Preliminary Proposal

Human Powered Dental Mixer (Team I)

Department of Mechanical Engineering

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1 Background

1.1 Introduction

A dental Triturator forms the basis for this project. This project is all about the schematics that go with the Triturator and the efforts that the team has applied to make changes to this device. The changes the team have instituted are informed by a need to have a more user friendly Triturator especially for the student users who are finding it hard to cope with the existing dental triturator. The team set out with the chief objective of making a hand driven Dental Triturator. This also doubled up as the client chief concern. The other pressing objective was to make a device that was portable to be moved from one place to another. There other subsequent minor objectives that were informed by the customer needs. However, the above three were the threshold that the team needed to be able to meet. The rest of them were subject to debate based on the analysis tools. The sponsor of this project was the NAU's Dental Hygiene (DH) Department. The department was shipping its students abroad to practice dental work. They are the biggest beneficiary of the project as the device is supposed to be used by their students before it goes to the rest of the world.

1.2 Project description

NAU's Dental Hygiene (DH) Department in conjunction with NAU Mechanical Engineering Department (CHHS and CEFNS) came up with a joint project description for the project. The tagline statement that was offered was 'create a human powered mixer that can shake a capsule for 10 seconds.' This original system description was informed by the gap that was seen as students went on their assignments to oversee where there was some condition that inhibited the use of the electrical dental triturator.

There are two conditions that go with the above description. The first one is that the model that the team had to make was to be human powered. This part of the description is informed by the oversee environment where there is no electricity to carry out the dental mixing. The second condition was on the time factor. A research reveals that existing mixer uses ten seconds to mix the dental formulation. [1] This purpose therefore informs the desire to keep the time that is used to make the mixing to be a constant for the students. This is for professional efficiency as the students will come back to the country after their oversee assignment and work as such.

1.3 Original system

What is being undertaken in this project is not something entirely new. This is because there already exist a dental system that is used to make the dental mixing of dental formulations. Our process can therefore be regarded as redesign process of an existing system. The existing system is fondly regarded as the dental triturator. There are various bleeds of dental triturators that are there. These bleeds are all different to some extent but they all have quite a range of similarities. [2] First of all, they all run on electricity. This is the most basic unifying factor of the triturators. This is also the most basic factor that the redesigned model will alter in the triturator.

1.3.1 Original system structure

The original system comes in different particulars but there are some structures that are generally the same for these devices. One of the common features is the size. Most of the devices have the

dimension of 7 Inch by 10 inches by 9 inches. There may be some variance to these measures but they are never all that far from the dimensions that have been mentioned above. The other common feature is that most of them have a metallic outer casing. [3]However, there are some that have some plastic outer part. Given that the mixers run on electricity, they all have a chord that is attached to them and runs to a source of power where they can be plugged in. There are two compartments to the existing model. The first compartment is opaque. This is the compartment that holds the motor and all the other parts that are part of the motor system that drives the mixer. The second compartment is visible as it is usually on a glass casing. This compartment contains the two hooks that anchor the dental capsule firmly as a swirling motion is the one that mixes the capsule.

1.3.2 Original system operation

The operation process begins with the plug in of the power cable into a socket. Current flows into the mixer to the lower compartment where the motor setup is located at. Before switching on the device, the upper compartment is opened and the dental capsule is placed between the two hooks. When the capsule has been hooked, the compartment is then closed. The main reason why this compartment is closed is to avoid any possible accident that may happen if the capsule was to dislodge from the hooks that holds it. After the compartment is closed, the timer that is on the timer screen is set. By convention, a timing of ten seconds is the most common place timing scale that is used. The start button is then pressed to start the mixing process. After ten seconds, the device switches itself off. During this time the dental formulation is usually well mixed. One of the observations that the team cannot overlook is the way that the hooks twirl the capsule. The twirling of the hooks is out of phase with each other. This helps to mix the capsule contents from all the sides of the capsule. [4]

1.3.3 Original system performance

This device works at a voltage of about five units. The task that is performed by the device is quite light given that it has to shake a capsule that weight only 20 grams. There is therefore not much of a need for excessive force. The chief part of the device is the motor. The motor is connected mechanically to toe hooks and gives them the motion.

