Portable Glove Dryer

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Bachelor of Science

in Mechanical Engineering Technology

by

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ABSTRACT

The main objective of this project was to create a portable device that could dry a glove once its integrity had been compromised by moisture. The device must be compact, lightweight, battery-powered, but at the same time powerful enough to have the capability to dry moisture from the fabric. This was the most difficult part to accomplish during this design since the heating source and fan utilize a lot of current and voltage to produce the airflow and heat needed for evaporation. This is the reason there is nothing on the market currently that is small and portable enough to dry fabric with the energy source of a battery.

In my research, the only such thing that is like a portable glove dryer was a wall-powered unit that is not portable enough to fit in a jacket pocket. The design began with finding a fan and heat source. This drew me to the most similar product on the market which is a hairdryer. The only issue was finding an energy-efficient hairdryer due to these products having such high wattages to output the high heat and airflow as possible. Then I stumbled across a 12-volt compact hairdryer that was utilized in RV applications where 12-volt energy sources are the only source of energy. This was a 150-watt airflow and heat source which was my best bet for an off-the-shelf design that focused on minimizing energy consumption but maximizing drying efficiency. Next was to figure out a way to sufficiently power the device which required a lot of background research into battery technology to find the most energy-dense compact battery design. I needed something with a high capacity for amp hours as well as a high C rating for the current draw. With a low voltage application, this requires a high amp draw to get a sufficient wattage to power the device. I finalized on a compact 12-volt Lipo battery with 5200mAh and a 50C rating. This had enough energy density to theoretically power my device for 25 minutes.

Now that the primary componentry of the device has been established, I needed to design a compact robust housing to house the components. This was completed in SolidWorks and then 3-D printed utilizing the 1891 innovation hub. I chose the Industrial FDM PLA which is a stronger option than the standard Desktop FDM PLA material. This was needed for strength in my design due to its portable usage and design. The design consists of a housing for the fan and heating element and separate housing for the battery. This design can be found in the document below.

PROBLEM DEFINITION AND RESEARCH

PROBLEM STATEMENT

Designing portable glove drying solution to aid humans in cold climates to aid in comfort when cold moisture penetrates the integrity of a glove. The device must be compact, lightweight, battery-powered, and powerful in terms of drying capability.

RESEARCH

BACKGROUND AND SCOPE OF THE PROBLEM

Keeping your hands warm in the cold winter months is one of the hardest things to do since your body has a difficult time getting warm blood to the farthest tips of your fingers when the cold air is whisking it away so quickly. "Frostbite is most likely to affect body parts that are farther away from the body core and, therefore, have less blood flow. These include your feet, toes, hands, fingers, nose, and ears "(1) According to Mayo Clinic health professionals "Risk increases as the air temperature falls below 5 F (minus 15 C), even with low wind speeds. In wind chill of minus 16.6 F (minus 27 C), frostbite can occur on exposed skin in less than 30 minutes." (3). The different severities of frostbite can be seen in Figure 1 in Appendix (2). This requires us to use protection from the elements such as gloves and hats that were designed to insulate the body and reflect the cold temperatures. This can be a viable solution to the problem until some form of moisture encounters the garments." Wet clothing increases the risk of developing frostbite" (4). Once this occurs the garments fail to do their job and the elements quickly find their way chilling the skin ever so rapidly. Real images of frostbite can be seen in Figure 2 in Appendix (5) This requires you to either suffer the chilling effects or retract from your activities and dry the gloves or hopefully have a second pair. But unfortunately, this will be met with more crushing elements as soon as your activities begin once again. With 13.9 million Americans, participated in winter skiing at least once in 2016. (6) There are plenty of people who would potentially want this ease of keeping their hands safe from the cold elements.

This issue is currently being addressed with at-home glove dryers or units that are in place within the lodge. These units lack the portability for the user to be able to continue their outdoor activity without first initially withdrawing from it and returning once their gloves have been dried. There is no possible way for the user to have the ability to quickly remove the glove and dry the glove as soon as snow penetrates the internal cavity. A spare set of gloves will only be a Band-Aid on the solution delaying the inevitable.

CURRENT STATE OF THE ART

Technology #1: Dry Guy

Figure 3: Dry Guy

- Price: $73
- Forced-air boot, glove, and garment dryer works on four garments simultaneously
- Includes two removable extension tubes for use with boots up to 16 inches tall; whisper-quiet rotary blower; 3-hour timer; heat or no-heat switch
- Heats to 105-degrees F. (40.5-degrees C.); safe for liners, clothes, and boots; includes two removable extension tubes for use with boots up to 16 inches tall
- Helps eliminate odors and reduce the growth of bacteria and mold; dries most clothes in 1-2 hours; Power – 120 Volt AC Household Outlet
- Dimensions: 12 inches deep x 7.5 inches high x 15 inches wide; 6-foot power cord; 1-year warranty

Pro's	Con's
• A stable unit that dries 4 different gloves at once • Safe for linen, garments, and boots. • Helps eliminate odor • Nice look at the device • Fast Drying	• Is made in China • Isn't portable for use of the application • Cost $73 just to dry boots when you could throw them on the vent • Bulky unit

Technology #2: PEET - Ultra Dryer, Sanitizer, and Deodorizer

Figure 4: PEET - Ultra Dryer, Sanitizer, and Deodorizer

- Price: $49.99
- RY AND DEODORIZE: Removes wet, sweat, and odor from your footwear, keeping your feet comfortable, healthy, and dry.
- TAKE IT ANYWHERE: Enjoy PEET-Dry footwear everywhere you go. The Ultra Dryer is extremely portable, fits all standard outlets, and even comes with a travel carrying bag.
- SUBTLE YET EFFECTIVE: Silently dries, deodorizes, and sanitizes footwear in a matter of hours, all while using less electricity than a standard light bulb.
- ALL FOOTWEAR, ALL MATERIALS: Safely and effectively dries leather, rubber, vinyl, neoprene, canvas, synthetics, fleece, felt, microfiber, and more.
- 2-YEAR WARRANTY: Our products are designed to last and we're confident that your PEET Dryer will exceed expectations for years to come. Register your PEET product within 10 days of purchase to take advantage of our warranty.

Pro’s	Con’s
• Small and portable • Low Energy Consumption • Nice look to the device • Sits directly into shoe or gloves	• Is made in China. • It cost $49.99 for only 2 dryers. • Does not blow air, just heats.

Technology #3: Deal Bonanza Gloves - Hats - Mitten and Boot Drying Rack

Figure 5: Drying Rack

- Price: $14.99
- Well designed rack helps gloves dry quicker and hold their shape to prevent cracking and bending.
- Effectively dries items by opening them up and allowing air to flow through the full length slots into the garment
- Garments dry in minutes if you place the dryer over a forced air register, and overnight if placed beside convection heat - baseboard heating or fireplace
- Organize mud rooms, work shops and your cabin. No more soggy gloves and boots
- Size: 10.25 x 6.75 x 5.25 inches

Pro’s	Con’s
• Safe for linen, garments, and boots. • Cheap cost to design • Zero energy consumption design	• Is made in China • Must be at home with a vent • Doesn’t get deep into glove

Technology #4: Kendal Shoes Boots Gloves Dryer

Figure 6: Kendal Shoes Boots Gloves Dryer

- Warm air dryer for shoes, boots, gloves, pants, and more in about half an hour, you can go back to wearing them again shortly.
- The shoe dryer can dry 2 pairs of shoes at the same time; the glove dryer can dry 2 pairs of gloves at the same time.
- Warm air protects clothes. Aroma active carbon is used to absorb odor and make your shoes smell better.
- With a up to 3 hours timer. Low and High temperature mode can be selected. Weighing in at 3.5 pounds, this machine will take up very little space on your next outdoor trip or as a permanent fixture at your home.
- Include wall-mount kits if you want to mount it on the wall. CE certified. AC 110-120V, 60 Hz, 325 Watts. 1 year warranty.

Pro’s	Con’s
• Flexible houses for versatile usage. • Quick dry for easy turnover in dryness	• Is made in China • Larger unit • Not easily portable

END-USER

Recreational

This user is the individual who will be outdoors in a winter climate by choice. Whether it is a mother and her kids outdoors playing in the snow, either sledding or simply throwing snowballs, or someone looking for a bit more of an adrenaline rush skiing or snowboarding down the side of a mountain. This was my original targeted audience since I thought of this design while sitting on a ski lift with frigidly cold hands. This user would purchase the device and keep it in their jacket pocket every time they go out into the elements. This way every time the user encounters cold moisture within their gloves they will be able to pull the device out of their pocket and dry the glove as quickly as possible without having to step inside to throw them in a dryer or blower.

Industrial

The industrial user is someone that unlike the recreational user they do not voluntarily go out into the cold harsh elements. This user goes into the elements to put food on the table and a roof over their head. From someone building builds, to roads, to truly anything within the industry. They are always battling the climates in the northern hemisphere. This user would bring the device with them at the start of their shift and use it as necessary whenever the user encounters the elements within their glove. This user has truly transferred to my primary focus because they are forced to go out each day to keep our country going and these are exactly the kind of men that I am trying to support.

CONCLUSIONS AND SUMMARY OF RESEARCH

The portable glove dryer that I am looking to set out to design will utilize energy-dense lithium-ion batteries to power both the heating element and the electric motor with fan blades attached. Which will provide enough heat and airflow to evaporate the cold moisture that is found within the user's glove. This will all be tightly compact within a handheld unit that can be stowed in a jacket pocket with easy access to the user for a quick and easy solution. This will not only be great for parents who have kids that enjoy playing in the snow. But for anyone that must endure the frigid elements throughout the cold winter months.

QUALITY FUNCTION DEPLOYMENT

Customer Features

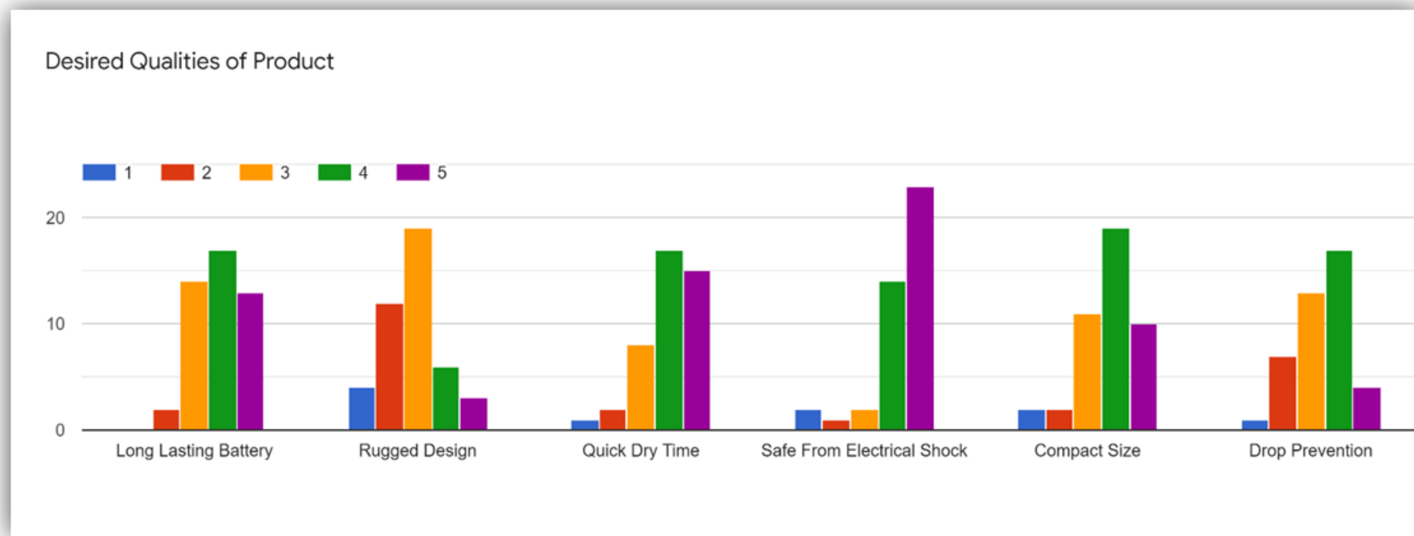

Figure 7: Desired Qualities

ENGINEERING CHARACTERISTICS

1. Removable Battery
2. Standard USB-C Charging capability
3. Rubber Bumpers on Exterior Shell
4. Quality/ Thick Plastic for Exterior Shell
5. Fast Fan
6. Powerful Heating Coil for High Heat
7. Circuit Breaker on Device for Shock Protection
8. Compact Design for the entire device. Quality through design
9. Wrist Strap

