Dental Hygiene

Background Report

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2017

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1 BACKGROUND

1.1 Introduction

Our project consists of creating a Dental Triturator that will be human or battery powered. This machine is used by dentist to shake and mix a capsule made up of amalgam and glass ionomer sealant. This capsule contains liquids and metals used for teeth fillings. The problem with current triturator is that it requires electricity. Our client frequently travels to third world countries to give dental services to people in need. The problem is some of the places they go to do not have electricity. Our job is to design and create a Dental triturator that does not require electricity to mix the dental capsules. This new triturator will help improve the lives of our client and many people in third world countries.

1.2 Project Description

The following is the original project description provided by the sponsor. ‘’A dental triturator is used to mix the components of dental capsules before certain dental procedures and they are usually powered by electricity. When dental hygiene students travel internationally, often times there is no electricity and/or the powered triturations are not compatible with international outlets. Collaboration between NAU’s Dental Hygiene (DH) Dept and NAU Mechanical Engineering Dept (CHHS and CEFNS) have created this Spring 2017 capstone project for 3-5 mechanical engineering students to create a human powered mixer that can shake a capsule for 10 seconds’’.

1.3 Original System

The original system for this project is an AC powered dental triturator. A dental triturator is used to mix a capsule filled with amalgam and glass ionomer sealant. The capsule is mixed for a certain time and speed to ensure that the filaments are properly mixed. This sealant is then used to fill cavities or holes in teeth.

1.3.1 Original System Structure

The dental triturator contains a motor, shaft, and rotational components that convert electrical energy to shake the capsule in a semi-linear motion. There are plastic bands that act as arms to hold the capsule in place. Figure 1, below, shows the components of the triturator. The triturator only allows one capsule at a time to ensure the mixture has the right viscosity. The internal components are some kind of metal or alloy and the cover and buttons are plastic.

1.3.2 Original System Operation

The team observed the active operation of the existing triturator while meeting with our client. We noticed that the motion was not directly linear but almost a figure eight motion. It was a non circular motion since a circular motion would not work for this capsule. The motion of the device was quick and the capsule was shaken for about 10 seconds. The capsule was then put into a tool and the components were squeezed out as a liquid. If the triturator does not do its job correctly then the capsule components remain unmixed or overmixed and it can not be used.

1.3.3 Original System Performance

The function of the dental triturator is to shake a capsule at 4000 rpm for 10 seconds. When we observed the triturator, we timed it for 10 seconds but could not directly measure the rpm's. The capsule being used calls for 4000 rpm but we estimate that the triturator may not always reach this requirement. Each capsule weighs around 2 grams and the triturator weighs on average 5 kilograms. The power requirements for the triturator are 115V and 60Hz. A negligible amount of power is used for the buttons and lights so the majority of power is directly converted to the capsule. The triturator has a high efficiency since it is small and there aren't so many parts. The energy required to properly mix the capsule is about 1.15 kilojoules.

1.3.4 Original System Deficiencies

The only deficiency with the dental triturator is that it is dependant on electricity. The Dental Hygiene Department wants a triturator that can be easily transported and used in countries that may not have electricity.

2 REQUIREMENTS

This project requires us to engineer a dental triturator that is manually or battery operated. The current dental triturator is run on electricity(AC power) and this resource is not always available in other countries. The Dental Hygiene Department wants a triturator that can be run off of manual power such as a hand crank or DC electric power such as small battery. The triturator needs to function the same as the current triturator so that the user can do their job properly. The triturator will be engineered using the requirements below so that it can produce the proper results for the Dental Hygiene Department.

2.1 Customer Requirements (CRs)

This section contains the customer requirements that are based off of what our client wants from the design. Lightweight, easy transportation, and shaking the capsule for 10 seconds are the top customer requirements so we gave them a ranking of 5 out of 5. The triturator will be lightweight so the user can carry it onto a plane, bus, or car. Also, it will fit in a bag for easy

carry. The triturator will have shake a capsule for 10 seconds in order for the filling to be used, so this must be ranked highest.

Reliability and easy operation are the next customer requirements with a ranking of 4 out of 5. This project is not meant for a single person so we are going to make it easy to operate for any person who uses it. Our team wants the triturator to work every time and will make sure that we develop a reliable design to satisfy our customer.

The last customer requirements are quality of parts, cost, and easy maintenance with rankings of 3 out of 5. Aesthetics is also a requirement with a ranking of 2 out of 5. The triturator will have a few different parts and they may break or need to be changed in a few years. Maintenance on the device can be done by anybody and the parts will be easy to locate. The team will stay under budget by developing a triturator with low cost parts and fabrication. The quality of the parts have to be good and will have a lifespan of at least 1 year of moderate use. Aesthetics are ranked last since we do not need a good looking design in order for it to work.

Table 1: Customer Requirements

Customer Requirements	**Weighting**	**Justification**
Lightweight	5	Request of the Client
Easily Transportable	5	Travel is necessary
Shake Capsule for 10 Seconds	5	The capsule must be properly mixed
Reliability	4	The device must not break or function improperly
Easy Operation	4	Anyone should be able to use it
Quality of Parts	3	Parts should last a couple years
Cost	3	Cost cannot be to high
Easy Maintenance	3	Operators must be able to change a broken part with ease
Aesthetics	2	The device should not have internal parts visible

2.5 House of Quality (HoQ)

The house of quality shows our customer requirements, engineering requirements, and appropriate weightings. The HoQ shows how each engineering requirement relates to each customer requirement. We completed the weightings for each requirement with the approval of our client ’Appendix:A’ .

