White Paper

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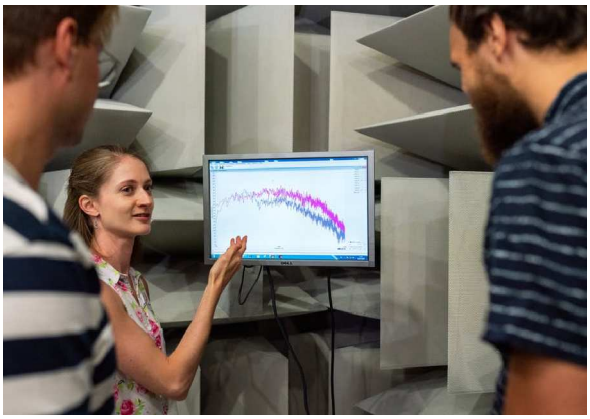
Executive Summary



Solution:
The Rime Systems personal vest is designed to cool down an individual for the purpose of preventing heat-related illnesses. This vest is designed for hot environments where water and other traditional resources used for cooling can be scarce. Our personal cooling vest is designed with electronic components that do not require large amounts of electricity. This design also does not require water for the cooling process which conserves a precious resource in the targeted environments. This also reduces the weight of the product, which is a key aspect for people that have to carry it while working all day.

Customers & Users:
Targeted toward the personal protective equipment (PPE) industry, the Rime cooling vest will assist those who are prone to heat-related illness due to their environment. We have constructed the business plan around the initial market including construction and mining industries, due to the large number of industrial workers who need relief from dangerous environments. As our business continues to grow, our market will expand into the rest of the PPE industry, reaching from humanitarian aid organizations to the military.

Business Personnel:
Our team is perfect for taking on this project because we have a wide range of skills and experiences. Every member of our team is driven by a passion for helping others. Mentors with decades of experience in the fields of engineering and business supply the team with the resources needed to bring this product to life. An end goal of improving the lives of those facing hardships is more than achievable with the help of our mentors as our business grows.

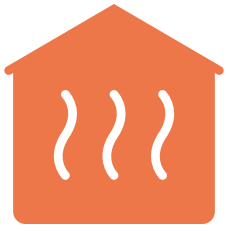
Value:
Because of the reliability, our product has over any competitors, we expect that the industrial industries will see the value that our device will provide for people in these hazardous conditions. We expect that our gross margins from sales will be around 57%. The company is expected to have a break-even point between our first and second year of operations. Rime Systems is surrounded by possibilities for market expansion in the future. All indicators point to our company having long-term profitability.

Next Steps:
We currently have plans to begin testing the device in the field and create a redesign before taking this product to market in the fall of 2022. This field testing would be critical in creating a device that will be able to help people in these harsh environments. We will continuously improve our design while expanding into other markets in the near future.

The Problem

Around the world, millions of people are exposed to extreme heat. Although some may escape the brutal temperatures thanks to air conditioning or ventilated shelter, many populations are not as lucky. In some cases, the human body's natural method of cooling is not sufficient, and those who are not equipped to handle these conditions often suffer. Exposure to these extreme temperatures can result in heat-related illness, whether that be dizziness, loss of concentration, fatigue, or fainting. In the most extreme cases, heatstroke can cause permanent brain damage or even death. As the climate continues to change, the cases of extreme temperatures will increase, and more people will be affected.

Extreme heat is dangerous and even life-threatening, yet life must go on for many people in vulnerable populations. Refugees in refugee camps have few cooling options in suffocating heat; their tents have little ventilation and many suffer the effects of heat exhaustion. Construction workers in the Middle East work with heavy gear and machinery in temperatures that cause dizziness and fainting. In areas near the Persian Gulf, many workers are required by law to take breaks mid-day to avoid peak temperatures due to the dangers of exposure.



Solution

`The Rime Systems Personal Cooling Vest

The Rime Cooling Vest uses proprietary cooling technology to efficiently dissipate heat from the user. Every component in the electrical system is held in the hard box enclosure. The thermoelectric cooling is spread across the back of the user using highly conductive fabric. Using rechargeable battery power, we power Peltier devices to create a cooling effect that will dissipate across a thermal sheet. The heat will be prevented from going off the back through insulation. Bringing the heat to the electronics enclosure, it is vented out of the case.