HOUSE OF QUALITY

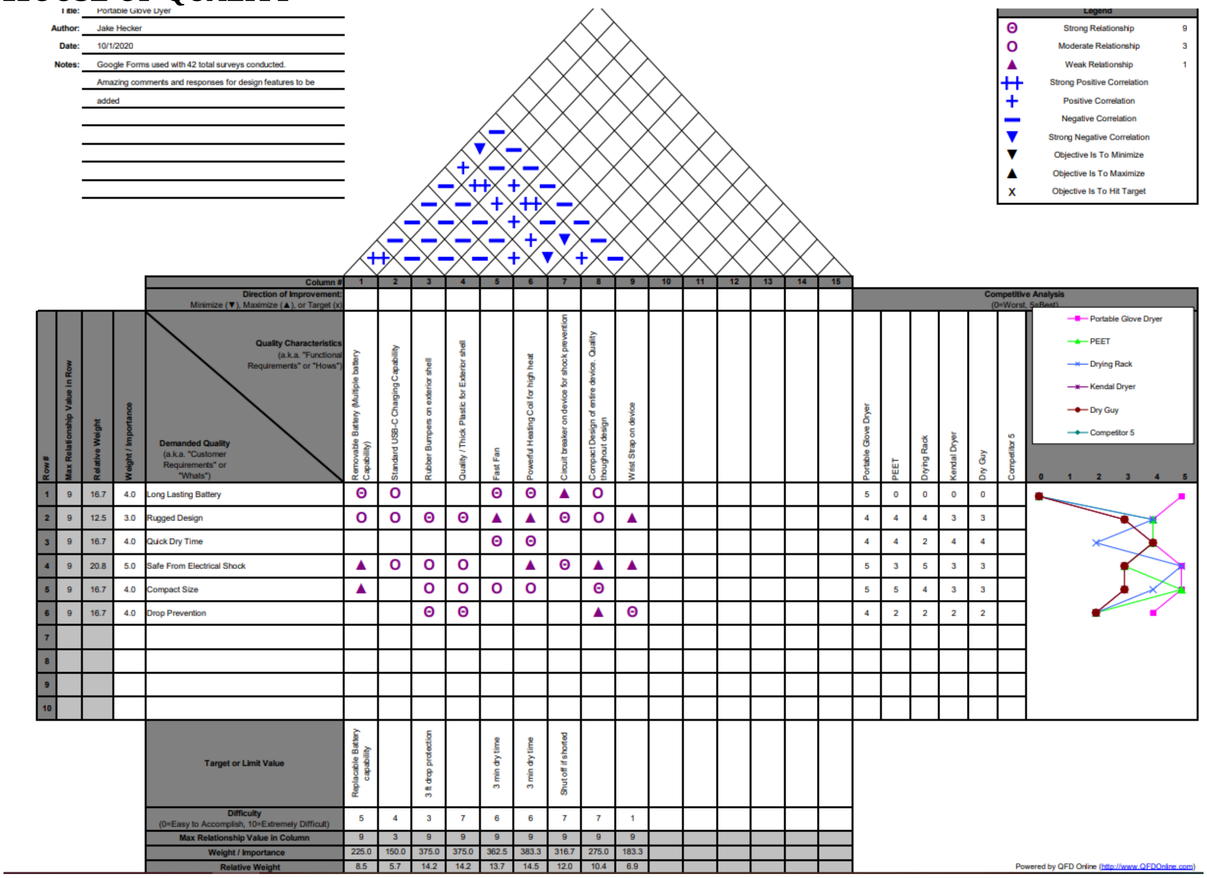

Figure 8: House of Quality

PRODUCT OBJECTIVES

Long-Lasting Battery: 80%
Rugged Design: 60%
Quick Dry Time: 80%
Safe from Electric Shock: 100%
Compact Size: 80%
Drop Prevention: 80%

DESIGN

DESIGN ALTERNATIVES AND SELECTION

<u>Version 1</u>

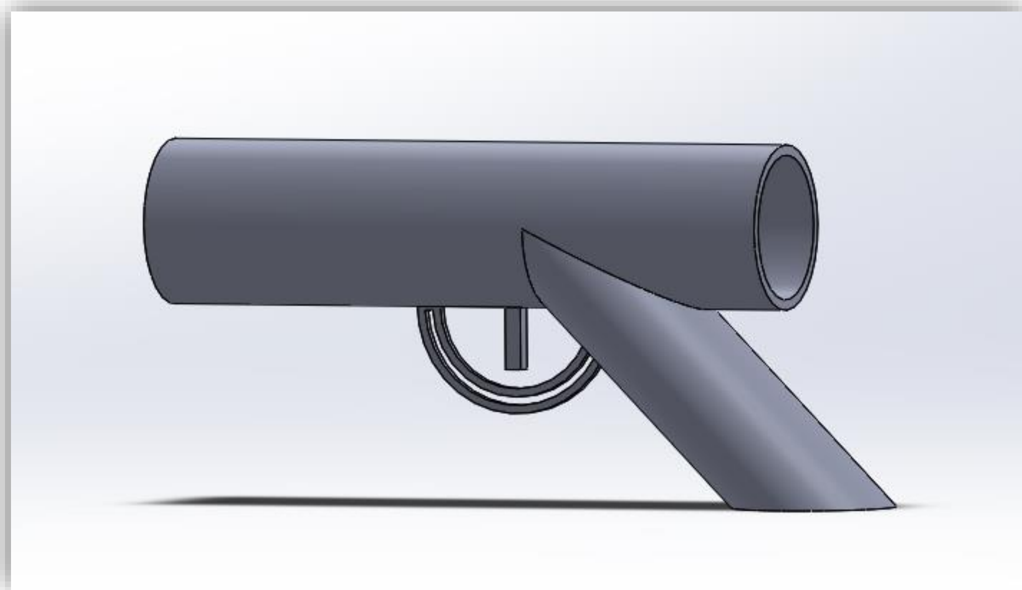

Figure 9: Concept Model 1

Summary

This model is a design based on the single-hand control of a piston. This will allow the user to not only operate the dryer with one hand with ease of control so the user can hold the wet glove in the other hand. The fan motor and heating element will be in the primary tube with the lithium battery stored away in the handle of the pistol design. This will also have a slide-out design for the battery like a pistol releasing its magazine. So, the user could have multiple battery capabilities. The trigger will be the on and off function to activate the dryer with a trigger guard around it to aid in false triggering while stowed away. There may even be a safety function to prevent false triggers even more.