There is a high performance that characterizes the original system. It is only a device with high performance that can complete a task in ten seconds. There are other uses that the dental triturator is put to other than mixing of the capsule. The time scale that the device has is testimony to this. The performance of the original system is characterized by a motion that has a periodic time of 4000 revolutions per minute. This is a relatively high frequency and is the one that leads to the task being completed in the ten seconds.

1.3.4 Original system deficiency

The device is as good as the best when it is working in an environment where there are the ideal conditions. However, in places where the conditions are less than ideal, the device slowly becomes useless. One of the less ideal conditions is the lack of electrical power. Without the electricity, this device becomes a useless box.[2] The other deficiency is related to flexibility. This device is made of metallic parts for most of the components. This makes it to be relatively heavy. The other shortfall is the shape. This device is shaped like a cube for the most part. If one is traveling in a bag pack, this device had to be carried with a carton as it is so rugged.

2 Requirements

The requirements for the device are particulars that need to be satisfied for the device to function in the way that it should perform. Some of the requirement is the ones that were specified by the project client and others based on the design necessities it self. Of essence in the requirements are the necessities that are required by the customers and the design requirements that need to be met.

2.1 Customer requirements

The design requirement sets for the first set of the criterion of the customer needs that needs to be met by the redesigned model. The first among the design requirements is the ability to use human power to make the device to work. This function is the one that will replace the use of electrical current to drive the device. The second among the design requirements is the ability to carry out the mixing of the dental formula in ten seconds.

There are other customer requirements that are a derivative of the student concerns. Weight is of concern to the students. The current device is too heavy that tires the traveling students easily. The shape is also extremely rugged and this is of concern to the students. The rugged shape makes carrying of the device to be uncomfortable to the carriers. If the size could be reduced for the device, there are many customers who would be glad. Students like travelling with bag packs and if it could fit in a bag pack, it would do a lot of good to the students.

Table 1: Relative weight of the customer requirements

Customer requirement	Weight of customer requirement
Use of human power to power the device	5
Light weight	4
Smaller in size	3
Be durable	2
Speed between 3000 rpm to 4500 rpm	5
Easy to use	3
Transparent compartment	1
Takes 10 seconds to shake	5

2.2 Engineering requirements

One of the engineering requirements is that the device should shake the formulation that is in the capsule for ten seconds. The device that currently exists can shake the formulation for ten seconds.

The team does not seek to create any inconvenience in the use of the new device. The dentist should use the same time as he was using before. This is to make sure that the dentist can be able do adequate planning as they do their work. There only difference should be the source of the power that is to be used to make the device to work. The other engineering requirement is that the device should have enough power to shake the capsule thoroughly. The point is not just to shake the capsule for ten seconds but also to make sure that in the ten seconds, the device has produced enough energy to shake the capsule thoroughly. This will only be possible if the mechanism that is made has enough power to shake up the capsule. The mechanism made should therefore be strong enough to provide the power. The final engineering requirement should be the presence of safety through the use of the device. Many times, locally made devices may have shortcomings in regard to the safety aspect.

2.3 House of quality

The house of quality is the second ranking procedure after the customer requirement prioritization. The HOQ aids in making decisions in regard to the importance.

Table 2: House of Quality

10 sec time interval									
Mixing energy									
Safety		1	1						
Stability				-1					
		Technical requirements				**Customer Opinion Survey**			
Customer Needs	**Weight**	10 seconds time interval	Mixing energy	Stability	Safety				
Hand powered dental mixer	5	2				*Fair*	*Good*		
Light weight	4		1		1	A	C		
Smaller in size	3	2					B		
Be durable	2			2	1	C			
Transparent compartment	1	1	3		3	B	B		
Units		Sec	J	N/A	N/A				
Technical target		15	10	8	10				
Technical score		18	8	3	9				
Technical Importance		1	3	4	2				

3 Existing designs

This section will include an overview of some appropriate existing designs; some intensive research was performed on each exiting design in order to help the team create an appropriate design eventually.

