Electric Toothbrush Redesign

EDSGN 100

Section 19

Team #5

"The Flashdrives"

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Abstract

As a group, our goal was to design and create the best possible toothbrush for both the consumer and the producer. Through external research and dissection we took into account everything a consumer would want in a toothbrush design. Keeping in mind that unlimited wants cannot all be incorporated into a single design, we had to eliminate irrational designs. By ranking factors in order of importance, we designed the best possible toothbrush while also keeping production costs down.

Introduction

Our team, the Flashdrives, was given the task of analyzing the current offerings in the market and to design an electric toothbrush that would better meet the needs of our targeted population. We worked in the product design and engineering department of a fake company to create a newly designed electric toothbrush.

1.1 Mission Statement

We, as the Flashdrives, strive to present the best possible product to ensure customer happiness. Our electric powered toothbrush takes into account customer needs, concept generation, selection, and the manufacturing process to produce the highest quality product at the lowest possible price in order to maintain our position as one of the top hygiene product producers on the open market.

2.0 Customer Needs Analysis

Our customer needs were selected by putting our own ideas, along with our peers' ideas, into consideration. We sat down as a group and analyzed what we thought the most important aspects of a toothbrush are. We also asked our friends and fellow classmates their views on toothbrush aspects. Through these ideas, we were able to compare each aspect with each other and create criteria weights.

Table 1. Initial Customer Needs List Obtained from Background Research

Efficiency
Lightweight
Graphics
Cost
Durability
User Friendly
Packaging
Practicality
Long Lasting
Safety
Color
Affordability
Function
Low Maintenance
Aesthetics
Simple Design
Size

Table 2. Hierarchal Customer Needs List

1. Function
    - 1.1 Efficiency
    - 1.2 Durability
    - 1.3 Long Lasting
2. Simple Design
    - 2.1 Lightweight
    - 2.2 User Friendly
    - 2.3 Safety
    - 2.4 Low Maintenance
    - 2.5 Size
3. Aesthetics
    - 3.1 Graphics
    - 3.2 Packaging
    - 3.3 Color
4. Affordability
    - 4.1 Cost
    - 4.2 Practical

2.1 Weighting of Customer Needs

AHP Comparison charts are needed to weight each category and subcategory. These charts will determine which aspects of a toothbrush are most important, and what should be considered while designing a new toothbrush and ultimately selecting a final design.

Figure 1. AHP Chart determining the weighting for the main categories

	Function	Design	Aesthetics	Affordability	Total (Ri)	Weighting (wi)
Function	1.00	0.33	5.00	1.00	7.33	**0.34**
Design	0.33	1.00	3.00	3.00	7.33	**0.34**
Aesthetics	0.14	0.33	1.00	0.33	1.81	**0.08**
Affordability	1.00	0.33	3.00	1.00	5.33	**0.24**
Total					**21.81**	

Figure 2. AHP Chart to determine Function sub-category weighting

	Efficiency	Durability	Long-Lasting	Total (Ri)	Weighting (wi)
Efficiency	1.00	3.00	3.00	7.00	0.60
Durability	0.33	1.00	1.00	2.33	0.20
Long-Lasting	0.33	1.00	1.00	2.33	0.20
Total				11.67	

Figure 3. AHP Chart to determine Simple Design sub-category weighting

	Lightweight	User-Friendly	Safety	Low Maintenanc	Size	Total (Ri)	Weight (wi)
Lightweight	1.00	0.20	0.33	3.00	1.00	5.53	0.14
User Friendly	5.00	1.00	1.00	5.00	3.00	15.00	0.38
Safety	3.00	1.00	1.00	3.00	5.00	13.00	0.33
Low Maintenance	0.33	0.20	0.33	1.00	1.00	2.87	0.07
Size	1.00	0.33	0.20	1.00	1.00	3.53	0.09
Total						39.93	

Figure 4. AHP Chart to determine Aesthetics sub-category weighting

	Packaging	Graphics	Color	Total (Ri)	Weighting (wi)
Packaging	1.00	3.00	0.33	4.33	0.37
Graphics	0.33	1.00	1.00	2.33	0.20
Color	3.00	1.00	1.00	5.00	0.43
Total				11.67	

Figure 5. AHP Chart to determine Affordability sub-category weighting

	Cost	Practicality	Total (ri)	Weighting (wi)
Cost	1.00	0.33	1.33	0.25
Practicality	3.00	1.00	4.00	0.75
Total			5.33	

