists of one or more bars, usually made of brass. Once the plastic sheet is placed between the two platen, they are pressed together and the machine is turned on, causing the sheets to fuse together. This fusion can occur from two sources: heat or radio frequency energy.

4.5.1 Constant Heat Sealing

Constant heat sealing technique is the most straightforward and commonly used method. The heat on the brass bars from the sealing die, in conjunction with the pressure applied, will melt the plastics together. The challenge found in this type of sealing is determining the amount of heat required to fuse the sheets of plastic together without burning them. The disadvantages of this process are that its parts are constantly hot and consume energy to maintain this temperature. In addition, the cooling process is not sped up in any way, and is left to effects of natural convection.

Figure 1 - Constant Heat Sealer

4.5.2 Impulse Heat Sealing

Figure 2 - Impulse Heat Sealer

Allows thermal sealing through thermal conductivity. When pressed down current and heat are delivered on impulse to the heat-sealing lever, then the current is stopped and the pressure still available to cool and provide a nice finishing. An advantage of this process is that it does not require warming up time after turning it on, electricity is only use during the plastic welding process, components are not always hot, and the cooling process happens under pressure.

4.5.3 Radio Frequency Sealing

Radio frequency sealing is different from heat sealing in that it uses radio frequency energy to seal the plastics, just like radio frequencies are used in inside a microwave oven to heat up food. Radio waves have different frequencies, the radio waves used for food and sealing plastics together are very powerful mostly thanks to the proximity of the product, food or plastics, to the transmitter and because of the high frequency.

The frequency of the radio waves in a microwave is such that it excites the water molecules in the food placed inside of it. When water molecules are excited and move fast they create heat, so the food heats up from the inside. For the purposes of sealing plastics together, some plastics have polar molecules, which in terms means that they can be excited by this “RF” energy found in some heat sealers. So the RF heat sealer working like an enclosed microwave can excite the polar molecules on the plastics, causing heat and finally sealing two or more sheets of plastic together.

With RF energy sealing just like in microwaves the response is faster because it does not require heating time, also the cooling down process is much faster. With a faster cooling process than regular heating, the integrity of the seal is better, it is safer to handle, and the product turn over faster.

4.5.3.1 Buffers

Another factor to take into a count is the need of a buffer when using RF energy. The buffer you should be used between the plastics and the lower platen. The purpose is to require the sealer to use *more* RF energy to weld the plastics together. While the RF energy is melting the plastics its electrical field is trying to complete a full circuit and the nearest place is the bottom of the sealing die, without a buffer the thinnest part of the welded plastic will be the easiest way to complete a full circuit and the RF energy would be flooded to the bottom platen and create a hole in your seal.

A buffer provides enough resistance to the RF energy and will keep it distributed through the seal being put by the die. This way the seal will not be unevenly heated and the seal will be uniform. The determination of what is too much power or too little is wider when the seal is being dealt evenly. Buffers also help with sticking of the material and the releasing after the seal is done, the heat sealing die being softer than the bottom plate usually made of steel, will use the buffer as landing place.

4.6 Vacuum Sealing

When food is exposed to the air, it ripens faster due to oxygen exposure than when food is vacuumed sealed. Food is undesirable and/or uneatable as a result of the exposure to oxygen. This exposure helps the growth of mold and bacteria. By removing the air from the bag we can effectively impede some mold and some bacteria growth. The life of fresh foods packed inside a vacuum is elongated and flavor and appeal conserved. This process is called vacuum sealing and is being investigated for our design.

This type of sealing refers to the process in which a product is introduced inside a plastic bag and the air accumulated inside the bag is evacuated. There are different types of vacuum sealers, we would research the different options available and determine which one could be used for our design. Some of the machines being considered are explained as follows.

4.6.1 External Sealer

The sealing during an external sealing process describes when a vacuuming machine does the sealing and vacuuming outside the actual machine. An example of this kind of machine is shown below in fig(3):

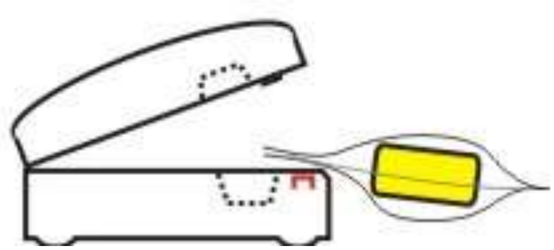


Figure 3

This type of external vacuuming machine uses bags that have ridges, and it is mainly used for at home vacuum sealing. The air is vacuumed out of the bag by the use of cavities; these cavities are present where the machine, right at the bag's open edges, is holding the plastic bag. Another type of external sealing is used for commercial sealing, this machine uses a "snorkel" and smooth bags, as shown below in fig (4).