3.1 Design research

The Internet was the primary source of information for the existing designs of the dental triturator. 'Human Powered Dental Mixer' was the term that the team used to surf through the internet for existing design. There are about two dozen sites that had information on the existing designs. There are not all that many types of triturators are in the world. Many of the sites had repeated information that was in other sites as well. There are about five types of triturators that the team were able to trace. [4] Two of them seemed to be out-of-date and we therefore settled on three that seemed to make sense to us.

3.2 System level

The system selections were based on the closeness of the devices to the type of device that the team were seeking to have. The first thing that the team were keen to check was if the system did use any power or it was a manual system. The designs that were selected were all operated manually and they therefore met the needed criterion effectively. The other thing that the team checked was the usefulness of the design in regard to our necessity. Two of the designs that the team did not consider were as big as a Piano. The other thing that the team checked was the potential for speed. The team needed a design that could reach 4000 rpm or could be modified to reach this speed.

3.2.1 Existing design #1: **Mixacap dental triturator**

This design has a basic layout of a PVC pipe. The pipe has a screw on one side and a thread that runs in the PVC pipe. On the other end is held the holder for the capsule. When the screw is turned, it makes the holder to vibrate the capsule and therefore mixes the formulae. The shortcoming of this model is that it cannot be able to reach the 4000 rpm.

3.2.2 Existing design #2: **Janis titurator**

This design is made of a gears cogs and sprigged system. The gears multiply the power and the spring's offers the return force for the transfer of the force from the triturator to the holder of the capsule. A hand is used to move the system and it has to keep moving to make the device to transmit the power. The shortcoming of this device is that it is very large for use by the students as they move.

3.2.3 Existing design #3: **Motor and pestle**

This design is the simplest of all the designs that were researched. This design operates in a tradition of just spilling the content of the capsule into a motor. Then the mixture is ground with a pestle till it is mixed thoroughly. This method however causes a lot of wastage of the capsule content.

3.3 Subsystem level

The subsystems that were traced in the design held potential for the development of our designs. Sometimes, it takes just some modification of the existing models to come up with a totally new concept that is viable for application.

3.3.1 Subsystem #1: **The Sprigged rod**

In the subsystem, there is the rod that is at attached to a spring. The spring receives the depression and then gets released. When the spring is released, it bounces back and oscillates at a certain speed. As it oscillates the capsule bounces up and down with the rod that is holding it.

3.3.2 Subsystem #2: **Sprigged box**

This concept makes a direct translation of force from one side to the other. A spring inside a box is depressed on one side. As the spring gains it length after the depression, it becomes longer in length. It pushed a holder that is supposed to hold a capsule. As a result, the holder vibrates informed by the compressions and the rare functions of the spring inside the sprigged box.

3.3.3 Subsystem #3: **Gear mechanics**

Gears operate on the principle of speed multiplication. The factors of multiplication are dependent on the diameters of the gears or the number of the teeth that are in the gears that are interacting with each other. The requirements for the device are particulars that need to be satisfied for the device to function in the way that it should perform. Some of the requirement is the ones that were specified by the project client and others based on the design necessities it self. Of essence in the requirements are the necessities that are required by the customers and the design requirements that need to be met.

3.4 Functional decomposition

Our functional decomposition consists of the black box and the functional model. The black box is the basic understanding of the operation of the hand powered dental triturator. The team seek to make the hand powered dental triturator to be as the flow black model shows below. The black box just shows the materials, the energy that is to be used and the signals that will be emitted. The thick line is for the input and the output materials the moderate line is for the energy input and output while the within line is for the signal emission.