Table 3. Weighted Hierarchal Customer Needs List

1. Function (0.34,0.34)
    - 1.1 Efficiency(0.204,0.60)- (Actual weight, second level weight)
    - 1.2 Durability(0.068,0.20)
    - 1.3 Long Lasting(0.068,0.20)
2. Simple Design (0.34,0.34)
    - 2.1 Lightweight (0.0476,0.14)
    - 2.2 User Friendly (0.1292,0.38)
    - 2.3 Safety(0.1122,0.33)
    - 2.4 Low Maintenance (0.0238, 0.07)
    - 2.5 Size(0.0306, 0.09)
3. Aesthetics (0.08, 0.08)
    - 3.1 Graphics (0.0296, 0.37)
    - 3.2 Packaging (0.016, 0.20)
    - 3.3 Color (0.0344, 0.43)
4. Affordability (0.24, 0.24)
    - 4.1 Cost (0.06, 0.25)
    - 4.2 Practical (0.18, 0.75)

3.0 Revised Problem Statement

We will analyze the current offerings in the market and then design a toothbrush that is most importantly efficient, user-friendly, aesthetically pleasing, practical, and affordable.

4.0 External Search

It is important to research all the current offerings on the market as to not create a design that is currently already on the market.

4.1 Literature Review

Our external literature search consisted of researching different types of toothbrushes that are already currently on the market. Through Internet research of the different already existing products, we were able to find strengths and weaknesses of each design. After benchmarking these products in a table, we found the ideas that we thought were best for our product. For example, the simple aesthetic designs of the SoniCare FlexCare and Braun toothbrushes were more appealing to a larger audience; rather than the cartoon designs of the Colgate and Spinbrush products. Also after benchmarking, we analyzed that too much technology in a toothbrush can be a bad thing. The SoniCare

FlexCare toothbrush has a lot of cutting edge technology, but this also drove the price to $136.99, which we feel is much more than a normal consumer will be willing to pay.

4.2 Patent Search

A patent search is important in order to recognize the kind of technology that is already out in the world and to give credit to the ones who have already designed toothbrushes or aspects of toothbrushes.

Table 6. Art Function Matrix for an Electric Toothbrush

	Art					
Functions	Gears, Cranks, Pivotal Motion	Lithium Ion battery, circuits	Slider, recess, groove, latch	Electromagnetic fields, lithium ion cell batteries	Switch, button	Grip
Oscillating Head	US7020925 US4710995 US7377000					
Energy Storage		US7570018 US5170525				
Replaceable Brush Heads			US11495291 US10361653			
Charger				US6798169 USD508019 USD589255		
On/Off Control					US5930858 US5943723	
Non-Slip grip						US5339482

Patent Descriptions

Patents US7020925, US4710995, and US7377000 are all patents for the mechanical part of an electric toothbrush. Each describes how the motor connects with the head and moves the bristles. They all describe a motor driven toothbrush with a housing having a motor in one end connected to the bristles in the other end.

Patents US7570018 and US5170525 are patents dealing with the battery/charge holder of the toothbrush. They describe a battery cell where charge is held allowing the toothbrush to be rechargeable.

Patents US11495291 and US10361653 describe the design of a toothbrush with a detachable head. “At least one toothbrush head separator tool configured to separate a worn toothbrush head from a head assembly of an electric toothbrush having a shank that holds said worn toothbrush head; and, at least one replacement toothbrush head configured to couple said head assembly of said electric toothbrush.”

Patents US6798169, USD508019, and USD589255 are all patents describing the rechargeable nature of an electric toothbrush with a charging station. Each describes an apparatus attached to a source of electricity (an outlet in the wall, etc.).

Patents US5930858 and US5943723 are patents describing the on/off switch. When someone presses the on button it completes the circuit within the toothbrush, signaling the motor to start operating. When someone presses the off button, it makes a break in the circuit, signaling the motor to stop and thus turning the toothbrush off.

Patent US5339482 is a patent describing the design of toothbrush with a no-slip grip handle.

4.3 Benchmarking

Table 7. Benchmarking table

Model Name/ Number	Colgate 68745	SonicCare Flex Care	Spinbrush Kids Thomas & Friends	Braun Oral-B Sonic Clean
Aesthetics	Flashy colors and cartoon design	Sleek, simple design	Child pleasing pictures	Thin, blue sharp look
Comfort	Hard plastic grip, spinning circular head	High tech bristles	Spinning circular head	Vibrating
Cleaning	Stationary	3 cleaning settings	Stationary	2 separate vibrating heads
Power	2AA	Rechargeable	2AAA	Rechargeable
Cost	$9.99	$136.99	$6.99	$24.82

4.4 Product Dissection

Table 8. Part 1 of the product dissection'

Manufacturer/ Model Number: Colgate/ 68745

How many detachable pieces does the product have? 1

Part Number	Part Name
1	Battery Compartment
2	Main body frame and head

Describe the pieces including their functions and their materials:

Part Number	Part Name
1	Plastic; holds batteries which power the toothbrush; aluminum springs to hold battery
2	plastic/head made of bristles/ body made to be held by small hands/ bristles to scrub teeth

Is it easy to detach each part?

Part Number	Part Name
1	difficult, requires screwdriver
2	difficult, requires screwdriver

describe the packaging, is it easily opened? Describe the opening procedure.

-yes. On the back there are defined lines where to push to open the package

have you had any disagreements to this point?

-how far the battery piece goes up inside the toothbrush- it was not easily opened even after the screw was removed.

Table 9. Part 1 continued

Packaging	**- no info insert** **- good frame to hold brush w/o too much packaging** **- text is too small on back; ripped off piece also has info on it**
Aesthetics	**-flashy colors and cartoon design are attractive to the eye: aesthetically pleasing**
Cleaning	**- spinning circular head on top for main cleaning** **- -stationary bristles next to spinning bristles to aid in the cleaning process**
On/Off Switch location	**-conveniently located on the front** **- right where the thumb is located when held in the hand**
Battery location	**- good location out of the way** **- - difficult to remove and reassemble though**
Ease of switch use	**- easy to click but requires enough force to not press by accident**
Handle (Ergonomics)	**- bulky, could be tough for a child to grip**
Quality	**- seems durable when first opened**
Safety	**- too big to choke on**
Versatility, attachments	**- spinning circular head as well as stationary piece**
Weight with batteries	**- light: 2.575 oz**
Environmental friendliness	**- not very environmentally friendly; uses batteries and a lot of plastic; it could potentially be recycled though**
Other features	**n/a**

Table 10. Part 2 of the dissection

1. Noise Measurement:

Location:	**Noise level:**
Brush head 4 in away from decibel meter	66.5 dB
Brush head 3 in away from the decibel meter	67.6 dB
Brush head 2 in away from decibel meter	70.0 dB
Brush head 1 in away from the decibel meter	73.2 dB
DC motor 4 in away from decibel meter	67.4 dB
DC motor 3 in away from the decibel meter	68.0 dB
DC motor 2 in away from the decibel meter	72.1 dB
DC motor 1 in away from the decibel meter	74.0 dB
Approximate duration of brushing per day:	6 minutes
Average noise level during brushing:	72 dB

2. Power Measurement:

Voltage supplied to the circuit:

	Battery Type	**Volts (V):**
Battery 1	Energizer AAA	1.491 V
Battery 2	Energizer AAA	1.491 V

Total Voltage:

	Connection Type	**Volts (V):**
Battery 1 and Battery 2	Series	1.847 V

Current Measurements	**Averaged Current Value**
No load condition	126.4 mA

Load condition(s)

1.	87.0 mA
2.	86.5 mA
3.	84.0 mA
4.	85.2 mA

Mean current 'under load' 85.425 mA

	Voltage		Current			
Power (no load) =	1.847	X	126.4	=	233.460	Units VmA

	Voltage		Current			
Power (under load) =	1.847	X	85.425	=	157.78	Units VmA

Table 11. Part 2 continued

Battery Life
1. Number of hours available per single battery 'under load' conditions: 6 Hours
2. Estimate duration for each brushing 1/12 Hours
3. Number of days before battery replacement 72 Days

