RETRACTABLE EARPHONE CASE

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ABSTRACT

This project mainly focus on the product development and analysis of retractable earphone case. A model has been designed based on the survey and market analysis. Each component of the model is optimized since it's the key in decreasing manufacturing cost using ANSYS Explicit Dynamics module. Further, business plan and market analysis have been conducted on the product to generate break-even analysis, capital and equipment list.

1. Introduction

With the growing interest in compact and user-friendly devices there has been a huge market for various gadgets that solve day to day problems. One such problem identified was how headphones frequently get tangled or misplaced. Moreover, the tangles tend to damage the earphones thereby reducing the life of the earphones and it is not too late before we must buy a new one. The inspiration for this project was from one of the customer reviews for a headphone company, "***Headphone cable tangle is annoying. And despite the small armada of accessories which try and combat this problem, none have proven themselves as our savior from cable tangle. What we want are a pair of headphones with retractable cord - a retractable cord that's well designed and not attached to a crap of buds. Is that so much to ask. Does this unicorn actually exist?***". The major challenge in this project is to deliver an accessory, which would overcome the common problems in storing and protecting the earphones.

These are day to day problems faced by students, travelers, music lovers, etc. The solution is to provide an accessory that can be compact, reliable and user friendly. Since the lifetime of the earphones could be improved with the accessory, the manufacturing companies might face a decrease in their earphone sales. But if the manufacturers become our buyers for the accessory, both the manufacturers and customers would benefit from this product.

2. Existing Solutions and Problems

To overcome the problems of the tangles companies came up with the solution of Bluetooth earphones. Though it did solve one problem they could still be misplaced or forgotten. Also, to use these earphones, the phone must be Bluetooth enabled causing heating and an excessive drain in the charge of the phone which is not a favorable condition.

Some companies came up with the idea of a retractable earphone which solves the problems of tangles but they could still be misplaced or cause damage to the cords of the earphone. These designs also come with their own pair of earphone which could not live up to the standards of popular earphone brands. There has been a lot of reviews such as the poor sound quality, insufficient strength of the cords could not withstand the torque experienced from the spool, flaws in the design of the spool, weight of the spool causing the earbuds to bounce off from ears, design flaws with cord retractions.

Also, if customers already own earphones, they would look for a way to solve the problem with their earphones rather than search an accessory which comes with its own earphones.

3. Functions and Design Attributes

Objectives	Functions	Design Attributes
Profit and Market Share		Thickness of the casing
	Portability	Material
	Life of headset	Diameter of the casing
	Prevention from tangle	Design of Spring mechanism
	Compactness	Pitch of the spring
	Compatibility	Diameter of the spring
	Aesthetics	Mode of attachment
		Price

Table 1 Product Function and Design Attributes

3.1 Functions

- **Portability**: The headphones are easy to store and the chances of misplacing is near to zero as it is attached with the phone cases.
- **Life of headset:** This mechanism prevents headphones from experiencing damage to external physical storage as it is going to get placed inside the casing therefore, increased reliability.
- **Prevention from tangle**: The headphone has near to zero chances of getting tangled as the storage is limited within the casing.
- **Compactness**: The product will be designed in a manner that it would be considered as a part of the user's device.
- **Compatibility**: All types of wired headphones can be used with the product.
- **Aesthetic**: The physical appearance of the object, which is one of the major aspects for a product market.

3.2 Design Attributes

- **Material selection**: Light weight, easy to fabricate materials chosen for manufacturing the product.
- **Design of retraction mechanism**: The primary functioning of the product is based on coil spring mechanism. Which is to retract the headphone wires back to the casing. The forces of the spring are transmitted to a pawn provided inside the casing instead of the cord of the earphone.

- **Sizing (Diameter and thickness)**: The diameter and thickness of the casing will determine the compactness and aesthetics of the product. The idea is to keep the diameter as low as possible to accommodate/ place the casing in the phone.
- **Mode of attachment**: This will secure the product to the user's intended device.

3.3 Mapping of Design attributes and Functions

The functions or customer requirements are mapped with their respective design attribute using Quality Function Deployment Tool (QFD). Quality Function Deployment (QFD) is a structured approach to defining customer needs or requirements and translating them into specific plans to produce products to meet those needs.

3.4 Outtakes from the Mapping

- The mapping of has given us more valuable information on which attribute needs more time and resources and how much stronger they are linked to each other.
- In our case the main design attributes are the Design of Coil Spring mechanism, ratchet-pawn mechanism and the size of the product.
- Understandably the spring and ratchet design has strong correlation with tangle prevention, life of the headset and ease of use.
- The diameter and thickness of the casing has a direct correlation with the aesthetics, ease of use and portability.
- The correlation between design attributes and functions are studied and the key aspects are carried forward into next phases of design.

4. Patent Review

4.1 Retractable Cord Device

Publication No.	: US6616080 B1	**Publication type**	: Grant
Application No.	: US 09/560,631	**Publication date**	: Sep 09, 2003

Inventors : Bruce Philip Edwards, Craig M. Janik, Andrew Ivan Poutiatine

Overview of the paper:

- A retractable device is provided for a headphone used with a cell phone.
- The device is formed of a housing with one rewinding spool for the earphone end of the cord with allowance for twisting of the connector end of the cord.
- The device with two spools allows for independent rewinding of earphone end portion of the cord and the connector end portion of the cord

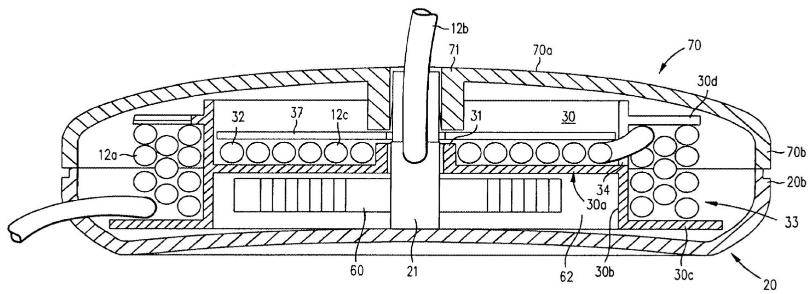


Figure 1 Patent Cross sectional view

4.2 Retractable Cable Assembly

Publication No. : US20020040945 A1 **Publication type** : Application

Application No. : US 09/963,264 **Publication date** : April 11, 2001

Inventors : George Stepancich, Yuval Shenkal

Outline of the paper :

- A retractable cable reel assembly that has a spring loaded reel which attaches to a midpoint of a cable. When rotated by the spring, winds both ends of the cable up on the reel.
- A releasable detent arrangement is used to retain a desired amount of cable extending.