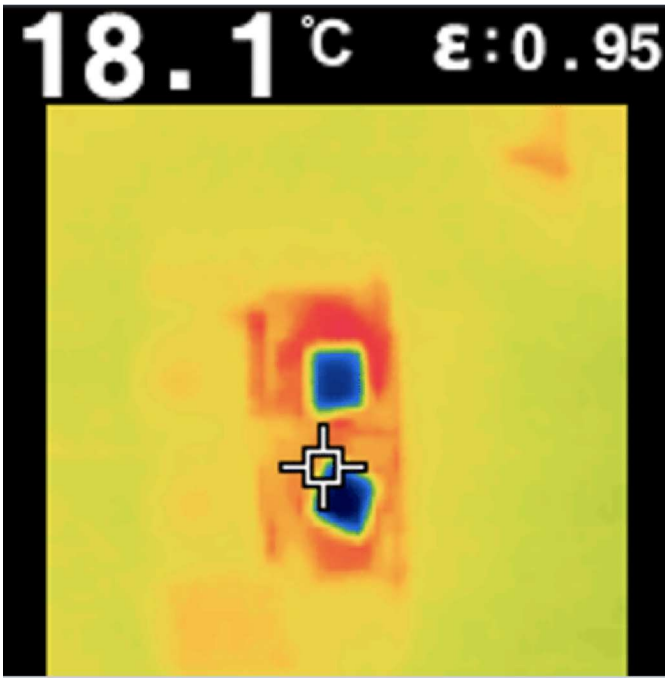
Designed with all body sizes in mind, the vest has elastic velcro straps along either side and both shoulders to ensure adjustability in more than one area. The main parts of the vest are made out of nylon ripstop, which is a durable, lightweight, and tear-resistant fabric. When the user puts on the vest, they will zip the zipper along the front for maximum security.

From there, the user will turn on the vest, and the electrical system will begin its cooling process. The heat will be dissipated from the user and the lower temperature will be spread across the cooling layer, and in turn, will be spread across the back of the user via physical contact.

Design Priorities and Requirements

When designing our cooling vest, we determined priorities and requirements we needed to include in our design:

- Fits a wide range of body sizes: We wanted our vest to be highly adjustable in order to be comfortable for anyone in a size range of an S-M.
- More efficient and reliable than other cooling methods: Our team began our electrical system design with the hopes of being the first to develop this specific technology.
- Lowers user's body temperature: The main goal of our cooling vest is to effectively lower the user's body temperature in hot environments.
- Is comfortable: In order to truly be applicable in real markets, we wanted to make our device comfortable. This meant using breathable and soft fabrics, multiple adjustable areas, a lightweight electronic enclosure, ideal vest design with no protruding seams or edges.
- Works in high humidity: Some cooling methods such as air conditioning do not work in high humidity conditions. We designed our device to be able to work at both dry bulb and wet bulb temperatures, meaning that the cooling effect can still be achieved at high humidity levels.
- Is safe to touch: Due to the fact that our device will be regulating heat flow, the heat that is dissipated from the user will need to be placed elsewhere. In the electronic enclosure, heat will be localized while ventilation is occurring. Because components in the enclosure will get hot, our team researched "safe to touch" temperatures. We decided that we did not want any exposure to temperatures above 130 degrees Fahrenheit, and designed the enclosure to follow that.



Design Overview

The Vest

The vest includes various fabrics for different purposes. The base fabric of the vest is Nylon Ripstop. This fabric is what many parachutes are made out of and is very tear-resistant and durable for this reason. The type of Nylon Ripstop our team picked is also lightweight and breathable. All of these qualities were necessary for our team when selecting our main vest fabric, which is why we selected Nylon Ripstop.

The adjustable parts of the vest across both sides of the torso and along both shoulders utilize an elastic nylon cotton mix. This fabric paired with strong velcro allows for maximum adjustability. The user can either stretch the elastic and secure it with the velcro to fit as a larger size or secure the velcro in a shorter position to fit as a smaller size.

To increase adjustability even further, we included a zipper down the front of the vest. While this ensures that users will be able to get the vest tight to their body, it also allows them to take the vest on and off without having to release the velcro straps.

The Electronic Enclosure

The electronic enclosure was designed using Fusion360 and printed using a Markforged 3D Printer. This type of 3D printer allows for extremely smooth edges and accurate dimensions, which was crucial for our high-fidelity prototype.

The enclosure was designed to fit all of our electronic components as a functional system. To do this, our team selected all of our components initially and designed the system, and then based our AutoCAD design on it.

Our team decided that a lightweight enclosure would be critical for our product. In order to achieve this, we designed our electrical system to have a limited number of components, and limit the weight of the enclosure to below 7 pounds. This guaranteed the vest to be comfortable even with the electronic enclosure attached. We had to restrict the number of batteries included in the system due to the fact that they contributed largely to the weight of the enclosure, meaning that there is a tradeoff between power/battery life and weight. The team found a balance between the two and went forward with this compromise.

Manufacturing

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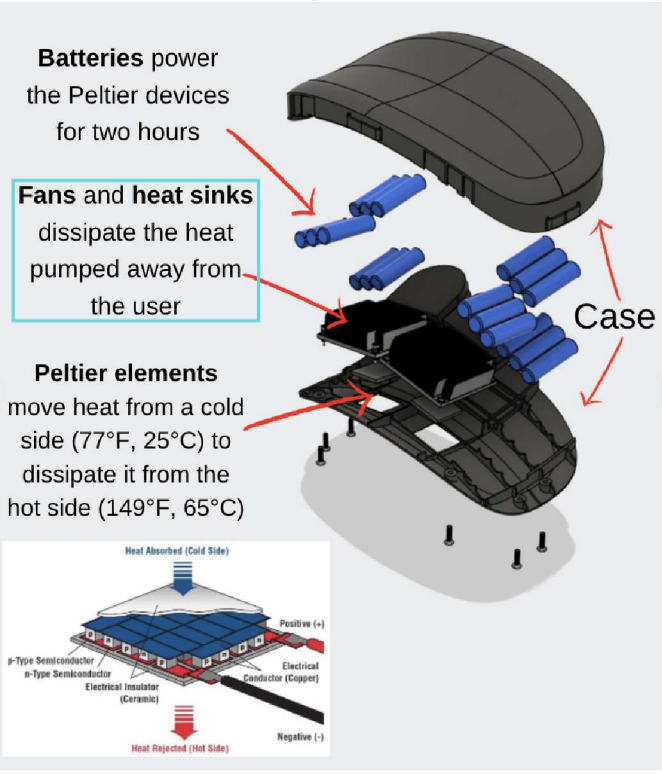

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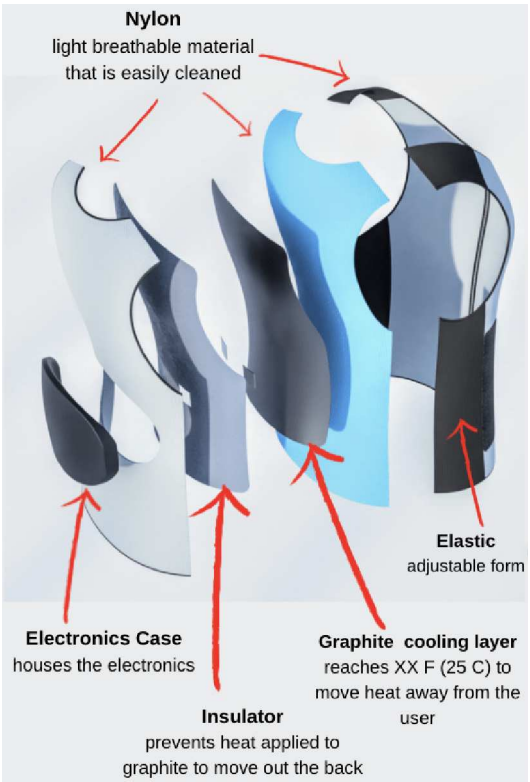


Testing

Testing the key functions of our project was essential to ensure our design goals were met and identify how to improve in future iterations. The key design aspects that needed to be tested were the comfort for various users and achieving the cooling effect with our electronic components. Testing underwent multiple iterations

Vest Comfort Test

Testing the comfort of the vest is necessary to ensure the form-fitting aspect of our design is effective and does not create discomfort for the user. The purpose of our design is to increase the comfort level of the user through cooling, which is achieved by having our electronic components pressed firmly against the user's back. The purpose of this test is to identify if the vest does achieve a snug fit for various body sizes and identify any issues with the comfort of the form-fitting design. These issues would then be addressed in the next iteration of the vest design.

We found all users felt little to no restriction with sitting, walking, or breathing. All but one user found little to no restriction on waist mobility. All users felt adequate contact with the enclosure to their backs, and 90% of users felt a moderate to a very comfortable fit with 10% finding the fit somewhat comfortable. 90% of users found little to no chaffing/fabric rubbing on skin, and 80% of users felt moderate to high ease of stretching with the device on. In the comments of the test users reported that the shoulder straps were loose making the upper half of the vest loose.There were also comments on the amount of velcro on the front of the vest causing some sweating on the belly and bunching up when sitting. In the initial test before user testing, one of the loops from the vest to support the enclosure came undone, which was then addressed by extra reinforcement.

These results guided our discussion for the next iteration of the vest design. To address issues with the shoulder straps we will shorten the length of the straps to prevent the loose fit of the upper body and bunching of the straps. For the amount of velcro on the belly/front, we will remove velcro from the chest area and create slits with no velcro to allow for a curved fit when seated. To address concerns about chafing, we will narrow the fabric on the chest to allow for a wider range of motion for the arms that will not come in contact with the vest fabric.

Electronics Test

Electronics testing began when components arrived by testing their resistance, capacity, and effect individually. One of the main lessons learned through the initial inspection testing was that the Peltiers used for our cooling effect require a method to draw and move heat away from the hot side of the Peltier. If moving the heat away is not achieved, then the Peltier will collect heat on the hot side quickly to the point where it will heat up the cool side of the peltier and fry the peltier, rendering it unusable.

The next iteration of the electronics testing identified the effectiveness of a heatsink and fan combination to draw and move heat away from the hot side of the peltier. This test was done using a constant heat source and checking the voltage of the peltier throughout the test. This test proved that our method of heatsink and fan combination was effective enough to prevent the peltier from being damaged.

Once our method to ensure the peltier would not be damaged was confirmed, we moved on to testing the electronic assembly with a constant regulated voltage power source, then with our selected batteries. These tests checked the voltage of the pelteirs and voltage of the DC to DC converter to ensure our theoretical voltages aligned with the experimental values. The results for both of these tests were that the experimental values performed as expected and could move forward into incorporation with the enclosure and vest design.

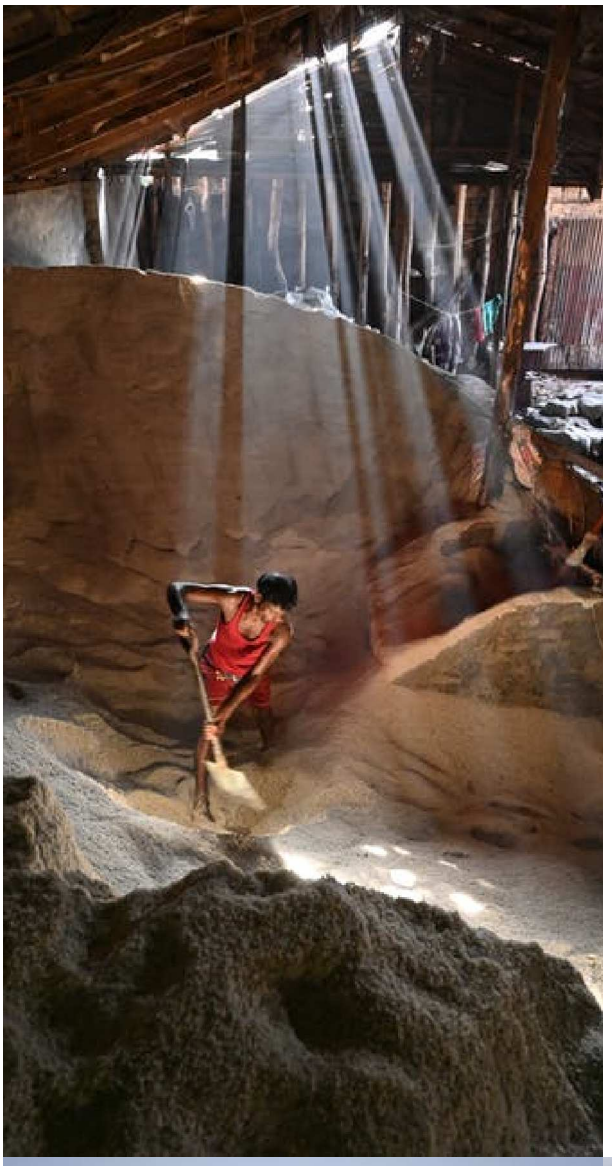
The final testing done on the electronic assembly was to confirm our goal to create a cooling effect with the vest. This test was conducted after assembling the electronics circuit into the enclosure, adhering the conductive layer to our electronics, and finally attaching the enclosure to the vest. Infrared imaging was used to identify the temperature at the contact points of the electronics to the vest, and the temperature gradient along the fabric where the user’s back would be located.