Version 2

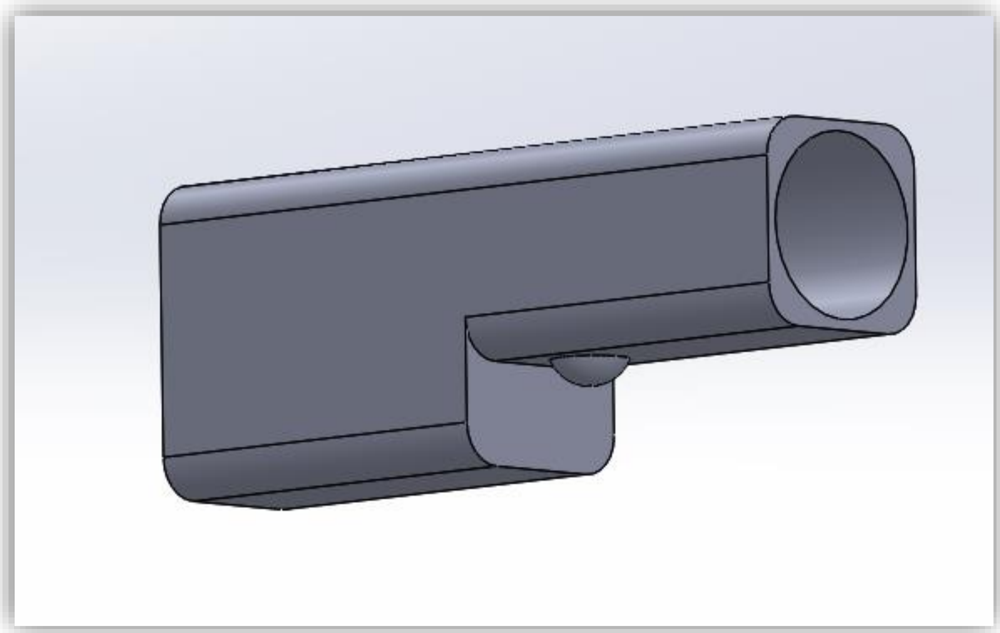

Figure 10: Concept Model 2

Summary
Version 2 has more of a boxier design to it which will be held with one hand around the larger portion with the pointer finger placed on the small button found on the underbelly of the device seen in the figure above. That button will be the the button for the device. The battery will be stowed in the larger portion of the device with the upper half of the larger portion being the threw hole for the air intake with the fan and heating elements stowed accordingly in the inlet and outlet portion. This device will allow for multiple batteries like power tool connections that can be connected and detached.

Version 3

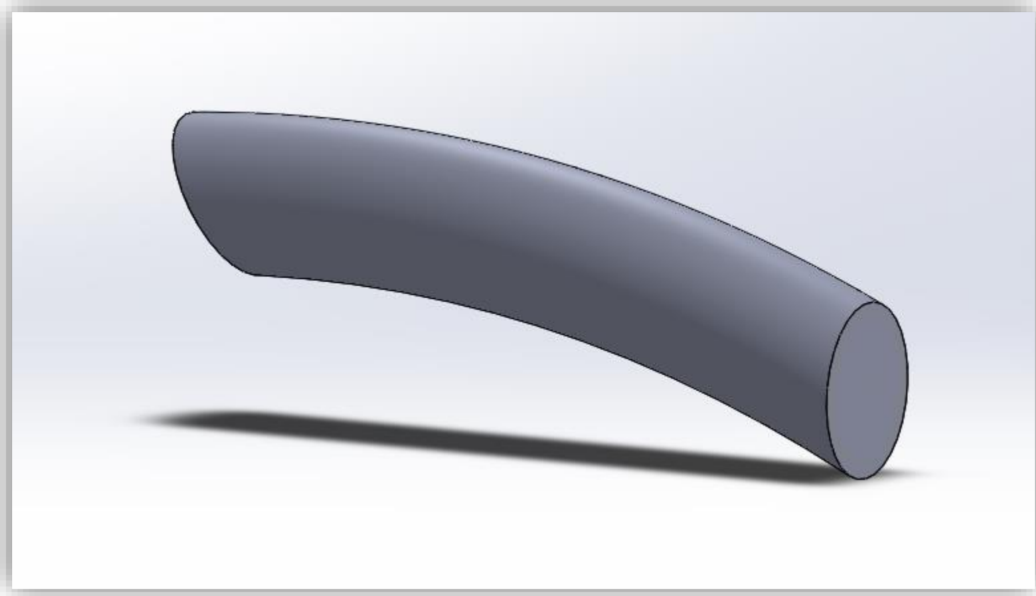

Figure 11: Concept Model 3

Summary

This version is a sleek pipe-like design that will be gripped like Version 2. But this design will not have detachable batteries, so the user must charge the device with the power inlet port. The air will flow in the inlet port with the heating element and fan motor in line with the device. This is a much smaller and sleeker profile than the other versions to aid in user portability.

Final Design (Version 4)

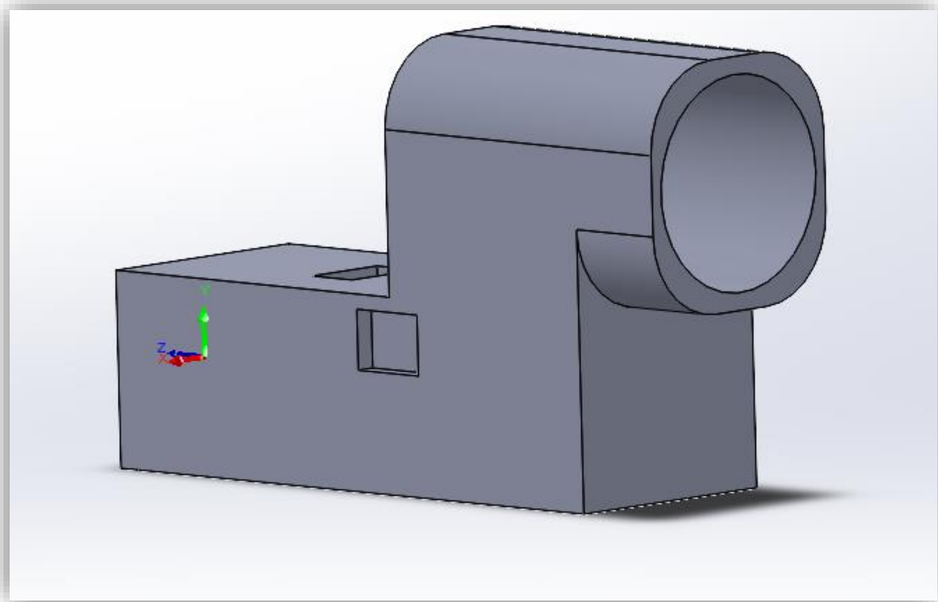

Figure 12: Final Design - Model 4

This final version of my design has been based on the size of the components that I have selected for the fan/heating element and the battery which powers the device. The device is about 7.5 inches in length, 2 inches in width, and 4.5 inches in height. This has been a combination of all my concept designs but most similar to version 2 seen above. The heating element goes in the top cavity and the battery goes in the bottom cavity of this housing. The on/off switch is on the right side and the voltage reader with sound alarm goes on the top face of the battery cavity.

