[Human Power Dental Mixer]

[Background Report]

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1 BACKGROUND

1.1 Introduction

Many of the places in developing countries are not connected to the electrical grid. Following the challenges posed by lack of electricity in all these places during the trituration process due to there being only electronic triturators, there is need to come up with a manual mixer that does not need electricity. Through the adoption of the manual Triturator, the challenges of electric triturator will be reduced therefore, the aim of this project is to come up with a manual dental triturator. In order to help in mixing of amalgam even in remote areas where electricity connection is not available.

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) Department and NAU Mechanical Engineering Department (CHHS and CEFNS) have created this spring 2017 capstone project for 3-6 mechanical engineering students to create a human powered mixer that can shake a capsule for 10 seconds."

1.3 Original System

Our project is considered as a re-engineering project. The original system is an electronic device that needs a specific amount of power in order to shake the capsule for 10 seconds. Mixing speed is between 3000 rpm to 4500 rpm. With the existing electronic triturator, the challenge is that it is not compatible with the existing outlets of certain countries and sometimes, lack of power in some places makes it difficult to use. In order to achieve the expected results, requirements from the sponsor constraints will be followed by taking a number of tradeoffs such as weight, life expectancy and size of the triturator.

1.3.1 Original System Structure

The original system was built of metal gears, heavy plastic, rubber, plastic handle and a metal capsule holder. The heavy plastic is used to protect the metal gears and the plastic handle is to crank the gears to operate. The rubber is used a plastic box to protect the interval material. The gears were made of metal with gear oil on it. The shaking part was made of rubber to protect the capsule from and damage also to help in tighten the capsule.

1.3.2 Original System Operation

The existing device uses electric power to operate. The operator need to turn the handle at a constant speed for a certain amount of time (10 seconds). This will result that the capsule will shake in forward and backward motion until it reaches the mixing level that it's required.

1.3.3 Original System Performance

The original devices uses different gear sizes to increase the shaking speed with the lowest handle cycle possible. the mixer was designed to meet the existing electronic design version which shakes the capsule with 4000 rpm / min.

1.3.4 Original System Deficiencies

The existing device met the requirement that was listed from the dental hygiene department. However, this device had some disadvantages but specifically, the device was heavy and wasn't easy to transport overseas.

2 REQUIREMENTS

The Manual Dental mixer is a device that uses human energy to triturate the capsules that contain amalgam and glass Ionomer sealant so that it can be used in places where there is no provision for electricity. The new design also should have better features than existing designs like weight of the product, cost of manufacturing, provision for replacement of parts etc. to meet customer requirements.

2.1 Customer Requirements (CRs)

The importance of customer requirements to satisfy their demands are tabulated in section 2.5. The team contacted the Department Chair of dental hygiene Tracye Moore in order to get the approval of the Weights the team chose. The weight of the device must be as low as possible so that it is easy to handle the device and less effort is needed to operate it. As the existing designs, which are usually powered by electricity, are not possible to use in places where there is no provision of electricity it should be replaced with human power in accordance with the customer's wmain requirement. With this feature, you can use the device anywhere with just a bit human effort. As the design should be affordable to most, the budget should be as low as possible which can be reduced by making simple design and using parts that can be manufactured using simple processes. The design should shake the capsule at 4000 rpm so that the mixture will be homogenous. It should also shake for 10 seconds hence the time taken will be less. The team will try to reduce the size of the device in order to make it as big as the electrical device so that it is easier for customers to handle the product. The life expectation should be 2+ years which can be achieved by using quality parts and robust mechanisms. Having a device with replaceable parts is one of the most important things that the customers care about. The complete system must be enclosed in order to be safe to use, easy to handle, and the product will not harm the user.

2.2 House of Quality (HoQ)

The team created a house of quality which can be found below. Basically, each customer requirement had given weight out of 5, where 5 is most preferable and 1 is least preferable. Our client approval signature can be found in Appendix A.