House of Quality (HoQ)

Customer Requirement	Weight	Engineering Requirement	Weight	Energy	Cost	Dimensions	Materials	Number of Parts	Manufacturing Time	Life Expectancy	Ambidextrous
Lightweight	5		x		x	x	x	x			
Easily Transportable	5		x		x	x	x	x			
Shank Capsule for 10 seconds	5			x							
Reliability	4			x			x	x	x	x	
Easy Operation	4		x					x			x
Quality of Parts	3			x	x		x		x	x	
Cost	3				x	x	x	x	x		
Easy Maintenance	3					x		x	x		
Aesthetics	2				x		x	x			
Target(s)			8 lbs	1.15 kJ	$350	32 in	Metal	7	5 days	3 years	L/R Hand
Tolerance(s)			<10 lbs	1.15 kJ	<$400	L+W+H ≥ 45 in	Durable	<10	<1 week	>2 years	L/R Hand

Team member 1: Keenan Lacey 3/24/17
Team member 2: Rodrigo Ojeda 3/24/17
Team member 3: Meshal Alrashari 3/24/17

Client Approval: Email

Figure 1. House of Quality

Table 2: Engineering Requirements

Engineering Requirements	**Target**	**Rationale**
Weight	8 pounds	To minimize the weight during transportation
Energy	1.15 kilojoules	To properly mix the capsule components
Cost	$350	The device must be affordable and within budget
Dimensions	L+W+H ≥ 32 inches	Must fit inside the dimensions for a carry on bag at all airlines
Materials	Metal	Must have strong internal materials
Number of Parts	7	To minimize maintenance and wear
Manufacturing Time	5 days	Must have accessible parts
Life Expectancy	3 years	Must be long lasting for travel
Ambidextrous	L/R Handed	To ensure that anyone can use it

3 EXISTING DESIGNS

Existing designs are devices on the market that have a similar system to our ideal device. The paint shaker shakes paint in a similar way we need to shake our dental capsule. The eggbeater uses manual power to rotationally mix all the cooking ingredients. The Sawzall blades moves in a similar motion we need to move our dental capsule. The team has to create a project that shakes a dental capsule for 10 seconds and 4000 rpm.

3.1 Design Research

Our team has done the research by an examining similar systems and the web. For the examining similar systems portion of this report the team used the electrical dental device. After extensive research, the team choose three existing devices that are similar to the same system used by the electrical dental titrator.

3.2 System Level

A dental capsule machine is a device that mixed the components of the capsule. Nowadays, it can be found in every dental clinic. The team choose three different devices which are a paint mixer, egg beater, and sawzall. First, the paint mixer will provide the necessary semi-linear motion which is needed in the project. Second, the egg beater provides the concept of using the manual method. Finally, the sawzall provides the missing key of the back and forth movement that is needed for the success of this project.

3.2.1 Existing Design #1: Paint Mixer

This is a gas powered paint mixer. If paint is left alone the ingredients will separate. This is why paint must be mixed before use. This paint mixer requires 3.2 cfm at 70 psi pressurized air to shake the paint in a semi-linear motion. The paint can is heavy so it requires more gas than a capsule would. The air pumps a piston and this is how it moves. This relates to our project because we should shake the capsules in a semi-linear motion.

Figure 2: Paint Mixer

https://i.ytimg.com/vi/o4QIBHXVEPs/maxresdefault.jpg

3.2.2 Existing Design #2: Egg Beater

Figure 3: Egg beater
https://www.oxo.com/egg-beater-304
This existing design is the most related design to the team's project requirement. This is called egg beater from XOX. In the discription it says they have combined the idea of the egg beater and the smooth movement crank from a fishing rod.

3.2.3 Existing Design #3:Sawzall

Figure 4: Sawzall
http://toolguyd.com/blog/wp-content/uploads/2013/09/Milwaukee-M18-Fuel-Sawzall-Recip-Saw.jpg

The sawzall is an existing design that is used to cut different materials. The reason the sawzall is relevant to our project is because the movement of the Saw is back and forth. This is the same movement we need in our project.

3.3 Subsystem Level

In this section the team describes the system and subsystems of the existing designs we found. Each system and subsystems is explained how they work and why they are relevant to our project design.

3.3.1 Subsystem #1: Paint Mixer

The paint mixer has multiple sub-systems. They consist of the base, the air motor, and the Air feed system.

3.3.1.1 Existing Design #1: Base

The base is a really important in this model because it holds the whole system together. In this particular model the base needs to be very sturdy because a gallon of paint weighs 11.3 pounds. When the paint is shaken it emits a tremendous moment and force that the base has to withstand.

3.3.1.2 Existing Design #2: The air motor

The air motor is the most important subsystem in this item. The air motor converts the power of air into a kinetic energy. This kinetic energy is then used to shake the paint.

3.3.1.3 Existing Design #3: Air feed system

Air feed system is important because it allows the source of energy to enter the Paint mixer. There is a valve to manage the intake of the air on the motor. There is also a filter to keep trash from entering the motor.