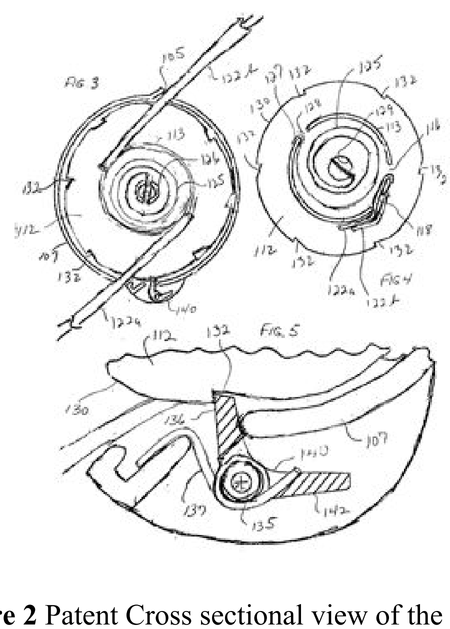


Figure 2 Patent Cross sectional view of the product

5. Survey Analysis

The purpose of the survey was to evaluate the customer preferred specifics for the design of the product. Various design attributes were chosen to finalize on the important aspect for customer satisfaction.

Survey was conducted using ASU qualtrics. Questions were uploaded online along with the answers required for conducting the analysis. A total of 15 questions were asked to the surveyors who were mostly students from the class and rest being alma mater. The product was surveyed largely by 20-25 age group since the product is being targeted at them. The survey was posted online for 4 days and we received over 50 responses and the data's were pulled out for further analysis.

The collected data was analyzed using Conjoint Analysis. It is the systematic way to match product design with the needs of customers, especially in the early stages of the Product Development process. The main advantages of this process are, it helps us to understand how consumers make trade-offs and to determine customer's most preferred product attribute.

Results of Analysis:

The analysis was done on MATLAB and the part-worth are displayed as shown below

Attributes	Part worth of attributes	Attributes	Part worth of attributes
Size (Diameter)		**Thickness**	
40 - 50mm	2.1366	Less than 12mm	0.2656
50 - 60mm	1.9064	12-17mm	0.0981
Life of earphone		17-22mm	-0.1369
6 months	-1.1732	**Compatibility**	
1 years	0.0746	With all earphones	1.5314
2 years	0.2815	Only with flat wires	0.8679
Prevention of tangle		Only with circular wires	1.2165
Good	-0.3534	Price	-10.4889
Moderate	-1.2612		
No Prevention	-2.133		

From the survey the part worth of price value has reduced to the maximum negative value which implies that cost is the most influential attribute.

The part-worth for size (diameter) which is a key attribute in our product is positive for a portable

product and this means that consumers prefer a portable headphone accessory.
One of the prominent attribute is the life of the headphones of all the attributes has equal importance as other attributes. This indicates that this attribute plays a major role in the decision made by the customer.
Thickness and compatibility also has a positive influence on the choices made by the customer.

6. Engineering Functionality

6.1 Concept Design

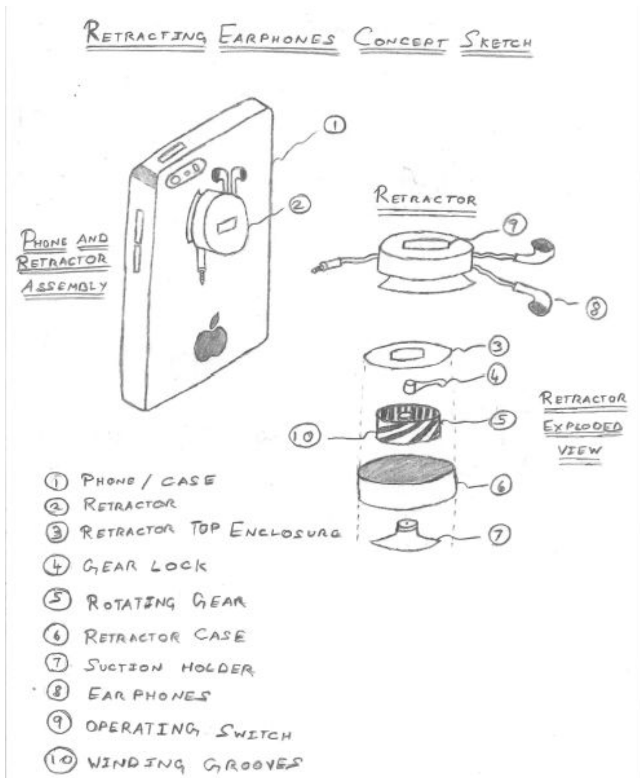


Figure 3 Concept Sketch

Base on the customer survey and feasible market conditions a concept design was made. The design was generated as CAD models and required engineering analysis was performed on the design to optimize for a suitable design.

6.1 Product Mechanism

As per our concept, the pawn stage is fixed with the base of the casing whereas the hollow ratchet is placed in coincidence with the axis of the casing. The ratchet's degrees of freedom are arrested in all directions except its rotational motion about its axis center. The pawn is fixed to an extrusion provided at the pawn stage so that the pawn does not move in any other direction except rotate about its axis. A coil spring with a calculated spring stiffness is attached to the base and the ratchet. The ratchet is rotated about its axis when the cord of the earphone is pulled out of the casing therefore, compressing the spring as the pawn locks itself to the gear tooth at every successive pull and does not let the spring to return to its equilibrium state. When the pawn is released from the ratchet teeth the spring retracts the cable through friction as the spring gets back to its equilibrium state. The calculation of the nominal angular velocity with which the gear rotates is already given in the design section and because of the varying nature of the angular velocity in case to case basis, it is also added to the input parameters of the DOE for optimization.

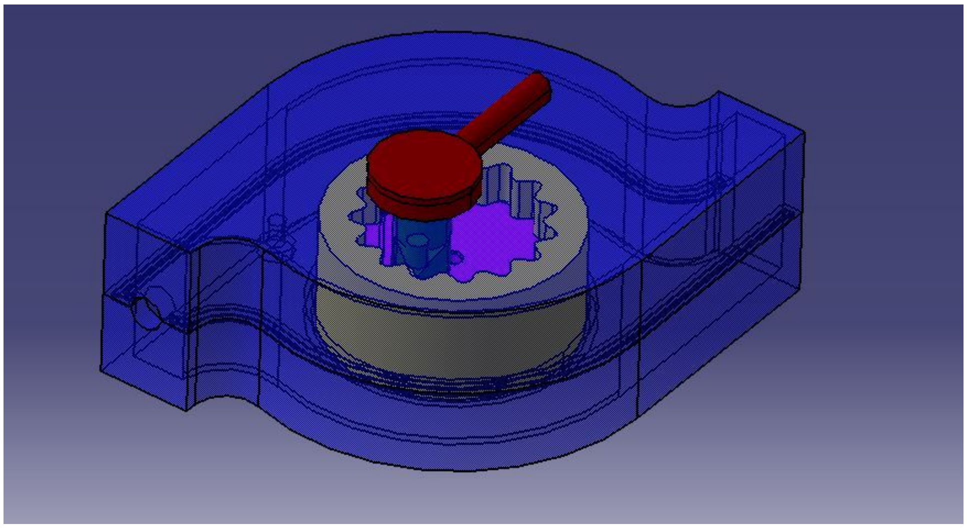
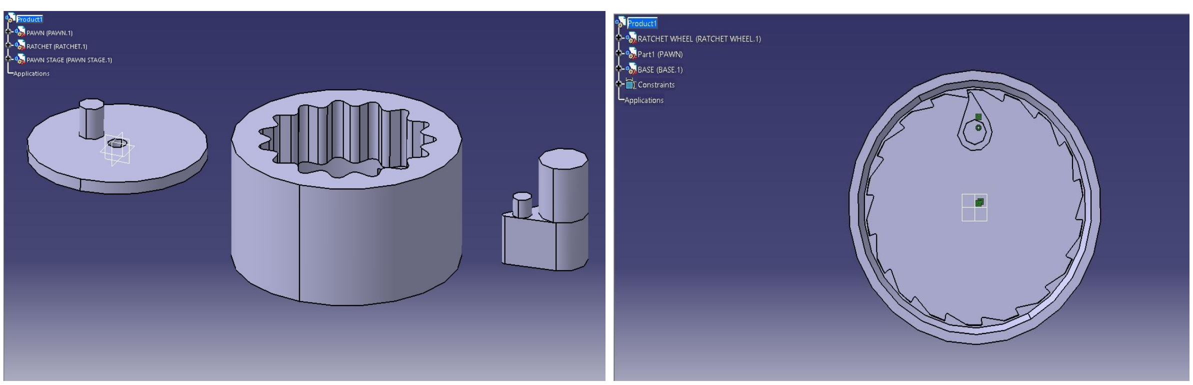


Figure 4 Assembly of CAD Design

6.3 Product Dynamic Analysis

To simulate the exact condition of the mechanism, angular velocity of 1.6 rad/s is applied to the gear as it rotates about its axis and the end of the gear which is fixed to the casing is given a fixed support. A fixed support is also assigned to the Pawn



(a) (b)

Figure 5 (a) Parts for analysis from left to right - Pawn stage, Ratchet, Pawn. (b) Mechanism Assembly

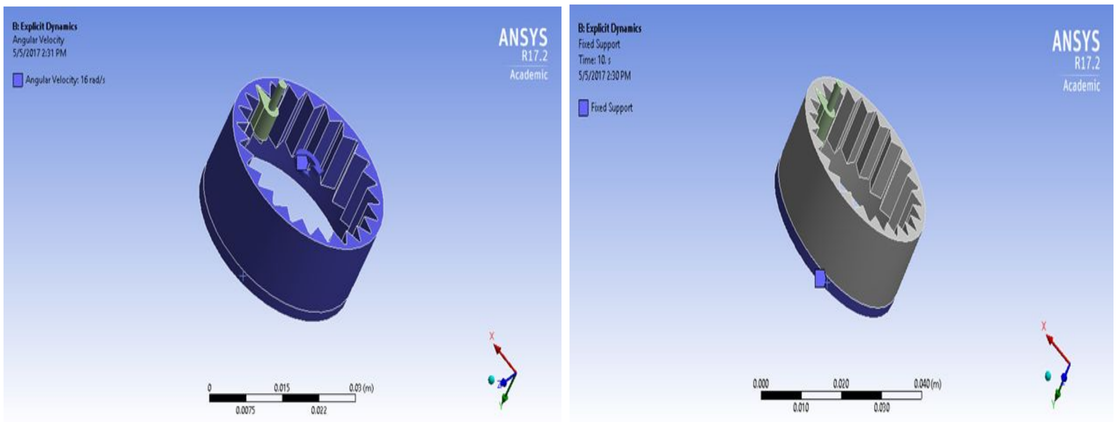


Figure 6 (a) BC - Angular Velocity applied to the ratchet (b) Fixed Support applied to the base

In ANSYS Explicit Dynamics, the angular velocity is applied in the initial condition tool. While applying angular velocity, direction was an important parameter.

6.4 Analysis Result

After applying the boundary conditions, explicit dynamics is run for solution and von mises stress is added as the solution and considered as the single output parameter. The result after simulation is given below.

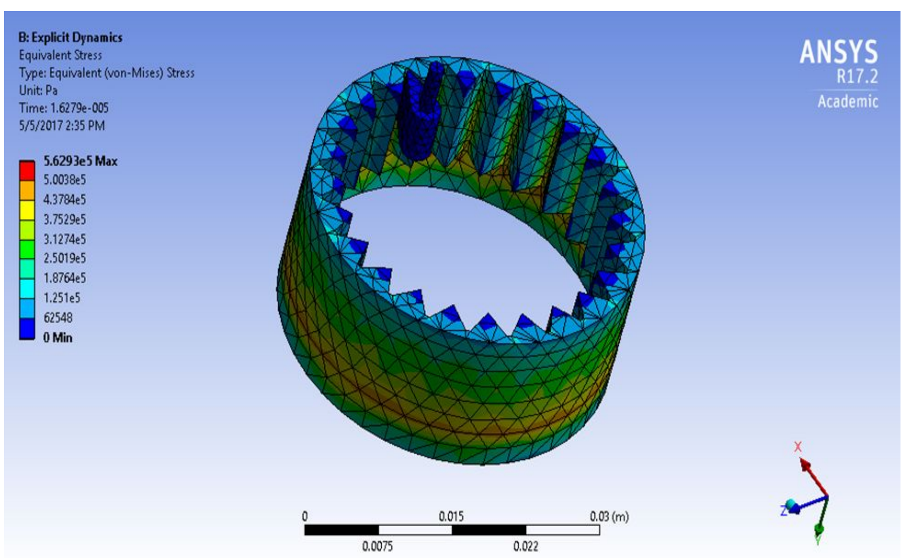


Figure 7 Max Von Misses stress - 5.6 X 10^5 Pa

In our case, structural failure of the component does not occur because of the low angular velocity that is generated in our model. The component may fail on fatigue due to the repeated cyclic loading and unloading occurring on the Teeth and the Pawn. The reason that we used Von Mises stress as an output parameter is to get an optimized structure that will have a less stress concentration with an optimum usage of the material. As material is an important resource in 3D printing.

6.5 Design of Experiments

Design of experiments is a systematic method to determine the relationship between factors affecting a process and the output of that process. In other words, it is used to find cause-and-effect relationships. This information is needed to manage process inputs to optimize the output. There are several Design of Experiment methods in ANSYS. The most common ones being *Latin Hypercube Sampling* (LHS) and *Optimal space filling* with user defined sample points. There are also other methods like *Sparse grid* (which only samples a few points initially and adaptively add new sample points based on the response surface), *Kriging with auto-refinement*, and *Central Composite Design* (CCD). We have used *Latin Hypercube Sampling* DOE method. The main advantage of this method is that the number of samples is independent from the number of parameters. Another advantage of using this method is that it allows the creation of experimental designs with as many points as needed or desired.
The table below shows the results of 25 DOE analysis done and the sampling is done by means of Latin Hypercube method.

S.no	Angular Velocity Total (rad/s)	Inner diameter (mm)	Outer diameter (mm)	Thickness (mm)	Max.Equivalent Stress (Pa)
1	32.472	35.21	21.824	16	454302
2	34.32	37.31	21.648	16.512	3954302
3	33	37.87	20.592	14.464	198600
4	35.904	36.89	21.472	16.256	654802
5	30.888	35.91	23.232	14.72	195600
6	33.792	35.77	23.584	17.408	345637
7	34.584	37.45	23.408	16.128	484576
8	31.416	37.03	22	17.28	174385
9	34.848	36.05	22.88	15.36	650012
10	31.152	38.43	24.112	15.104	356687
11	30.36	35.07	20.064	15.616	498312
12	35.64	36.61	22.176	14.976	554683
13	35.376	36.19	21.12	15.872	452584
14	32.208	38.01	20.24	16.64	394582
15	36.168	35.63	23.76	15.488	0
16	31.944	37.59	21.296	17.024	405863
17	31.68	36.47	23.936	16.896	452846
18	33.264	38.15	20.416	16.384	402589
19	30.096	36.33	20.768	14.848	312245
20	34.056	38.29	20.944	14.592	421114
21	33.528	37.17	23.056	15.744	324482
22	35.112	35.35	19.888	17.152	587885
23	32.736	37.73	22.352	17.536	387458
24	30.624	35.49	22.704	15.232	344720
25	29.832	36.75	22.528	16.768	358941

Table 8.1

The analysis of the mechanism can be verified by going through the table. The Von Mises stress increases when the angular velocity increases and the difference in diameter decreases. From the definition of stress when the area on which the force is applied decreases the stress value increases. This effect can be visually seen in the sensitivity graph.

6.6 Response Surface

The response surface is created after the data are collected from the Design of Experiments process. ANSYS provides us with the following list of response surface methods:

1. **Standard Response Surface:** This method uses a polynomial surface to fit the data. It requires the least amount of computation in both fitting and prediction. However, the performance of the prediction largely depends on the choice of the polynomial bases.
2. **Kriging:** This method is nonparametric, meaning that the prediction will depend on all existing data points. Thus, the method could be slow in prediction when you have many data to fit. It is also slow in fitting the data due to the calculation of pairwise distances among data points. However, this method automatically fits through all data points.
3. **Nonparametric Regression:** This method uses Support Vector Regression. It is like Kriging in that the prediction depends on the current data. But instead of using all the data, this method chooses the most important data point to perform prediction. Thus, its computation cost for prediction is less than that of Kriging. Yet, its cost of fitting is still high. The model does not fit through the data.
4. **Neural Network:** Feedforward neural network creates a nonlinear mapping from the input (a design) to the output (its objective value) that mimics the expensive simulation. It is slow in training (and may end up with a different model each time you train, even if the data is the same) when the network is deep, but the prediction only involves simple matrix calculation and is fast.
5. **Sparse Grid**: This method goes with the corresponding DOE method. It is like Kriging in that it handles highly non-linear objectives. It does so by adaptively sampling in the most uncertain areas of the design space, and thus may reduce the number of samples needed.

We have used the standard response surface method from the above as this method is commonly used when the data is large and the change in objective is smooth.

6.7 Goodness of Fit

To show that a suitable response surface is selected. Design verification points are selected and plotted in the goodness of fit graph. As we had a total of 25 samples we have taken ¼ (7) as verification points. By the view of the graph we can conclude that the verification points also fit on the linear regression model that is adopted. As the optimization is run on surface model rather than the actual model in ANSYS. This does not affect the optimization much.

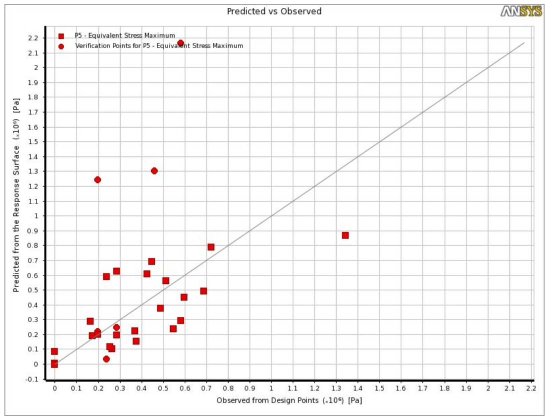


Figure 8 Goodness of Fit

6.8 Sensitivity Analysis

The sensitivity curves show how the Von Mises stress changes with respect to other input parameters. We can clearly see from the bar graph that the most sensitive parameter is the outer diameter and the inner diameter is the least sensitive parameter. The output is also equally sensitive to the input parameters thickness of the gear and the angular velocity with which the gear rotates. So, changing the most sensitive parameters like the outer diameter will affect the maximum stress in the gear

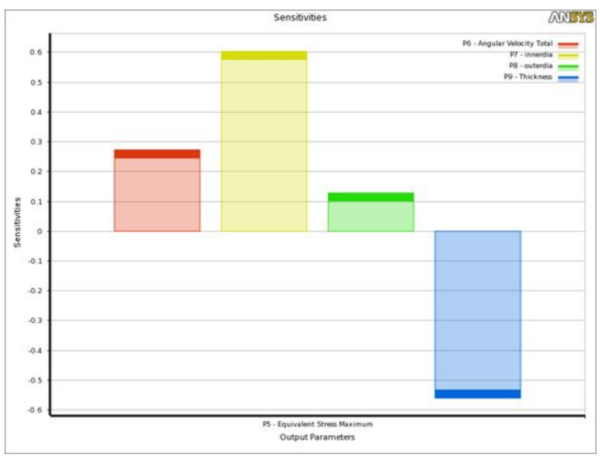


Figure 9 Design Parameter Sensitivity Analysis

The relation between Von Mises stress and Outer Diameter is illustrated below

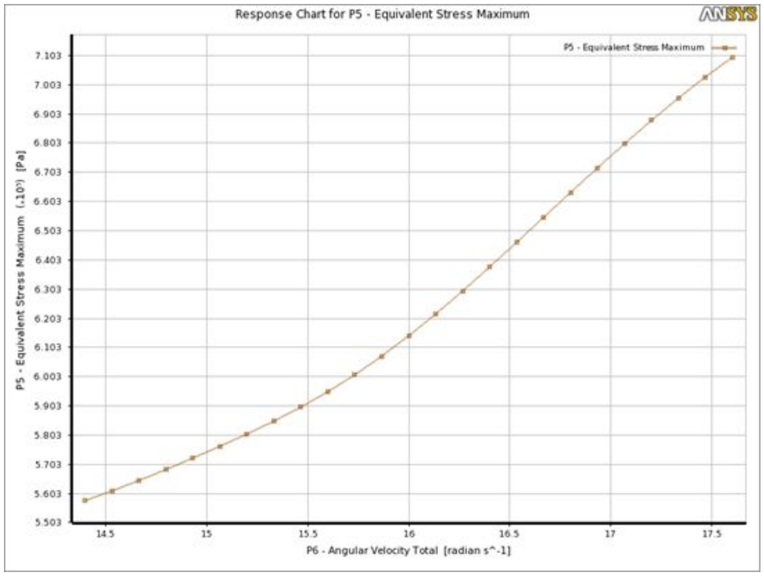


Figure 10

Since the change in outer diameter was the most sensitive parameter we will be using it as a parameter in design optimization.

6.9 Optimization

After setting up the response surface, the optimization is done on the response surface. The response surface optimization tool is used in ANSYS.

Screening is used as the optimization method for calculating the optimized solution with the inputs given to the optimization analysis.

In our case the input parameters Outer diameter, inner diameter can be increased to reduce the thickness of the gear to reduce the overall thickness of the product. As the angular velocity depends on the spring and the is user-defined as no objective. The output parameter Von Mises stress should be reduced to increase the life of the component.

The constraints are already given in the DOE process and so in optimization same upper and lower bounds are taken

The objectives of the optimization are as below,

- Increase the diameter between the bounds to compensate for the thickness of the gear
- Reduce the thickness of the gear as it affects the usability of the product
- Keep the Von mises stress to minimum to increase the life of the product.

Table of Schematic C4: Optimization

	A	B	C	D	E	F	G
1	Name	Parameter	Objective		Constraint		
2			Type	Target	Type	Lower Bound	Upper Bound
3	Minimize P9	P9 - Thickness	Minimize		No Constraint		
4	Maximize P7	P7 - innerdia	Maximize		No Constraint		
5	Minimize P5	P5 - Equivalent Stress Maximum	Minimize		No Constraint		
6	Maximize P8	P8 - outerdia	Maximize		No Constraint		
*		Select a Parameter					

Figure 11 Optimization Parameters

After updating the objectives and the method for optimization the results are obtained and they are shown below.