Conclusion

The current technology is missing one key element which separates my design from the rest. Mobility/ Portability of the technology. If you take similar designs of the current state of the art and make it portable to be used directly at the source of the issue. This is the exact portion of the market that I am trying to hit. With the ease of application at the source of the issue, this allows the user to solve the issue of wet/cold gloves as soon as the user is experiencing such effects. With plenty of different groups of end-users, this design has the potential to be used not only in recreation but in the industry to protect the hands of plenty of hard-working individuals.

ENGINEERING CALCULATIONS

Energy Calculations

12 Volt System	5200 mAh Lipo Battery Pack
150 Watts = 12V x 12.5 amps	12.6 Volts 50 C discharge rating 5.2 Ah / 12.5 Amps = 25 min run time

MANUFACTURING DRAWINGS

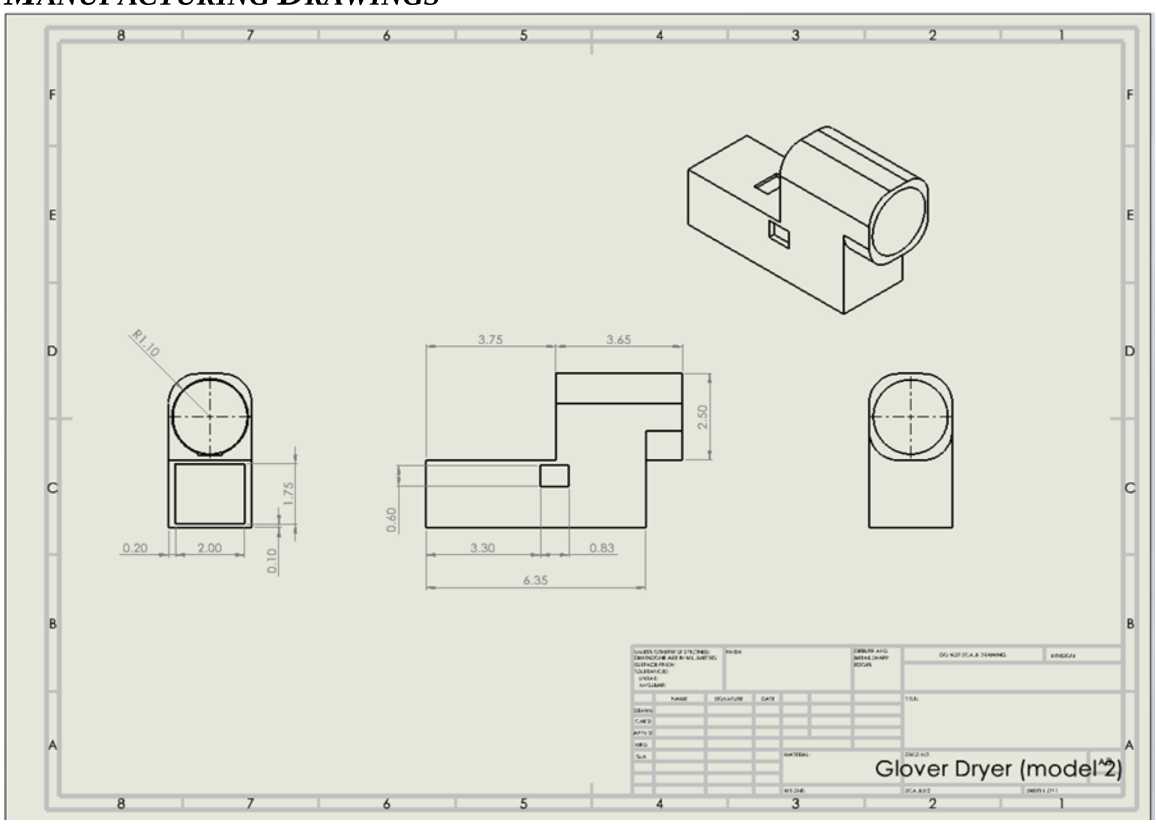

Figure 13: Engineering Drawings

BILL OF MATERIAL

Item	Quantity
12 Volt Heating Coil and Fan	1
5200 mAh LiPo Battey Pack	1
Custom Housing	1
On/Off Switch	1
Battery Charger	1

Table 1: Bill of Materials

BUILD AND TEST

DISCUSSION OF THE MANUFACTURING PROCESSES UTILIZED

- <u>Housing</u>
  For the manufacturing of the housing, I chose to utilize the 1819 Innovation Hub 3-D printing capabilities. Simply by designing the housing in solid works and then sending in the file to the facility and choosing the Industrial FDM PLA material which has a stronger print than standard FDM PLA. The print was completed in 2 days and then picked up the following day. The design came out to meet my prototype standards. This would not be the final material in a functioning product ready for market I would utilize injection molding and thermoplastic for durable housing and ease of manufacturing.