Customer Requirement	Weight
1.Light weight (less than 10 Lbs)	5
2.Human Powered	4
3.Budget (Less than 750$)	4
4. Shakes at 4.000 RPM	5
5. Time (Shake for 10 sec.)	5
6. Same size as electric model	3
7. +2 years life expectancy	2
8. Replaceable parts	4
9. Easy to use	3
10. Complete enclosed system	5

Table 1 : HoQ

3 EXISTING DESIGNS

3.1 Design Research

Dental triturators are a perfect example of how a single task can be performed slightly differently using dozens of very slightly different methods. This is easily seen from doing an internet search for triturators, or amalgamators, and clicking on any of the links that appear. While one particular link, medicalexpo.com, has over twelve different models displayed, they all perform the task of trituration in the same way. Each triturator shakes the amalgam capsule back and forth in the same manner but they come in all shapes, sizes, and prices while also being very different designs. From viewing these designs, as well as our conversation with Dr. Moore (our client), we know that we must follow the commonly used method of shaking the capsule back and forth.

The main benchmark that we are using to design our device is the triturator that was shown to us by Dr. Moore is very similar to the Rinn Wig-L-Bug mixer. Compared to most of the other triturators on the market, this model is quite small and compact but is also heavy. Using this design, it is our goal to design a new device that is, at most, the same size as the Wig-L-Bug but much lighter. Another major trait of dental triturators is their ease of use. From the demonstration we were given, we saw that the entire process of trituration involved only loading the capsule into the device and then pressing a button. With devices that are this easy to use, it is crucial to our design that it retains that ease of use.

One of the biggest things that we have learned from benchmarking is that triturators are already very advanced and that we should learn from existing designs. Because our project is to make a manual triturator, we do not have to focus on improving the process of trituration but rather recreate the same technology in a human-powered device.

3.2 System Level

A number of different mixers are in the market currently. Despite that they have the same objective of mixing the capsules, they have different advantages and disadvantages. This is due to the tradeoffs taken during the designing process. Such tradeoffs include, time, frequency of operation, weight, size of the mixer. Therefore, in order to achieve the expected results, certain properties get compromised, and that is why one machine cannot have all the properties at the same time. For example, in this case, three different types of capsule mixers will be considered in the designing of the manual mixing Triturator.

3.2.1 Existing Design #1: GC Capsule Mixer CM-II

This is a digitally controlled high speed Triturator which has both a manual and a pre-programmed timing modes. The system is easy to operate. In addition to that it has the following advantages [1]:

1. It provides an easy insertion point due to its flexible arms
2. It has a preset timing modes
3. It has both manual and auto programs
4. It is easy to design.

3.2.2 Existing Design #2: Capsule Mixer

The Henry Schein mixer has 10 programmable mixing time which can be used in for regular dental capsules mixing. This is because of its high frequency of 4.200 rpm, 180 watts usage and small in size of 22 x 23 x 18cm/weight. Therefore, this type of capsule mixer is important to my project more so in terms of frequency, weight and size of the proposed manual dental Triturator [2].

3.2.3 Existing Design #3: ProMix 2

This is a type of a universal capsule mixers that has a precise mixing time with a homogenous

mixing times. This type of mixer is helpful in the project has this will enable us to design the specific times for high precision designed mixer in our project [3].

3.3 Subsystem Level

The device is made up of three main subsystems, method of providing power to the device, how the power is increased or converted, and finally the method of using that power to shake the capsule.

3.3.1 Subsystem #1: Power Input Method

There are several methods of providing power to the device. The first method is to attach a hand crank to a drive shaft. This drive shaft turns and moves the inner mechanisms of the device. This type of design would be very durable and simple to design. The drawbacks to this option is that it would require that the operator has sufficient strength to turn the handle and that is also increases the size of the device quite a bit.