3.4.1 Black box model

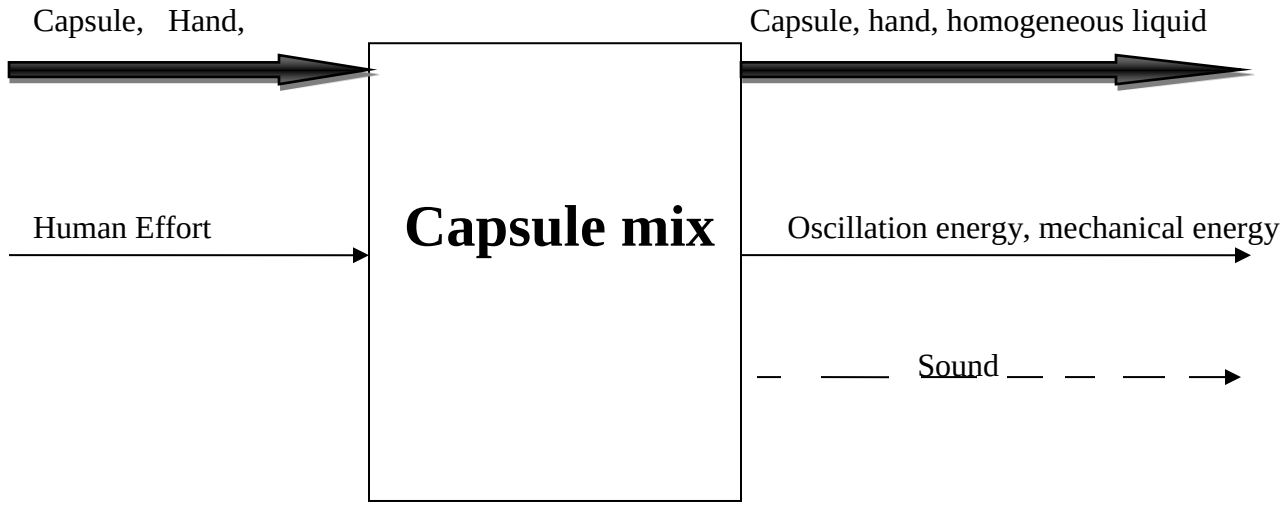

Figure 1: Black Box Model

3.4.2 Functional model

The functional model has a more detailed analysis of the processes that are to take place in the hand powered dental triturator. The process begins with the source of the power which is the human hand. The hand provides an effort that is converted to mechanical energy. There is then the capsule that is imported as well. The capsule is shaken by the mechanical energy and as a result there is the mixing of the capsule content.

