Midterm Report I

Team 6

Design of a Less-Deafening Hair Dryer

Members:

Shawn Eckert	sme13b@my.fsu.edu
Kiet Ho	kth13c@my.fsu.edu
Mark Johnson	maj12b@my.fsu.edu
Peter Van Brussel	pav11b@my.fsu.edu

Faculty Advisor

Dr. Cattafesta

Sponsor

Dr. Devine

Instructors

Dr. Gupta

Dr. Shih

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ABSTRACT

There is a fundamental problem with the current design of many hair dryers, which is the fact that they produce an unappealing amount of sound during use. This present endeavor will seek to design a hair dryer that is quieter than what is currently in the market, while also maintaining low cost of manufacturability. Optimal results to this project will include a working and effective prototype, as well as a business plan for marketing and commercializing the product. In order to reduce the sound produced, Team 6 will target and aim to improve the loudest noise sources that are currently in hair dryers. The significant noise sources are found to be a combination of the fan and its intake, the fan flow over internal components and the motor operation. Many of the project constraints were chosen in order to maintain consistent with the current market for hair dryers. Some design concepts are presented along with a Gantt chart that contains future tasks for the project.

1. Introduction

Hair dryers are an easily found appliance in countless homes across the country. Currently the average hairdryer produces a sound level that is bothersome, invasive and harmful. Some examples include salons where hair dryers are constantly in use producing excessive noise pollution, or the case where someone is sleeping in close proximity of someone needing to dry their hair. The average hair dryer also produces a sound level that can be threatening to one's long term hearing with prolonged use. Being that there is this inherent problem associated with the current hair dryer, it offers a niche in the market for this project to fit a need. A solution that would be deemed fit is to be able to offer the same amount of power output, while reducing the noise that it produces compared to current hair dryers in the market. This project also asks the group to analyze the entrepreneurship aspect and to generate a product that is suitable for the current market by creating a device that meets safety regulations, provides equivalent drying quality, and also is quieter. With this in mind, all design aspects must be made to ensure the product can easily be transferred to the market and be mass-produced.

This assessment will begin with some background on the current state of hair dryers to give insight into some design features, where the current noise sources come from and information on components critical to the design. The needs of the project and design goals will be clearly stated to give an idea of what we would like to accomplish in this project. The methodology for which the designs will be based off is presented in the form of a house of quality; this shows what is important to the customer as well as what the important engineering characteristics are. Major components of a hair dryer are analyzed, along with technical specifications and a functional analysis. This will transition into the presentation of some concept designs. A Gantt chart is created in order to aid the project in moving forward and keeping with the schedule. It is present and explains in detail some key points for the project plan.

2. Project Scope

2.1 Background Research

Hair dryers are one of the most widely used hair-related instruments, seen in both personal and commercial environments with the purpose to style and dry hair quicker. Their primary use is to speed up the time that it takes to dry hair. In order to make hair dryers perform efficiently, their heating elements and air flow rate must be extremely effective. However, this causes one big problem: the level of sound created by the hair dryer. It has been observed that people are unhappy with the noise that is associated with using a hair dryer. The typical hair dryer produces anywhere between 80 - 90 decibels [1]. This not only creates an unpleasant experience for the user of the hair dryer, but also can produce undesired noise to the surroundings of both business and personal settings. Many sources cite that noise-induced hearing-losses begin at the sound level of 85 decibels [2], thus making the average hair dryer detrimental to ones hearing over time. The range of noise levels generated with different hair dryer designs vary greatly based on the design. The causes of the sound come from a plethora of sources. Some of these include the fan intake, vibrations from the motor, and turbulent flow over internals components. The measure that is used to quantify the acoustic power of the sound produced is the decibel (dB).

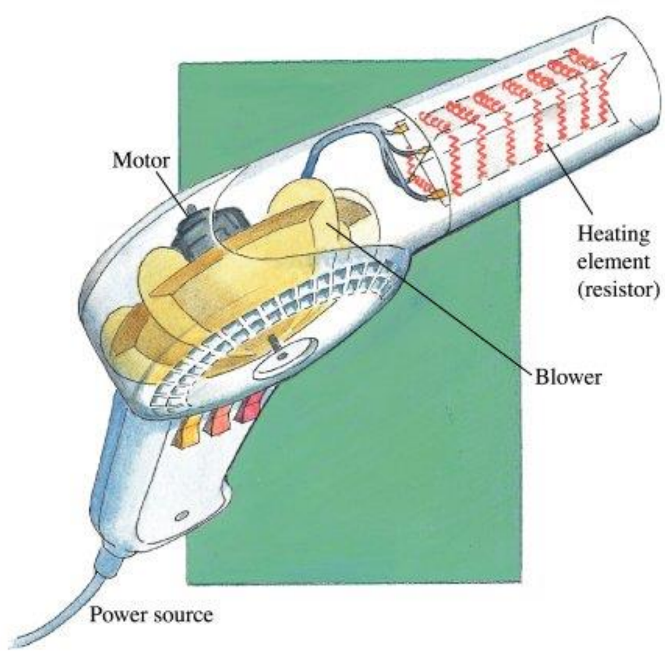

Figure 1: Breakdown of a Simple Hairdryer

A hair dryer is a simple electromechanical device, some basic parts are shown on the left (Figure 1). It begins with a power source that reaches a motor to power a fan device that forces air over hot wiring, thus producing a hot stream of air. The heat is generated by passing a current through the wires where the resistance is high, then subsequently pulled away by the air forced over it. This means of heat transfer is called *forced convection*. The progression of the handheld hair dryer design has been happening since the 1920's when the first of its kind was invented. Over the years, its design has changed to a lighter, safer, and more powerful device. Most of the safety measures include mechanisms that are connected to the circuitry that kill power if something that isn't supposed to happen. These protect against water immersion as well as a sudden fan stoppage; both cases will cut the power to the device.

The main mechanical component of hair dryers are the motors and device that moves the air. Most models use either a DC or an AC motor to rotate the fan component. It is observed that more expensive and quieter designs use an AC motor even though a DC motor weighs less. Typical hair dryers run on 6-24 volts and operate around 6000 rpm. The DC-type motors have two varieties: brushed and brushless. Brushed DC motors typically provide more torque than the brushless counterpart, while both have a higher torque output compared to AC motors. The AC motors have a much longer lifespan compared to DC, making them more desirable to be applied to a consumer product. As for the device that the motor powers which moves the air thru the hair dryer, some common ones seen are axial fans and impellers shown below (Figure 2). All of these designs are protected by an inlet cover to prevent objects from reaching the moving parts. The axial fans are the most common types in hairdryer designs and it works by pulling air thru, parallel to the shaft. The radial impeller on the other hand takes air in, then ejects it in a manner that is perpendicular to the inlet. [3][4]

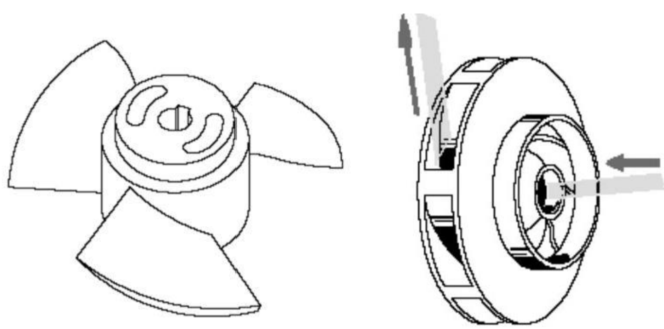

Figure 2: Axial Fan and Radial Impeller

Performing a review of literature of cases where tests were performed to target and improve the noise output of hair drying devices showed helpful in better understanding the problem. Akehmetov et al. [5] examined the noise source ranking of a hair dryer. They focused on using microphone array measurements in a semi-anechoic chamber to record the sound pressure level at distances comparable to those encountered during use. They tested two hair dryers: one normal and one marketed as "quiet". Tests were performed measuring the SPL during operation. They quantified various noise sources by isolating various sound sources by removing components, then measuring again. This included the intake and outlet grill, an air filter and the heating element. Results showed a decreases in SPL for removal of components. An observation they made was for the quieter hair dryer; there was acoustic treatment applied to the interior. Shen et al [6] sought to enhance the performance and the noise of the hair dryer though improved designs to the inlet cover, fan rotor, and stators. They were able to achieve a 9 dBA level of noise reduction while maintaining the same volume flow rate.

This problem of noisy hair dryers has been undertook by multiple companies (one of these being Revlon) to produce a “quiet” hair dryer. The “Revlon RVDR5045 Quiet Pro Ionic Dryer” was claimed to be 50% more quiet than the leading brands [7]. Another device is the “Centrix Q-Zone” hair dryer, and it is said to produce roughly 10 less decibels than its competitors [8]. The other is the “Envy + Onyx” made by Velecta-Paramount, which is said to produce only 64 decibels, but with its higher price tag of $300 and its production in Paris, it is not as popular as other models. [9] Both companies suggest that their products utilize advanced noise-cancelling technology. Unfortunately, these companies do not give much more insight into their design improvements as to protect their trade secrets.

2.2 Needs Statement

Existing hair dryers are too loud. Currently, the average hair dryer on the market operates between 80 and 90 decibels. This type of noise can be damaging to one’s long-term hearing and also cause unwanted disturbances to the user’s environment. Currently, the top-performing and quiet hair dryers on the market are upwards of $200. This creates a need for a hair drying device that is both quiet and effective, while also remaining at an inexpensive price point.

2.3 Goal Statement

The goal of this project is to design and build a working prototype of a hand-held hair drying device that significantly reduces the noise output compared to that is currently available; it must also be roughly equal in its effectiveness of drying hair. Along with designing a quieter device, a business model of the manufacturability and marketability of the current design will be done. Ultimately, the final package submitted will include both a working prototype, as well as this in-depth market study.

2.4 Constraints

Team 6 was set with only two restraints: the device needed to be quieter than current hair-dryers, and that the budget for this project is $1500. The product is also being designed for the market, therefore there will be additional constraints, such as being manufacture-friendly and affordable. Some aspects of a hair-dryer design have become a "norm" in most user's experiences. Although, in this case, the user expects a safe and effective heat output, a light-weight product, and an inclusion of all standard safety measure. These, along with other constraints and needs that Team 6 deems necessary, will be listed below to give an overview of where the design is bounded.

- Budget of $1500, yet can be extended with special permission
- Noise generated less than 70 dBA
- Must weigh less than 1.5 lbs.
- Heat of exposed parts may not exceed 115^{o} F
- Have maximum size dimensions less than 10 x 10 x 4 inches (length x height x width)
- Insulation and casing needs to be melt-resistant at any usable temperatures
- Safety components, must include ground fault circuit interrupter for immersion protection

Elaboration on some key constraints will be given below.

- Budget – This budget will be used for the prototyping and testing of the device.
- Noise Output – The team evaluates a "quieter" hair-dryer constitutes a sound output of less than 70 dB.
- Weight – The device should not cause struggle or be uncomfortable to hold during use.
- Temperature Output – The device must be limited on the heat that it can produce to ensure safe use and no burns occur.
- Size – The size of the design should be similar to current products on the market due to a "norm" associated with current hair dryers.
- Safety – Certain safety measures are required to be incorporated in hair dryers based on regulations from the Consumer Product Safety Commission. This includes a means to prevent electrocution from immersion in water [7].

3. Methodology

Team 6 will produce a device that is effective at drying hair and is not unpleasant nor damaging to ones hearing during use. Starting any project from scratch requires a lot of foundation-work and background research in order to determine the best possible method of moving forward. The team will need to determine the type of technology that is used in current hair-dryers, as well as other plausible technologies that could be integrated. The reverse engineering of hair-dryers will also aid in understanding the intricacies of these devices. Other topics of interest to study that will help in design include air flow using fans, acoustics and circuitry. The main focus in reducing sound from the device is to target the highest source of noise; this will be the most effective means at reducing the overall sound produced.

Team 6 constructed a House of Quality diagram (Figure 3) in order to determine the most important customer requirements for the product, as well as the engineering design characteristics, that are most significant. This is important for the team to effectively design around the things that make for a better product. Research that has been done was incorporated into its creation [10]. The top customer requirements were that it must be quiet, dries effectively, and operates safely. The highest ranking engineering characteristics were the air supply source, the type of motor and the speed of the output flow.

		ENGINEERING CHARACTERISTICS							
Customer Requirements	CI	Air Supply Source	Air Flow Rate	Convert Electricity to Heat	Temp Control	User Protection	Electric Supply	Motor	Material Selection
Quiet	10	10	6	0	0	0	0	6	3
Dries Effectively	10	10	10	10	10	0	3	6	0
Ease of Use	6	0	3	6	3	0	0	0	0
Operates Safely	10	6	0	3	3	10	6	6	0
Lightweight	6	3	0	0	0	0	0	3	10
Ergonomic	3	0	3	0	3	0	0	0	3
Variable Heat Settings	6	0	0	10	10	0	0	0	0
Variable Speed Settings	6	6	10	0	0	0	3	10	0
Affordable	3	6	0	0	0	3	3	6	3
SCORE		332	247	226	217	109	117	294	108
Relative Weight		20%	15%	14%	13%	7%	8%	18%	7%
Rank		1	3	4	5	7	6	2	7

Figure 3: House of Quality

Once sufficient background research was done, the team will progress to testing of the components and creating conceptual designs where multiple ideas will be implemented. The team will look to use parts from purchased hair-dryers in order to reduce costs; other needed parts will be ordered once designs are finalized. The team plans on constructing the circuit component of the hair dryer during the design-phase, because this is something where a majority of the work can be done simultaneously, and minor changes can be made as permanent designs come about.

A working prototype is aimed to be completed by the end of the fall semester. This will leave plenty of time to perform enhancements and testing in the spring, as well as give some leeway in this design process if/when delays occur.

3.1 Schedule

The group's work breakdown structure can easily be viewed in the created Gantt chart listed in the appendix of this report. It contains group tasks per scheduled submission deadlines for the course requirements, and also includes subtasks which describe the specific details of what must be accomplished prior to submission dates. There are also user-created tasks included in the chart which are not mandatorily established by the Senior Design course; these tasks are intended for the group members to complete project-related items in order to progress with their future plans toward the development of a prototype. The current Gantt chart is scheduled to the end of the initial senior design course.

3.2 Resource Allocation

There are multiple current resources utilized by the group. The first of which is the internet; the group has used this resource in order to obtain and cite publications that are oriented toward the disassembly/assembly and component-comprehension of the hair dryer. The group's secondary resource is their appointed advisor. This individual provides technical supervision and motivational support for the group; his job is not only to provide assistance with possible issues, but also to point the group in a reasonable direction. A ternary resource would be the use of the anechoic lab in the AME building. This testing location allows the group to perform necessary sound-quality tests of the hair-dryer in a quiet environment. The final resource (the most viable resource) are the actual group members. Mark Johnson is not only the team leader of the group, but also is the individual who delegates tasks to other members, maintains the quality of the group's overall activity and progress, controls the schedule of events, edits final reports, and provides technical engineering support toward the production of the group's project. Peter Van Brussel is the person in charge of financial expenditures, provision of detailed measurement tools, webpage design leader and assistance in technical fluid-dynamics knowledge. Kiet Ho is responsible for providing expertise as one of the two lead mechanical engineers in computer aided drafts and designs for the hair dryer; he also is responsible for including the mathematical support which correlates to the information created and tested via CAD, Matlab, Mathcad, or any other useful software programs. Shawn Eckert is the other leader in engineering designs, but is not limited to just this task; he is also responsible for maintaining communications between the group and the sponsors/advisors/instructors. Nevertheless, each individual in the group is not limited to their specified tasks; all students will provide assistance to each other as needed.

4. Design and Analysis

4.1 Functional Analysis

Within a hair dryer, there are numerous components; some of which are mechanical, while others are electrically-based. Eventually, these components will be integrated into a single electromechanical device. Each of these parts are listed below.

- Impeller
- AC or DC Motor
- Motor-to-Fan Transmission Shaft
- Motor Vibration Housing
- Fan Speed Switches
- Device On/Off Switches
- Sound Dampening Material
- Heating Element
- Inlet/Exit Grill Covers
- Air Filter
- L-Shaped Housing Unit

The majority of the previously listed components are dependent on the overall final prototype design, however some components may be altered, replaced, or removed in order to achieve the goal of producing a less-deafening hair dryer.

With respect to the most important factor in decreasing overall sound pressure level, the impeller at the inlet must be observed. Generally, typical hair dryers contain an inlet grill with an air filter; both of which are utilized for safety purposes. Based on research regarding the determination of noise-source ranking in a hair dryer, the inclusion of an inlet grill and an air filter produce an overall sound pressure level of approximately 99 decibels. By further removing the grill, would reduce the previous tonal noise level by 4 decibels. Furthermore, by also removing the air filter would decrease the sound pressure level by an additional 7 decibels. These results indicate that the addition of grills, air filters, etc., in the path of the flow increase the noise considerably and innovative means to reduce their noise or alternate quiet means to provide their functions need to be implemented [11].

With respect to that actual impeller, the component needs to be designed to not only provide a fully-developed flow through the exit of the hair dryer's nozzle, but provide air to the motor. A proper impeller-housing unit that mutually functions in such a fashion has yet to be fully determined by the group.

When observing noise near the exit of the nozzle, it exhibits broadband behavior; this is where the sound pressure fluctuations are non-periodic in nature with relatively random phase and amplitude [12]. If one were to imagine an axis running through the center of the exit of the nozzle, and angularly deviate from said axis between 20˚ - 90˚, one would find that the overall sound pressure level of such noise is predominant the less one deviates from the axis. Therefore, the shape of the nozzle, along with the components which cover or surround the exit of the nozzle must be arranged and oriented in a fashion as to reduce such effects. One possible solution would be to design the nozzle's grill cover with a wedge-shaped wiring structure, i.e. the wiring spokes would be triangular in shape with the pointed-end facing the inside of the hair-dryer, while its flat base faces the outside of the hair dryer. If the angle of the triangular-shaped spokes are oriented at 45˚, extra unwanted noise can be potentially deflected away from the user's ear; prior research has shown that at a 45˚ angle from the center axis reduces the overall sound pressure level by approximately 5 decibels with respect to the results displayed from a 20˚ angle.

With regards to the housing unit of the hair dryer, the overall design has a major impact on sound pressure level output. For example, by designing a hair dryer whose length from the inlet to the exit, divided by the diameter of the nozzle is equal to a non-dimensional value of 3, would decrease the impact the overall sound pressure level. Based on research regarding non-dimensional results from lengths divided by diameters, ranging from 0 to 3, the overall sound pressure level decreases as the length over the diameter is increased.

Another aspect of the hair dryer's housing unit that affects pressure output is its overall shape. One may notice that the majority of hair dryers have a typical "teardrop" shape, with the wider end originating from the inlet, then decreasing in width toward the nozzle. This shape resembles that of a Helmholtz resonator. According to previous research, the resonant frequencies are inversely proportional to the volume of the Helmholtz resonator, and the increase of the volume results in a decrease of the resonant frequency [13]. Therefore, theoretically speaking, increasing the volume of hair dryer housing unit where the fan resides (in the cavity), has an overall decreasing output of resonant frequency; this ultimately reduces the pitch produced from the hair dryer, and provides added comfort to the user. Unfortunately, the blade passing frequency tuned-in from the resonator is directly proportional to the speed of the fan, which is directly coupled to the speed of the motor to which the fan is mounted [14]. Also, the speed output of the motor has to be tuned properly because the Helmholtz resonator is only effective at a small bandwidth; this may be determined via future testing.

Another important addition to the internal region of the housing unit is the implementation heat-resistant acoustic liners; these should either be placed near both the inlet and outlet, or throughout the entire interior of the housing unit.

With regards to the design/selection of motor implementation, the primary source of noise for DC motors generally results from vibration. According to a study of DC motor noise sources, shaft bearings can cause vibration and noise due to misalignment, improper lubrication, loose bearings, and high friction sintered bearing material [15]. Therefore, the group needs to design a more effective structure of the motor casing, and to also effectively ensure that the shaft which connects the motor to the fan is properly secured and adjusted to reduce vibrations.

4.2 Part Selection

The possible motor choices for the quiet hair dryer are a brushed dc motor, brushless dc motor, and an AC induction motor. Out of the three, only one motor will be chosen for the design. To help in the decision process, a few methods were incorporated, which include background research, an engineering characteristics table, and a Pugh matrix. To start the process, a great deal of background research was conducted to determine the basics of each motor, and from there an engineering characteristics table was created in Table 1, as seen ahead.

Table 1: Engineering Characteristics of Motors

Engineering Criteria	Motors		
	Brushed DC	**Brushless DC**	**AC Induction**
Price Range	$2-$6	$15-$100	$65-$165
Sound Production (dB)	N/A	N/A	7 - 10
Voltage	12V	225KV - 1300KV	110V - 120V
Life Length (hours)	2,000 - 5,000	20,000	40,000
Weight (grams)	64	115	425
Rpm	5,000 - 6,000	5,000 - 6,000	1,500 - 2,000

To further help in the decision process, a Pugh matrix was created, and the previous engineering characteristics table was used to weigh the benefits and down-sides for each motor. The weighing system can be seen below in Table 2. The group decided to make the brushed dc motor as the base motor because it is the most widely used motor for hair dryers; the other two motors were compared and were classified as either better or worse. The Pugh matrix can be seen in Table 2 ahead.

Table 2: Weighted Scale

Scale	
Concept Weighting	Weight
Datum/Base	0
Better than Base	1
Worse than Base	-1

Table 3: Pugh Matrix for the Motor

Customer Requirements	**Motors**		
	Brushed (base)	**Brushless DC**	**AC induction**
Quiet	0	1	1
Lightweight	0	-1	-1
Operates Safely	0	1	1
Affordable	0	-1	-1
Lifespan	0	1	1
Total	**0**	**1**	**1**

As one may see in Table 3, both the brushless dc motor and AC induction motor are tied in the weighted scale, however further analysis will state otherwise seeing as though a Pugh matrix only determines if the design is better or worse than the base design without applying a weight. During the background research portion of the decision process, it was found that a brushless motor for this project could be purchased at a much lower price than the AC motor; $15 compared to $65 respectively. The brushless motor is also much lighter than the AC motor, as one may see in the engineering characteristics table. It was also found that the brushless motor is quieter than the brushed dc motor due to the lack of brushes. Though no exact values were found for sound production of the brushed and brushless motor, multiple online sources suggest that the brushless is quieter than the brushed motor [16]. This meant that the brushless motor was the best all-around motor for the project. With respect to the safety aspect, the brushless motor was comparable to the AC induction motor because it doesn't create sparks like the brushed motor does. This may be "over-engineering" the final production, but having sparks ignite near dry hair is a fire hazard, and by choosing a brushless motor that risk is no longer a problem; this makes the final design easier to build and safer. For the final design, the brushless dc motor was chosen for its relatively cheap cost, light weight, and safety factors.

With respect to impeller selection, a choice could not be made because all three designs will need further testing. Amongst the three choices of blades (which includes the axial fan, compressor wheel, and radial blower), future testing will be required in order to gain better insight on how each blade design functions. All three impeller designs will be created by a 3D printer from HPMI, and will be smoothed out with acetone to ensure less friction from air flow, thus creating less vibration. Each blade design will be connected to the brushless dc motor and tested for sound production, force of air flow, and vibration effects. The force of air flow for each blade design will be calibrated by adjusting the brushless dc motor's revolutions per minute to ensure the desired amount of airflow is achieved. Keeping in mind that slower rotation speeds contribute to less sound production, the design that produces the most amount of air flow at the lowest motor speed, in addition with the least amount of vibration, will be chosen as the blade for the final design.

4.3 Design Concepts

Design Concept 1, as seen ahead (Figure 4), was based on the idea of a "Dyson" bladeless fan; it pulls in air from the middle of the design via compressor wheel, and forced out of the two streamline nozzles located on the head of the design. This design has incorporated flat heating elements in the head and an isolated motor in the handle for amplified sound reduction. To minimize noise produced by vibrations, the motor is placed within a rubber mount, and the blade is held in place by a bearing that supports the top portion of the blade shaft. The control will be very similar to any hair dryer currently on the market today, however this design is much more compact and easy to transport in bags due to its straight design.