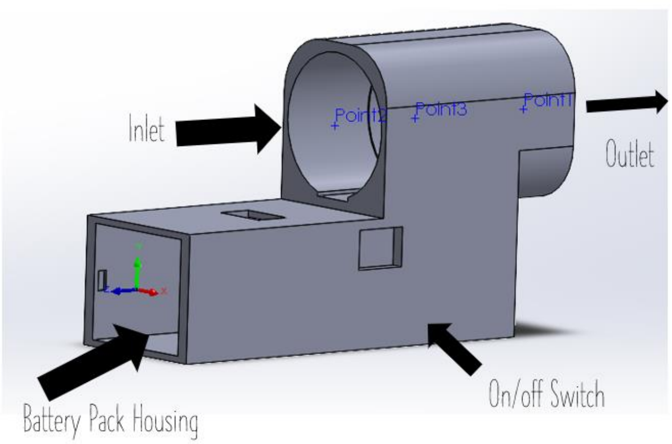

Figure 14: SolidWorks Housing Design and 3-D PLA Print

- <u>Battery</u>
  The battery selected for my design was an off-the-shelf LiPo battery. This provided me with a safe/reliable power source that met my design power needs. I initially

design a 18650 lithium cell design that also met my desired power needs but I didn't use this for my design simply due to the nature of the custom battery design and safety concerns. For a final product design, I would utilize the 18650-cell due to its durability and capability in low-temperature applications.

LiPo Battery Pack	18650 Lithium Cell
	

Figure 15: Battery Selection

- Heating Element and Fan
  The heating element and fan was an off-the-shelf 12-volt hair dryer off of Amazon. This worked great for my design as a working prototype. The assembly was not the best that you could get on the market, but it did the job. For a future model, I would do a customer heating element and high voltage fan to get more heat and airflow for an improved drying time.

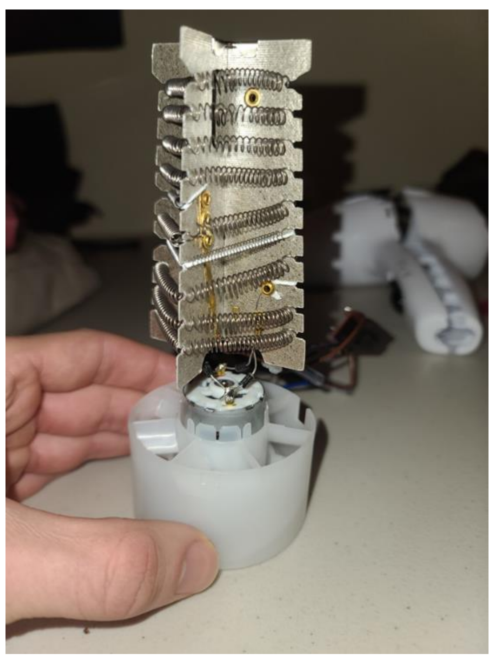

Figure 16: Heating Element- Nichrome Wire and 12 Volt Fan

TEST PROCEDURE AND CRITERIA

For the testing of the device, I was testing to find a benchmark for how much time it would take my device to dry a glove from a certain moisture level. This required me to have my device dry gloves at different moisture levels. With a damp glove always having different levels of moisture I used my judgment based on my knowledge of getting gloves wet while skiing.

Moisture Level in Glove	Time Until Dry (Minutes)
Lightly Damp	5-10 min
Medium Damp	10-15 min
Heavily Damp	15-20 min

Table 2: Testing Results

TEST RESULTS AND FINDINGS

After running my initial testing, the results came back favorable as being able to dry the glove as intended. The only variable that leaves me questioning my testing method is ambient temperature input into the device. I ran the test with an ambient temp of about 60 degrees. But if the user were using the device in extremely cold temperatures this would theoretically lower the output temperature of the device. Thus, possibly compromising the capabilities of the device to dry a glove. For a design improvement in the future, I would add a temperature gauge to the device that would auto-adjust the heating coil’s output temp to adjust for the variable ambient temperature.

PROJECT MANAGEMENT

BUDGET, PROPOSED/ACTUAL

Project Budget Limit
The project is being personally financed so I would like to keep this project under $200
R and D budget: $50 examining used hairdryers buying off Facebook to better understand heating coils.
$150 to build a working prototype. I am hoping UC lets us have access to the resources that we are paying for and not receiving this year.

Actual Budget
Research: $50 in hairdryers to take apart and learn heating elements and wiring
Design: $100 in batteries and chargers
$50 Heating element and fan
$75 Housing 3-D print design
$50 tools for build

Total: $325

SCHEDULE, PROPOSED /ACTUAL

Proposed
10/10/2020: Began examining hair dryers to understand the heating coil process and fan.
12/30/2020: Have a semi-working prototype for testing this winter.
3/01/2020: Adjust design based on prototype usage in winter.

Actual
10/10/2020: Began experiments and researching heating coil and batteries.
3/10/2021: Working prototype and materials orders for assembly.
4/01/2021: Final Design assembled and tested.

SUSTAINABILITY AND MATERIAL USAGE

Improvement 1: Detachable Battery

Having a detachable battery from this housing design improves the design in multiple ways. The first benefit is that you can quickly swap batteries and extend the capabilities of the device to be able to dry more gloves for the user. As well, making the device more portable due to being able to split the device in half and into two different pieces. Thus, allowing the device to be carried in separate pockets making it much more portable and promotes the device to be carried in a pocket and used as intended.