The second method of providing power to the device would be a pull cord such as those used to start lawnmowers. This design would work well as it would be able to provide a very large amount of power to the device per cycle while remaining very compact and easy to use. The drawbacks to this design are that, due to the forces involved, it puts a lot of stress on the internal mechanisms, which requires that they be made of sturdier, and also heavier, materials.
The third method would use solar panels as the main power source. Solar panels would be very useful because solar technology has advanced to the point that they are both effective and also affordable while remaining portable. However, solar panels would require that the device is used somewhere near sunlight, meaning that extension cords would probably be required. Also, this would require electric motors which tend to be very heavy.

3.3.2 Power Use and Transfer

After the power has been transferred into the device, it must either used, or converted into a usable form before it can actually move the capsule. This can be done in many different ways by using gears, springs, and electric motors.

The first, and simplest method, is the same that was used in the initial prototype. It uses a multiplier gearbox to increase the speed of the input shaft before exiting the device and shaking the capsule at the other end. This design is a proven method that is known to work reliably. The downsides to this design is that gears, when made of metal, are very heavy. If lighter materials are used, the torque inherent in this design can easily be too much for the gears to handle and will lead to a failure in one of the parts.

The second method would use a system similar to those used in clocks and wind-up toys which uses a coiled spring that can be wound up and then released when ready. This method would allow the user to wind the device using a key and then press a button to release the tension and shake the capsule. This could potentially allow multiple uses per winding which would allow for more efficient use and less effort from the operator. The problem with this design is that leaving anything like a spring under tension can be dangerous if a part fails and releases the stored energy. Also, springs can suffer from fatigue after prolonged use if not made from high quality materials. If a spring degrades to the point where it can no longer sufficiently shake the capsule, it could lead to a very costly repair for a very specialized part.

The third method would use a system up electric motors powered by either a power source or a hand crank. Electrics motors are a very good choice for this sort of device because they will operate in the exact same manner as long as power is supplied to them, which would allow easily repeatable results for

every patient. Electric motors can also create a very large amount of power which is necessary to this device's effectiveness. The problem with motors however is that they are very heavy and can be difficult and expensive to replace if in a remote environment.

3.3.3 Method for Shaking Capsule

The most important part of this device is its ability to shake the amalgam capsule at a precise speed for a precise length of time. This can be done using two different methods; a piston with the capsule attached to the end, an arm with the capsule attached that waves back and forth.

The first method would attach piston to a crankshaft similar to what is used in a combustion engine. The capsule would be attached to the end of the piston and would move back and forth linearly. This method would work well because a high rpm is easily sustainable without putting a lot of stress on the device. The second method using an arm would work in a similar manner by using a crankshaft or piston but, because the capsule is attached to the end of an arm, there is a much greater range of motion that can be achieved which will more efficiently mix the amalgam.

4 REFERENCES

[1]"GC EUROPE", *Gceurope.com*, 2017. [Online]. Available: http://www.gceurope.com/products/detail.php?id=146.

[2]"ProMix 2 | DENTSPLY Middle East & Africa", *Dentsplymea.com*, 2017. [Online]. Available: http://www.dentsplymea.com/products/restorative/restorative-equipment/promix-2.

[3]"Henry Schein Corporate Brand", *Henryscheinbrand.com*, 2017. [Online]. Available: http://www.henryscheinbrand.com/product.php?leader=9001171.

APPENDICES

HoQ – Client Approval

House of Quality (HoQ)

Customer Requirement	Weight	Engineering Requirement						
1. Light weight (less than 10 Lbs)	5							
2. Human Powered	4							
3. Budget (Less than 750$)	4							
4. Shake's at 4.000 RPM	5							
Time (Shake for 10 sec.)	5							
6. Same size as electric model	3							
7. 2+ years life expectation	2							
8. Rplacable parts	4							
9. Easy to use	3							
10. Complete enclosed systeam	5							
[add or remove CR rows, as necessary]								
Absolute Technical Importance (ATI)								
Relative Technical Importance (RTI)								
Target(s), with Tolerance(s)								
[add or remove T/T rows, as necessary]								
Testing Procedure (TP#)								
Design Link (DL#)								

Approval (print name, sign, and date):

Team member 1:

Team member 2:

Team member 3:

Team member 4:

Team member 5:

Team member 6:

Client Approval: