REDESIGN OF ORAL-B ELECTRIC TOOTHBRUSH

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Abstract

This report will explain the detailed steps we undertook during the redesign of a Braun Oral B electric toothbrush. The goal of this project was to increase the sustainability of the electric toothbrush through a user center design process that simultaneously allowed us to create a user-friendly toothbrush. The 2003 Oral B toothbrush we redesigned contains several construction flaws, which we aimed to correct in our final design. Through collective brainstorming, our team analyzed the problems associated with the old toothbrush. We decided which aspects needed improvement, which ones needed to be redesigned, and which ones could be left alone. Our team conducted a survey of potential customers and examined the data through various PCC and AHP charts. From the results of the survey and our team's ideas, we felt the most important features that needed to be improved were the power source, the grip, and the overall weight. Each of these features needed to be redesigned in order to create a high quality user centered design. We successfully accomplished our overall goal of creating a more sustainable toothbrush by modifying key aspects of the toothbrush design and power mechanism. The following report outlines the research process and development that we undertook to create the toothbrush, and concludes with the finished model of our redesigned product.

1.0 Introduction

Modern electric toothbrushes have been around for a few decades, and they have undergone significant advances in design and technology since their inception. With the increasing emphasis on dental hygiene, their popularity has grown and the need for a high-tech, functional model has become imperative. There are many electric toothbrushes on the market, and the one our team has been tasked with redesigning is the Oral B AdvancePower toothbrush. This model is one of Oral B's many electric toothbrushes, but it is not the newest or the most efficient. Our initial mission was to redesign the toothbrush to be more sustainable and consumer-friendly.

To begin the redesign process, our team analysed and inspected the toothbrush. To make the toothbrush more efficient and customer-friendly, we began by dissecting it and examining its parts, and we made a list of facets that we thought would be important to the redesigned model. We later used this list more extensively to determine actual consumer needs. We researched the toothbrush and its parts, and measured its dimensions, weight, and sound output.

In order to determine the importance of the various qualities of the toothbrush, we surveyed and interviewed potential consumers and used this information to begin assessing the important attributes of our redesigned model. Using our initial list of possible consumer needs, we then used the collected data to prioritize these needs and create charts, like the AHP Pairwise Comparison Chart, to better understand which aspects of the toothbrush on which to focus for our redesigned model.

1.1 Initial Problem Statement

Our team must redesign an electric toothbrush to create a more sustainable and user-friendly device. Through a series of surveys and concept generation models we aim to improve an existing model.

2.0 Customer Needs Assessment

In order for our team to properly redesign the electric toothbrush we initially came up with survey questions that would allow us to assess which attributes of the toothbrush were important to members of the community. Then, we conducted a survey through which we identified these aspects that needed revision and those that didn't. Each group member interviewed three students on Penn State's campus about which features of a toothbrush were most important to him or her. We had each subject assign a value from 1 to 5 (5 being the most important) rating the importance of each attribute of the toothbrush. The subjects that the group members interviewed were freshmen living on Penn State's campus in residential halls, aged between 18 and 19 years old.

2.1 Weighting of Customer Needs

From the data collected in the survey, we created an AHP and PCC of the attributes, so that we could create a weighted customer needs chart. Weighting our customer needs was an important step because it allowed us to determine which aspects of the redesign to focus on. Table 1 lists all the criteria that our team has identified as integral in our revision process, as determined by the results of the surveys. As a group, we conducted a product analysis and determined which attributes we needed to improve. We considered our target audience and their answers to our surveys and decided that the following criteria would be necessary to revise. The weights determined from the AHP and PCC gave us better information on the importance of the different attributes.

Table 1. Initial Customer Needs List Obtained from Team Focus Group

This table lists the criteria that our group, prior to surveying our target audience, felt needed to be emphasized and/or improved. We later used this list to categorize and weight our main objectives of our redesign.

Lightweight
Rechargeable Battery
Low Noise
Comfortable Grip
Bristle Design
Left Hand Accessible
Strong Material
Battery Life

Table 2. Hierarchal Customer Needs List Obtained from Focus Group and Individual Interviews

This table shows how we organized our criteria into different categories to better understand the main ways in which the product needed to be redesigned. This allowed us to focus on overall aspects of the design process to improve the final product.

1.Portable
1.1 Lightweight
2. User-Friendly
2.1 Low Noise
2.2 Comfortable Grip
2.3 Bristle Design
2.4 Left-hand Accessible
2.5 Rechargeable Battery
3. Durable
3.1 Strong Material
3.2 Sustainable motor
3.3 Battery Life

Figure 1. PCC (Pairwise Comparison Chart) to Determine Weighting for All Customer Needs

Evaulated	Lightweight	Rechargeable battery	low noise	Comfortable grip	Bristle design	Left Handed acc	Strong Material	Battery life		Total
Lightweight		-1	1	-1	-1	1	1	-1		-1
Rechargeable battery	1		1	1	-1	1	1	1		5
low noise	-1	-1		-1	-1	1	-1	-1		-5
Comfortable grip	1	-1	1		-1	1	1	-1		1
Bristle design	1	1	1	1		1	1	1		7
Left Handed acc	-1	-1	-1	-1	-1		-1	-1		-7
Strong Material	-1	-1	1	-1	-1	1		-1		-3
Battery life	1	-1	1	1	-1	1	1			3

This pairwise comparison chart compares the importance of each attribute. This gave us a better idea of which aspects of the redesign should take precedence over the others. The attribute got a score of 1 if it was more important than the base attribute, 0 if it was of the same importance, and -1 if it was less important.

Figure 2. AHP Pairwise Comparison Chart to Determine Weighting of All Customer Needs

Evaulated	Lightweight	Rechargeable battery	low noise	Comfortable grip	Bristle design	Left Handed acc	Strong Material	Battery life		Total	weighted
Lightweight	1	0.83	1.47	0.91	0.76	2.13	1.11	0.83		9.0361	0.126
Rechargeable battery	1.2	1	1.92	1.19	1.00	2.78	1.47	1.09		11.649	0.163
low noise	0.68	0.52	1	0.62	0.52	1.45	0.76	0.56		6.116	0.086
Comfortable grip	1.1	0.84	1.62	1	0.84	2.33	1.23	0.92		9.878	0.138
Bristle design	1.32	1.00	1.92	1.19	1	2.78	1.47	1.09		11.765	0.165
Left Handed acc	0.47	0.36	0.69	0.43	0.36	1	0.53	0.39		4.231	0.059
Strong Material	0.9	0.68	1.31	0.81	0.68	1.89	1	0.69		7.960	0.111
Battery life	1.21	0.92	1.77	1.09	0.92	2.55	1.35	1		10.810	0.151

The AHP takes the criteria from the PCC and gives them a weight to further evaluate the importance of each attribute.

Table 3. Weighted Hierarchal Customer Needs List Obtained from Focus Group and Individual Interviews

This table shows the weighted values of each attribute as taken from the AHP Pairwise Comparison Chart. This step is important because it emphasizes which attributes of the redesign are most important to customers and should therefore be focused on during the design process.