10	Candidate Points			
11		Candidate Point 1	Candidate Point 2	Candidate Point 3
12	P7 - innerdia (mm)	36.297	35.822	36.138
13	P8 - outerdia (mm)	38.17	38.416	38.334
14	P9 - Thickness (mm)	13.656	14.122	14.704
15	P10 - Angular Velocity Total (radian s^-1)	17.502	12.585	9.3075
16	P5 - Equivalent Stress Maximum (Pa)	8.0944E+05	6.5672E+05	5.5447E+05

Figure 12 Optimization Results

Results:

From the three candidates, candidate 3 is chosen from the suggestion because

- The inner and outer diameter difference is high enough for the groove to be made for winding of the headphones.
- The thickness of the gear is reduced from its original design.
- The coil spring will be designed and selected to produce an angular velocity closer to the optimization result.
- The Von Mises stress has increased when compared to the original design but the increase is well within the ultimate tensile strength of $1.3*10^6$ Pa.
- So, in our design a tradeoff has been made between the diameters and the thickness of the product.

The original design values and the optimized values are shown in the table below.

Parameter	**Initial values**	**Optimized values**
Inner diameter	33 mm	36 mm
Outer Diameter	35 mm	38 mm
Thickness	22 mm	14.704 mm
Von Mises stress	0.453 MPa	0.55 Mpa

The below images show the change in structural aspects of the model before and after the optimization.

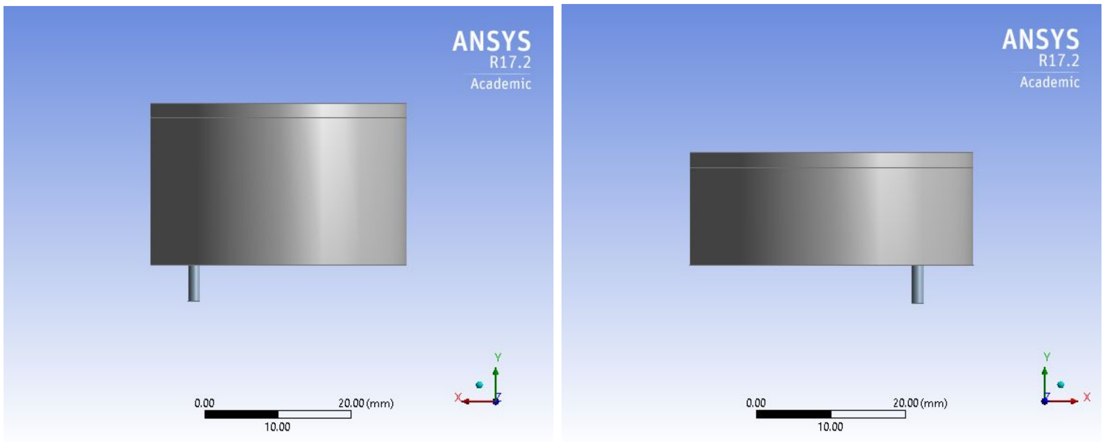


Figure 13 (a) After Optimization (b) Before Optimization

6.10 Product Prototyping

Based on the optimized design the a Prototype was 3D printed with an extrusion type printer. The prototype was completely made of PLA material as they are very good for prototype testing. Th infill density was chosen as 100 % to make the material stronger. The Layer per run was reduced to 0.8 mm to have a better adhesion to previous layers. A certain tolerance was necessary for the CAD models so that the parts fit perfectly even if there was any kind of dimensional expansion and contraction during printing. The final parts printed and assembled product prototype are shown below. A link to the assembly and the function of the prototype is as follows: https://www.youtube.com/watch?v=fgRg_3dSpOE&feature=youtu.be

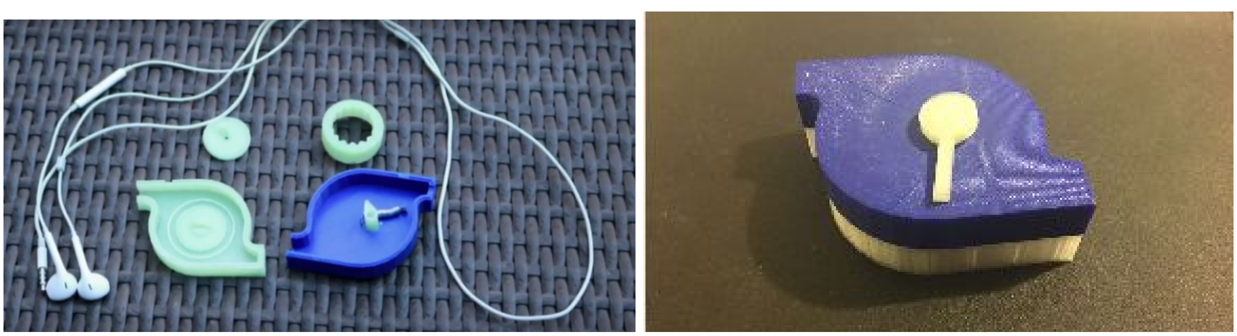


Figure 14 (a) Components of Prototype (b) Assembled Prototype

7. Business Plan

7.1 Objective

AlphaPress Technologies objective is to build an earphone case that utilizes the retractable mechanism to prevent the cords from getting tangled or damaged. AlphaPress Technologies intends to utilize the following strategies to achieve these objectives:

- ➢ Conduct a survey and develop the earphone case depending on the audience response.
- ➢ Utilize the retractable mechanism to prevent the earphones from getting tangled.

