Application of TEC (Thermoelectric Cooler)

Project 1 (Summer Internship)

IDC
May-July 2015
Project report by:

Amol Bhangare
Jinesh Bhaskaran
Neha Thawali

Guide: Prof. Nishant Sharma

Acknowledgements

Prof. Nishant sharma (IDC, IITB)
Dr.Ainapure(IITB Hospital)
Mrs. Anegha Subedhar (Kalwa Hospital)
Mr. Deshmukh (Sr. Staff Dist. Health officer)
Mrs. Shubhangi Deshmukh (ANM IITB- Hospital)
Mrs. Jenifer (IITB Hospital)
Devendra Vani(Godrej)

Declaration

We declare that this written submission represents our own ideas in our own words and where others ideas and words have been included, we have adequately cited and referenced the original sources. We also declare that I have adhered to all the principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. We understand that any violation of the above will be cause for disciplinary action by the institute and can evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed

Name of Students:	Amol Bhangare	Jinesh P Nhaskaran	Neha Tawali
Institution:	IDC	IDC	NID
Roll no:	146390002	146390001	

Date

Approval Form

The project titled Application of TEC (Thermoelectric Cooler by Amol Bhangare, jinesh P Bhaskaran is approved for the partial fulfillment of the requirement for the degreeof Master of Design in Product Design.

Guide:

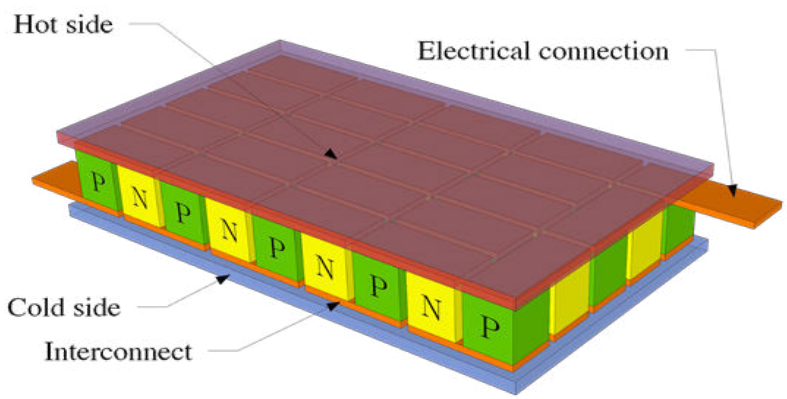
Internal examiner:

Date:

Contents

I. Introduction

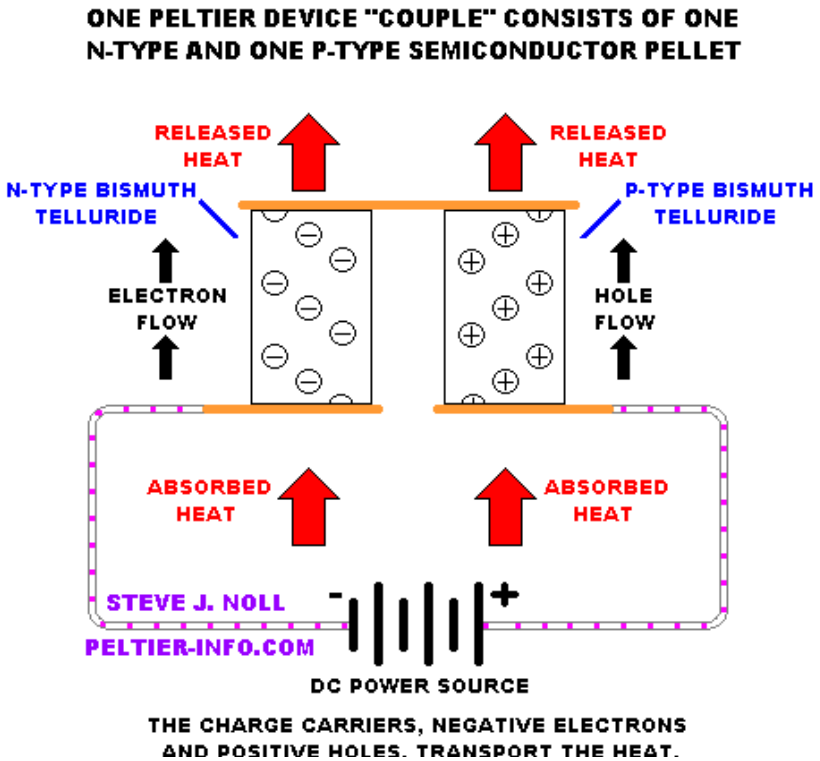
The intention behind this project was to study and analyze Peltier's effect and based on the insights, to create and realize an innovative application for the same.



1. About Peltier

The Peltier effect is named after Jean Charles Peltier who first observed it in 1834. The Peltier effect is a temperature difference created by applying a voltage between two electrodes connected to a sample of semiconductor material.

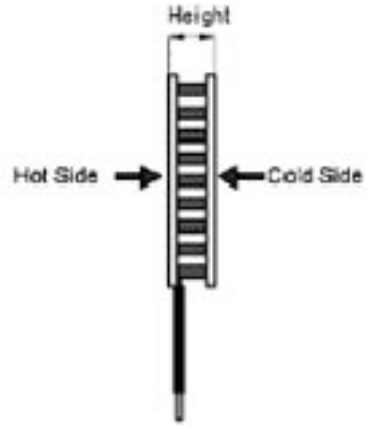
Thermoelectric cooling uses the Peltier effect to create a heat flux between the junction of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). It can be used either for heating or for cooling,[1] although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools

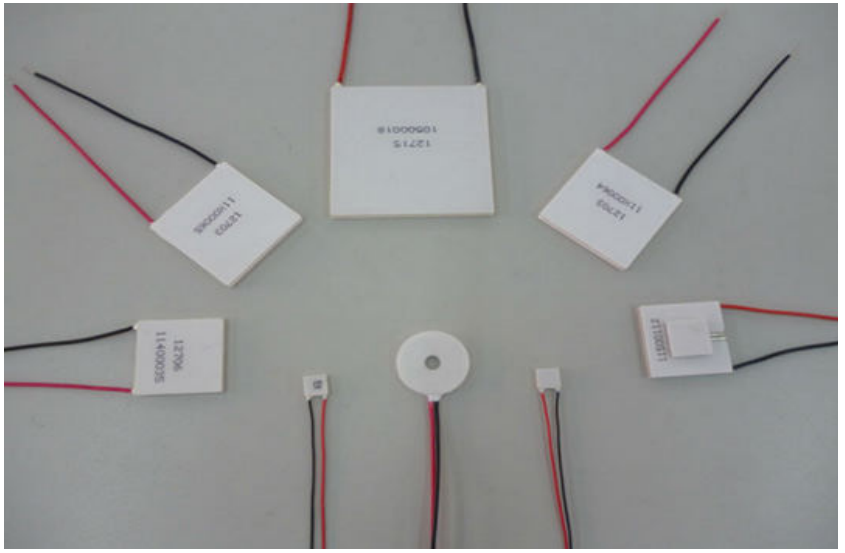


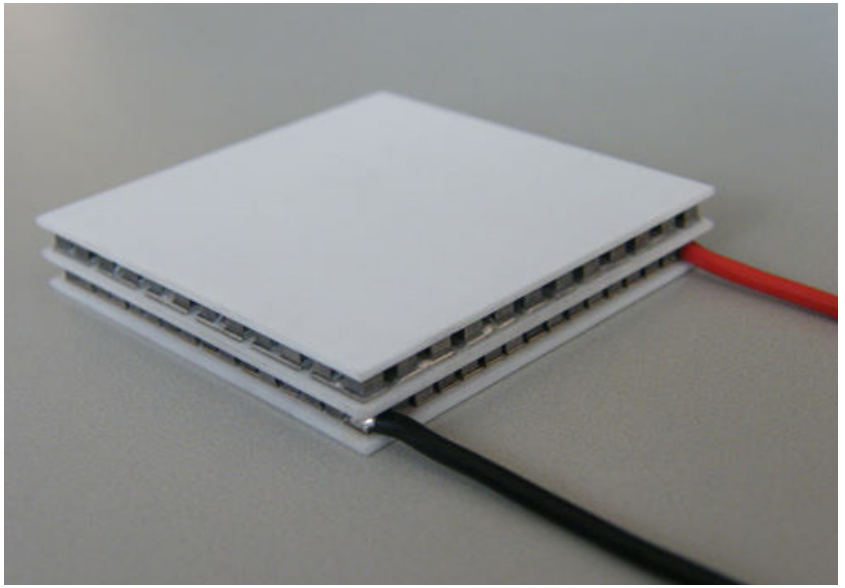
1.1Typical Product details

TEC1-12706-Cooler-Thermoelectric-Peltier-92Wmax

- Type number: TEC1-12706
- Couples: 127
- Vmax (V): 15.2V I max (A): 6A
- Tmax (degree Celsius): 67
- Dimensions: 40mm x 40mm x 3.7mm
- Max. power consumption: 91.2W
- Ceramic Material: Alumina (Al 2 O 3), Bismuth Tin (BiSn)
- Package Contains 1 X Thermoelectric Cooler 5 X Thermal Paste Sachet

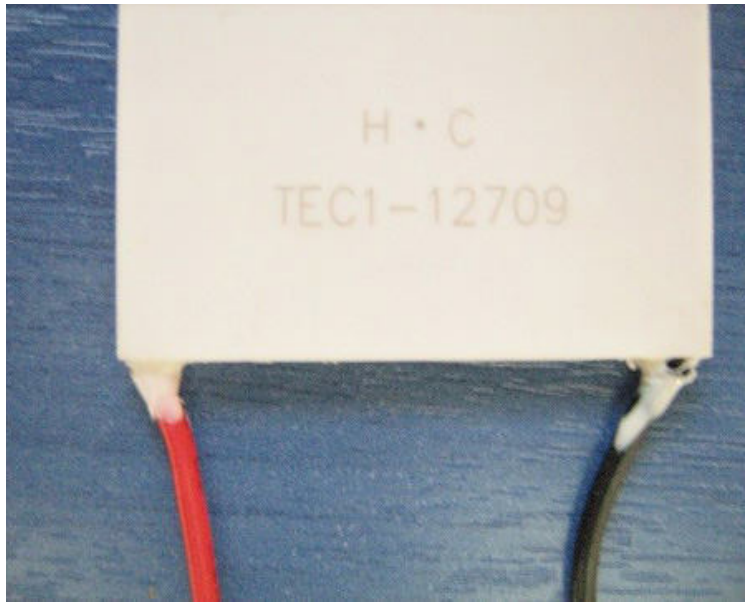




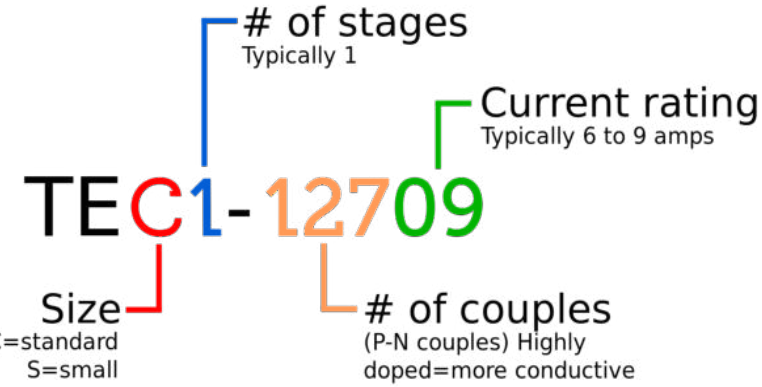


1.1. How to identify?

In this picture you see the ID: TEC1-12709



- The first two digits shall be always "TE"
- The next digit shall be "C"or"S". "C" stands for standard size and "S" for small size.
- The following digit is a number and indicates the number of stages that the TEC has. In our example (and the vast majority of TECs) is a one-stage TEC
- Right next comes a dash. After the dash, the 3 first digits indicates the number of couples that the TEC has inside. In our case it has 127 couples. If the couples are 2-digit, then the number has a leading zero, for example 062 for 62 couples.
- Next comes two more numbers that indicate the rating current of operation for the Peltier. In our case this is 9 Amperes



II. Objective

To find an effective application of peltier (TEC) in improving everyday life.
Possible areas of application explored

SELF COOLING BOTTLE

MILK STORAGE UNIT FOR INFANTS

VACCINE STORAGE UNIT

III. Research on existing products

1. COOLEST

The COOLEST is a portable party disguised as a cooler, bringing blended drinks, music and fun to any outdoor occasion.
the product comes with a powerful blender, usb charger, blue-tooth speaker, led lid light, cutting board,bottle opener, 20v li-ion rechargable battery. Is a kickstart project by Ryan Grepper.

Coolest measures just about 26" (L) x 21" (W) x 19" (H) and has 55 quarts volume inside. With all the gadgets included, the Coolest weighs about 30 lbs (without ice).

There are two separate removable, rechargeable lithium-ion batteries: one that powers the blender/USB port/lid light, and a second within the Bluetooth speaker.

When you first receive your Coolest, we recommend you charge the batteries fully. This can take three to four hours for the main lithium-ion battery and about an hour for the speaker.

All batteries with the Coolest are 100% reusable and recharge-able. The main battery pops out from underneath the lid and charges on a charger dock from a wall socket (a car adapter is in the works).

2. INSULIN STORAGE

Dison diabetic mini fridge is battery operated, was designed to provide a convenient and affordable way to keep medicines (such as insulin or other medicines that are injected) at a safe temperature during:

•Travel
•Work and Home
•Vehicles and Outdoors

Features:

Support DC12V DC,AC110V~240V,7.4V battery, Battery ensure more than 12 hours working while no vehicle power or household power. keep insulin safe for 30 days under ambient 40C. Large LCD display,show the time and refrigeration temp clearly,interchangeable between C and F. Antifreeze function, Environment friendly:Using thermoelectric refrigeration.

•Refrigeration space 170*46*18mm

•Dimensions (L*W*H) 187*80*68mm

•Refrigeration temperature 2~8°C (under ambient 25°C)

•Current (vehicle power) 2A

•Voltage (lithium battery) DC7.4V

•Capacity (lithium battery) internal 2300mAh/external 8200mAH

•Power rating 7.6W/DC9.0V,5.9W/DC7.4V

•Product Net weight 540g

•Battery working time:Battery working 12 hours under 35'C,battery is interchangeable and rechargeable.

Price: $232.59ww

3. MINI MEDICATION REFRIGERATOR

Portable solution for-

Vaccine, biological, blood, specimen or other heat-sensitive medication distribution and turnover on outdoors;

Suitable for-

Individual, immunization stations, health centers, CDC, Bureau of Animal Husbandry, etc

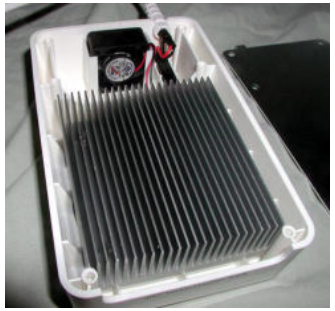
Specifications:

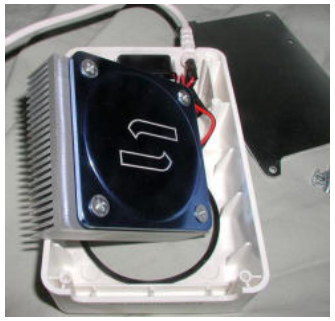
1. Support AC110~240V, DC12~24V, 7.4V battery;
2. Keep 2-8`C under ambient 32`C;
3. 1.5L big capacity, portable, only 3.5kg;
4. Per battery working 6~8 hours under 35`C
5. 400-500 US $

4. USB BEVERAGE CHILLER / WARMER

Product Description

The USB Beverage Chiller / warmer is the way to keep your drink cold or heat it while you are at your computer. Plugs into your computers USB port.





Cooling temperature : 7 deg
Warming temp : 112 deg

Current : 1.2 amp

Weight : 500 grams
Dimension : 16 X 10 X 4 cm
Peltier used : 12704
Price : Rs. 2000

Cons:

Noisy fan
Inefficient contact
Expensive
Condensation
Extracts more current from the port than its scope.

The less soda in the can, the more effective the CoolIT chiller is at keeping the contents cool. When the can is full, the unit is of little use. But as the can goes down to half full and less, the unit becomes increasingly effective.

5. CHOTUKOOL (MINI FRIDGE)

Gross Capacity : 35L

Connection Voltage : 110-240V AC or 12V DC

Power Consumption : 62W

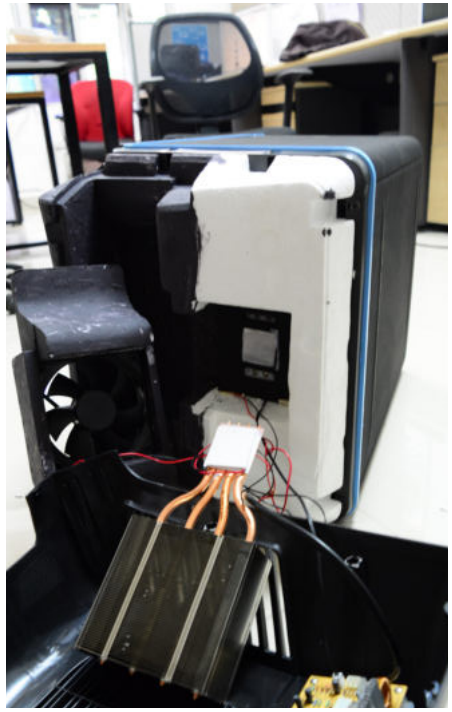
Cooling capacity : 28°C drop from ambient temp.

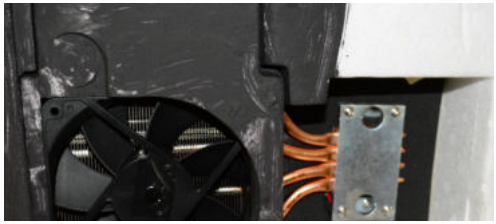
Weight- 7.3 kg

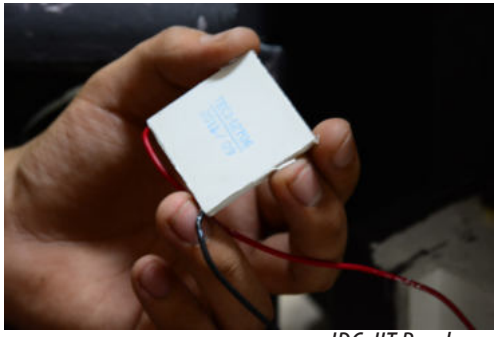
Dimension : 736 x 431 x 383 mm

Peltier used : 12706

Radiator and copper tubes used for better conduction & cooling.







IV. Self-cooling water bottle

Self-cooling water bottle

A bottle which can be a lifestyle accessory for a professional, or a sport person and which should match their personalities. Today there are bottleas and coolers which are far apart in an office space. It should be in one place so this concept can make it into one. A Bottle which can preserve the chillness of your drinking water till you consume the last drop.

Hydration is vital to an athlete's performance, and usually the liquid consumed is cold, because not many people find a warm beverage to be refreshing during a workout. Few studies have investigated how the temperature of the ingested liquid effects performance and core temperature during an exercise session

A recent study published in the Journal of the International Society of Sports Nutrition investigated the effect of a cold beverage on core temperature and performance during an exercise session.

The study included 45 physically fit adult males who completed two 60-minute exercise sessions per week in a moderate climate. The sessions consisted of a 5 minute warm-up with dynamic stretching, 5 minutes of medicine ball exercises, 35 minutes of full body strength training, and 15 minutes of conditioning. The participants consumed randomly assigned cold or room temperature water during rest periods. Every 15 minutes core temperature was measured using an ingestable thermometer. Upon completion of each exercise session 3 performance tests were performed: bench press to fatigue, standing broad jump, and bicycle time to exhaustion.

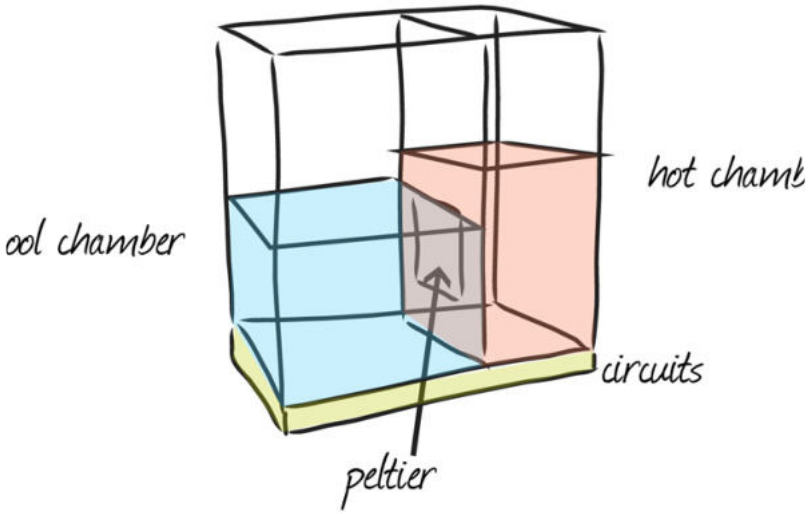
The results of the study showed that both groups significantly increased their core temperature during the exercise session, and demonstrated a significant decline in hydration status. The participants who had consumed the cold water during rest periods had a significantly smaller rise in core temperature compared to those who consumed the room temperature water. The cold water consumers were able to delay their increase in core body temperature for at least 30 minutes, while the room temperature consumers increased body temperature from baseline after just 15 minutes.

This self cooling bottle concept can provide optimum temperature water to the athlete or the man/woman at the gym.

1. Initial experiments

Apparatus : Aluminum heat sink, Fan, 12706 peltier

Purpose : By arranging the Peltier and the heat sinks in different order, we tried to find the most effective placement for the

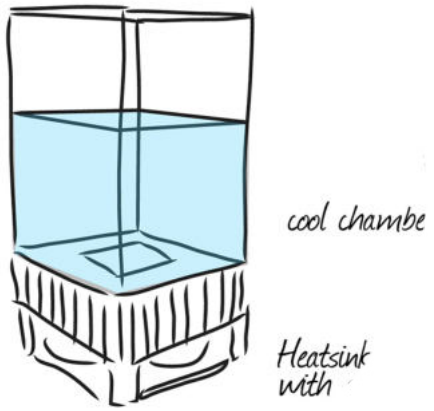


1.1 First Arrangement

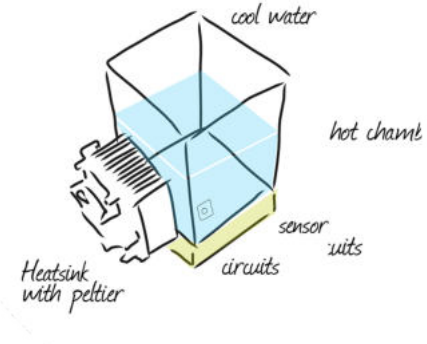
A simple set up with two compartments, where the cold side of the peltier meet the water to be chilled and the other side to other chamber where the water will take out heat from the peltier

Cons: The system hit an equilibrium after certain point where the cold side started to gain heat from the hoat chamber

1.2 Second Arrangement



In this we put the peltier at the bottom and this time with a heatsink and cooling fan. The cooling effect was fairly good. but the problem with this arrangement was that natural convention was not happening inside the chamber so the hot(room temp in this case) stayed on top and only the bottom part chilled properly.