1.Portable (0.126, 0.126)
- 1.1 Lightweight (0.126, 1)

2. User-Friendly (0.611, 0.611)
- 2.1 Low Noise (0.086, 0.141)
- 2.2 Comfortable Grip (0.138, 0.226)
- 2.3 Bristle Design (0.165, 0.270)
- 2.4 Left-hand Accessible (0.059, 0.097)
- 2.5 Rechargeable Battery (0.163, 0.266)

3. Durable (0.262, 0.262)
- 3.1 Strong Material (0.111, 0.424)
- 3.2 Sustainable motor
- 3.3 Battery Life (0.151, 0.576)

3.0 Revised Problem Statement

Our mission is to redesign an electric toothbrush so that it is sustainable and consumer friendly. According to the customer assessments, it is important that the toothbrush has a rechargeable battery and be somewhat lightweight. It is also important that the bristles be uniquely designed to be better at cleaning teeth and increasing dental hygiene. Our design will also aim to improve the grip, and to make it more ergonomic and user-friendly.

4.0 External Search

To aid our redesign process, we collected external research regarding the market for electric toothbrushes. This included history of electric toothbrushes on the market, the cost of other products on the market, and patented features already in existence. We then dissected the toothbrush to learn more about the internal functions of the parts.

4.1 Lab 1 & Lab 2 Reports

4.1.1 Lab 1 Report

We conducted a basic part evaluation of the toothbrush, and we gathered research about the product. This gave us the basis for what parts needed to be redesigned. We analyzed the cost, target audience, possible improvements, and patents.

Figure 3. Data Sheet 1 for Lab 1: Pre-Dissection Evaluation

DATA SHEET 1	
Getting Ready for Dissection: Part I (cont.)	
Product Features: Provide team's collective opinion related to features of the product using the following list as a starting point.	
Packaging (including information insert)	The packaging was very robust and strong making it difficult to open. Our group didn't like the fact that it was very hard to open but its efficient in deterring people from trying to steal the toothbrush by removing it from the packaging.
Aesthetics (multi-color, etc.)	The aesthetics were not very appealing to our group. The handle is too wide and thick. The overall appearance is not appealing, its very wide at the bottom and then skinny at the head. The design doesn't flow well. The grip makes the body appear larger than it is.
Cleaning	This product gets dirty very easily. The white color makes the dirt on it stand out. The battery cover builds up dirt and grime that is hard to clean.
On/off switch location	The location of the power switch is optimal for operation. It is located where the thumb is when you hold it and makes it easy to operate.
Battery location	The battery is located at the best position possible. The bottom of the toothbrush is naturally the preferable location for the batteries.
Ease of switch use	The pressure necessary to press the switch is optimal for operation. The button is not easily pressed when you are using the toothbrush, so you will not accidentally turn it off when using it and it is not too hard to turn it on/off.
Handle (Ergonomics)	The handle is designed specifically for right-handed use. The lack of grip on the left of the toothbrush makes this evident; however this does not bring any negative effects on left-handed users.
Quality	The quality of the product is not very optimal. The quality could be improved on by using better materials.
Safety	The product is reasonably safe. No major safety flaws were detected under first inspection.
Versatility, attachments	The product's design leaves room for using several other unique attachments, but these require external purchase. These include other head designs.
Weight with batteries	The weight is too high. The product is not comfortable in the hand and feels like something too heavy to be a toothbrush.
Environmental friendliness	Very low with this product. The use of external batteries makes this product less optimal for sustainability.
Other features	None

This chart shows our findings from the initial product evaluation.

Figure 4. Data Sheet 1 for Lab 1: Pre-Dissection Evaluation (Continued)

DATA SHEET 1

Getting Ready for Dissection: Part I

Manufacturer/Model Number: Braun/Oral B Advanced Power 400

General Product Information:

How many detachable pieces the product has? ___4___

Part number:	Part name:
__101_____	__Head_____
__201_____	__Body_____
__301_____	__Battery Cover_____
__400_____	__Batteries_____
_____	_____
_____	_____

Describe the pieces including their functions and their materials.

Part number:	Material & Functional Description:
__101_____	_Composite plastic with synthetic bristles for brushing teeth_
__201_____	_Composite plastic with polymer grip with metal powertrain for oscillating the bristles ____
__301____	_Plastic cover with metal battery terminals for housing batteries_
__400_____	__Double AA batteries for power source _____
_____	_____
_____	_____

Is it easy to detach each part?

Part number:	Detachment (Easy, difficult, use of force etc.):
__101_____	__Easy, requires light pulling to remove ____
__201_____	__Center of toothbrush. non-removable_____
__301_____	__Difficult, requires firmly pressing two buttons simultaneously __
__400_____	__Very easy, they slide _____
_____	_____
_____	_____

Describe the packaging. Is it easily opened? Describe the opening procedure.
The packaging is not easily opened. It required the use of a knife and scissors to cut and pry open to reach the toothbrush. This leaves sharp edges in the plastic packaging that could be potentially dangerous.

This chart shows more of our findings from the initial product evaluation.

Figure 5. Data Sheet 1 for Lab 1: Pre-Dissection Evaluation Part 2

DATA SHEET 1	
Getting Ready for Dissection: Part II	
Cost (Be prepared to record multiple values and sources)	12.99 Just4teeth.com 10.96 Ebay.com 17.93 Amazon.com
How long has the product been in the market?	Since 2001
Target population	Young adult- adult
Versions of the product (Previous versions of the product)	1978- D1 was their first electric toothbrush 1991- D5 1994- D7 1996- D9 2000- Oral B Excel
What are improvements between versions of the product?	Handle- More comfortable More effective bristles
How is it sold (TV infomercial, drugstores, etc.)	Drugstores Commercials on TV
Patented Features (Please include patent dates).	US 20030084524 head US 6955539 Motor US 7941886 Bristles US 7810200 Design US D508199 Packaging US 5378153 Acoustical US 6463615 Bristles

This chart shows more of our findings from the initial product evaluation. In this part of the lab, we researched online to find out more about the product and its market life.

4.1.2 Lab 2 Report

We found how fast the brush head spun. We also found the power that the toothbrush would use during one use. From that, we found how long the toothbrush would last with those batteries in it. Following that, we disassembled our toothbrush. The parts were in their most basic form and we reported what we had in the Bill of Materials chart in section two. We tested the noise level of the toothbrush and calculated power of the batteries. From that, we found how long it could be used at the maximum output, the average output, and the minimum output. The outputs respond to the amount of power used to amount of pressure put down, which would increase in power output as pressure increased.

Figure 6. Data Sheet 2 for Lab 2: Mechanics of the Toothbrush

DATA SHEET 2

1. Noise Measurement:

Location:	**Noise level:**
Brush head 4 in away from decibel meter	64.8
Brush head 3 in away from the decibel meter	65.7
Brush head 2 in away from decibel meter	71.3
Brush head 1 in away from the decibel meter	74.1
DC motor 4 in away from decibel meter	61.5
DC motor 3 in away from the decibel meter	63.7
DC motor 2 in away from the decibel meter	65.2
DC motor 1 in away from the decibel meter	68.2
Approximate duration of brushing per day:	4 min.
Average noise level during brushing:	

2. Power Measurement:

Voltage supplied to the circuit:

	Battery Type	**Volts (V):**
Battery 1	AA duracell	1.541
Battery 2	AA duracell	1.537

Total Voltage:

	Connection Type	**Volts (V):**
Battery 1 and Battery 2	Series	3.079

Current Measurements	**Averaged Current Value**
No load condition	300 mA
Load condition(s)	
1.	380 mA
2.	330 mA
3.	390 mA
4.	390 mA

Mean current 'under load' 373 mA

Power (no load) = Voltage 3.079 X Current 300 mA = 923.7 Units mW

Power (under load) = Voltage 3.079 X Current 373 mA = 1,149 Units mW

This chart shows the results of our tests on the toothbrush including power measurement and noise levels of the toothbrush.

Figure 7. Data Sheet 2 for Lab 2: Bill of Materials

DATA SHEET 2 cont.

Bill of Materials

Product Manufacturer/Model Number:

Date: 1/30/13

Disassembly method:

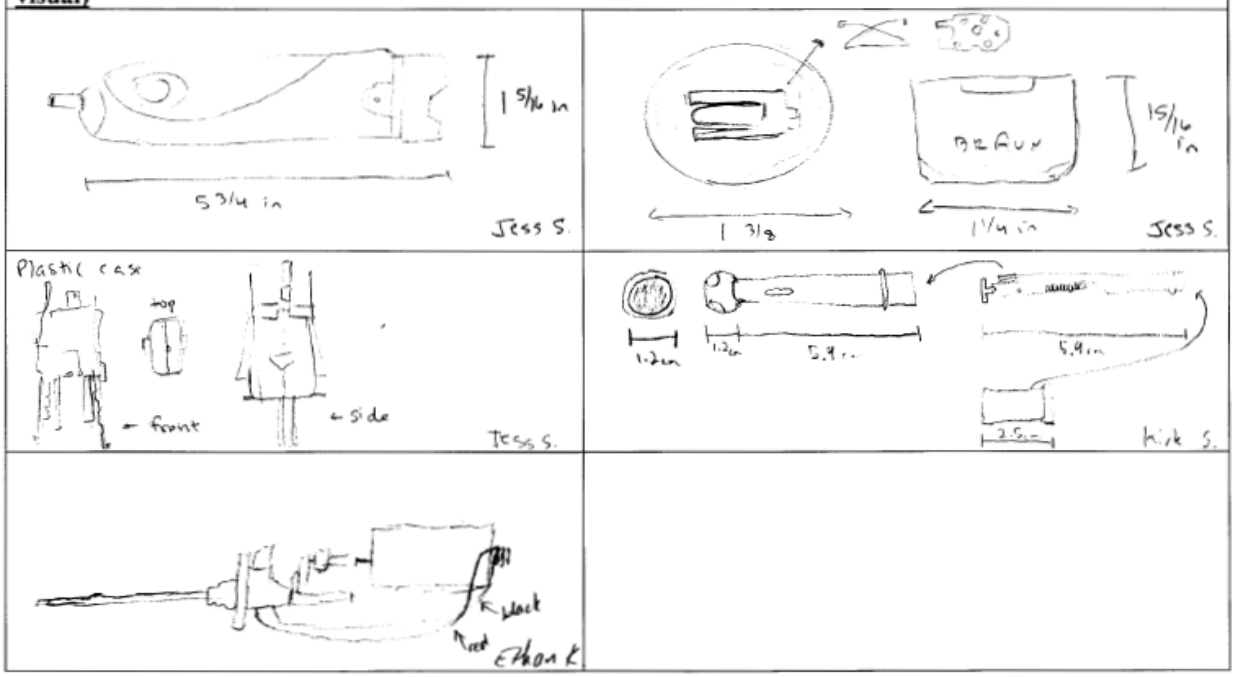
Subtract and Operate Procedure (SOP): Yes, No. **Force (Energy) Flow Diagram: Yes, No.**

Team leader name(s)	Part#	Part Name	QTY	SOP Effect	Function	Mass (oz, g)	Material	Manuf. Process	Dimensions	Cost	Time to Complete Part Dissection
David	101	Brush head	1		brush teeth	.002	Synthetic fibers	molding/sewing	1.2cm Diameter uniform circular head	$.40	15 min
Kirk	201	body	1		to house internal components	0.672 oz	Synthetic plastic	molding / coloring	14.6cm tall 3.5cm wide 2.5cm long	$1.25	10 min
Jess	102	inner head piece	1		connect brush head to motor	.006	Synthetic plastic	molding	5.8cm long 1.2cm wide	$.40	10 min
Ethan	400.	batteries	2		Power source	.057	battery acid and metal cover	wiring	5cm long 1.8cm wide	$2.00	1 min
Jess	301	battery cover	1		hold batteries in place	1.92 oz	Plastic & metal	molding	3.5cm wide 2.4cm tall 2.5cm thick	$.10	1 min
Jess	202	Plastic motor cover	1		hold motor in place	0.256 oz	plastic	molding	1.9cm wide 11.3cm long	$.10	15 mins
ethan	203	DC motor	1		operates toothbrush	1.408 oz	metal	wiring / metal processing	5.2cm long 1.7cm wide	$3.00	30 min

This chart shows the results of our disassembly of the toothbrush. For each part of our disassembly, we found its dimensions, mass, function, manufacturing process, and cost.

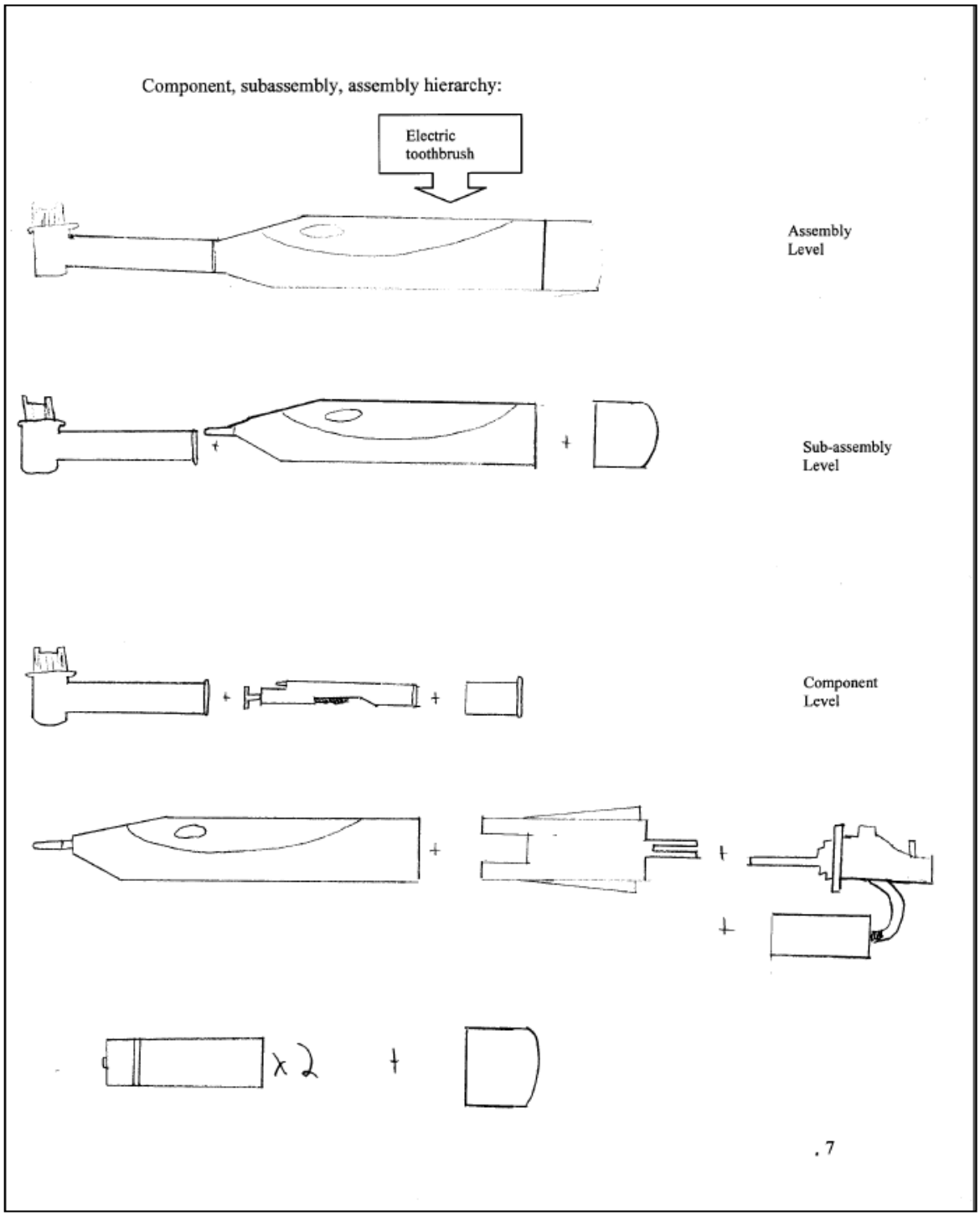
Figure 8. Sketches of the Components of the Toothbrush for Lab 2

Visuals: Component pictures, sketches and/or solid models (place team members name who completed each visual)



This chart shows the sketches we completed of the different parts of the toothbrush after we disassembled it.

Figure 9: Assembly Hierarchy for Lab 2



This sketch was completed after the disassembly of the toothbrush. It shows the way in which the toothbrush was assembled to give us a visual representation of how the toothbrush and its component parts fit together.

4.2 Patent Search

We performed a patent search to determine the important parts and technologies of the electric toothbrush.

Table 4. Art-Function Matrix for Electric Toothbrush

This table shows the results of our patent search, including the patents for important aspects of the toothbrush, i.e. the rechargeable battery, the well-cleaning bristles, and the removable and high-tech toothbrush head.

FUNCTION			
	Rechargeable	Plastic monofilament; clover-shaped	Oscillating and replaceable
Battery	US 7049790 B2		
Bristles		US 6871373 B2	
Heads			US D459892 S

4.3 Product Archaeology

The first electric toothbrush was created in Switzerland in 1954 by Dr. Philippe-Guy Woog. It required the use of two D-cell batteries making it very inefficient for customer usage. It wasn't until several years after that that a viable toothbrush was made that could be used in a home environment. Electronic toothbrushes were originally created for people with limited motor skills but have now turned into a billion dollar market. Now electric toothbrushes run on rechargeable batteries or with much smaller batteries, usually AA or AAA.

4.4. Benchmarking

Table 5.1 Benchmarking of Four Products (Qualitative)

This table shows the results of our benchmarking research: we looked up other electric toothbrushes on the market and compared their features to those of our toothbrush to decide which features to improve and how to improve them.

Feature	**Oral B (our toothbrush)**	**Crest Spinbrush**	**Colgate Motion**	**Phillips Sonicare**
Battery life / Power	41 days – batteries	53 days - batteries	65 days - batteries	Rechargeable battery
Noise level	70 dB	22.25 dB	86 dB	Very loud (unknown specifics)
Bristle design	Small oscillating circle	Blue color signal bristles	Small oscillating circle plus large brush	Larger brush head for whitening and removing plaque
Cost	16.99$	14.90$	6.99$	99.95$
Grip/Comfort	Blue rubber grip	Varied color rubber grips	Green rubber	White and light blue plastic

Table 5.2 Benchmarking of Four Products (Weighted)

This table uses the same electric toothbrushes that we compared in Table 5.1 for our benchmarking research. We ranked each toothbrush on a scale of 1 to 5 for how successful it was in each category/feature. Then we assigned a category weight to each feature, so that we could find the total score of the toothbrush's success overall. This allowed us to then rank the toothbrushes (1 having the most successful toothbrush features). This gave us an idea of which toothbrush's features to keep in mind when redesigning our toothbrush.

Feature	**Oral B (our toothbrush)**	**Crest Spinbrush**	**Colgate Motion**	**Phillips Sonicare**	***Category Weight***
Battery life / Power	1	2	3	5	40%
Noise level	3	5	2	1	10%
Bristle design	2	3	4	5	35%
Cost	5	4	5	1	10%
Grip/Comfort	3	3	2	4	5%
Total score (weighted)	2.05	2.9	3.4	4.15	
Rank	4	3	2	1	
Image					

4.5 Design Target

Our team's target design is a user-friendly toothbrush with a sustainable and environmentally friendly power source. From the external research, we need to provide a long battery life, a low cost, quality bristle design, and comfortable grip. We want our toothbrush to be easy to use and effective in meeting customer needs.

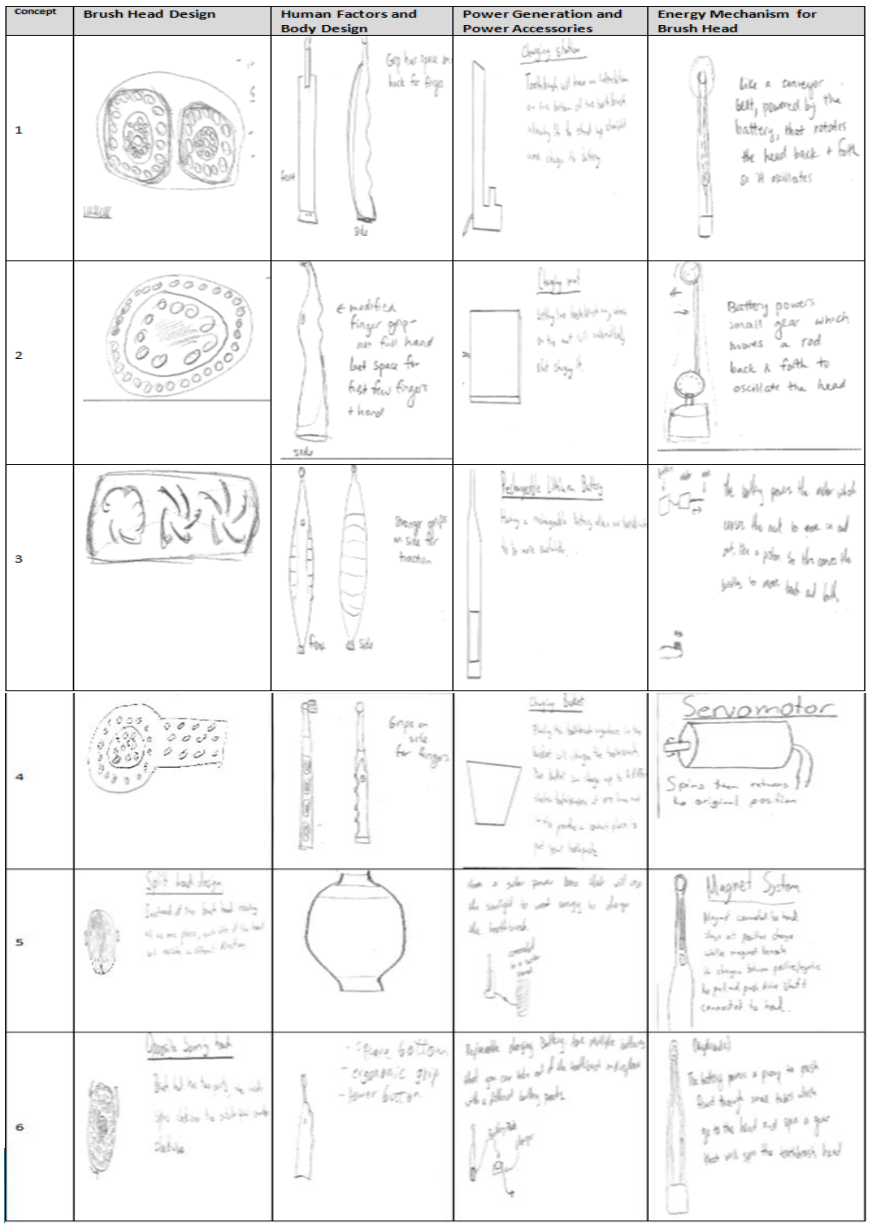
5.0 Concept Generation

Before beginning the concept generation process, we gathered all the research we conducted previously from the product archaeology, patent research, and survey to aid us in the process. Using the research we conducted and previous knowledge we brainstormed ideas within our group that addressed the problems we found in the electric toothbrush we are re-designing. The survey we conducted helped our group target which aspects of the electric toothbrush were most important to our consumers and which aspects needed improvement. Our goal is to generate several concepts that create a more sustainable, use-friendly electric toothbrush best suited to our consumer's needs.

5.1 Concept Generation

Using the information gathered in the previous sections about consumer needs our group developed a set of possible concepts to be implemented in our re-design. We generated concepts for each of the four main divisions of the re-design: (1) brush head design, (2) human factors and body design, (3) power generation and power accessories, and (4) energy mechanisms for the brush head. We organized our concepts in the morphological chart below (see figure 10). Our final design will contain the best concept from each of the four categories in order to provide the highest quality and most sustainable toothbrush for the customers.

Figure 10: Morphological Charts



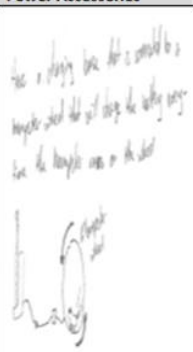
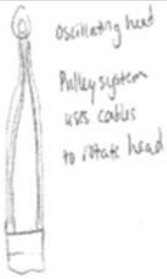
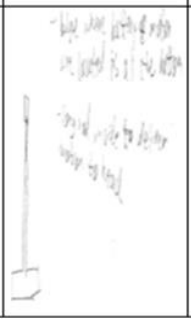
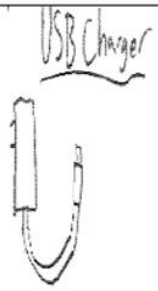
Concept	Brush Head Design	Human Factors and Body Design	Power Generation and Power Accessories	Energy Mechanism for Brush Head
7				
8				

Figure 10 is a morphological chart containing our group's generated concepts. These are possible concepts that could be implemented in our final design.

6. Concept Selection

Figure 11: Brush Head Design Pugh Chart:

Iteration 1						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-	-	-	0	6
	2	-	1	0	0.126	5
	3	-	0	1	0.611	2
	4	-	0	-1	-0.611	7
	5	-	-1	1	0.485	4
	6	-	0	1	0.611	2
	7	-	-1	-1	-0.737	8
	8	-	1	1	0.737	1
Iteration 2						
Concepts						
	1	-	0	1	0.611	2
	2	-	-	-	0	3
	3	-	-1	1	0.485	4
	4	-	0	1	0.611	2
	5	-	0	1	0.611	2
	6	-	1	1	0.737	1
	7	-	0	0	0	3
	8	-	0	0	0	3
Iteration 3						
Concepts						
	1	-	0	0	0	3
	2	-	1	-1	-0.485	4
	3	-	-	-	0	3
	4	-	1	0	0.126	2
	5	-	0	1	0.611	1
	6	-	0	1	0.611	1
	7	-	1	0	0.126	2
	8	-	1	0	0.126	2
Iteration 4						
Concepts						
	1	-	-1	1	0.485	2
	2	-	0	0	0	4
	3	-	-1	1	0.485	2
	4	-	-	-	0	4
	5	-	-1	1	0.485	2
	6	-	1	1	0.737	1
	7	-	1	0	0.126	3
	8	-	1	0	0.126	3

Iteration 5						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-	0	0	0	2
	2	-	1	-1	-0.485	4
	3	-	-1	0	-0.126	3
	4	-	1	-1	-0.485	4
	5	-	-	-	0	2
	6	-	0	1	0.611	1
	7	-	0	-1	-0.611	5
	8	-	0	-1	-0.611	6
Iteration 6						
Concepts						
	1	-	0	0	0	2
	2	-	1	-1	-0.485	3
	3	-	0	0	0	2
	4	-	1	-1	-0.485	3
	5	-	0	1	0.611	1
	6	-	-	-	0	2
	7	-	1	-1	-0.485	3
	8	-	1	-1	-0.485	3
Iteration 7						
Concepts						
	1	-	0	1	0.611	2
	2	-	0	0	0	4
	3	-	-1	1	0.485	3
	4	-	0	1	0.611	2
	5	-	1	1	0.737	1
	6	-	1	1	0.737	1
	7	-	-	-	0	4
	8	-	0	0	0	4
Iteration 8						
Concepts						
	1	-	0	1	0.611	2
	2	-	0	0	0	4
	3	-	-1	1	0.485	3
	4	-	0	1	0.611	2
	5	-	1	1	0.737	1
	6	-	1	1	0.737	1
	7	-	0	0	0	4
	8	-	-	-	0	4

Figure 11 displays the Pugh Chart for the brush head design. The concept selected was Concept 6: the head with the opposite spinning bristles.