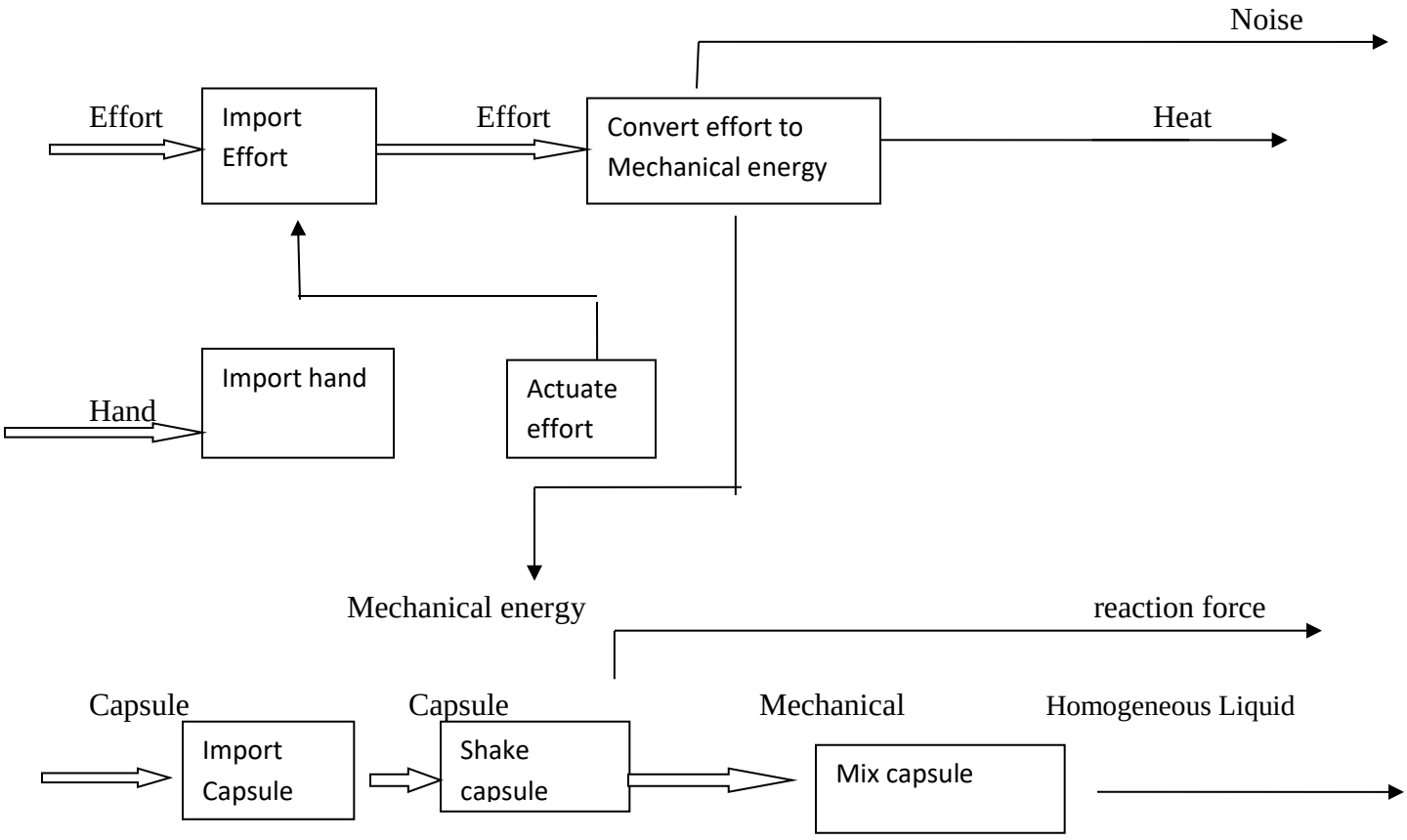

Figure 2: Functional Model

The functional model and the black box will be instrumental in defining the processes that needs to be followed in making the designs that will need to be considered. With this understanding the team will go the designs that are considered for this the hand powered dental triturator.

4 Designs considered

This section will include the design that the team came up with, and it is based on the engineering requirements and customer requirements that were set. The team considered about ten designs that have their own advantages and disadvantages.

4.1 Design #1: Resonate box

On two sides of a box, there are springs that are springs that are attached. These springs resonates out of phase with each other. This happens when the handle is displaced downwards with a hand. As the spring gain its mean point, the spring on the other side is displaced downwards. This simple one displacement and the resonance can last for a minute a time over which the capsule could be well mixed.

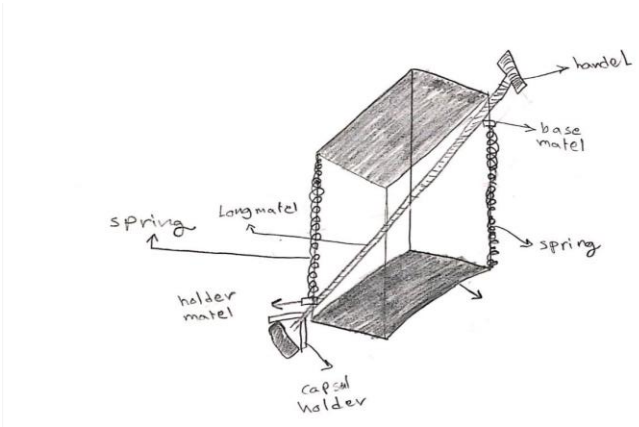

Figure 3: Resonate Box

4.2 Design #2: vibrating spring

This model has a basic functioning where there is holder that is suspended by springs. The springs are in return attached to a base. What happens is that the prongs are displaced sideways by a hand and then released. As the springs return to the mean point, they surpass it to the opposite direction and there is a continuous vibration until there is no more impetus. The hand could keep on vibrating the capsule.

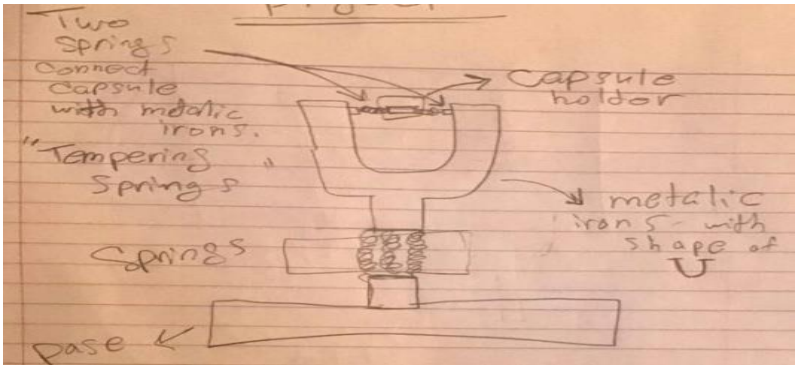

Figure 3: Vibrating Spring

4.3 Design #3; Gear triturator

The gear triturator utilizes the concept of gears to multiply impetus. This model is driven by hand. The hand has a force that drives the first gear that is normally a very large gear, smaller subsequent gears are driven as a result; their speed is multiplied all the way to the capsule holder.

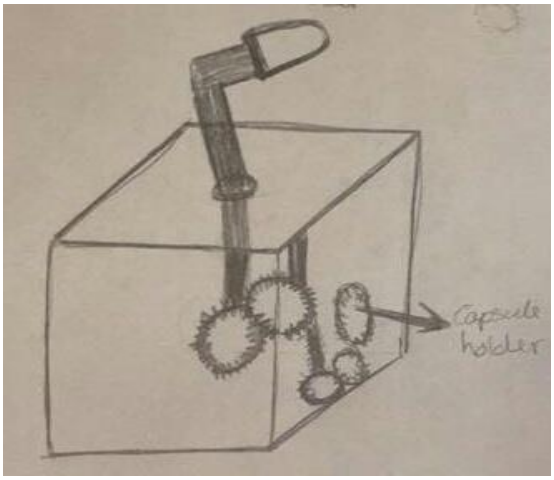

Figure 4: Gear Triturator

4.4 Design #4: Sprigged pipe

In this design, there is a pipe that contains a spring. On one end, there is a faucet that is pushed downwards and then released to return to the mean point. As the faucet returns to its mean point, it makes the spring to send waves of compressions and rare functions. These waves are successively continuous as the faucet is continuously displaced. The waves hit the capstone holder and make it to vibrate.

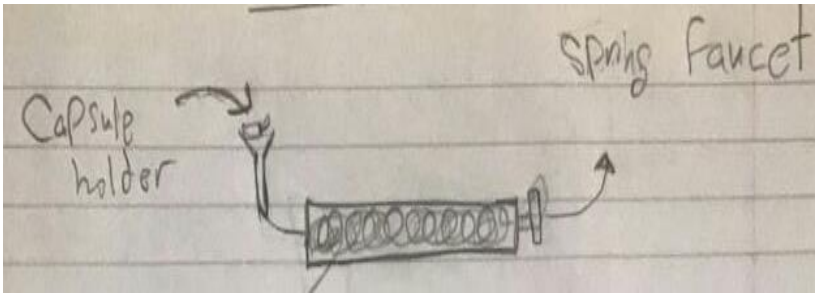

Figure 5: Sprigged Pipe

4.5 Design #5: Bearing

The bearing works in more or less the same way like the gears would work. There are bearings that have teeth like the ones that are utilized in this model. The gears are lined up so that they drive each other. As the gears drives each other, they becomes complimentary of the force transition to the capsule holder.