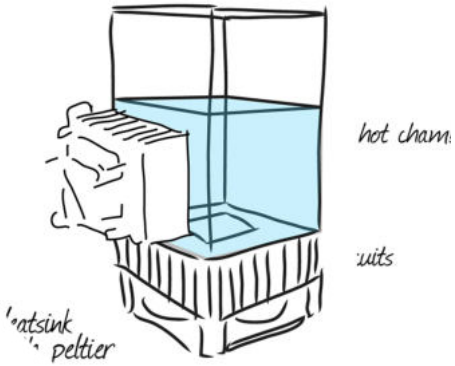


1.3 Third arrangement:

In this the peltier is on the side of the cold chamber and the whole circuitary is placed at the bottom part. The main advantage with this setup was that we achieved natural convention inside the chamber. The cold water will move down and the water in room temperature went up and achieved even cooling throughout the volume.

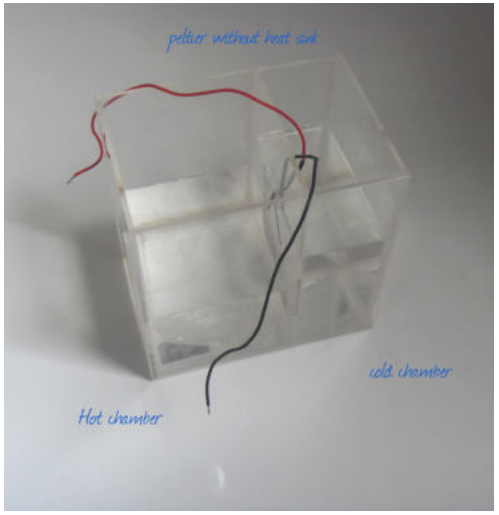
1.4 Fourth Arrangement

After the above observations we decided to put two peltier to one chamber where one helps in cooling the water and other will help in accelerating natural convention. While the side peltier cools the water in the side it will move down and the bottom peltier will cool it again and it will go on.



2. Prototypes

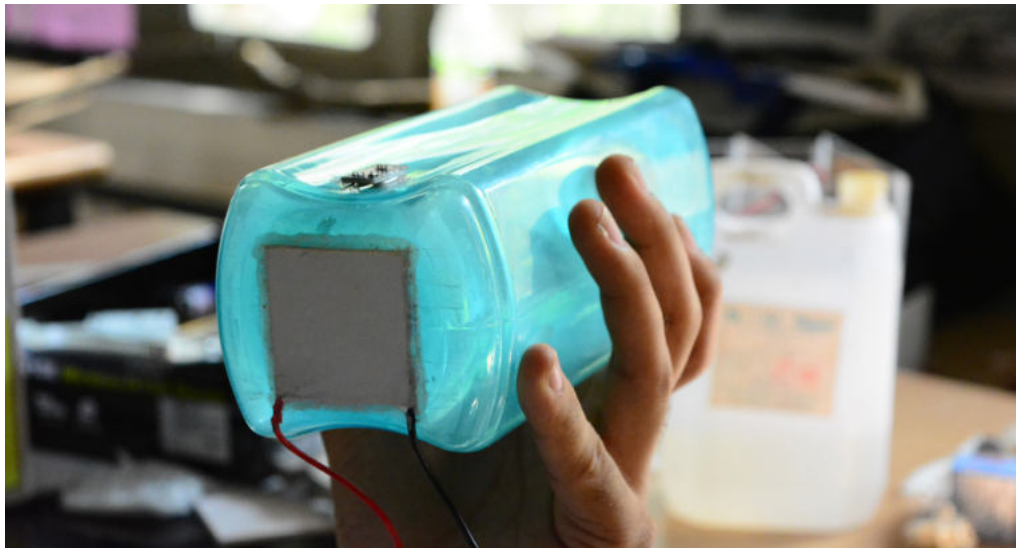
2.1 Prototype 1



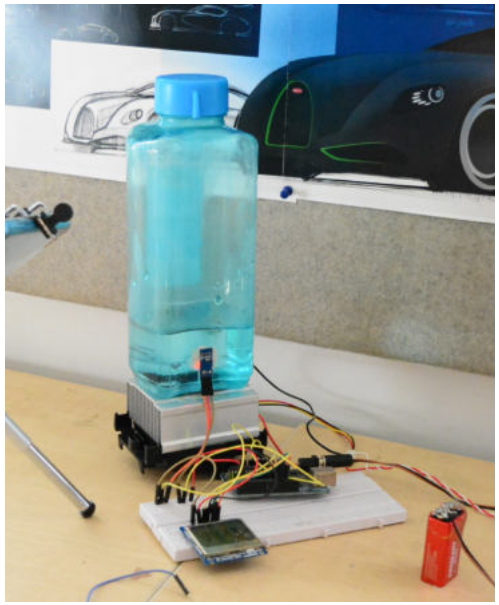
Two chamber arrangement no 1

Single chamber with peltier on wall

2.2 Prototype 2



Current : 12 amp | Voltage : 5 V
Time : 40 mins | Temp reduction : 7 deg



One of the early prtotype with peltier at the bottom, offered reasonable cooling. It had single peltier arrangement at the bottom cooled by a fan fitted to a heatsink. A LCD display arduino set up to measure the real time temperature. Components used

1.Peltier chip
2.Nokia 1554 Display
3.Arduino UNO
4.LM 35 Temperature sensor

Milk container for infants

1. Brief

To preserve milk by cooling and delivering warm milk whenever required by the infants

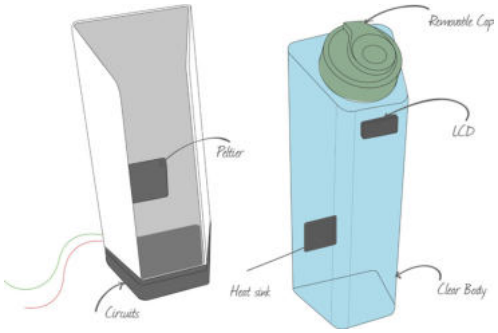
Milk needs to be stored at or below 40°F
Infants are fed with milk which is around body temperature (72°F)
Milk containers require proper sterilization and frequent maintenance and care.
It needs to be protected from light because light destroys some essential components necessary for the baby's growth.