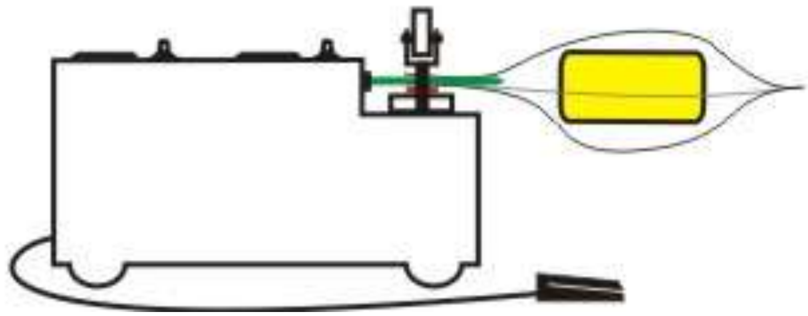


Figure 4

This external vacuuming machine evacuates the air from the smooth bag by means of a “snorkel”, represented below as a probe inside the bag.

4.6.2 Vacuum Chamber Sealer

For this type of vacuuming smooth bags are used and the product is entirely inside the machine. A pump inside the machine extracts all the air inside the chamber, and after that the open edges of the plastic are heat sealed, closing in the bag and finishing the process. Some machines introduce inert gasses like nitrogen after air evacuation and before sealing. This produces a seal that not tight like the one with vacuuming alone, this is used for fragile products such as potato chips. Figure (5) shows a vacuum chamber machine schematic:

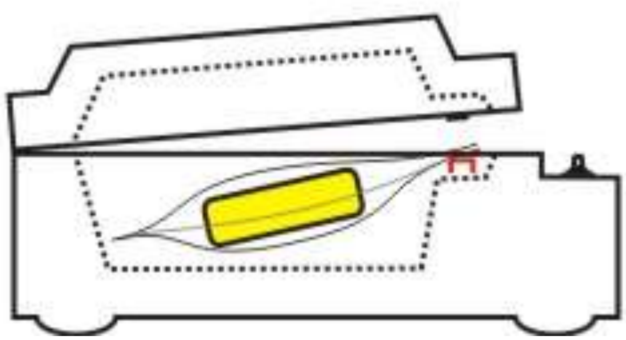


Figure 5

4.7 Plastics

Plastic wrapping can be made in different ways and depends on the type of machine used. Individual bags can be used, these are usually better for in home use. Another way to use plastic wrapping is to buy rolls of plastic and make your own pouches or bags. The latter one is more cost effective and better for commercial use.

Plastic sheets are also different as far as materials and thickness. For the purpose of our project we need only use FDA and USDA approved contact safe materials. TO determine if one ply or several ply sheets could be used; we would need to take into consideration how well the plastics keep freshness, the cost and their heat-sealing properties.