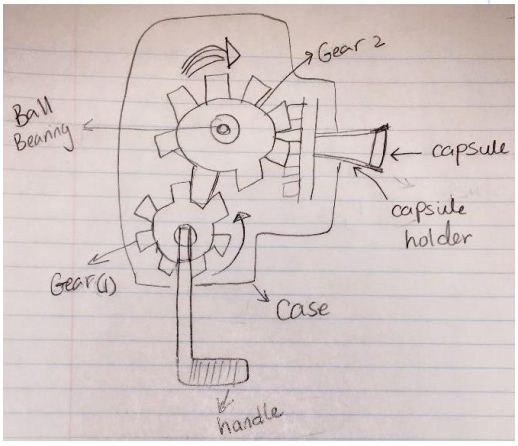

Figure 6: Bearing

4.6 Design # 6: Solar powered model

The solar power can be a great source of energy to drive our triturator. The solar panel replaces the cable system that supplied power to the original model. The solar panel is connected to a storage unit for power that is used to drive the motor.

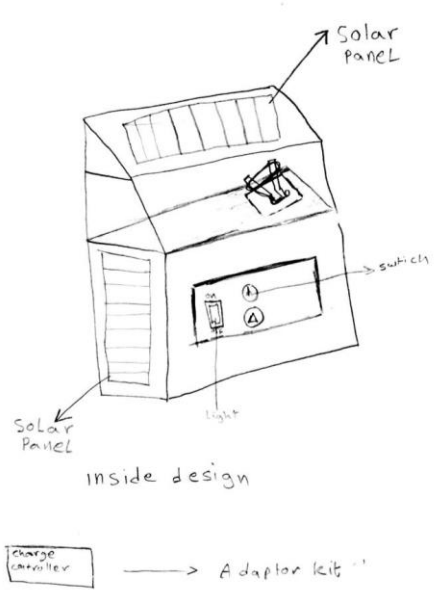

Figure 7: Solar Powered Model

4.7 Design # 7: Series gears

These gears are connected in a way that they following each other. In this connection, the gears are all transmitting power to each other. There is a uniform force that is transmitted to the successive gears. The force that starts on one end is the same force that is delivered other other end.

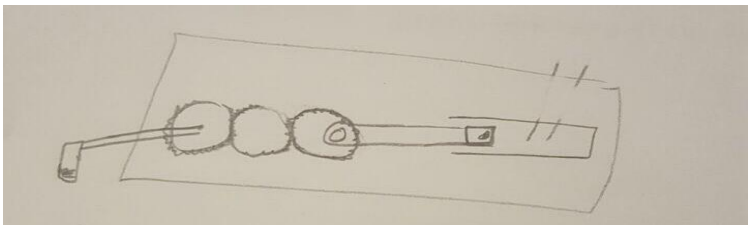

Figure 8: Series Gears

4.8 Design # 8: Single pulley

This model has is made of a single gear that is attached to a triturator. The gear has protrusions on the side that continuously hits the holder as it rotates. There are as many as ten hits that happen to the holder in one revolution and as this happens, the capsule is well mixed.

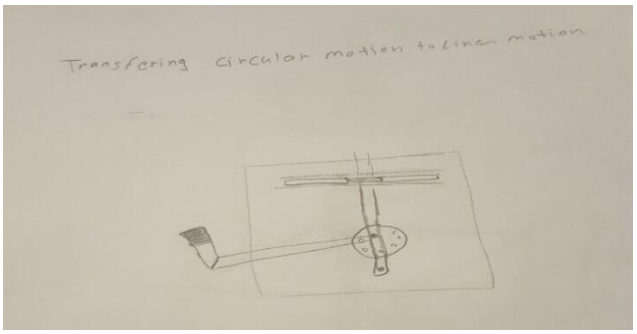

Figure 9: Single Pulley

4.9 Design # 9: Disposable batteries

Given that the challenge that is major is the lack of electrical energy, this model recommends the use of batteries that are disposable. The batteries can replace the electrified system that does not work anymore due to the lack of electrical power to be used.