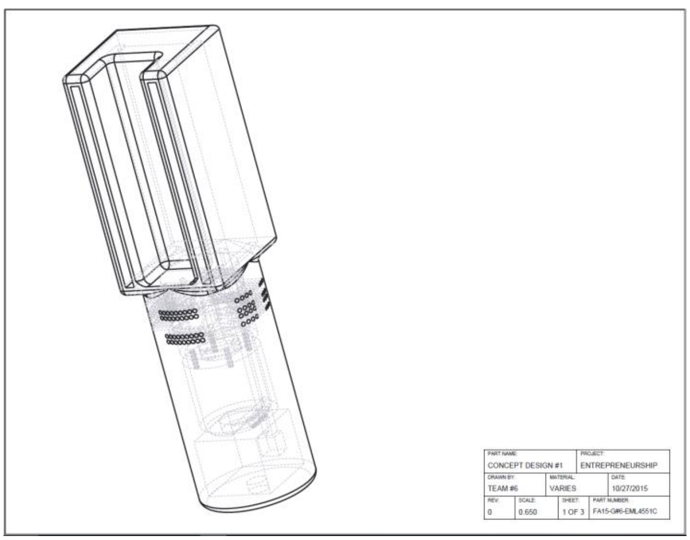

Figure 4: Design 1 Schematic

Design Concept 2 is an "out-of-the-box" design (Figure 5) that will hopefully be an "eye-catcher". Unfortunately, not seen in the schematic is a handle attachment that would allow users to be more familiar and able to use the device easier. In this "straight-through" design, the motor powers a wheel compressor in the bottom (or rear) of the design which pulls air in, which is then forced around the motor where the air is compressed. The air flowing around the motor will not only cool the motor, but also flow past the heating element; this process is similar to radial heating elements in current hair dryers. This design allows the user to either hold the hair dryer much like a water bottle, but with an attachable handle, it will seem more like a normal hairdryer. Not only does this design make for a more compact structure, but it also allows for weight-saving so that more insulation and vibration controls may be implemented in the overall design. The motor will be held in the center of the design by a stator blade composed of rubber; this will allow the air to flow with less turbulence, and further reduce motor vibration.

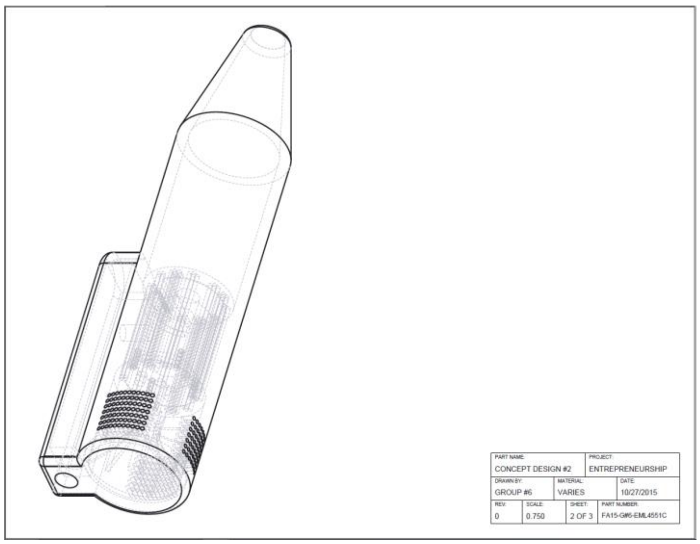

Figure 5: Design 2 Schematic

Concept Design 3, as seen ahead (Figure 6), was designed to be the most user friendly of the three designs; it appears to resemble the typical hair dryer in today's market. However, some major differences in this design (compared to hairdryers on the market) is that the motor is located in the handle; this ensures manageable vibration control and sound isolation. The motor powers a blade located at the top of the hair dryer by a rod that is supported by a bearing so that the overall vibration is controlled better. The air would then be pulled in from the top, and forced through the nozzle where a typical radial heating element heats the air. In this design, the heating element can be extracted directly from a downer hair dryer because its nozzle due to its similarity to hairdryers in today's market.

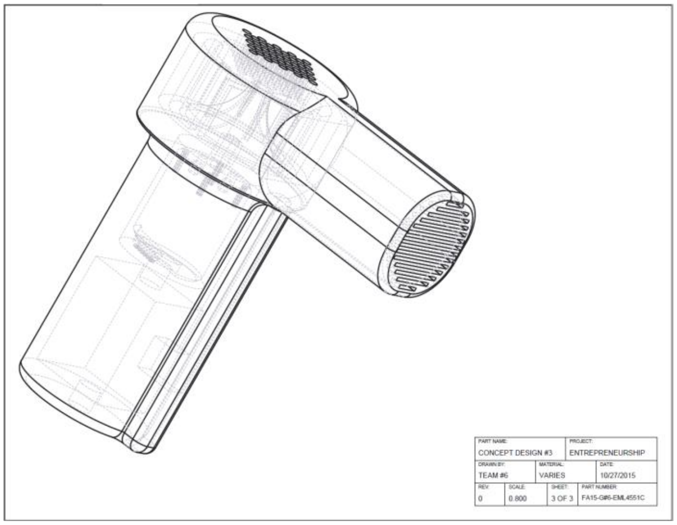

Figure 6: Design 3 Schematic

4.4 Evaluation of Designs

To help choose a concept design, a Pugh matrix was created as seen below in Table 4; each design was compared by factors of safety, lightweight, ease-of-manufacturing, visual appeal, low complexity and familiarity. This Pugh matrix doesn't mean that a design was chosen, but it does allow the team to determine a design easier in the future.