Table 12. Bill of Materials

Bill of Materials

Product Manufacturer/Model Number: Colgate

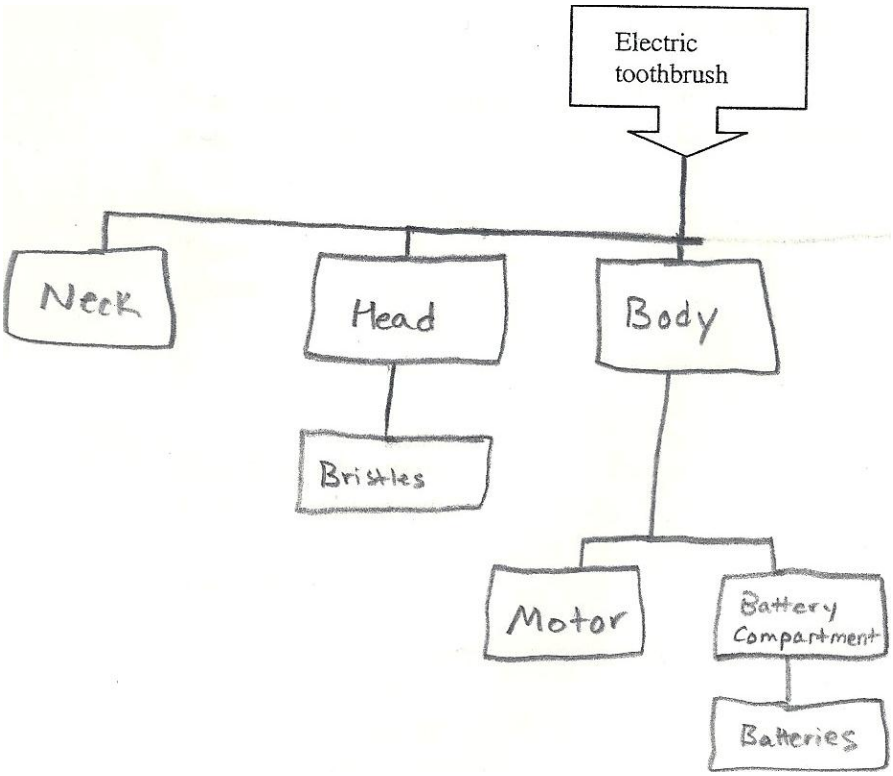
Date: 9/10/10

Disassembly method:
Subtract and Operate Procedure (SOP): Yes, No. **Force (Energy) Flow Diagram: Yes, No.**

Part #	Part Name	QTY	SOP Effect	Function	Mass (oz, g)	Material	Manuf. Process	Dimensions	Cost
1	Battery Compartment	1	No	Hold Batteries	6.1 g	Plastic	Injection Molding	8 cm. X 5 cm.	$0.60
2	Head	1	Yes	Holds bristles	3.0 g	Plastic w/ plastic bristles	Injection molding	2 cm. X 1 cm.	$0.40
3	Neck	1	Yes	Connects body to head	3.5 g	Plastic	Press molding	5.5 cm. X 2.5 cm.	$0.10
4	Body	2	No	Holds motor and batteries	12.8 g (total)	Plastic and rubber	Press molding	11.5 cm. X 2.24 cm.	$0.30
5	Motor	1	No	Power the spinbrush	2.34 g	Plastic, metal, wires	Assembly	13.5 cm. X 2.5 cm.	$1.25
6	Battery	2	No	Power	23.6 g	Alkaline	Assembly	4 cm. X 1 cm.	$0.50

1
2
3
4
5
6
Energizer

Figure 6. Component, subassembly, assembly hierarchy:

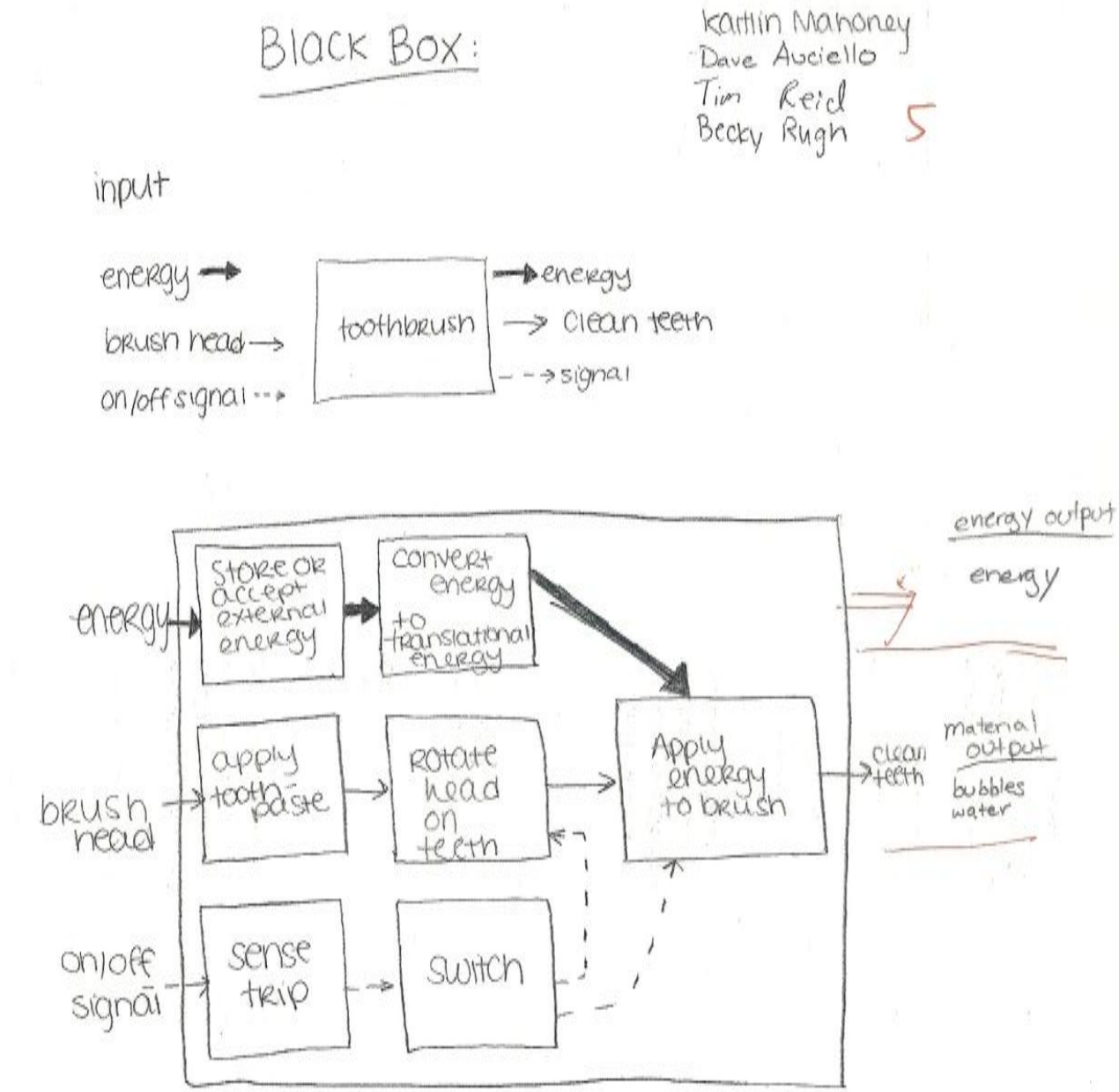


Assembly Level

Sub-assembly Level

Component Level

5.0 Concept Generation



* energy needs to be converted from the power source to rotate the head
* after toothpaste is applied and the brush rotates on the teeth, the teeth will be clean.
* hitting the switch will send the energy to the head, allowing it to rotate

Concept Combination Table:

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Head Design

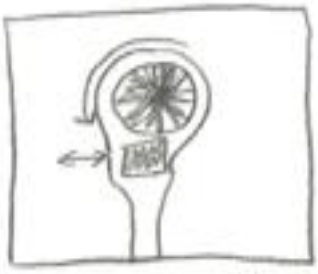
1.

The bristles rotate in a counterclockwise motion.

2.

The bristles just vibrate while brushing your teeth

3.



The top bristles rotate in a counter-clockwise motion while the bottom bristles move left to right

4.

The bristles move in every direction

Body Design

1.

The heads are replaceable

2.

The middle of the toothbrush is skinny so it's comfortable to hold whilst the rest of the body is not so the toothbrush is balanced and free-standing

3.

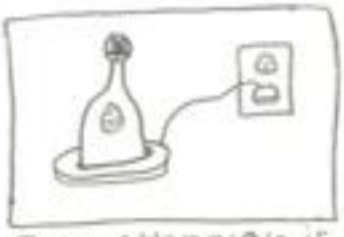
The body is thin and not bulky

4.

The toothbrush has a base so it's free-standing.

Power Source

1.



The toothbrush is rechargeable so no batteries are used.