The opportunity lies in making a container which can used to store baby milk at low temperatures especially while travelling. This is particularly important because baby's are usually given a low fat cow milk different from the ones we consume. So it important to carry the same milk while travelling. Besides babies cannot be given very cold milk so there is an requirement to heat the milk.

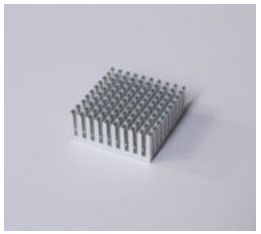
At present, mothers feed their babies with ready to make milk powders which simply require mixing with warm water. This warm water is carried in a thermos. Thus, currently, there is no way of accessing baby milk at required temperature as soon as needed. We can imagine a scenario where the baby is crying and the mother is trying to prepare the milk.

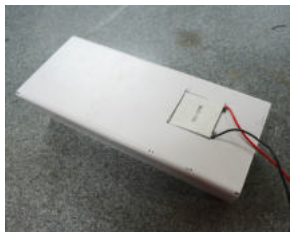
2. Prototype 3

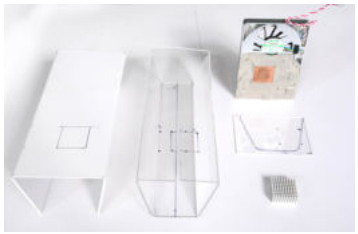
To begin, we aimed at achieveing the temperature for keeping the milk cold.



Components







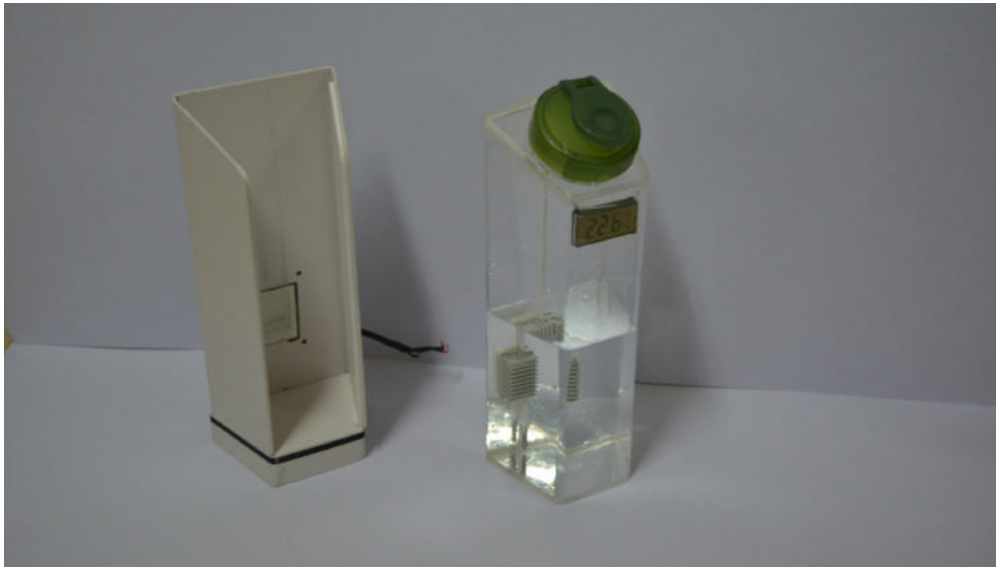
This prototype for the self cooling bottle contains mainly two parts.

1. Cooling unit with peltier heat sink and fan
2. Bottle

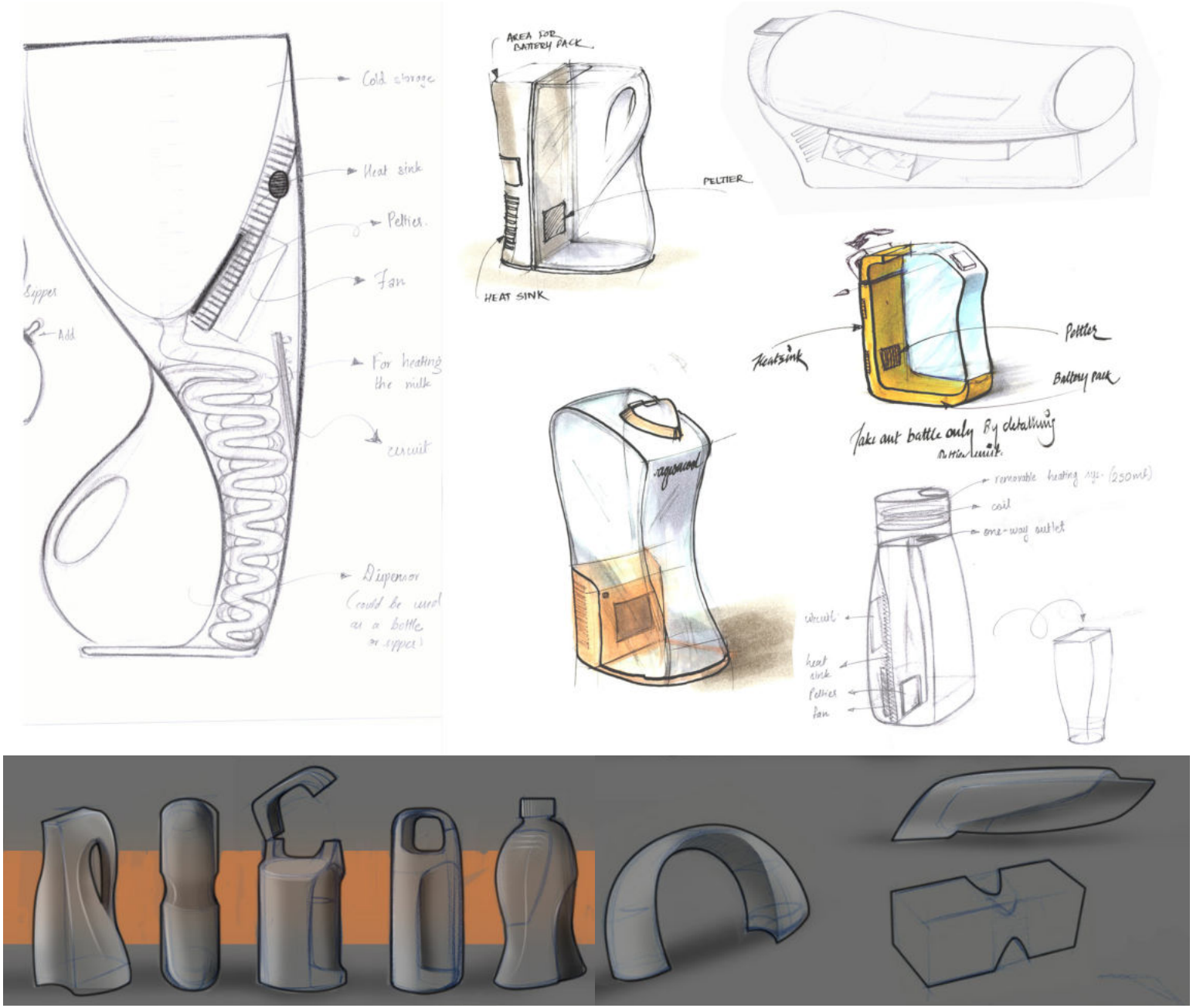
The cooling unit can be kept on table and keep it plugged into the power source. The bottle can be removed from the cooling unit and drink water directly wfrom the bottle. Once you put back the bottle on the cooling unit the temperature is maintained. The bottle also have a temperature display on it's neck.