Improvement 2: Increased Voltage for Heating Element and Fan
One thing that I noticed for my current design was that the dry time could be improved by a higher heat and increased airflow. This could be accomplished by a higher voltage application which would allow increased power by the fan and heating element. This would require me to personally design a heating element and most likely find an off-the-shelf electric fan motor for the custom design.

Improvement 3: Better finger protection and electrical shock prevention

My prototype did not have protection for the fan or heating element. This was due to just simplicity in the design and achieving a working prototype. For a final design, protection would be a must to be able to take this product to market.

CONCLUSIONS

The portable glove dryer did meet the capabilities of being able to portably dry a glove. With the 12 Volt drying element and fan being a low voltage viable drying element. This was able to be portably powered by a LiPo battery which was an energy-dense battery selection capable of powering the device. Simply being able to dry a glove with a portable powered device was my problem statement that needed to be solved, and this was met at its most basic level.

As for meeting all the engineering characteristics, this was not the case, I was not able to design a detachable battery for the first iteration of the design. Which would vastly improve the device's charge ability and portability. I utilized a LiPo 3S battery charger and did not have a simple micro-USB battery charger.

Engineering Characteristics

Met	Not Met
Fast Fan	Removable Battery
Powerful Heating Coil	Standard USB-C Charging Capabilities
Quality/Thick Plastic for Exterior Shell	Circuit Breaker/Shock Protection
Compact Design	Wrist Strap

Table 3: Engineering Characteristics

Throughout the design process for this product, I attempted to utilize as many off-the-shelf components as possible that I could use to save myself both time and money. With this mindset, I was able to choose both my heating element, fan, and battery as off-the-shelf components. As for the housing did a custom design based on the dimensions of my components and designed it in SolidWorks and then printed it at the 1819 innovation hub. I chose the industrial-strength PLA as my printing material and the housing came out as intended for my design. Throughout the testing, the device performed as intended and I noticed some design improvements that I would do if I were to redo the project.

The first design improvement that I would do is to design a detachable battery. This would improve the device in multiple ways and I would also utilize the 18650 lithium cells due to them having a larger battery capacity and perform better in low-temperature environments. With an improved battery, I would step up the voltage to allow the fan and heating components to have more power and thus increasing its drying capabilities. I would also add a small clip for the glove to attach onto the device while drying so the user would not have to hold the glove in the proper drying position while using the device. I would also design proper finger guards for safety while using to protect both the components and the user.

Overall, the design process was a huge learning experience for me individually designing the idea and then stepping through the proper steps to have a working prototype for the design. The entire build went smoothly and there were not many large obstacles that I ran into throughout the design process. Even with all the covid restrictions, this made resources from the university limited. This simply required me to be more innovative in my process and be more self-reliant to design the device.

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APPENDIX A

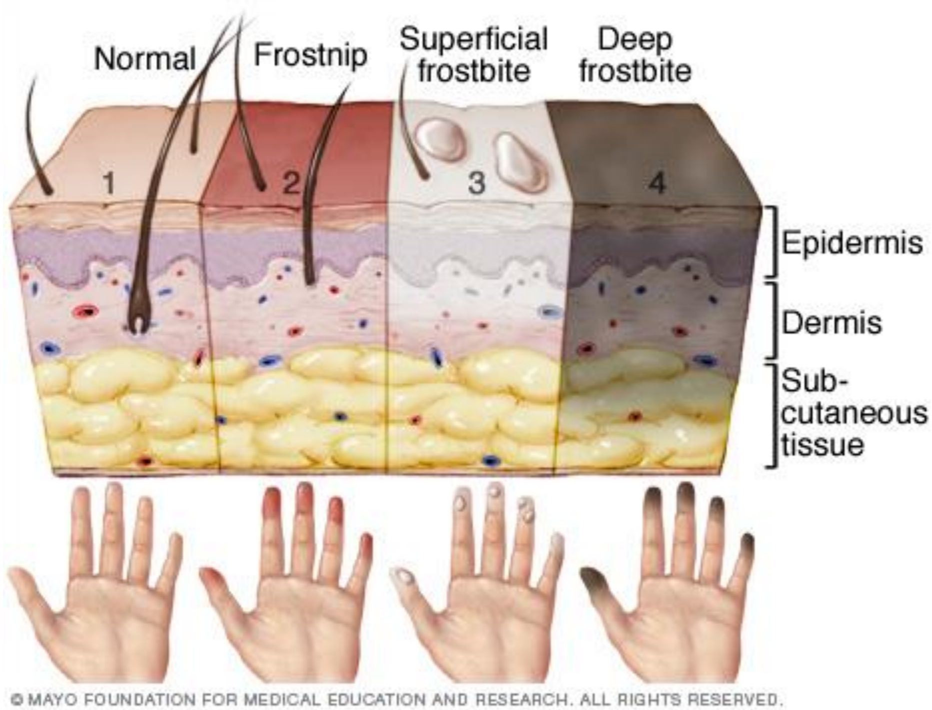

Figure 1 – (Different Severities of Frost Bite)

Figure 2 – (Real Image of Frostbite)