Hwa Chong Institution

Project Work

Category 3 Inventions Log Book

Title of Project: SuperChiller
Group Name: SuperChillers
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1. Problem Finding

Firstly, we thought of the community or the general consumers that we were doing the project for. We identified that we were doing for the people with disabilities or sportsmen.

Refer to Annex 1 Figure 1.1 (List of Problems)

After exercising, sportsmen would like a chilled drink. However, they may not find a vending machine or it may be too far away. Even if they bring their own drink from home, under the hot sun, the drink will not stay chilled for very long. If they put ice cubes in their drink, it will make it diluted and not as tasty. When people want a cold beverage, they will add ice to it to cool it down. One example of a beverage is coffee. To turn warm coffee into ice cold coffee, a lot of ice has to be added and in the end, the coffee would only be lukewarm and diluted which makes the coffee weak in taste. If the coffee is put into the fridge or freezer, it will still take a considerable amount of time to be cold enough. Therefore, our product will cool down drinks with zero dilution.

After doing a Decision-Making Matrix, we decided to do a project on the problem of Drink Dilution.

Refer to Figure 1.2 (Decision-Making Matrix)

2. Define the Problem

Primary problem: When people want a cold beverage, they will add ice to it to cool it down. One example of a beverage is coffee. To turn warm coffee into ice cold coffee, a lot of ice has to be added and in the end, the coffee would only be lukewarm and diluted which makes the coffee weak in taste. If the coffee is put into the fridge or freezer, it will still take a considerable amount of time to be cold enough. Therefore, our product will cool down drinks with zero dilution.

Secondary problem: After exercising, sportsmen would like a chilled drink. However, they may not find a vending machine or it may be too far away. Even if they bring their own drink from home, under the hot sun, the drink will not stay chilled for very long. If they put ice cubes in their drink, it will make it diluted and not as tasty.

We did a survey on the problem, asking the respondents questions on the problem of drink dilution. Based on the survey results, the problem of drink dilution is faced by 72.7% of the people, and 85.1% think that it would be helpful that a product be made to solve the problem.

Refer to Figure 2.1, 2.2, 2.3 and 2.4 (Survey Results Pi Charts)

This shows that the problem exists and needs to be solved.

In the market right now, there is a similar invention. It is called the HyperChiller. This available product is specialised to cool down hot coffee into cold coffee. It is not suitable for soda and sweet drinks. This existing product also does not have a spinning function. It is simply three layers of containers without any spinning. However, our invention is different as it has a spinning function , it is for all drinks, and it is more portable.

Refer to Figure 3.3 (Photo of HyperChiller)

3. Your BIG IDEA

SuperChiller has three layers of stainless steel containers to insulate. The innermost layer has ice inside. To cool down a drink, simply pour the beverage into the product. The innermost container will be spun by the motor while the layer in between the outermost and innermost layers will have the drink. Then, drink from the product and enjoy an ice cold beverage.
Refer to Figure 3.1 (Top View) , Figure 3.2 (Side View), Figure 3.3 (Sketch) and Figure 3.4 (3D Model)

The purpose of SuperChiller is to cool down drinks fast. We are also planning for the product to be easily portable to make it convenient for users to chill their drinks.

In the market right now, there is a similar solution, called the HyperChiller. This available product is specialised to cool down hot coffee into cold coffee. It is not suitable for soda and sweet drinks. This existing product has three layers of containers but does not have a spinning function and is not portable, which makes our invention different.

Refer to Figure 3.5 (HyperChiller)

Another similar solution is stainless steel cubes called “Pucs”. This available product will not dilute the drink so the taste will stay the same. Pucs can chill room temperature drinks and bring hot coffee to a manageable drinking temperature. However, it lasts shorter and does not chill drinks as fast as SuperChiller.

Refer to Figure 3.6 (Pucs)

Lastly, there is a machine called ProntoBev that is used for cooling wine. It utilises a special frozen gel and is able to chill drinks down to whatever temperature wanted. It is very bulky as it is a machine.

Refer to Figure 3.7 (Pronto Bev)

Some problems we expected were making the innermost container spin, attaching motors as we lacked experience, and how to obtain stainless steel to make the product.

Timeline:

In February, we did brainstorming and the proposal. In March, we did data collection and the slides. In April, we had a Project Evaluation and started prototyping. In May, we did the first Prototype. In June, we updated the prototype to become the second prototype. In July, we had a Project Evaluation and created the third prototype. In August, we had our final Project Evaluation.

4. Construction Process.

As stated earlier, our product’s material will be stainless steel, due to the fact that stainless steel is a good conductor of heat and is waterproof, therefore our drink will lose heat faster and will not be diluted.

Before use of the product, the user has to unscrew the cap of the product (which is permanently fixed to Layer 1) and flip it over, where there is a screw-on cap on the bottom of Layer 1. The user will then add water and close it. Next, the user will add water into Layer 3 before closing the whole product with the cap and putting it into the freezer to freeze.

To use the product, the user will pour the drink through the opening at the cap. The user will then press a button on the top of the cap and Layer 1 will spin. After 1 minute, the user can drink straight from the opening at the cap or pour it out to drink.

We decided that the volume of the area where the drink would be should be around 500 ml, since a typical canned drink is 330 ml and a bottled drink is 500 to 600 ml.

Calculating the volume of this design,

$$Volume\ of\ layer\ 1 = \pi \times (3cm \div 2)^2 \times 15cm \approx 106cm^3$$

$$Volume\ of\ layer\ 2 = (\pi \times (7cm \div 2)^2 \times 16cm) - 106cm^3 \approx 510cm^3 = 510ml$$

First, we discussed the design. As our product is based on heat loss, the best heat conductor is metal, so we would be using metal for highest rate of heat loss. Also, most products in the market currently which is related to food, use steel as the main material as it is one of the safest materials. We also decided that a motor would be required, as we need it to spin the blades to spin the liquid inside the second container. We also needed wires, batteries and a switch to complete the circuit to make the motor run and the product work. We would use two metal containers and another plastic container trapped with air on the outside so that the inner containers would gain heat less quickly.

We decided to do an experiment to find out what was the best combination of materials for the prototype/product.

Refer to Figures 4.01 and 4.02 (Experiment Set-ups)

Refer to Figure 4.03 (Graph)

Refer to Figure 4.04 (Table)

Refer to Figures 4.05 and 4.06 (Ice melted)

The ice from the set-up with a metal container (Figure 4.05) and spinning mechanism melted evenly into a ball, meaning that the water lost the most heat and heat transfer was the most efficient with this set-up.

Whereas, the ice from the set-up with a metal container and NO spinning mechanism (Figure 4.06) barely melted into a huge chunk, showing that the rate of heat loss and melting was a lot slower than the setup with the spinning mechanism.

One such consideration would be the material of the containers, for example, if we used plastic containers, a poor conductor of heat, the time taken for the liquid to lose heat and cool would be longer, whereas using a metal container, a good conductor of heat, the time taken for the liquid to lose heat would be faster. Thus, we chose to build our prototype with metal containers for faster and more efficient heat transfer to cool down the drink. Thus we decided to do the experiment from above. Thus, we decided to use ready made snack containers to construct our prototype.

Refer to Figures 4.07 and 4.08 (Containers and Prototype 1)

First, we made a small hole in the Redondo cap bigger than the exact diameter of the rod on the motor. Next, we made a hole in the bottom of the Yu Yee Oil container according to the exact size of the rod. Then, we attached both containers through the rod and put the gear in through the other side to lock the Yu Yee Oil container in place. This would ensure only the Yu Yee Oil container would spin without the Redondo cap. With the first step done, we superglued the Con Con Chips container onto the Redondo container to ensure that the two pieces were now one piece.

When testing the motor, there was a lot of screeching and sounds of metal scratching against metal. The motor was spinning at a faster rate than the Yu Yee Oil container, thus the metal gear was scratching against it with a lot of friction and caused the noise. This meant that the hole in the Yu Yee Oil container was not tight enough to make the container spin fast and quiet.

We tried testing the whole product but quickly realised that our motor was not waterproof and if we put water into the Yu Yee Oil container, our motor would spoil. Thus, we decided to test how much mass the motor could carry while still spinning. Due to the immense amount of friction and electrical energy being converted into heat and sound energy, the motor was unable to handle the stress that the weight was putting on the whole item, and spun extremely slowly even with little weight.

Refer to Figures 4.09, 4.10, 4.11, 4.12, 4.13, 4.14 (Prototype 2)

Thus, we decided to do a 2nd prototype and improve on it. We spray painted the containers and soldered the motor, battery and switch together to make sure that the circuit was always in place. However, what we did not realise was that our switch was spoilt, thus it was always on, and the only way to stop the motor from spinning was to remove one battery from the battery holder.

Next, we mixed epoxy and applied it to the gear and the Yu Yee Oil container. This, when dried up, caused the gear and the container to be together as one piece, meaning that the motor would spin with greater efficiency and less energy would be wasted. This also almost completely waterproofed the Yu Yee Oil container by covering up the spaces in the hole and preventing the water from reaching the motor and spoiling it. We also added strong double sided tape on the cap to secure the battery and motor. When tested, there was minimal noise and just a lot of vibration.

Refer to Figures 4.15 and 4.16 (Experiment Set-up)

We then did an experiment on the heat loss efficiency between spinning and no spinning with the product. The results proved that our product could cool drinks down up to 17.5 degrees Celsius with spinning in a short time and the spinning helped to speed up the cooling by a lot.

Refer to Figure 4.17 (Graph)

After the Mid-Term Evaluation, the judges commented that it would be better if we could find a way to allow for the product to be brought out and still be used without the need of ice cubes as ice cubes would need constant replacement, which was inconvenient.

Refer to Figure 4.18 (Graph)

Thus, we decided to make some alternatives that were longer lasting than ice for the product. We did some research and came up with two other alternatives. An ammonium nitrate, calcium ammonium nitrate, urea gel, in the form of an ice pack, gotten from ice-cream packs and a homemade starch salt gel. The homemade starch salt gel has a very low freezing point, lower than the ice pack and ice, due to the starch and salt content. From the results of the experiment, it can be seen that ice and ice pack are both most efficient in cooling the drink down, followed by the starch salt gel.

We also wanted to test how long the different alternatives could stay cold the longest, thus we brought the three alternatives to school to test. At 6.30 am in the morning, all three were taken out of the freezer and put into three separate metal containers. At 1.30 pm, we checked the temperature of all three. The ice melted, the ice pack was no longer cold, but the starch salt gel was still cold. Hence, we decided to make a Decision-Making Matrix to find out which is the best option.

Refer to Figure 4.19 (Decision-Making Matrix)

Based on the results of the Decision-Making Matrix, all three cooling agents had the same score. Thus, we decided to give the user a choice, either to use ice cubes, the ammonium nitrate gel, or the starch salt gel based on the situation.

For example, if the user is going out for a short while (like going for a short workout outdoors) and wants a very cold drink in a short amount of time (about 3 minutes to get very cold drink), he should choose ice cubes. If the user is going out for about an hour (like jogging outdoors at a reservoir) and wants a cold drink in a short amount of time (about 5 minutes to get a cold drink), he should choose the ammonium nitrate gel. If the user is going out for more than an hour (like hiking up Mount Faber) and wants a relatively cold drink in about 7 minutes, he should choose the starch salt gel.

The next improvement we made to the prototype is a straw. Before, the only way to drink from the SuperChiller was to open up the cap and drink from it directly or to pour it into another container to drink, which is very troublesome. Thus, we drilled a hole in the cap and put a metal straw inside that went to the container with the drink, so the user could simply sip from the straw.

Refer to Figures 4.20, 4.21, 4.22, 4.23, 4.24, 4.25 (3 cooling agents and Prototype with straw)

With that, there were no other changes to the prototype, ending the modification process. Thus, this is our final SuperChiller before the Final Evaluation.

5. Modification and Evaluation

Prototype 1

Test Iteration: 1	Tick			Remarks
Test Date: 25-6-2019	Pass	Fail	Potential Failure	This test could not test our product purpose as it was not waterproof and would spoil in contact with water
Sound		✔		Very screechy and noisy
Spin			✔	The spinning was fine without mass although the motor was spinning at a faster rate than the container, meaning that the motor was not efficient and battery was being wasted. With weights (coins), the motor spun very slowly
Waterproof		✔		There are gaps in the hole between the rod and the container, so water will leak and probably spoil the motor

Prototype 2

Test Iteration: 1	Tick			Remarks
Test Date: 3-7-2019	Pass	Fail	Potential Failure	Test for heat loss efficiency
Sound	✔			Little to no sound, just some vibration
Spin			✔	The motor is able to spin when full of water and ice, but it uses a lot of battery. Powerful batteries are required in the long run
Waterproof	✔			No water drips out, just some condensation inside due to the coldness
Cooling drink down	✔			The test showed that even when every minute, the cap was opened to take temperature, the water was able to be cooled down to 19.5 degrees Celsius

Prototype 3

Test Iteration: 1	Tick			Remarks
Test Date: 4-8-2019	Pass	Fail	Potential Failure	Test for heat loss efficiency
Easy to drink	✔			Metal straw added, hole drilled
Ways to cool drink/ alternatives to ice cubes	✔			Ice cubes, ammonium nitrate gel or starch salt gel, giving the user a choice depending on the situation

6. References

References for ideas and photos:

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References for making gel and gel contents:

Art365. (2014, October 09). Retrieved August 04, 2019, from https://www.youtube.com/watch?v=3k210f6aTAU&t=181s

Ice pack. (2019, July 06). Retrieved from https://en.wikipedia.org/wiki/Ice_pack

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- Ramesh from Wong Hing Long Technologies
- Our parents

Appendix

Annex 1 (Problem Finding)

Figure 1.1

List of problems:

- Ohtahara syndrome patients need to be encouraged to exercise
- Diabetic patients cannot eat food with sugar content
- Sportsmen want chilled drinks after exercise but the drinks would not be cold
- Trash bins in Singapore are very full and spill out
- When fruits are put out into the open, they will oxide
- Immobile people require someone or something to support them even on chairs.
- When it rains, clothes hanging outside will become wet
- Laptops become hot when used for too long.
- Drinks dilute when ice is added. Chilling a drink in fridge or freezer takes a long time

Figure 1.2

Problem Evaluation Grid

Considerations for Selection	Problems		
	Drink Dilution	Sports Drink	Laptop Hot
Is it really a BIG problem?	4	2	3
Existing solutions	4	2	1
Is it feasible?	4	3	4
Total Score	12	7	8

Annex 2 (Define the Problem)

Figure 2.1

Figure 2.2

When you put ice cubes into your drink to chill it, do you find your drink diluted after the ice melts?

161 responses

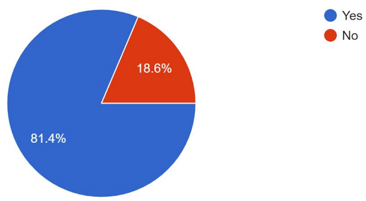


Figure 2.3

Have you ever encountered a situation where you could not find your preferred cold drink?