Figure 12: Energy Mechanism for Brush Head Pugh Chart:

Iteration 1						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-	-	-	0	4
	2	1	-1	1	0.747	2
	3	1	1	1	1	1
	4	1	1	1	1	1
	5	-1	-1	1	0.223	3
	6	-1	-1	-1	-1	5
	7	0	0	0	0	4
Iteration 2						
Concepts						
	1	-1	1	-1	-0.747	3
	2	-	-	-	0	2
	3	0	0	0	0	2
	4	1	1	1	1	1
	5	-1	-1	-1	-1	4
	6	-1	-1	-1	-1	4
	7	-1	1	-1	-0.747	3
Iteration 3						
Concepts						
	1	-1	-1	-1	-1	3
	2	0	0	0	0	2
	3	-	-	-	0	2
	4	1	1	1	1	1
	5	-1	-1	-1	-1	3
	6	-1	-1	-1	-1	3
	7	-1	-1	-1	-1	3
Iteration 4						
Concepts						
	1	-1	-1	-1	-1	2
	2	-1	-1	-1	-1	2
	3	-1	-1	-1	-1	2
	4	-	-	-	0	1
	5	-1	-1	-1	-1	2
	6	-1	-1	-1	-1	2
	7	-1	-1	-1	-1	2

Iteration 5						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-1	-1	1	0.223	3
	2	1	-1	1	0.747	2
	3	1	1	1	1	1
	4	1	1	1	1	1
	5	-	-	-	0	4
	6	-1	-1	-1	-1	5
	7	0	0	0	0	4
Iteration 6						
Concepts						
	1	-1	1	-1	-0.747	3
	2	-1	-1	-1	-1	4
	3	0	0	0	0	2
	4	1	1	1	1	1
	5	-1	-1	-1	-1	4
	6	-	-	-	0	2
	7	-1	1	-1	-0.747	3
Iteration 7						
Concepts						
	1	-1	-1	-1	-1	3
	2	0	0	0	0	2
	3	-1	-1	-1	-1	3
	4	1	1	1	1	1
	5	-1	-1	-1	-1	3
	6	-1	-1	-1	-1	3
	7	-	-	-	0	2

Figure 12 displays the Pugh Chart for the energy mechanism for the brush head. The concept selected was Concept 4: the servomotor.

Figure 13: Power Generation Pugh Chart:

Iteration 1						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-	-	-	0	4
	2	1	1	1	0.999	1
	3	0	1	0	0.126	3
	4	0	-1	1	0.485	2
	5	1	-1	-1	-0.475	7
	6	-1	0	0	-0.262	6
	7	1	-1	-1	-0.475	7
	8	0	-1	0	-0.126	5
Iteration 2						
Concepts						
	1	1	0	0	0.262	2
	2	-	-	-	0	4
	3	1	0	1	0.873	1
	4	0	-1	-1	-0.737	7
	5	1	-1	-1	-0.475	5
	6	0	0	0	0	4
	7	1	-1	-1	-0.475	5
	8	0	1	0	0.126	3
Iteration 3						
Concepts						
	1	0	1	1	0.737	1
	2	0	0	1	0.611	2
	3	-	-	-	0	5
	4	0	-1	0	-0.126	6
	5	1	-1	-1	0.475	3
	6	0	0	0	0	5
	7	1	-1	-1	0.475	3
	8	1	1	0	0.388	4
Iteration 4						
Concepts						
	1	1	1	1	0.999	1
	2	1	-1	1	0.747	2
	3	0	1	1	0.737	3
	4	-	-	-	0	6
	5	1	-1	-1	0.475	4
	6	0	0	0	0	6
	7	1	-1	-1	0.475	4
	8	1	1	0	0.388	5

Iteration 5						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-1	1	1	0.475	1
	2	1	0	0	0.262	2
	3	-1	1	1	0.475	1
	4	0	-1	-1	-0.737	5
	5	-	-	-	0	3
	6	-1	1	1	0.475	1
	7	1	-1	-1	-0.475	4
	8	1	0	0	0.262	2
Iteration 6						
Concepts						
	1	0	1	1	0.737	1
	2	1	-1	-1	-0.475	6
	3	0	0	1	0.611	2
	4	0	-1	0	-0.126	5
	5	1	-1	-1	-0.475	6
	6	-	-	-	0	4
	7	1	-1	-1	-0.475	6
	8	1	1	0	0.388	3
Iteration 7						
Concepts						
	1	-1	1	1	0.475	1
	2	-1	1	1	0.475	1
	3	-1	1	1	0.475	1
	4	0	-1	-1	-0.737	5
	5	1	-1	-1	-0.475	4
	6	-1	1	1	0.475	1
	7	-	-	-	0	2
	8	-1	1	0	-0.136	3
Iteration 8						
Concepts						
	1	0	1	1	0.737	1
	2	1	0	0	0.262	2
	3	1	0	0	0.262	2
	4	0	-1	-1	-0.737	6
	5	1	-1	-1	-0.475	5
	6	0	1	0	0.126	3
	7	1	-1	-1	-0.475	5
	8	-	-	-	0	4

Figure 13 displays the Pugh Chart for power generation. The concept selected was Concept 1: the charging base.