Mockup featuring seperate cooling unit temperature display and peltier on sidewall

Standalone units



3. Ideation



Concepts

The idea was to have two seperate chambers for the cold and hot milk. The milk will be stored in the cold chamber until required. When needed it will be heated using copper tubing and delivered to the hot chamber which will also serve as a bottle for the infant to drink milk from. A nipple can be attachted to this bottle. The amount of milk needed has to be pre-determined so that the required quantity can be heated. Once heated, the milk cannot be added back to the cold chamber. The main reason for this is that heating and cooling milk again and again leads to thawing which is not desirable.

The othere concept was to use the container as a jug for pouring the hot milk.

Polio Vaccine Container

1. Existing polio vaccine container

Dimensions-

OPV Box : 245 X 245 X 265 mm
Lid : 245 X 245 X 30 mm

Ice pack : 165 X 90 X 35 mm
capacity : 320ml

Health workers carrying polio containers

Ice packs arranged on four sides

Weight : 2.5 - 3 Kg (With ice-packs)
Each box contains 4 ice-packs.

Instructions written on the side

Polio Vials

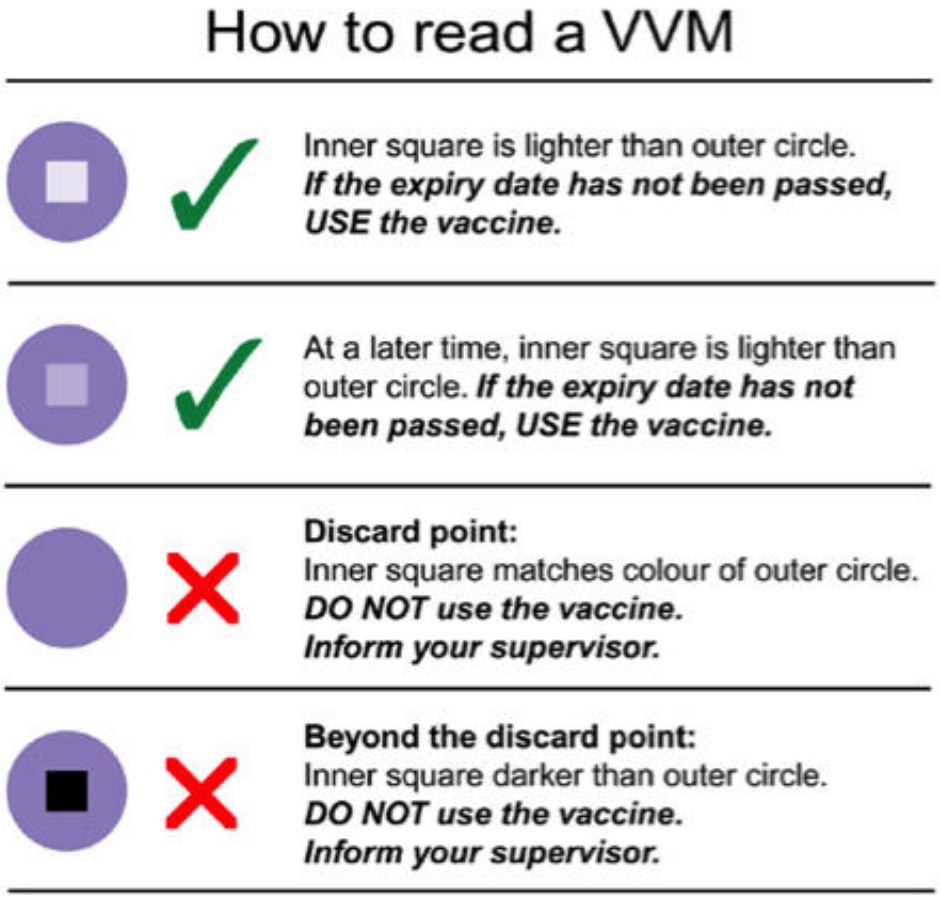
Polio Vials

Amount of liquid in each vial - 4ml

Dimensions :
(vial 1)
D = 21mm | L = 30mm | Cap = 42mm

(vial 2)
D = 16mm | L = 40mm | cap = 30mm

Material : Vial - Glass | Cap - Plastic



Temperaturealert.com,. (2015). Retrieved 6 July 2015, from http://www.temperaturealert.com/Libraries/MISC_Marketing/how-to-read-vvm.sflb.ashx