Table 4: Preliminary Pugh Matrix for Exterior Designs

Exterior Designs	**Criteria**						**Total**
	Safety	**Light Weight**	**Ease of Manufacturing**	**Visual Appeal**	**Low complexity**	**Familiarity**	
Design 1	1	0	-1	0	0	1	**1**
Design 2	1	1	0	1	-1	-1	**0**
Design 3	1	-1	1	0	1	0	**2**

As previously stated, classifying the designs within a decision matrix can be useful for future decision-making. The concepts and their criterion were extracted from the house of quality, and were weighed and compared for each design in the matrix. By comparison, the calculated scores yielded a solution value that would most likely be chosen against the other rivals, although this does not mean the chosen choice is the exact solution for the problem. Safety is always the first concern, and will always be taken into consideration for all designs, therefore they must be better, or at least the same as current designs. Towards the right-hand side, the lightweight category had immediately segregated the design differences as to whether it is heavy and off-balanced, average, or lightweight. As for the ease-of-manufacturing category, varying from the complexity of the infrastructure to the easily-defined geometry, parameters have to be taken into consideration for the purposes of mass-manufacturing at a good, substantial rate. Not only does engineering intuition factor into the designs, but also for the customer's satisfaction within each design; visual appeal is always a high priority in every product, and this scale can be ranked from looking at an entirely different design, to a recognizable one with a few modifications that are in a similar fashion with respect to other products. As for the familiarity and low complexity categories, visual appeal does contribute a factor into it, and these two categories do play a similar role for their ranking definition, which are scaled prior to the knowledge of the visual appeals. In other words, similar products will have the customers to easily synchronize to the product, where as if the product design is completely different, then it will definitely take a small amount of time to be adaptable to the product.

In conclusion, based on the total score computed (Design #3 equals a 2, Design #1 equals a 1, and Design #2 equals a 0), again the score did not indicate the best or the worst, due to the fact there are certain issues with balancing each of the countermeasures. It will be certain that the team will go further into more research, such as choosing more characteristics and re-evaluating their priorities to see a breakthrough point; this will eventually lead them toward the decision that will be focused and undergo modification.

5. Conclusion

In conclusion, the overall problem statement has been properly addressed; hair dryers are simply too loud. There are numerous factors which revolve around the source of noise, however either both the intake and exit of the air through the hair dryer have proven to be the most critical points of observation. Numerous studies have supported the previous statement, therefore it has caught the group's full attention. These studies have also shown other factors involved, and will not be remised, including a risk assessment; this can be found in Appendix B. Overlooking risks not only equals potential for a bad product, but also increased probability of injury upon either the users or creators.

By applying certain methods, such as the House of Quality table, has also narrowed down the priorities of engineering characteristics versus customer requirements regarding hairdryer selection, along with critical focal points. Also, with the application of a Gantt Chart, the group is able to stay motivated, prepared, and properly scheduled towards upcoming tasks.

With respect to the design and analysis of existing hair dryers, specific research has brought insight toward a future, less-deafening hair dryer. One that note, several concepts were digitally-devised by the utilization of complex design software. These conceptions are still merely conceptions. A satisfactory amount of research has been completed, along with some minimal testing, but future insight and progress will not end there. Eventually, a final, remastered concept will be selected for prototypical production.

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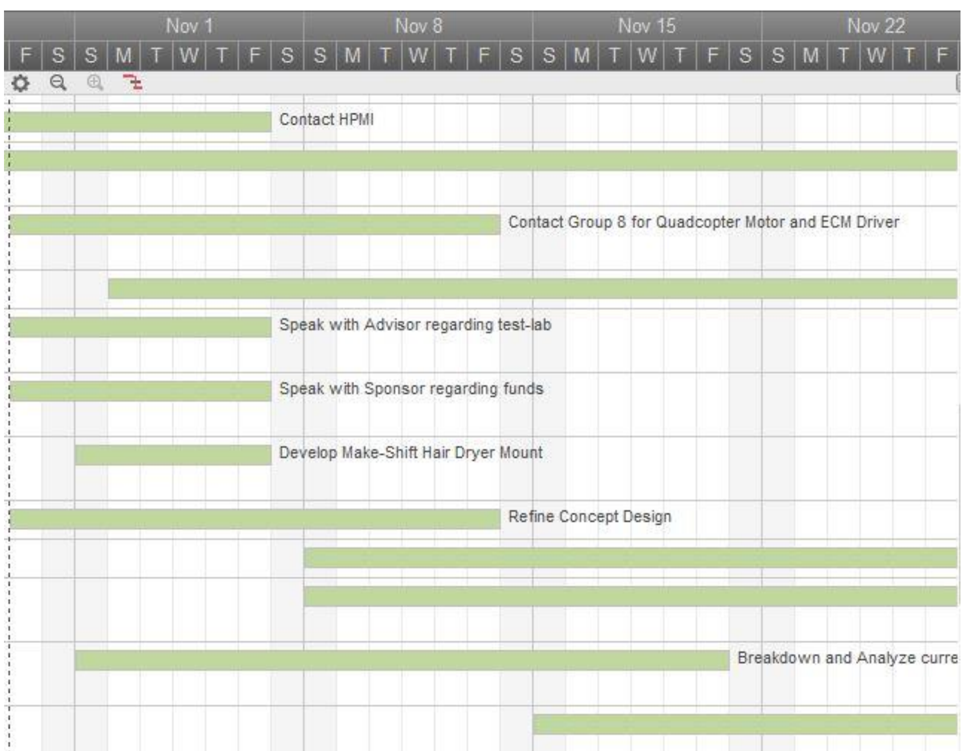
Appendix A – Schedule