3.3.2 Subsystem #2: Egg Beater

Egg beater contains several subsystems which are a plastic handle, crank, and beaters.

3.3.2.1 Existing Design #1: Handle

A plastic handle is attached to the crank with a carved stainless steel block. The plastic handle is a source that is used to generate human energy into kinetic energy. This is done by rotating the handle using human power to make the egg beater work. The dental capsule machine needs an electric source to function.

3.3.2.2 Existing Design #2: Crank

Crank is the most important subsystem in the egg beater, and without it the entire device can not function. The most significant thing about the crank is the faster the crank rotates, the faster the beaters will rotate, and that's why it is related to this team's project.

3.3.2.3 Existing Design #3:beaters

Beaters are the conclusion of the device, because they beat the eggs. And they are made of stainless steel. The function of the beaters is achieved by rotating them in a high circular speed movement. The team has deciding to change the movement of the beaters from a circular way to a back and forth way. With this method, the team will find a key of success to the project design (dental capsule machine).

3.3.3 Subsystem #3: Sawzall

The sawzall has a few main subsystems. The main ones are the Electric motor, the ANC gear drive, and the blade.

3.3.3.1 Existing Design #1: Electric motor

The electric motor needs to be powerful. The sawzall conducts heavy duty cutting therefore the saw has to have lots of force and torque in its motor to accomplish its goals.

3.3.3.2 Existing Design #2: ANC Gear Drive

The ANC Gear drive allows for the power of the electric motor to be converted into the back and forth motion of the saw.

3.3.3.3 Existing Design #3:The Blades

The blade is the simplest of the subsystems, but essential for the purpose of this device. The blade is what is used to cut the materials. The blade is where the linear motion is translated and we can observe the operation.

4 DESIGNS CONSIDERED

This section contains ten designs we have considered to engineer a final product. We will explain the function and the parts of each design. We will also discuss the advantages and disadvantages of each design. The designs we have chosen are the best designs that the team has generated. We will also explain the black box model and functional decomposition chart in this section to better understand the purpose of our design.

4.1 Design #1:Gear design

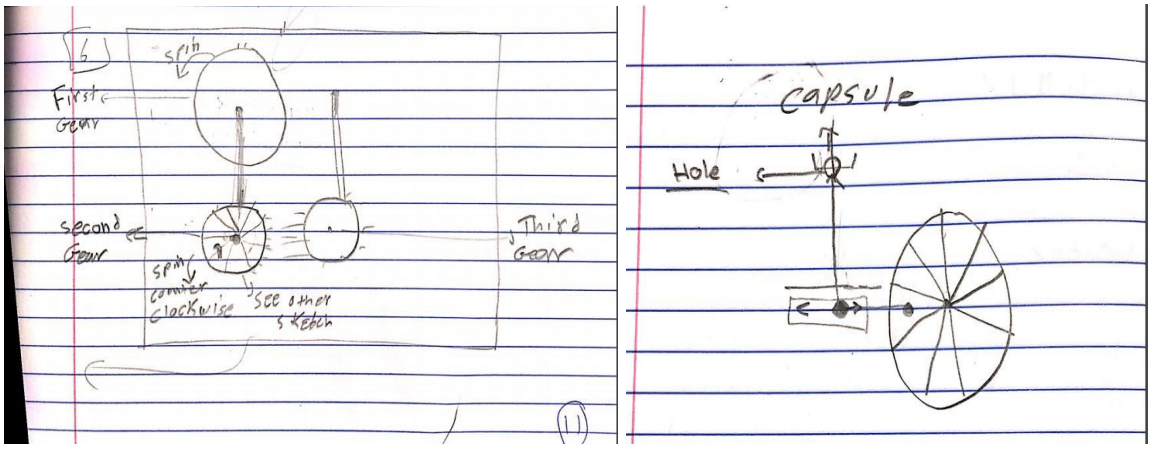


Figure 5: Gear design sketch

The Gear design has three gears. As shown in the figure above, the first gear is the spinning gear. Also, the first gear is attached to the second gear by a stick to spin the second gear. Also, there is a third gear which is connected to the second gear. The purpose for the third gear is to increase the rotational speed of the second gear. So this design will be in a box with holes in the above of the box. So, the second gear will have a two screw, the first screw is attached in the gear and the other is attached to the square and that square will have the second screw move right and left while spinning. When that screw is going right and left will move the top stick “which is in the right figure’ the holder of the capsule will shake in a semi-linear movement.

Table 3: Pros and cons for Gear design

Advantages	Disadvantages
Add more gears to increase speed	Limited length of the shaking Capsule
Ambidextrous	Heavyweight