7.2 Product Description

The product is a case that can be attached to the back of any phone with a velcro provided with the product. The adhesive in the velcro is non-corrosive and will not damage the phone. The objective of this product is to allow the users to be able to utilize their own preferred earphones rather than provide one of our own. The product has been designed to make it user-friendly for the customers to attach their own earphones. It utilizes a pawn and a ratchet mechanism to retract the earphones through a coil-spring mechanism. This is because instead of allowing the spring to directly apply torsional forces on the cord like conventional retractable mechanisms, we are transmitting the forces through the pawn to reduce the possibilities of damage to the earphone cord. The product can also be designed with various sizes depending upon the customer's phone requirements.

7.3 Keys to Success

AlphaPress Technologies has identified several keys which will be instrumental in the success of the company.

- ➢ Develop the finest product.
- ➢ Exceed customer expectations.
- ➢ Employ strict financial controls.

7.4 Market Analysis

This category of industry faces competition from the small and emerging businesses, mainly start-ups. Big companies do not manufacture this product. Retrak and TurtleCell are the two major competitors for this product.

Usually, the smaller businesses will spend no more than $25 on a product like this. AlphaPress Technologies believes there is a tremendous opportunity for a retractable headphone case with a $10 price tag.

Another opportunity area is the growing demand for devices that facilitates the usage of headphones and helps in ease of storage. The main problem of tangle can be avoided by using this product as we introduce a retractable mechanism inside the casing. In an age where variety of costly headphones are introduced every year, the ability to prevent such headphones from tangling and improving the ease of storage is essential.

Retractable headphones are designed to be used by students and working professionals whose usage of headphones is frequent every day.

7.5 Market segmentation

AlphaPress Technologies is targeting those who use their earphones often. Specifically, it will focus on these two targets groups:

1. Students who often have their earphone cords being tangled and those who can't afford to buy a new pair every time it stops working.
2. Working professionals who don't have time to entangle the mess or purchase a new pair of earphones.

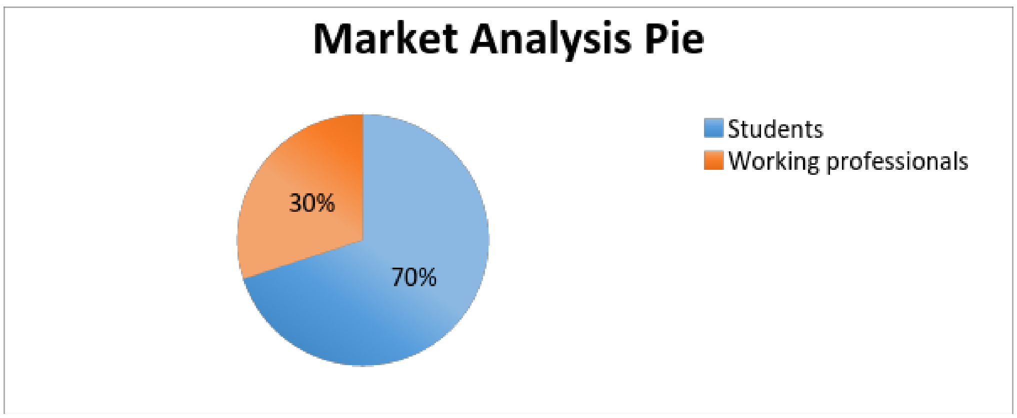


Figure 15 Market Analysis Pie chart

7.6 Positioning

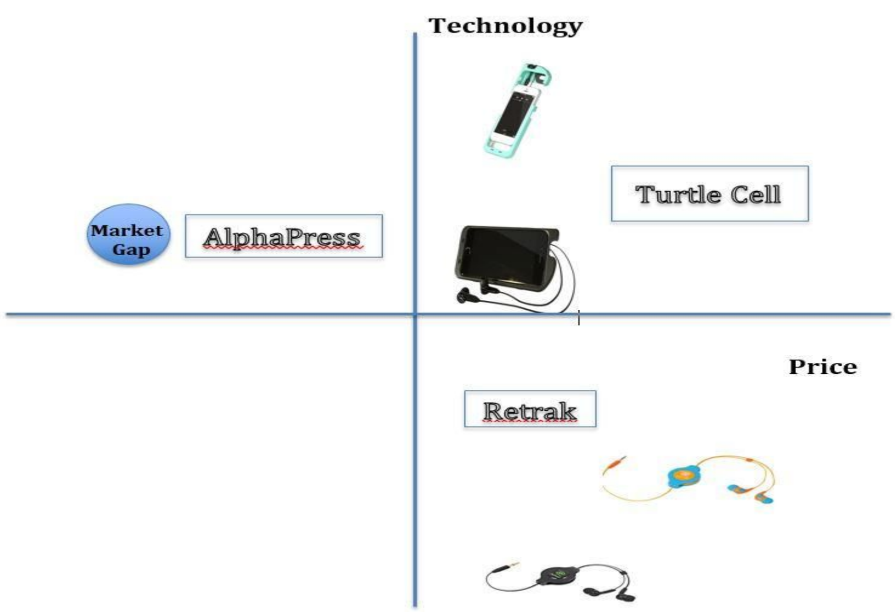


Figure 16 Position Map

7.7 Capital and Personal Resources

We are asking for an investment of $150,000. This amount will cover startup costs of facilities, workstations, and operation as well as minimal salaries for our employees during year zero when we will not be making any products. The exact distribution of this investment can be seen in our pro forma income and profit projections in the Financial Data section of this report. In year zero, we will set up a manufacturing outlet close to the university. We have chosen this location as our target population is majorly inclined towards students and working professionals. We are also planning to acquire a studio space in phoenix city where most of the working professionals are located. Another portion of the investment would go towards purchasing all the necessary tools, workstations, office supplies, and any other equipment that is needed for our business. We will not be making any products in year zero and will not need to hire assembly workers, however, some money will have to go into testing manufacturing processes, marketing, income for ourselves, and worker training at the end of the year.

7.8 Capital Equipment and Supply list

The capital equipment and supply list is show below.