Figure 14: Body Design and Human Factors Pugh Chart:

Iteration 1						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	-	-	-	0	4
	2	1	1	1	1	1
	3	1	-1	-1	-0.475	5
	4	1	1	1	1	1
	5	0	-1	-1	-0.737	6
	6	0	0	1	0.611	2
	7	0	1	0	0.126	3
	8	-1	-1	-1	-1	7
Iteration 2						
Concepts						
	1	-1	-1	-1	-1	4
	2	-	-	-	0	2
	3	1	-1	-1	-0.475	3
	4	1	1	1	1	1
	5	-1	-1	-1	-1	4
	6	-1	-1	-1	-1	4
	7	-1	-1	-1	-1	4
	8	-1	-1	-1	-1	4
Iteration 3						
Concepts						
	1	-1	1	1	0.475	2
	2	-1	1	1	0.475	2
	3	-	-	-	0	3
	4	1	1	1	1	1
	5	-1	-1	-1	-1	4
	6	-1	-1	-1	-1	4
	7	-1	-1	-1	-1	4
	8	-1	-1	-1	-1	4
Iteration 4						
Concepts						
	1	-1	-1	-1	-1	4
	2	-1	0	0	-0.262	2
	3	0	-1	-1	-0.737	3
	4	-	-	-	0	1
	5	-1	-1	-1	-1	4
	6	-1	-1	-1	-1	4
	7	-1	-1	-1	-1	4
	8	-1	-1	-1	-1	4

Iteration 5						
		Sustainability	Portability	User-Friendly	Sum	Rank
	Weighting	0.262	0.126	0.611		
Concepts						
	1	1	1	1	1	1
	2	1	1	1	1	1
	3	1	1	1	1	1
	4	1	1	1	1	1
	5	-	-	-	0	4
	6	1	1	0	0.388	3
	7	0	1	1	0.737	2
	8	0	0	-1	-0.611	5
Iteration 6						
Concepts						
	1	0	0	0	0	2
	2	1	1	1	1	1
	3	1	-1	-1	-0.475	3
	4	1	1	1	1	1
	5	-1	-1	-1	-1	4
	6	-	-	-	0	2
	7	0	0	0	0	2
	8	-1	-1	-1	-1	4
Iteration 7						
Concepts						
	1	0	-1	0	-0.126	4
	2	1	1	1	1	1
	3	1	0	0	0.262	2
	4	1	1	1	1	1
	5	-1	-1	-1	-1	6
	6	0	0	0	0	3
	7	-	-	-	0	3
	8	0	-1	-1	-0.737	5
Iteration 8						
Concepts						
	1	1	1	1	1	1
	2	1	1	1	1	1
	3	1	1	1	1	1
	4	1	1	1	1	1
	5	0	0	0	0	3
	6	1	1	1	1	1
	7	0	1	1	0.737	2
	8	-	-	-	0	3

Figure 14 displays the Pugh Chart for the body design and human factors. The concept selected was Concept 4: the body with the comfort-ergonomic grip.

6.0 Final Design

For the final design, the head has bristles that rotate in opposite directions. The outside bristles rotate clockwise and the inside bristles rotate counter-clockwise. The body features an ergonomic handle built for comfort. It has a charging base that can be plugged into the wall for easy charging. We have chosen the servomotor, which spins the head of the toothbrush and powers it.

Figure 15: Final Toothbrush Design

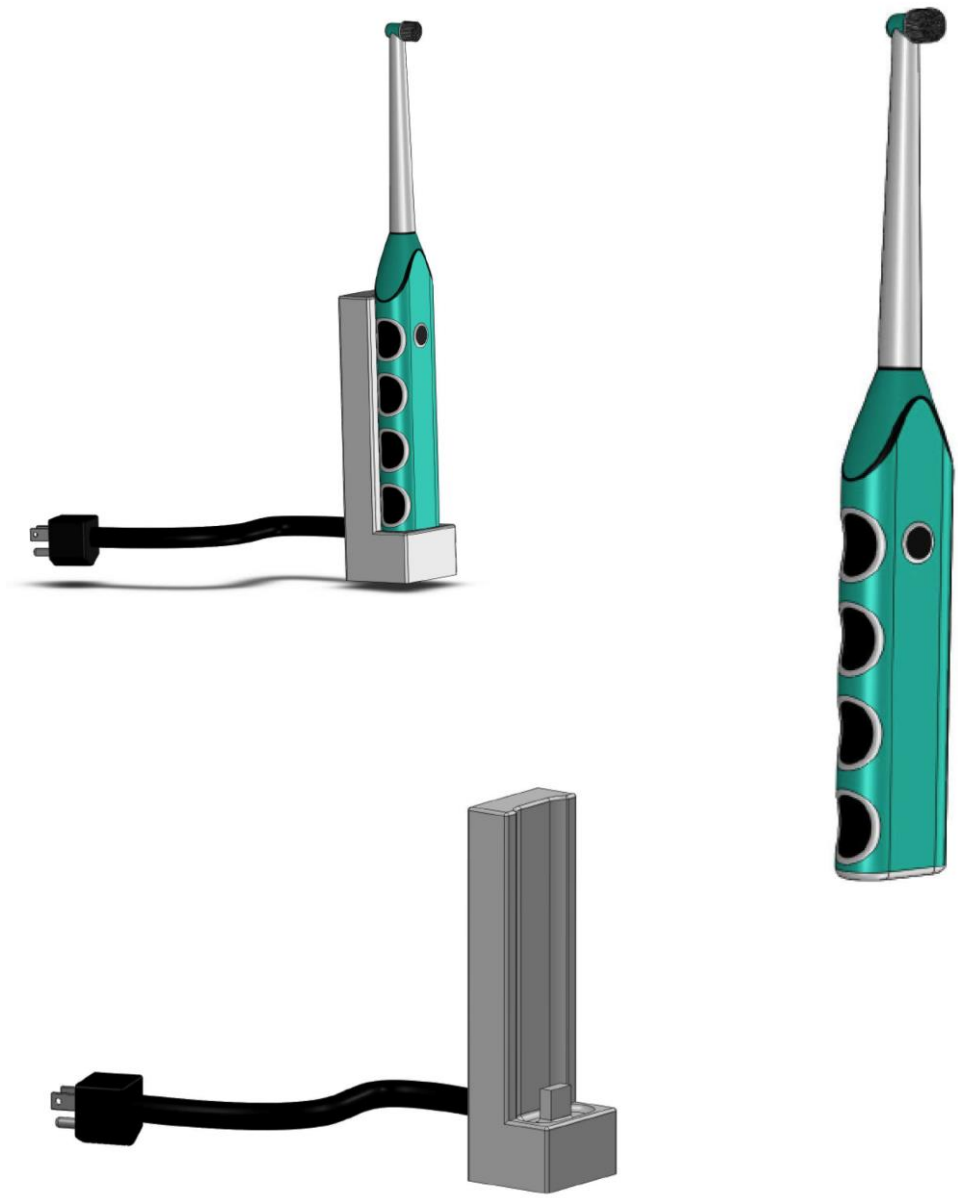


Figure 15 shows views of the final design of the toothbrush, as created in SolidWorks.