4.7.1 Poly/Nylon COEX

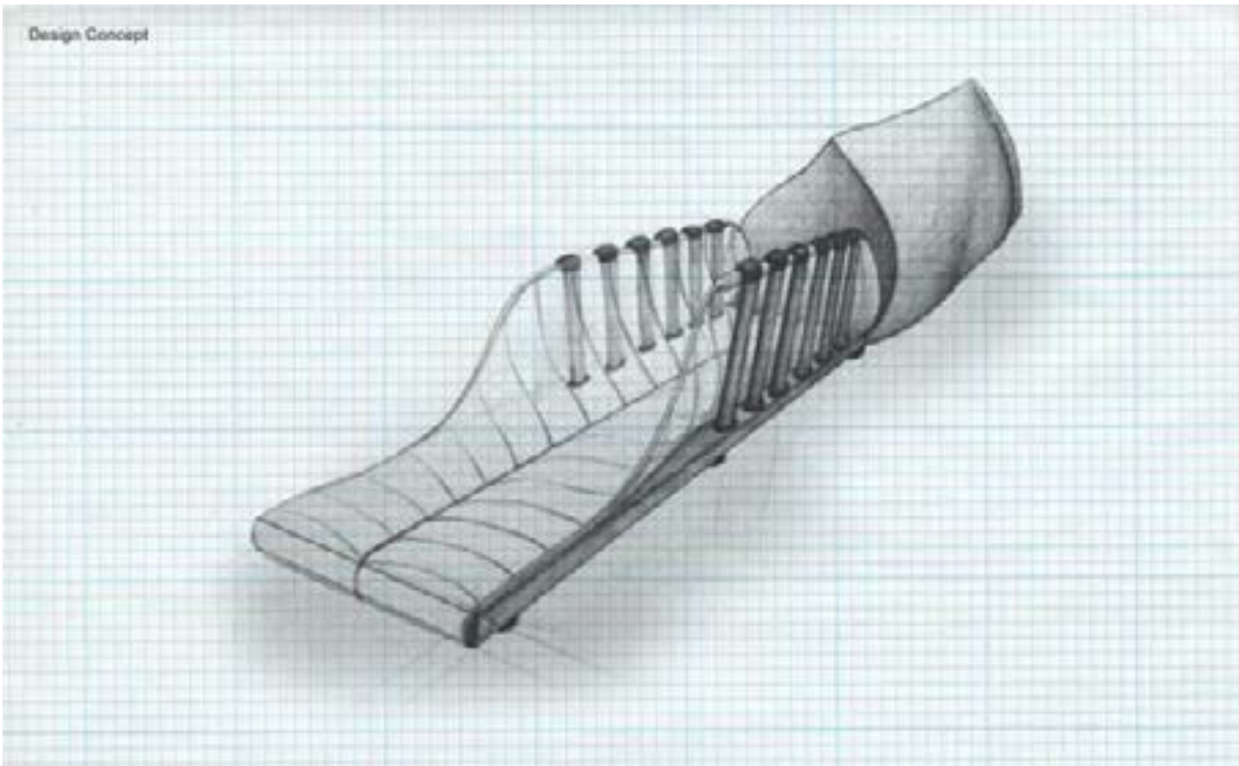
These types of bags for vacuuming are food contact safe and cost effective. They are a co-extruded vacuum pouches meeting FDA and USDA guidelines for food products. It is made of a mixture of polyethylene and nylon resins, and several layers allow it to be malleable and able to conform to different product shapes.

This material also has a high impact resistance and an oxygen transfer rate that is low. It is in a nutshell high in strength, clear, and flexible. It is resistant to oxygen transfer and vapor transmittance while meeting FDA and USADA rules.

5. Project Objectives

We have four main goals that we must meet in our final prototype. The paramount goal being safety will be tackled by possibly automating some of this process, and our initial idea is to use some type of conveyor system. Secondly, to make this final system efficient, we will look at incorporating two steps into one simultaneously; folding the sub as it is being packaged. Lastly, we must design this system to be practical and cost-effective. We tackle these two tasks by designing a system that is modular, expandable and marketable. Moreover, we design the system to eliminate the tedious, yet necessary task of folding and wrapping sandwiches. We have also decided to go one step further in our design, and look to incorporate vacuum sealing technology to extend the lifespan of the sandwiches, adding value to the product and marketability.

6. Conceptual Design



(description here)

7. Proposed Design

8. Project Management

8.1 Overview

The idea for this project was brought out by Mr. Norman Wartman. After meeting with him once we learned that he expects us to select alternatives for the project, cost estimation, final designs etc. For the fall semester we will have a 25% of the report ready in which we will have a preferred design and be ready to start drafting and simulating on CAD. For the spring semester starting on winter break we will construct and test and provide a final report including lessons learned as requested by Mr. Wartman.