4.2 Design #2:Quick Return Design

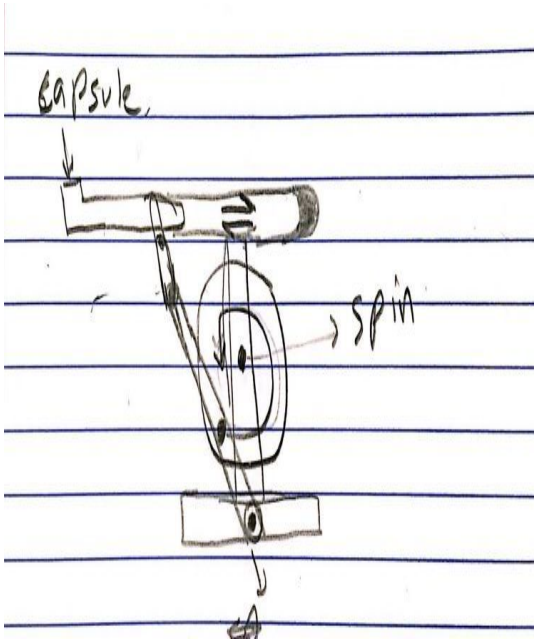


Figure 6: Quick return design

In the figure above is the quick return design. This design is basically has the spinning gear in the middle of the design. The spinning gear has a screw on it that attached to the stick as shown above. While spinning the gear the stick while move in a semi-linear motion. Also connected to another stick that makes the top holder move right and left "back and forth" movement. The Advantage of this design we can use any materials that can reach our engineering requirements like weight and quality. The disadvantage of this design is the speed of the shaked capsule since we cannot add more gears.

4.3 Design #3: Spinning design

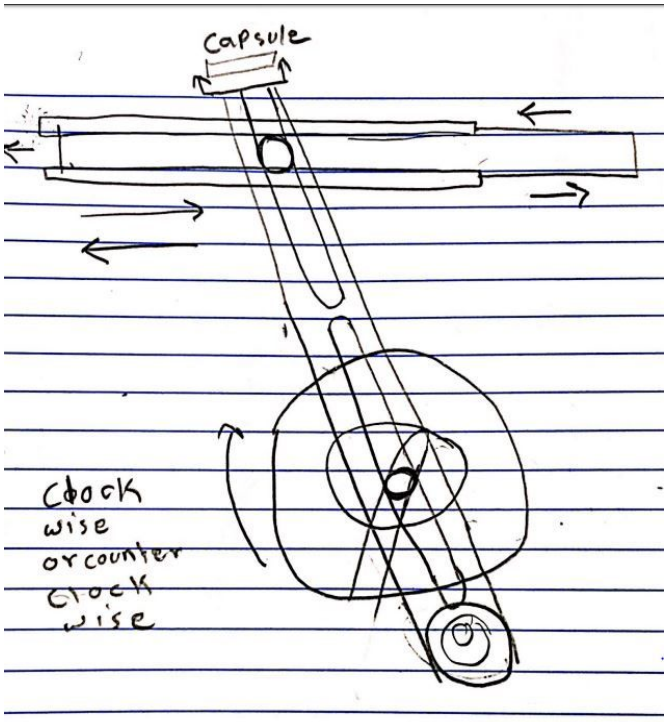


Figure 7: Spinning design

The team has called this design as a spinning design. This design is basically the same as the second design. However, this design has the semi-linear motion movement which is not in the quick return design. The spinning gear has a screw in the middle and that screw is connected to a stick as shown in the figure above. The advantage of this design is we can change the angular of the screw which thats will make the capsule shake in different lengths. However, the disadvantage of this design that it is complicated for the broken replaceable parts.

4.4 Design #4: Chain Design

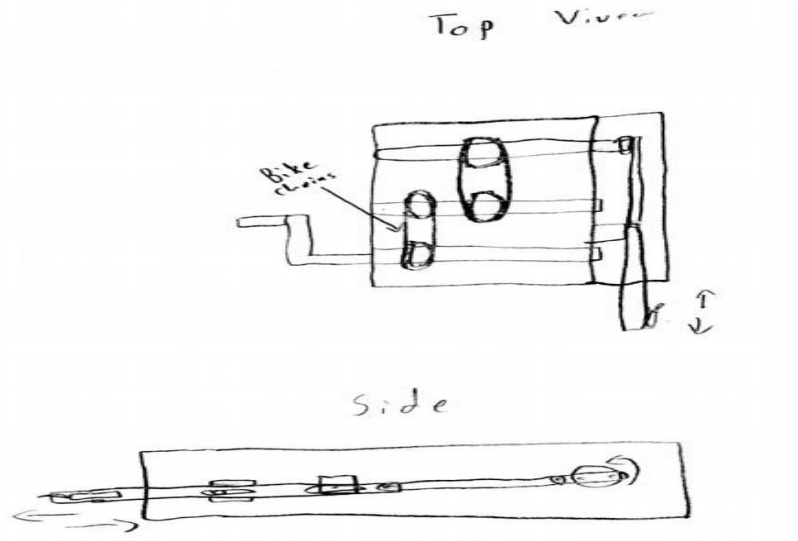


Figure 8: Chain design

This design called the chain design. This design can he used for both hands “left and right”. This design has two chains as shown in the figure above. It has three shaft on it. The purpose of using three shaft and two chains is to increase the speed of the shaking capsule. The top shaft is connected to the shake capsule. The advantage of this design is the team can increase or decrease the speed as the team can reach the required speed. The disadvantages of this design it will be a heavyweight design which our client while travel abroad seas and carry the project in a carry on luggage.