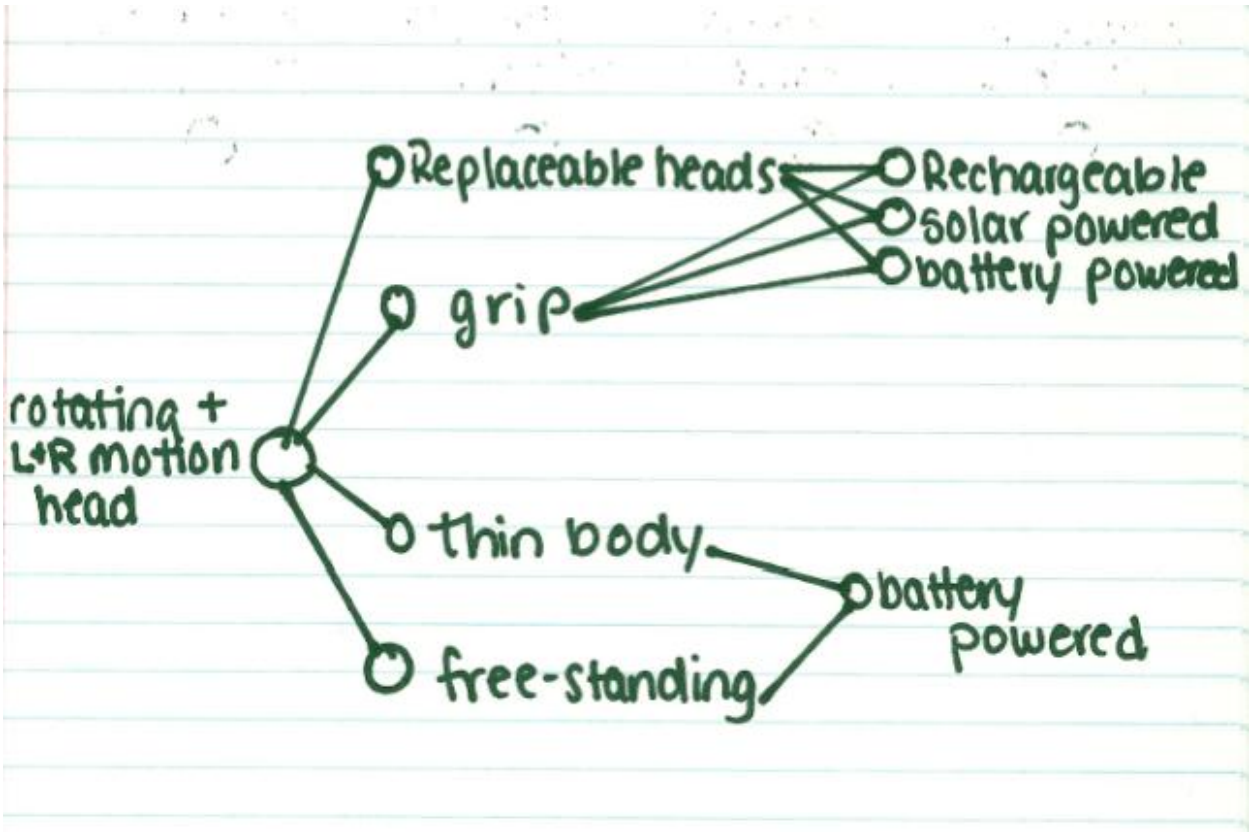
2.

The power source of the brush comes from stored energy after sitting in the sunlight all day.

3.

Batteries are used as the source of energy to power the toothbrush.

Figure 7. Concept Classification Tree



6.0 Concept Selection

Concept 1: Bristles move in a counterclockwise motion on top of the head and a lower set of bristles moves left and right on the bottom of the head. It has replaceable heads and is rechargeable.

Concept 2 Bristles move in a counterclockwise motion on top of the head and a lower set of bristles moves left and right on the bottom of the head. It has replaceable heads and is powered by batteries.