TASKS	Completion	Start Date	End Date
Contact HPMI		10/29/15	11/06/15
Observe 3D Development of Products		10/09/15	11/27/15
Contact Group 8 for Quadcopter Motor and ECM Driver		10/30/15	11/13/15
Sound Test at AME		11/02/15	12/04/15
Speak with Advisor regarding test-lab		10/30/15	11/06/15
Speak with Sponsor regarding funds		10/30/15	11/06/15
Develop Make-Shift Hair Dryer Mount		11/01/15	11/06/15
Refine Concept Design		10/30/15	11/13/15
Make Accurate Measurements		11/08/15	11/27/15
Purchase Parts that won't be 3D-printed		11/08/15	12/04/15
Breakdown and Analyze current used hair dryers		11/01/15	11/20/15
Test purchased or developed components		11/15/15	12/04/15



Appendix B – Risk Assessment

• Project information:

Name of Project	Date of submission
Design of a Less-Deafening Hair Dryer	October 30, 2015

Team Member	Phone Number	e-mail
Mark Johnson	850-524-2321	maj12b@my.fsu.edu
Shawn Eckert	850-826-2414	sme13b@my.fsu.edu
Peter Van Brussel	850-712-7869	pav11b@my.fsu.edu
Kiet Ho	850-322-4972	kth13c@my.fsu.edu

Faculty mentor	Phone Number	e-mail
Dr. Nikhil Gupta	850-410-6201	ng10@my.fsu.edu
Dr. Chiang Shih	850-410-6331	shih@eng.fsu.edu

• I. Project description:

Develop a quieter hair dryer than what is currently in the market. Also to understand the entrepreneurial aspect of it.

• II. Describe the steps for your project:

Know your group members. Gain research and literature based on hair dryer. Perform tests. Develop concepts. Select a concept. Purchase and assemble parts. Test some more. Refine device. Test again. Finalize prototype. Understand market aspect.

• III. Given that many accidents result from an unexpected reaction or event, go back through the steps of the project and imagine what could go wrong to make what seems to be a safe and well-regulated process turn into one that could result in an accident. (See examples)

Performing tests – Injuries could occur due to tool misusage, electric shock, loss of hearing, etc.

*These mishaps may also occur during the actual development of the device

• IV. Perform online research to identify any accidents that have occurred using your materials, equipment or process. State how you could avoid having this hazardous situation arise in your project.

-People have endured electrical shocking from improperly handling the electrical components of the hair dryers

-There have been incidents which involve cutting or scraping of body parts

- **V. For each identified hazard or "what if" situation noted above, describe one or more measures that will be taken to mitigate the hazard. (See examples of engineering controls, administrative controls, special work practices and PPE).**

-Don't be complacent
-Remain cognizant
-Don't operate something that you're not aware of
-Use protection

VI. Rewrite the project steps to include all safety measures taken for each step or combination of steps. Be specific (don't just state "be careful").

-During test performance, utilize all the proper safety gear to protect yourself
-Don't operate machinery without proper knowledge or without an advisor
-Don't be in a hurry when attempting to either take apart or assemble a device

VII. Thinking about the accidents that have occurred or that you have identified as a risk, describe emergency response procedures to use.

-Contact 911
-Inform faculty members
-Remain calm

- **VIII. List emergency response contact information:**

- Call 911 for injuries, fires or other emergency situations
- Call your department representative to report a facility concern

Name	Phone Number	Faculty or other COE emergency contact	Phone Number
Dr. Nikhil Gupta	850-410-6201		
Dr. Chiang Shih	850-410-6331		

- **IX. Safety review signatures**

- Faculty Review update (required for project changes and as specified by faculty mentor)
- Updated safety reviews should occur for the following reasons:

1. Faculty requires second review by this date:
2. Faculty requires discussion and possibly a new safety review BEFORE proceeding with step(s)
3. An accident or unexpected event has occurred (these must be reported to the faculty, who will decide if a new safety review should be performed.
4. Changes have been made to the project.

Team Member	Date	Faculty mentor	Date
DIGITALLY SIGNED			
MARK JOHNSON	October 30, 2015		
SHAWN ECKERT	October 30, 2015		
PETER VAN BRUSSEL	October 30, 2015		
KIET HO	October 30, 2015		

Biography

Mark is a Senior Mechanical Engineering student from Fort Walton Beach. He served in the US Airforce for 6 years as C-17 Airdrop Instructor Loadmaster and wants to apply the tools learned the military to a future career in Mechanical Engineering. His area of interests include dynamics and wants to start a business in designing and creating new and improved versions of old mechanical designs for entertainment.

Peter is a Senior Mechanical Engineering student from Pensacola, FL. He has interests in the topics of fluid dynamics and renewable energy. He is part of the Florida State University's BS-MS program and also a member of the university's nationally ranked ultimate Frisbee team.

Shawn is a senior in Mechanical Engineering completing his final year. He is from a small town known as Crestview and transferred to FSU in the fall of 2013. He specializes in mechanical work and analysis/simulation. Shawn is a brother of the Phi Delta chapter of Theta Tau. He would like to pursue a career in National Security for a defense contractor. He is also interested in pursuing an MBA after gaining experience in the workforce.

Kiet is from Florida and a senior in Mechanical Engineering. He is interested in the materials field in engineering and also going into research and development for new methods to enhance productivity. He was a FGLSAMP robotic technician under Dr. Collins Adetu in 2013 and worked on constructing robots with various sensors.