4.5 Design #5: Battery Operated Design

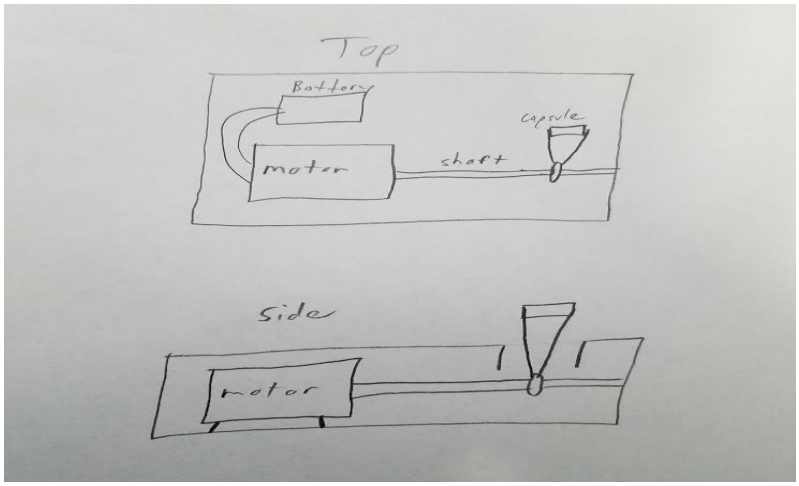


Figure 9: Battery operated Design

This design is inspired on the wiggle bug Dr. Oman has in her office. This design uses batteries. The batteries are connected to the motor and then the motor turns the shaft. This shaft then shakes the capsule in a figure 8 motion. The ideal speed is for the shaft to turn at 4000 rpm. The advantages of this design is it is battery powered. The disadvantages of this design is that the since it would need a lot of power it would also need a lot of batteries. This would make the design very heavy.

4.6 Design #6: Compressed Air Design

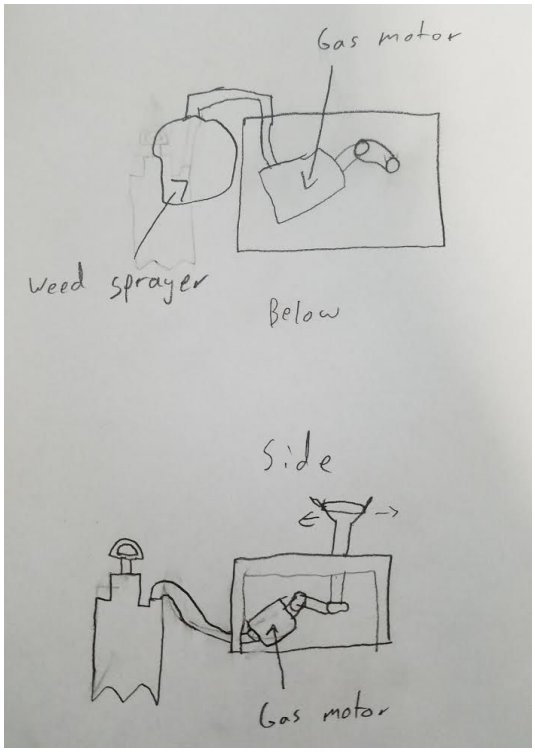


Figure 10: compressed Air Design

This design is inspired on the background research of the paint mixer. We would use a type of weed sprayer to load up pressurised air into the tank. The weed sprayer has a pump that is used to raise the psi inside the tank. Some of these types of weed sprayer tanks can have pressurized air up to 90 psi. The pressure needed to run this air motor is 70 psi. In this design you would pump the air into the tank then the motor would shake the capsule. The advantage of this is the shaking process would be very efficient. The disadvantages are that this design would be very large and it would be hard to transport it on an airplane.

4.7 Design #7: toothbrush design

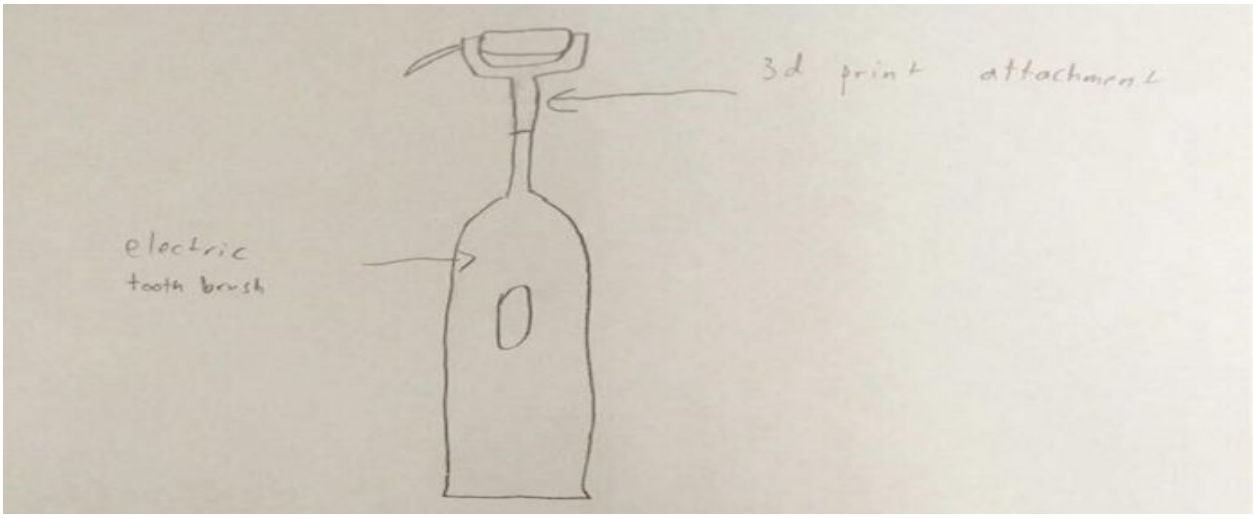


Figure 11: Toothbrush design (Outside)

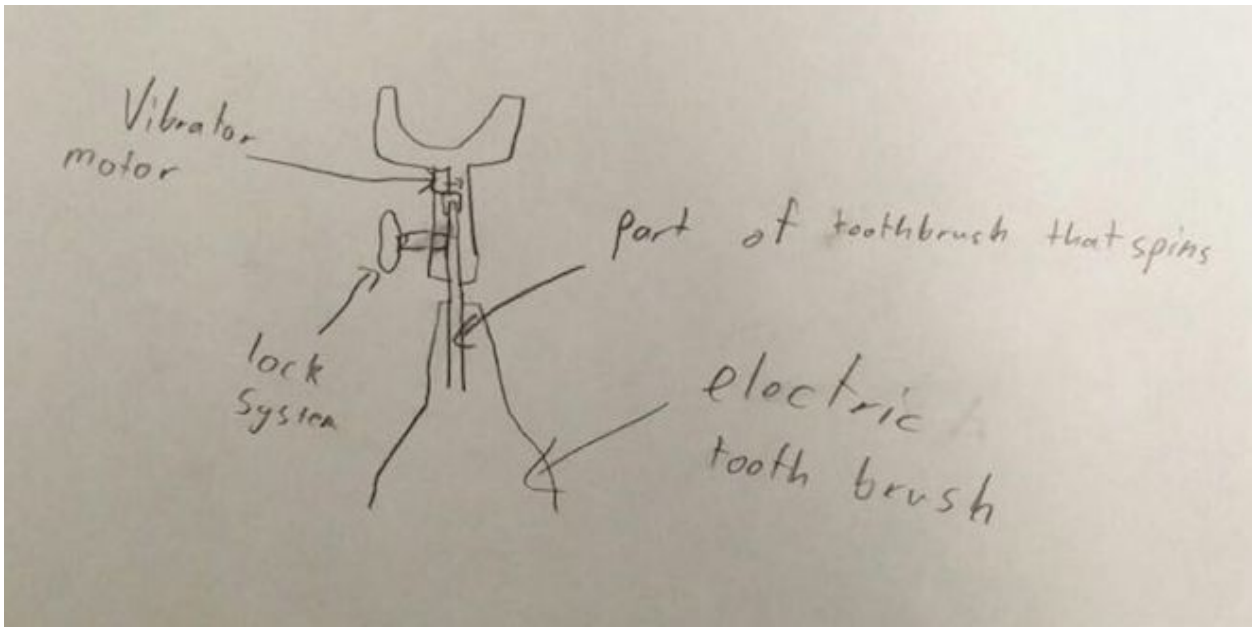


Figure 12: Toothbrush design with the vibrate system(inside)

Team have done some research on the toothbrush design. And have been considered this design. This design will shake the capsule by vibrating it is a simple electronic toothbrush. Toothbrush has a circular movement which that will not mix the capsule. So the team has found an idea which is to use vibrator motor and lock system in the toothbrush. The lock system will lock the the holder on the part that spins which shown in the above figure. The vibrator motor will vibrate the capsule's holder. And by a human hand can turn it left and right then the capsule will be mixed. So, the advantages of this design are light weighted, easy to use and a small

size. The disadvantages of this design are non-fixable parts, hard replaceable parts and electricity used in this design.

4.8 Design #8: Springs Design

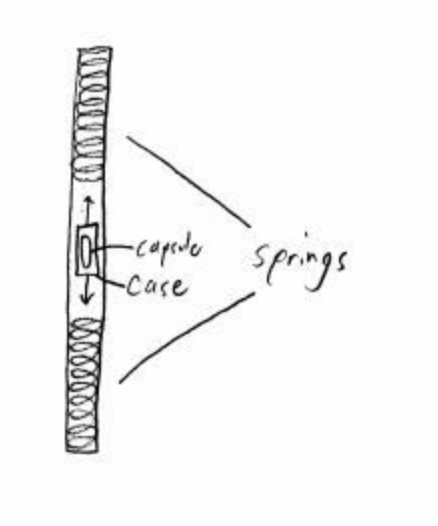


Figure 13: Springs Design

This design is the springs design. This design consists of a round tube, 2 springs, and a protective case inside the tube to place the capsule. The idea of this design is to place the capsule inside a tube with springs and shake it. The springs will bounce the capsule back and forth and since it is human powered it will be a semi-linear motion. The advantages of this design is that it is lightweight, easy to use, and cost efficient. The disadvantages are that the capsule may not get mixed properly and then it can not be used.

4.9 Design #9: Clapper design

Figure 14: Clapper Design

This design is called a clapper design. It has five clappers and a rod holder. This design works by shaking the rod left and right and the capsule will be mixed. The Advantages for this design is lightweight and small size so that will makes it easy to transportation. The disadvantages for this designs is it might not reach our capsule requirement which is the speed in a semi-linear motion for 4000 RPM.

4.10 Design #10: Two balls design

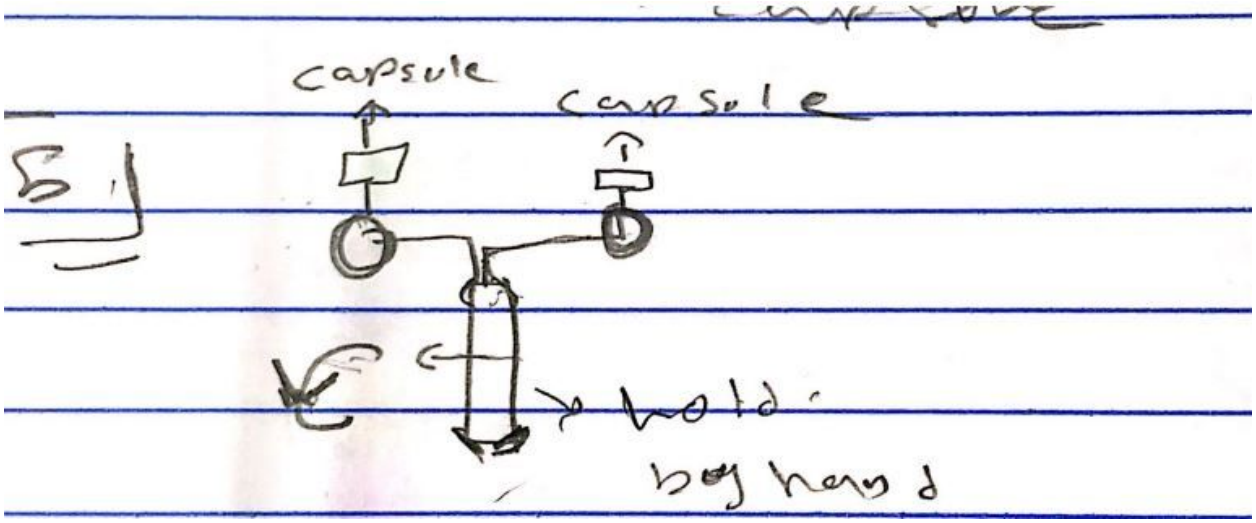


Figure 15:Two Balls Design

As shown in the figure above the team has considered a two balls design. This design is basically a hard rod with two connected ropes. The two ropes are attached by balls. This design is work by holding the hard rod and turn right and left by both hands. The advantages of this design are low cost and it can shake two capsules at the same time. The disadvantages of this device is people who's going to use this design must use their both hands to make the capsules mixed.

4.11 Black box and Functional Model

This section illustrates our black box and functional model. Our black box model shows the basic operation of what our device needs to do. That is to mix ingredients and produce a homogeneous mixture. The functional model shows what goes into mixing the capsule. It starts with a hand and human energy or electricity. The hand is used to hold the device and turn it on. Once activated the electricity or human energy will convert to linear motion and produce heat, noise, and energy. These models help the team and client understand what the device is going to accomplish.

Figure 16: Black Box model

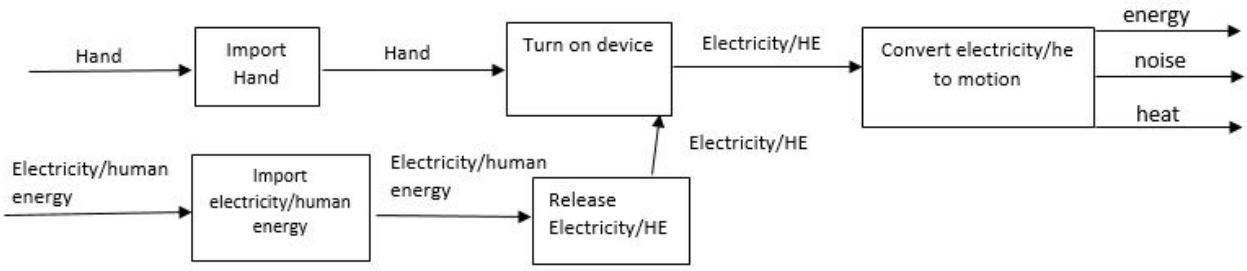


Figure 17: Functional decomposition chart

5 DESIGN SELECTED

The team have done multiple researches and designs for making a dental capsule shake and mix based on the engineering requirements and customer requirements. So, the team has decided to chose the toothbrush design as the final design. In the following section the team will discuss the design in details.

5.1 Rationale for Design Selection

5.1.1 Pugh chart

The team have decided to do a Pugh chart to determine the top ideas. As shown in the table below the team have provided top ten design and make them in a pugh chart. Also as shown the pugh chart has the team's customer requirements. The team has compared these design to the original design. So, the team have chosen the top three designs based on their best total scores. For the first design which is the toothbrush design got 23 points. The second design which is the battery operated design has 17 points. And the third design is the compressed air design which has 7 points. These three designs will be presented in the team decision matrix