8.2 Gantt Chart

Figure 6 - Timeline for Fall and Spring

8.3 Breakdown of Responsibilities

Carlos	Current Facility Research	Danny	FDA Regulation
	Patent Lookup		Material Specification and Selection
	Instruction Manual Production		Data Analysis

Omar	SolidWorks Design	All	Literature Survey
	SolidWorks Simulation		Conceptual Design
	ISO 22000 Regulation		Construction
	ISO 9000 Facility Allocation		Test Analysis

Table 1: List of responsibilities for each team member

9. Analytical Analysis and Structural Design

10. Major Components

11. Cost Analysis

11.1 Component Estimates

COMPONENT	ESTIMATED COST
Estimated total	$3,000

Table 2. Component cost

11.2 Funding and Sponsors

Mr. Norman Wartman is the source of 100% of our sponsorship. He estimates the cost to be about $5,000. $1000 short term, $1,000 Mid Term, and $3,000 long term. A short-term review will provide alternative designs, and options with pros and cons. A midterm review will include preferred alternatives, final design, and cost to build. Finally out long term goal is to build the machine, test it and provide a final report, including lessons learned

11.3 Man-Hour Costs

(include time spent on researching [from log] as well as fabrication and development)

12. Prototype System

13. Testing

14. Results

15. Conclusion

Appendix A – FDA Regulations

U.S. Department of Health and Human Services – Food and Drug Administration

When it comes to dealing with food, very strict guidelines and regulations must be followed to ensure the health and safety of the consumer. For this reason, we deemed it paramount to research the Food and Drug Administration (FDA) regarding food grade materials for our final design. The following represents the expectations the FDA has for anyone or anything dealing with food, and contains direct quotations from the U.S. Public Health Service Food Code.

Multiuse 4-101.11 - Characteristics

"Materials that are used in the construction of UTENSILS and FOOD-CONTACT SURFACES of EQUIPMENT may not allow the migration of deleterious substances or impart colors, odors, or tastes to FOOD and under normal use conditions shall be: P

(A) Safe; P

(B) Durable, CORROSION-RESISTANT, and nonabsorbent;

(C) Sufficient in weight and thickness to withstand repeated WAREWASHING;

(D) Finished to have a SMOOTH, EASILY CLEANABLE surface; and

(E) Resistant to pitting, chipping, crazing, scratching, scoring, distortion, and decomposition." [1]

Multiuse 4-101.12 – Cast Iron Use Limitation

"(A) Except as specified in ¶¶ (B) and (C) of this section, cast iron may not be used for UTENSILS or FOOD-CONTACT SURFACES of EQUIPMENT.

(B) Cast iron may be used as a surface for cooking.

(C) Cast iron may be used in UTENSILS for serving FOOD if the UTENSILS are used only as part of an uninterrupted process from cooking through service." [1]

Multiuse 4-101.13 – Lead Use Limitation

"(A) Ceramic, china, and crystal UTENSILS, and decorative UTENSILS such as hand painted ceramic or china that are used in contact with FOOD shall be lead-free or contain levels of lead not exceeding the limits of the following UTENSIL categories: P

UTENSIL Category	Ceramic Article Description	Maximum Lead MG/L
Beverage Mugs, Cups, Pitchers	Coffee Mugs	0.5
Large Hollowware (excluding pitchers)	Bowls > 1.1 Liter (1.16 Quart)	1
Small Hollowware (excluding cups & mugs)	Bowls < 1.1 Liter (1.16 Quart)	2.0
Flat TABLEWARE	Plates, Saucers	3.0

(B) Pewter alloys containing lead in excess of 0.05% may not be used as a FOOD-CONTACT SURFACE. P

(C) Solder and flux containing lead in excess of 0.2% may not be used as a FOOD-CONTACT SURFACE." [1]

Multiuse 4-101.14 – Copper Use Limitation

"(A) Except as specified in ¶ (B) of this section, copper and copper alloys such as brass may not be used in contact with a FOOD that has a pH below 6 such as vinegar, fruit JUICE, or wine or for a fitting or tubing installed between a backflow prevention device and a carbonator. P

(B) Copper and copper alloys may be used in contact with beer brewing ingredients that have a pH below 6 in the prefermentation and fermentation steps of a beer brewing operation such as a brewpub or microbrewery." [1]

Multiuse 4-101.15 – Galvanized Metal Use Limitation

"Galvanized metal may not be used for UTENSILS or FOOD- CONTACT SURFACES of EQUIPMENT that are used in contact with acidic FOOD. P" [1]

Multiuse 4-101.16 – Sponges Use Limitation

"Sponges may not be used in contact with cleaned and SANITIZED or in-use FOOD-CONTACT SURFACES." [1]

Multiuse 4-101.17 – Wood Use Limitation

"(A) Except as specified in ¶¶ (B), (C), and (D) of this section, wood and wood wicker may not be used as a FOOD-CONTACT SURFACE.