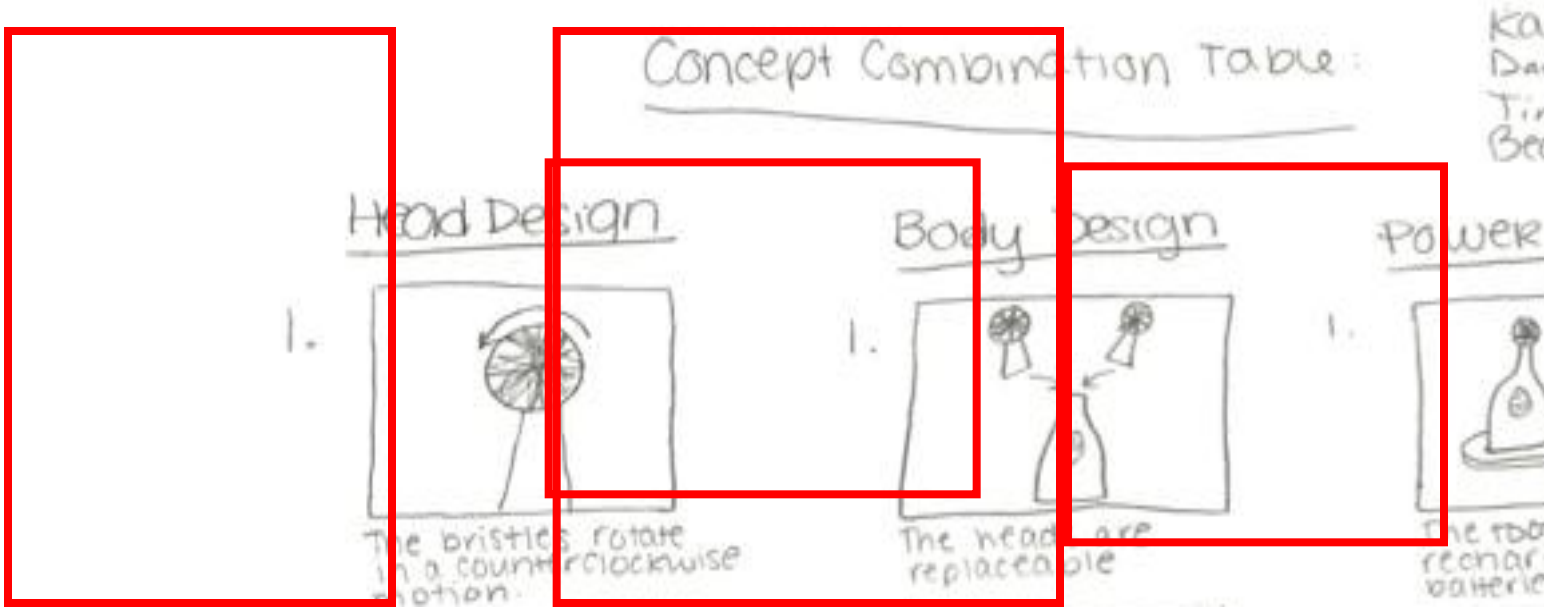
Concept 3: Bristles move in a counterclockwise motion on top of the head and a lower set of bristles moves left and right on the bottom of the head. It has a grip on the body and is rechargeable.

Concept 4: Bristles move in a counterclockwise motion on top of the head and a lower set of bristles moves left and right on the bottom of the head. It has a grip on the body and is powered by batteries.

Table 13. Concept Screening Matrix

	1	2	3	4
Functionality	+	0	+	0
Simple Design	+	-	+	-
Aesthetics	+	+	+	+
Affordability	-	0	-	0
Sum +'s	3+	1+	3+	1+
Sum 0's	0	2	0	2
Sum -'s	1-	1-	1-	1-
Net	**2+**	0	2+	0
Rank	**1**	**2**	**1**	**2**

Because both concept 1 and 3 had the same ranking, it is plausible that they could be combined in the final design. Our final concept design was chosen for a number of reasons. After analyzing our customer needs we discovered that efficiency and durability were most important to the consumer. To emphasize this, we implemented a reusable battery and interchangeable heads to keep the toothbrush efficient for an extended period of time. Our toothbrush being user friendly was also a main concept targeted. To satisfy this, we created a toothbrush with only one simple on/off switch and a base to stand the toothbrush on. Also the toothbrush has a large grip to minimize the slickness. We always thought that color woulc