Table4 : Pugh Chart

Concept Selection Legend Better + Same S Worse -			Designs									
Criteria	***Importance Rating***	Datum: Dental Triturator	Gear design	Chain design	Battery operated design	Quick Return Design	Spinning Design	Compressed Air Design	toothbrush design	Springs Desig	Clapper design	Two Balls Design
Lightweight	**5**		S	-	S	S	-	S	+	+	+	+
Shake capsule for 10 seconds	**5**		S	S	S	S	S	S	S	-	S	S
Easily Transportable	**5**		+	-	+	+	-	+	+	+	+	+
Reliability	**4**		+	+	+	-	+	+	+	-	-	-
Easy Operation	**4**		S	S	+	-	+	S	+	+	S	-
Quality	**3**		-	S	+	-	-	-	+	-	-	-
Cost	**3**		+	+	+	+	+	+	+	+	+	+
Easy Maintenance	**3**		-	-	S	S	S	S	-	S	S	+
Aesthetics	**2**		-	-	-	-	-	-	+	-	-	-
Sum of Positives			3	2	5	2	3	3	7	4	3	4
Sum of Negatives			3	4	1	4	4	2	1	4	3	4
Sum of Sames			3	3	3	3	2	4	1	1	3	1
Weighted Sum of Positives			12	7	19	8	11	12	26	17	13	16
Weighted Sum of Negatives			8	15	2	13	15	5	3	14	9	13
TOTALS			**4**	**-8**	**17**	**-5**	**-4**	**7**	**23**	**3**	**4**	**3**

5.1.2 Decision Matrix

The team has been done with the decision matrix for their 3 top designs by using the customer requirement and engineering requirements and to compare the three designs in the below table. These requirements are having a scale from 1 to 10. For 1 means that the requirement is unsatisfied, for 10 means that the requirement is satisfied.

Result shows that the toothbrush design has the top score which 165. That means the toothbrush design is better design than battery operated design and compressed air design. So that's the reason for the team by choosing the Toothbrush design as the final design.

Table 5: Decision Matrix

CR's	Toothbrush Design	Battery Operated Design	Compressed Air Design
Lightweight	10	8	8
Easily Transportable	10	9	7
Shake Capsule for 10 Seconds	10	10	10
Reliability	9	9	8
Easy Operation	10	9	8
Quality of Parts	8	9	7
Cost	10	8	9
Easy Maintenance	6	7	7
Aesthetics	9	7	7
CR Total	82	76	71
ER's	**Toothbrush Design**	**Battery Operated Design**	**Compressed Air Design**
Weight	10	8	8
Energy	9	10	9
Cost	10	8	8
Dimensions	10	8	7
Materials	8	8	8
Number of Parts	9	9	8
Manufacturing Time	9	8	9
Life Expectancy	8	9	8
Ambidextrous	10	10	10
ER Total	83	78	75
Total Score	165	154	146

5.1.3 Final design

The team has selected the final design which is the toothbrush(Figure 11 and 12). The advantages of this design is easy to use, lightweight, easily transportable, cheap parts and small size. The disadvantages of this design are it is not easy to maintenance, electricity used on this design, non-flexible and hard replaceable parts.

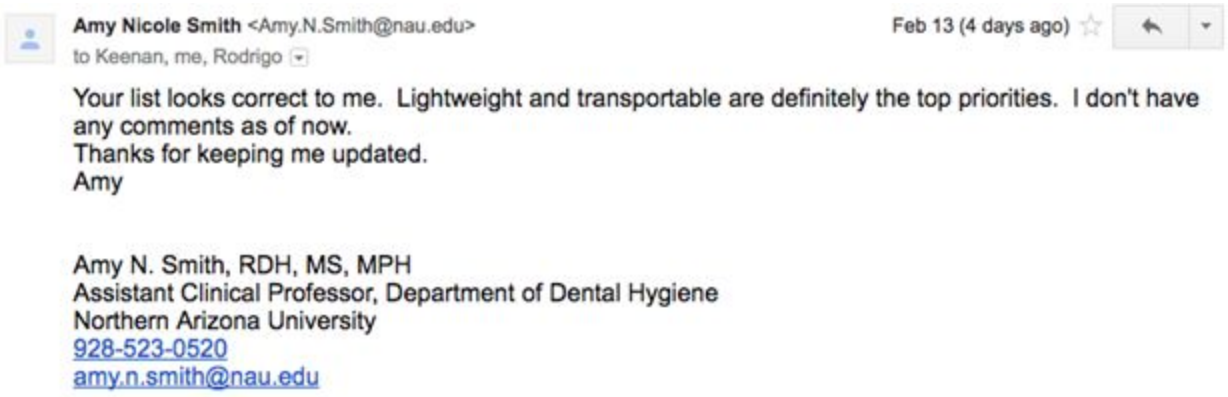
References:

[1] *Egg Beater*. N.d. *Egg Beater*. Web. 15 Feb. 2017. ''https://www.oxo.com/egg-beater-304''

[2] *Gas Paint Mixer*. Digital image. N.p., n.d. Web. https://i.ytimg.com/vi/o4QIBHXVEPs/maxresdefault.jpg

[3] *Sawzall*. Digital image. N.p., n.d. Web. http://toolguyd.com/blog/wp-content/uploads/2013/09/Milwaukee-M18-Fuel-Sawzall-Recip-Saw.jpg

Appendix:A



Amy Nicole Smith <Amy.N.Smith@nau.edu> Feb 13 (4 days ago)

to Keenan, me, Rodrigo

Your list looks correct to me. Lightweight and transportable are definitely the top priorities. I don't have any comments as of now.
Thanks for keeping me updated.
Amy

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