161 responses

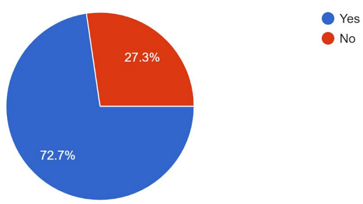
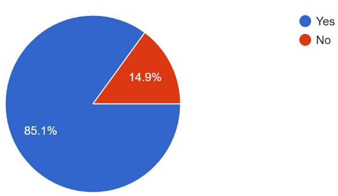


Figure 2.4

Do you think that it would be helpful that a product be made to solve this problem of drink dilution?

161 responses



Annex 3 (Your BIG IDEA)

Figure 3.1

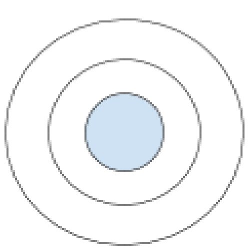


Figure 3.2

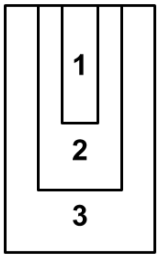


Figure 3.3

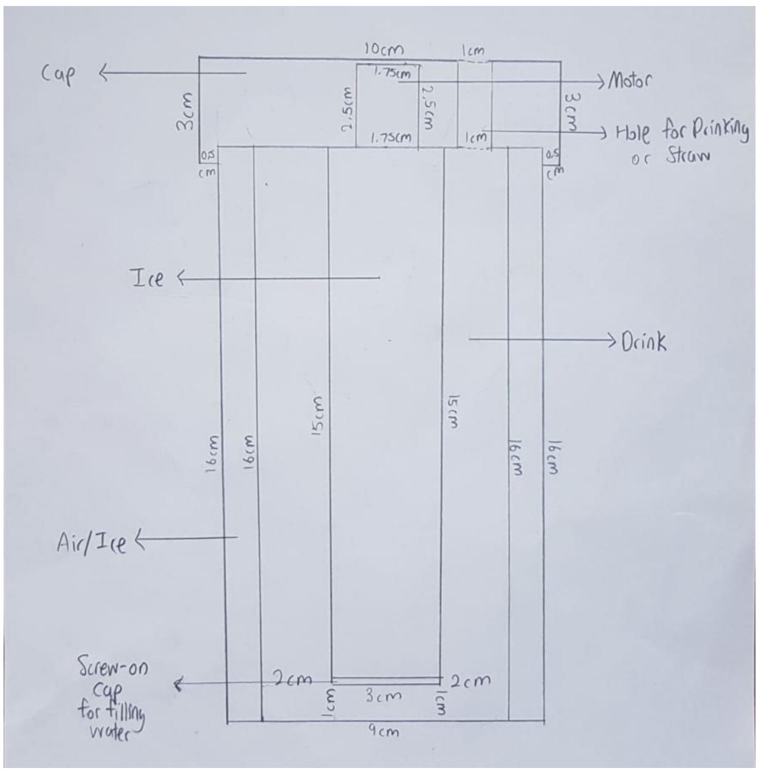


Figure 3.4

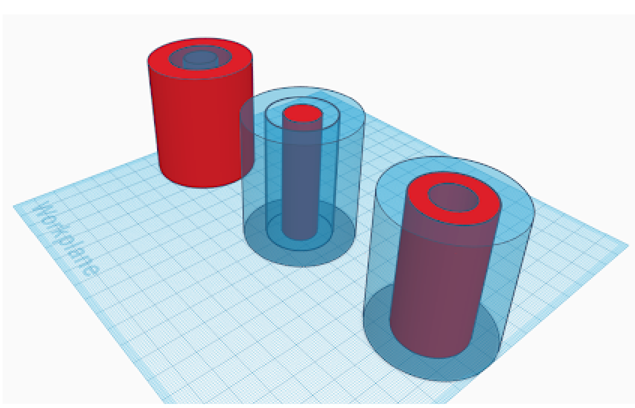


Figure 3.5

Figure 3.6

Figure 3.7

Annex 4 (Construction Process)