(B) Hard maple or an equivalently hard, close-grained wood may be used for:

(1) Cutting boards; cutting blocks; bakers' tables; and UTENSILS such as rolling pins, doughnut dowels, salad bowls, and chopsticks; and

(2) Wooden paddles used in confectionery operations for pressure scraping kettles when manually preparing confections at a temperature of 110oC (230oF) or above.

(C) Whole, uncut, raw fruits and vegetables, and nuts in the shell may be kept in the wood shipping containers in which they were received, until the fruits, vegetables, or nuts are used.

(D) If the nature of the FOOD requires removal of rinds, peels, husks, or shells before consumption, the whole, uncut, raw FOOD may be kept in:

(1) Untreated wood containers; or

(2) Treated wood containers if the containers are treated with a preservative that meets the requirements specified in 21 CFR 178.3800 Preservatives for wood." [1]

Multiuse 4-101.18 – Nonstick Coatings Use Limitation

"Multiuse KITCHENWARE such as frying pans, griddles, saucepans, cookie sheets, and waffle bakers that have a perfluorocarbon resin coating shall be used with nonscoring or nonscratching UTENSILS and cleaning aids." [1]

Multiuse 4-101.19 – Nonfood-Contact Surfaces

"NonFOOD-CONTACT SURFACES of EQUIPMENT that are exposed to splash, spillage, or other FOOD soiling or that require frequent cleaning shall be constructed of a CORROSION-RESISTANT, nonabsorbent, and SMOOTH material." [1]

Single-Service and Single-Use 4-102.11

"Materials that are used to make SINGLE-SERVICE and SINGLE-USE ARTICLES:

(A) May not:

(1) Allow the migration of deleterious substances, P or

(2) Impart colors, odors, or tastes to FOOD; and

(B) Shall be:

(1) Safe, P and

(2) Clean." [1]

Cleanability 4-202.11 Food-Contact Surfaces

"(A) Multiuse FOOD-CONTACT SURFACES shall be: (1) SMOOTH; Pf

(2) Free of breaks, open seams, cracks, chips, inclusions, pits, and similar imperfections; Pf

(3) Free of sharp internal angles, corners, and crevices; Pf

(4) Finished to have SMOOTH welds and joints; Pf and
(5) Except as specified in ¶ (B) of this section, accessible for cleaning and inspection by one of the following methods:

(a) Without being disassembled, Pf

(b) By disassembling without the use of tools, Pf or

(c) By easy disassembling with the use of handheld tools commonly available to maintenance and cleaning personnel such as screwdrivers, pliers, open-end wrenches, and Allen wrenches. Pf

(B) Subparagraph (A)(5) of this section does not apply to cooking oil storage tanks, distribution lines for cooking oils, or BEVERAGE syrup lines or tubes." [1]

Functionality 4-204.15 Bearings and Gear Boxes, Leakproof

"EQUIPMENT containing bearings and gears that require lubricants shall be designed and constructed so that the lubricant cannot leak, drip, or be forced into FOOD or onto FOOD- CONTACT SURFACES." [1]

16. References

[1]***Fda.gov.***

Food Code 2009

In-text: (Fda.gov, 2013)

Bibliography: Fda.gov. 2013. *Food Code 2009*. [online] Available at: http://www.fda.gov/Food/GuidanceRegulation/RetailFoodProtection/FoodCode/UCM2019396.htm [Accessed: 5 Nov 2013].

Vacuum Schematics

http://www.pleasanthillgrain.com/vacuum_packaging_machine_food_sealer_packing_machines.aspx

Heat Sealers

http://www.industrialsupplies.com/displayproductdetail.do?skuSearch=Q52634&mr:referralID=NA&itemGroupOID=165408&origin=pla&cid=pla_goog&9gtype=search&mr:filter=51436252777&baseItemOID=165408&mr:ad=25000371577&mr:trackingCode=F1763EA3-02AF-E011-87D9-001B21A69EB8&source=google_pla&sku=199730&mr:device=c&mr:adType=pla