6.1 Design Drawings, Parts List and Bill of Materials

Figure 16: Dimensioned Drawing of Toothbrush

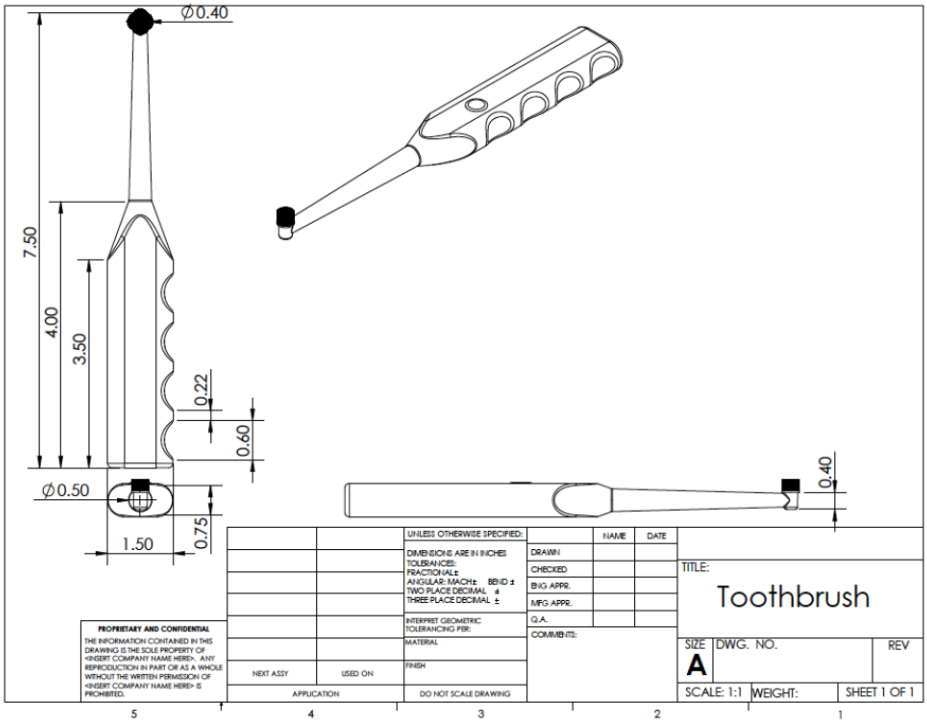


Figure 16 shows the dimensions for the toothbrush.

Figure 17: Dimensioned Drawing of the Charging Base

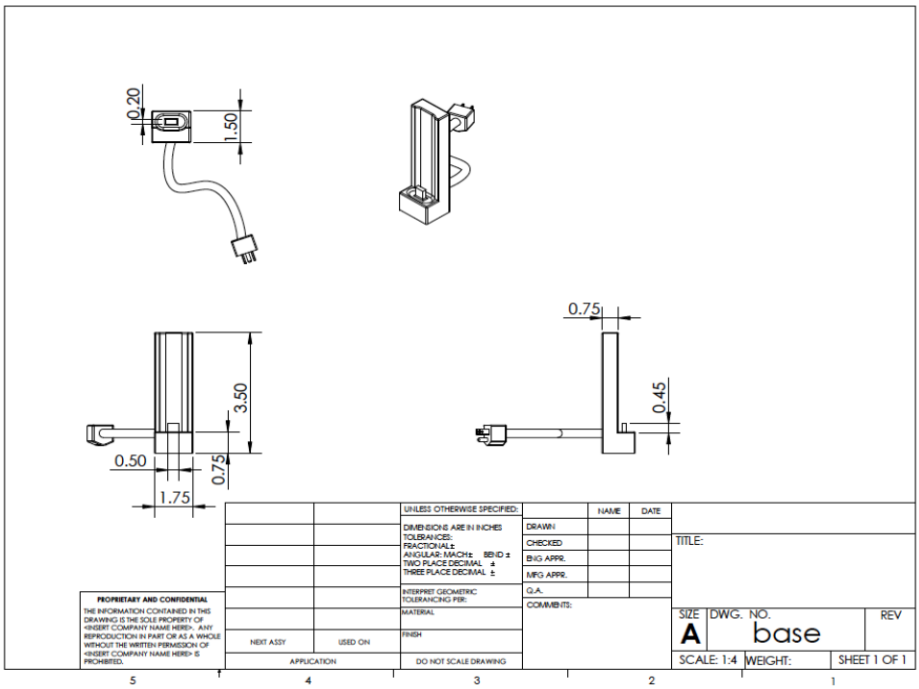


Figure 17 shows the dimensions for the charging base for the toothbrush.

Table 6: Removable Parts List

Table 6 lists and describes the removable parts for the final toothbrush design.

Part	Description
Toothbrush Head	Rotating bristles that clean the teeth.
Toothbrush Body	Protects the inner workings of the toothbrush (i.e. The motor and other parts). Comfort grip for the user.
Charging Station	Charges the toothbrush from a normal wall outlet, and keeps the toothbrush charged and ready to go.

Table 7: Bill of Materials:

Table 7 lists the costs of the materials needed for the toothbrush.

Part	Quantity	Cost	Function	Material
Motor	1	$10.00	Converts energy for use.	----------
Toothbrush Body	1	$3.00	Protects the motor, and adds comfort.	Hard Plastic and Rubber
Toothbrush Head	1	$1.00	Cleans teeth.	Bristles and Plastic
Charging Station	1	$7.00	Charges the toothbrush.	Hard Plastic and Rubber coated power cord
Gears and Screws	Toothbrush: 10 Charger: 25	$0.50	Makes design Stable	Metal

6.2 How does it work?

The new toothbrush is simple to use, yet it has an elegant design. The toothbrush has a two touch button, light press will give you precise power, or you can completely press the button down and have power without keeping your finger on the button. It is all powered by a servomotor which spins the head of the toothbrush. The spin on the bristles is a dual action spin with the outside bristles moving clockwise and the inside moving counter clockwise. This dual action will in theory clean your teeth better than the single spinning bristles. The toothbrush itself features an ergonomic handle with comfort in mind. With the cut outs for the fingers padded with soft rubber lining. Another advantage with our new toothbrush is the fact that it is rechargeable. The toothbrush has a wall plug in charger that charges the rechargeable battery inside the toothbrush. This will cut back on overall user expense because they no longer have to purchase and replace AA batteries.

7.0 Conclusions

Through brainstorming, concept generation, and extensive research we have successfully redesigned the Oral B AdvancePower electric toothbrush. Since our task was to create a user-centred design that would improve our toothbrush, we had to discover what the user wants. To do this, we surveyed twelve college-aged people about what they think is important in an electric toothbrush. Then we conducted background research on the history of electric toothbrushes and proceeded to dismantle our toothbrush and document the materials and internal design of the toothbrush. After this we began to generate concepts based on our customer needs assessment. We began narrowing down the concepts to those that would be feasible and best suited to our customer's needs. To do this we used several PCC, AHP, and Pugh charts to help us organize our information and aid us in selecting the best design. Once we completed the concept selection process we constructed our design using SolidWorks.

For our redesign, we aimed to improve the sustainability of our toothbrush. We considered the target age of our consumer to be 18-23 years old. With this in mind, we set out to create a more sustainable toothbrush while trying to minimize the cost. Due to this budget constraint, we had to throw out some of the more luxurious design concepts such as electromagnetic and hydraulic head mechanisms. Our choice to use rechargeable batteries in our design as opposed to AA batteries will greatly increase the life of the product and reduce the amount of waste and operating costs of the toothbrush.

Our design was very successful in increasing the reliability of our product while keeping costs to a minimum. We improved the life of the product and decreased the ecological impact and ultimately achieved our goal.

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