Figure 4.01

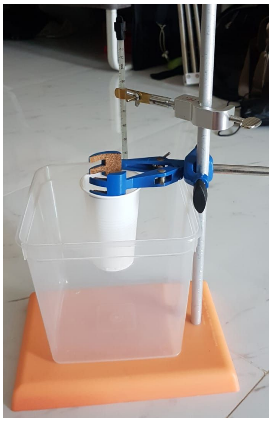


Figure 4.02

Figure 4.03

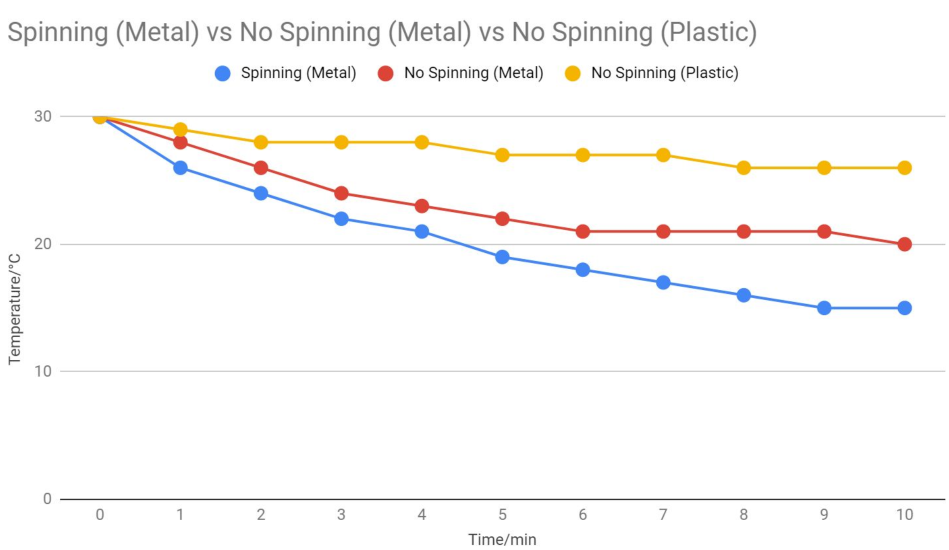


Figure 4.04

Spinning (Metal)		No Spinning (Metal)		No Spinning (Plastic)	
Time/min	Temperature/°C	Time/min	Temperature/°C	Time/min	Temperature/°C
0	30	0	30	0	30
1	26	1	28	1	29
2	24	2	26	2	28
3	22	3	24	3	28
4	21	4	23	4	28
5	19	5	22	5	27
6	18	6	21	6	27
7	17	7	21	7	27
8	16	8	21	8	26
9	15	9	21	9	26
10	15	10	20	10	26