Market Opportunity

Miners

Technology that is most similar to ours is aimed towards a separate sector. And the technology that the competition uses to cool miners and workers is severely outdated and they are in need of a new solution. For terms of market opportunity, this is a large gap in the market and is a good beachead market. The materials for this project are easily accessible and would make manufacturing at any place easy. This would allow us to address areas that heavily rely on mining. The vests will be sent to these mining regions and used for the intended purpose. We have already talked to several mining companies and have confirmed that they are trying to solve the problems that our project addresses. They are interested in the product and would be willing to pay for a device that would work.

There are nearly ___ million workers and miners around the world that would benefit from using our product. Companies would be willing to pay for a product that would help to prevent heat exhaustion and encourage more productivity in hot conditions. On average it costs around $__ to treat heat exhaustion. Our product almost pays for itself with one heat treatment prevented. An industry that deals with dangerously hot conditions is looking for new technology that will prevent more overheating.



Our Users

Our users are hard working people around the world. These people have to work really long shifts in constantly hot environments. Miners are equipped with ice packs to try to help prevent the heat, but those ice packs have usually melted by the time that they get down into the mines. The users are worn out from having to spend their entire day in the mines and are not motivated to do a good job when they are constantly trying to fight off their own fatigue.

Other than miners, the product has a wide range of people that it would be helpful to. It would be helpful to people that live in refugee camps, NASCAR drivers, and construction workers. This amount of users creates a large market opportunity that would be imperative to expand into from a business standpoint. Each of these demographics have outdated cooling systems. A personal cooling device would be helpful to prevent overheating

Team

Ethan Street

Project Manager

Ethan is graduating with a BS in Mechanical Engineering and a minor in Business. He will be moving on to get a masters in mechanical engineering as well as an MBA. He is interested in engineering management and projects that involve renewable energy or solving humanitarian needs.

Jacqueline Solis-Armenta

Testing Engineer

Jacqueline is pursuing a BS in Mechanical Engineering and a minor in Energy Engineering. She will be moving on to work in HVAC as a consultant Mechanical Engineer at 360 Engineering. She is passionate about sustainability and excited to start her journey by helping improve energy use in HVAC.

Paula Perez

Manufacturing Engineer

Paula is graduating with a BS in Mechanical Engineering and a minor in Energy Engineering, and will move on to pursue an MS in Global Engineering at CU Boulder. She is passionate about using engineering in interdisciplinary projects to address infrastructural, health and community needs for underserved populations.

Maia Freedberg

Financial Manager

Maia is graduating with a BS in Mechanical Engineering. She is passionate about utilizing engineering principles and design for social projects and is interested in managing projects that address humanitarian problems in disadvantaged communities.

Aven Hart

CAD Engineer

Aven is graduating in E+ Mechanical Engineering with a concentration in creative technology and design. She is passionate about creativity, sustainability, and using design to benefit the world. In her free time she enjoys drawing, playing the piano, nursing an amateur interest in architecture, and snowboarding.

Alexander Hernacki

Logistics Manager

Alexander is pursuing a BS in Engineering Plus, with an emphasis in Mechanical Engineering and a Minor in Creative Technology and Design. He is passionate about applying engineering to interdisciplinary design projects with an emphasis on industrial design. Alexander has internship experience with circuit thermal management and quality control engineering.

Contact Information

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Conclusion

We aimed to produce a product that would provide effective cooling in harsh environments. Preliminary testing showed that we have reached the goal of the project. The Rime Systems vest will be one of the only products on the market that uses Peltier devices for cooling purposes. The vest will be the only product on the market that effectively cools a large area of the person's body without using fluidic cooling methods. This means that the product is able to cool down an individual much more effectively than an individual. Despite the better effectiveness, the Rime vest will be able to enter the market at a competitive price point of around $500.

With further RND planned, this product will be able to achieve an even greater price point.