Item	Use	Cost per part	Cost (Initial)	Cost per year	Details of cost
Mechanical Work station	Manufacturing		$2000		
Assembly station	Assembly		$2000		
Line worker 1	Flow control	$0.333			$1 for all components for one assembly
Line worker 2	Assemble	$0.333			$1 for one complete assembly
Salaried person	Marketing			$45000	
Salaried person	Admin			$45000	
Production space	Property(Rent)			$54000	
Office	Office needs			$300	
Office	Utilities			$13610	
Unexpected cost	Misc.			$300	
Number of parts annual	40000 with 10% increase following years				
Material cost	Manufacturing	0.412			
Total		$2.412	$4000	$158210	

Table. 1 Capital and Equipment Supply List

The list of components and their costs are provided in the table below.

No.	Item	Machine	Material Type	Material Cost ($)	Tooling Cost ($)	Production Cost ($)
1	Casing	Injection molding	ABS	0.27	0.278	0.169
2	Gear	Injection molding	ABS	0.091	0.334	0.138
3	Pawn	Injection molding	ABS	0.051	0.22	0.137
4	Spring	Ready to use from market				
5	Coil Spring	Ready to use from market				

Table. 2 Components List

FIXED COST

Initial development

Engineering = $50,000

Marketing = $5000

Fixed operating cost

Employees = $25000

Maintenance and store = $10000

Salary for personnel's = $15000

Manufacturing process development

Equipment = Industrial partnering

Administrative

Rent = $54000

Insurance = $800

Utilities = $13610

7.9 Pro Forma Income and Cost Projections

Price	10.32					
Cost per unit	3.5					
Starting sales	40000					
Sales growth rate	10%					
Tax rate	39%					
Discount rate	6%					
Project year	0	1	2	3	4	5
Income						
Investor contribution	$150,000.00					
Total sales	$0.00	$40,000.00	$44,000.00	$48,400.00	$53,240.00	$58,564.00
Sales revenue	$0.00	$412,800.00	$454,080.00	$499,488.00	$549,436.80	$604,380.48
Expense						
Initial cost	$133,000.00					
Cost of product	$0.00	$140,000.00	$154,000.00	$169,400.00	$186,340.00	$204,974.00
Fixed operating cost	$0.00	$247,000.00	$247,000.00	$247,000.00	$247,000.00	$247,000.00
Net profit	$17,000.00	$25,800.00	$53,080.00	$83,088.00	$116,096.80	$152,406.48
Post-tax profit	$17,000.00	$15,738.00	$32,378.80	$50,683.68	$70,819.05	$92,967.95
Running cash balance	$17,000.00	$32,738.00	$65,116.80	$115,800.48	$186,619.53	$279,587.48
Present value conversion	$17,000.00	$30,884.91	$57,953.72	$97,228.32	$147,820.15	$208,924.03
Breakeven	-$133,000.00	-$119,115.09	-$92,046.28	-$52,771.68	-$2,179.85	$58,924.03

7.10 Break Even Analysis

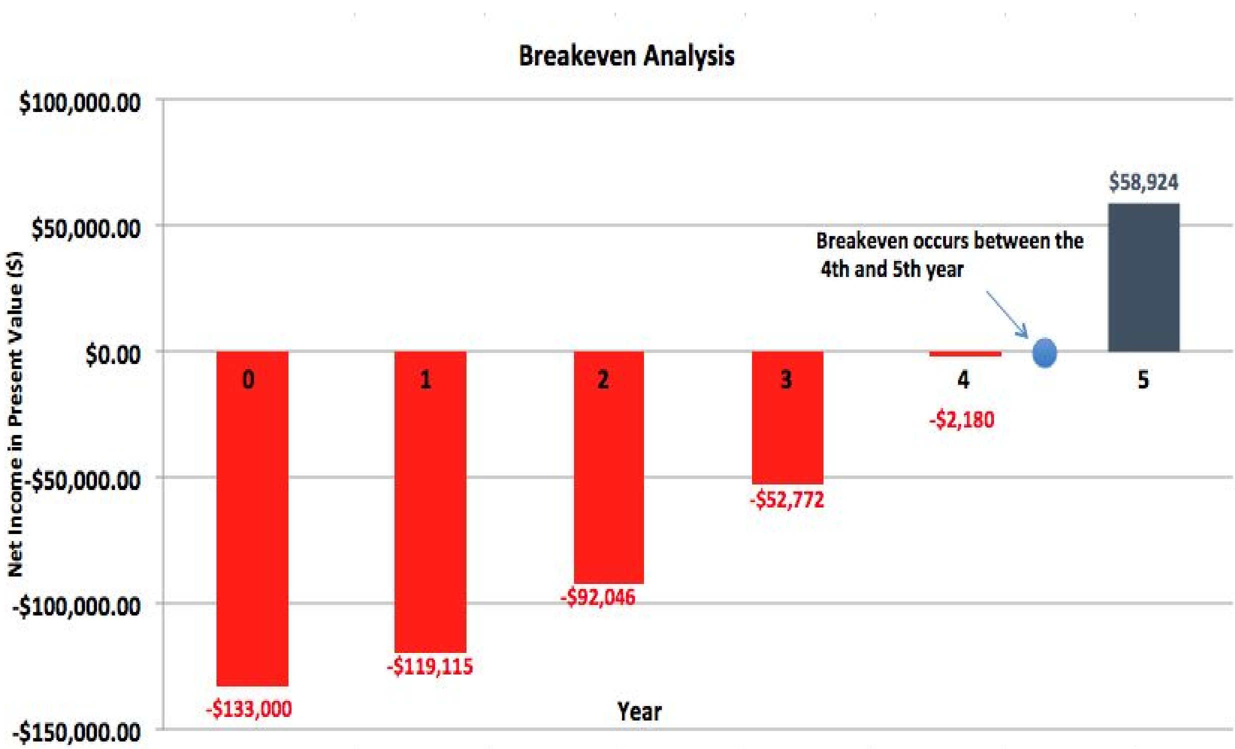


Figure 17 Break Even Analysis