Figure 4.05

Figure 4.06

Figure 4.07

Figure 4.08

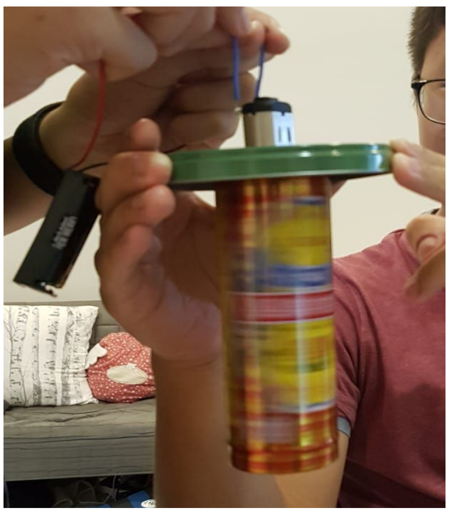


Figure 4.09

Figure 4.10

Figure 4.11

Figure 4.12

Figure 4.13

Figure 4.14

Figure 4.15

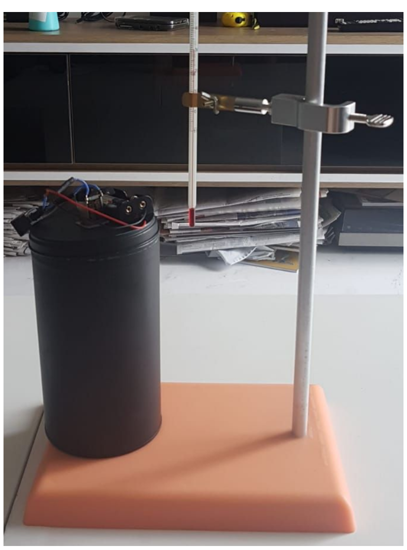


Figure 4.16

Figure 4.17

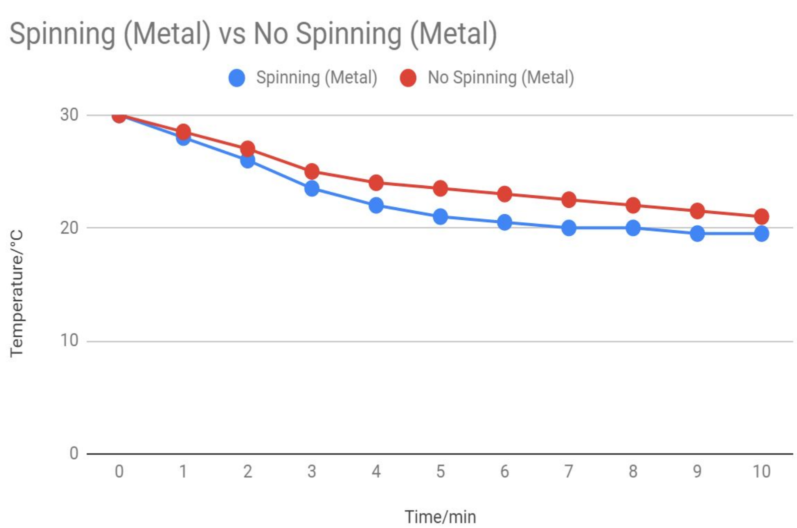


Figure 4.18

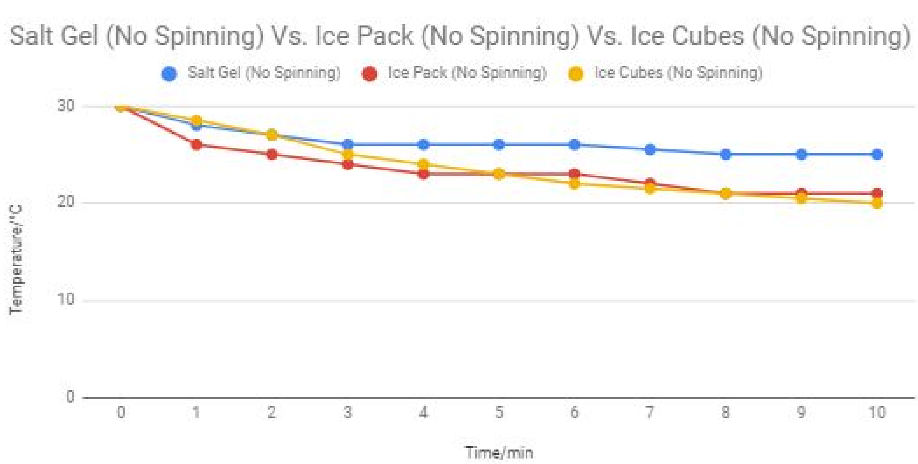


Figure 4.19

1 is the worst score possible and 3 is the best score possible.

Cooling Agent	Criteria		Total Score
	Temperature	Durability	
Ice cube	3	2	4
Ammonium nitrate gel (Ice Pack)	2	2	4
Starch salt gel	1	3	4

Figure 4.20

Ammonium Nitrate Gel

Figure 4.21

Ammonium Nitrate Gel in a tube

Figure 4.22

Starch Salt Gel

Figure 4.23

Starch Salt Gel in a tube

Figure 4.24

Ice cubes

Figure 4.25

Prototype 3