6.1 Final Design Drawing

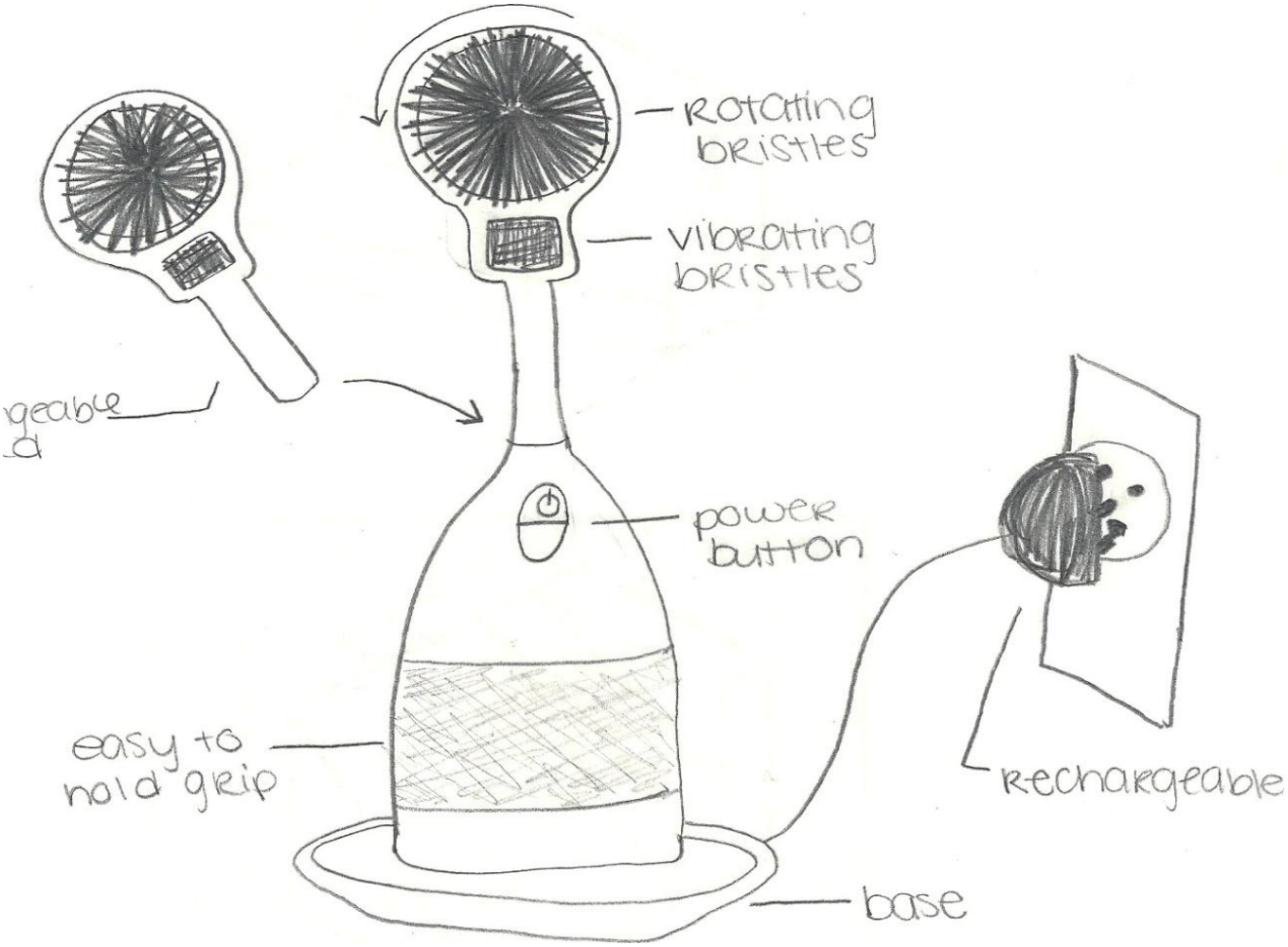


Table 14. Bill of Materials for Final Design

Part #	part name	quantity	mass	function	material	manuf. Process	dimensions	Cost
1	head	2	3.0g	holds bristles and rotates/vibrates to clean teeth	plastic (head & Bristles)	injection molding	2 cm x 1 cm	$0.60
2	neck (part of head)	2	2.0g	connects body and head	plastic	press molding	5.5cm x 2 cm	$0.10
3	body	1	13.5g	keeps battery enclosed/ hold toothbrush here	plastic	press molding	11.5cm x 2.5cm	$0.40
4	power button	1	0.2g	turns toothbrush on/off	rubber	assembly	.5cm x 1cm	$0.10
5	base	1	6.0g	holds toothbrush upright/ connects it to power source (outlet)	plastic	press molding	6cm x 4cm	$0.50
6	battery	1	11.0g	supplies energy	lithium	assembly	4cm x 3cm	$0.75
7	Motor	1	2.5 g	Rotates head/ vibrates bristles	Plastic/metal wires	Assembly	13.5 cm x 2.5 cm.	$1.25

6.2 Final Design Description

Our final design is an excellent product. We have exchangeable heads that are equipped with one large rotating bristle and a smaller square rotating bristles under the larger head. We will have a small neck connecting the heads and the main body. The main body will be a sleek silver color with an easy to hold grip wrapping around the center of the frame. There will be an easy to use power switch at the top portion of the body. There will be a separate base to keep the toothbrush upright when charging its rechargeable battery.

7.0 Conclusion

In conclusion, our toothbrush is designed to satisfy the customer needs that we felt were most important. The toothbrush is designed to be extremely efficient and long lasting. Although the rechargeable battery will raise costs, in the long run it will actually save the consumer money. The interchangeable heads will eliminate the issue of having to buy new toothbrushes to replace the heads.

8.0 References

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