4.10 Design #10: Flexible chorded

This design uses a flexible chord that has a high tensile strength. The chord is fixed on one end as the other end is free to be vibrated upon a slight displacement downwards. The displacement is done by the use of a hook that is attached at the base of the flexible chord. The hook is pulled downwards and as it makes the return vibration, it makes the capsule that is attached it to mix in the process.

4.11 Design # 11: Vibration string

This model is made of a string that is taut as a result of getting held at two ends a an interval of about 30 inches, The capsule is fasted to the string and then the string is plucked just like it would be plucked in a guitar. The string vibrates at a resonance that has a high frequency. As the string vibrates, there is the mixing of the capsule.

5 Design selected

This section will discuss the process that the team used to evaluate the considered designs, along with the design the team selected on behalf of the other designs. A brief description of the design selected is included. The team used a Pugh chart for the selection process along with a decision matrix to finalize selection.

5.1 Rationale for design selection

The ten designs that were made by team all have the same chance of getting chosen. To be able to choose the best among these designs, the team shall use the Pugh Chart and the decision matrix. These two will give the final model that is ideal for development. The team started with the use of the Pugh chart to reduce the options that the team had to a handful that can be sorted out through the decision matrix. There are the top customer needs and the engineering requirements that were synthesized earlier on. These are the ones that will be used to make the final decision on the model that will be choose.

Table 3: The Pugh chart.

Criterion	Models									
	Resonate box	**Sprigged pipe**	**vibrating spring**	**Gear triturator**	**Solar powered model**	**Series gears**	**Single pulley**	**Disposable batteries**	**Vibration string**	**Flexible chorded**
Use of human power to power the device	+	+	+	+	+	+	+	+	+	+
Safety	+	+	+	+	+	0	+	+	+	0
4500 rpm	+	0	+	+	+	0	0	0	+	0
10 seconds time interval	0	+	0	+	0	0	0	+	0	0
Light weight	+	0	+	+	0	0	0	0	+	+
Speed between 3000 rmp to	+	0	+	0	0	0	0	0	0	0
Total	**50**	**30**	**50**	**60**	**30**	**10**	**20**	**30**	**40**	**20**

From the Pugh chart, there is the list of the top four models that are the best among the choices that are available. The top one is the Gear triturator, this is followed by vibration spring. The vibration spring ties up the position with the resonate box. Finally, the team have the vibration string making it to the top four models.

5.2 Decision matrix

The decision matrix will act our last resort for the choice of the best model that will be adapted for development. The Pugh chart has given us five alternatives that the team could choose from. From these four, the team shall narrow down our criterion for the search to include other aspects that were considered in the Pugh chart. These aspects will be weighed and then used in the decision matrix. The requirements for the device are particulars that need to be satisfied for the device to function in the way that it should perform. Some of the requirement is the ones that were specified by the project client and others based on the design necessities it self. Of essence in the requirements are the necessities that are required by the customers and the design requirements that need to be met.

Table 5: Decision matrix

Criteria	weight	Options for model			
		Gear triturator	vibration string	resonate box	vibration spring
Cost	5	1	1	1	1
Portability	4	1	1	0	1
Size	3	1	0	1	0
Efficiency	2	1	0	1	0
Total		14	9	10	9

The designs that were evaluated here are the designs that were chosen according to the Pugh chart. From the relative scores that were gotten, the Gear triturator leads in the pack as the best of the models that are available. The rest of them follow close and since the team only needs one, the team agreed upon selecting the Gear triturator as the selected design, as the team thinks that it adequately satisfies the engineering and customer requirements more than to its comparisons .

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