1.1 Carrier for opened vials

Body : 280X138X62 mm

Thickness=19 mm

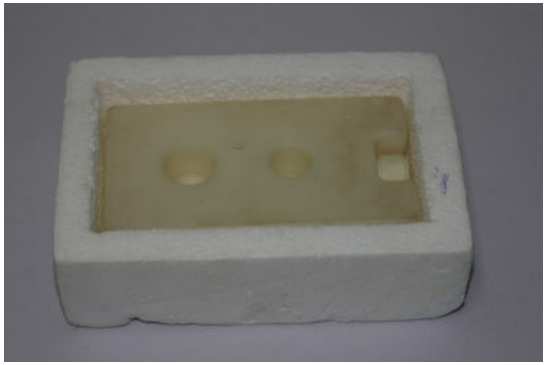
Depth=48mm

Lid : 280138X9 mm

Diameter (hole) = 32 m

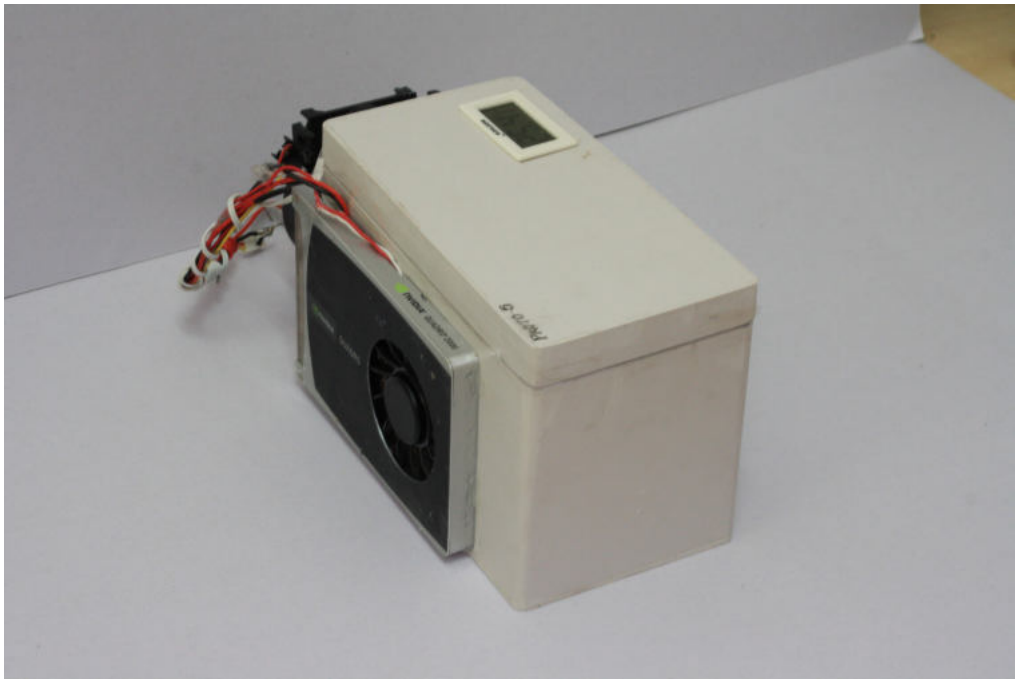
Preserving Time : 5 hours

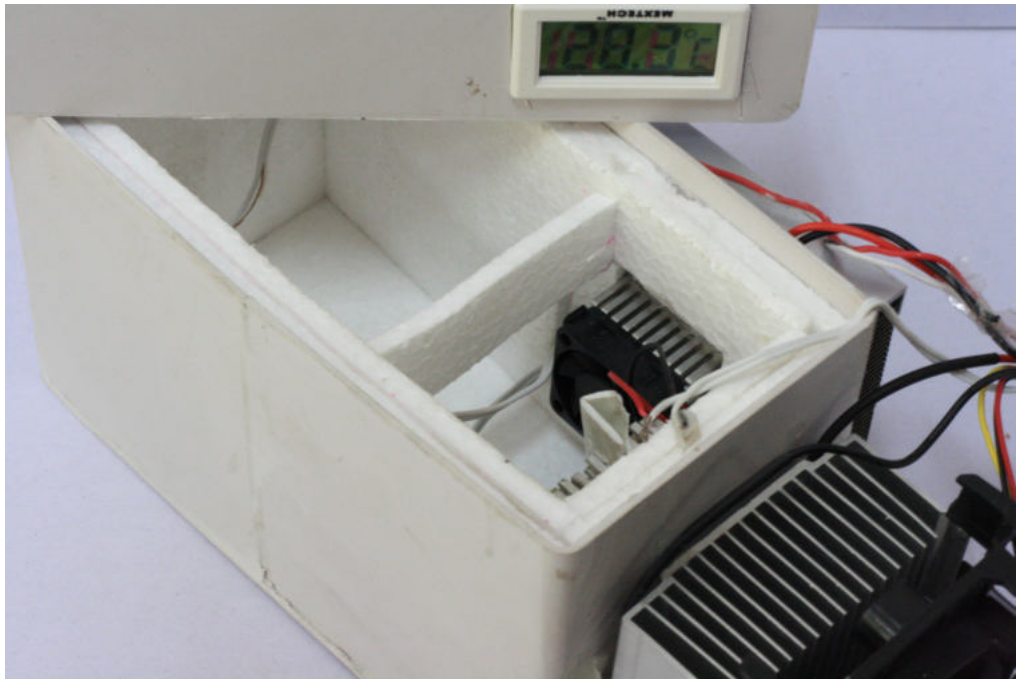
Material : Styrofoam



It contains one standard ice pack (same as used in the OPV carrier). The ice pack has two depressions for two sizes of vials. Depending on which vial is used, the styrofoam top is placed for easy and quick access of the vial.

2. Prototype 4





Two peltier on sidewall arrangement

Two peltier arrangement was effective in earlier experimets so we decided to go with two peltier arrangement for the alpha prototype of Vaccine storage unit. During primary stages we used a fan inside the box to circulate air, later found that the closed system inside was gaining heat from the fan's motor.

Lowest temperature achieved : 15 degrees
No. of Peltiers used : 2
Current : 2A
Voltage : 12V

1. Peltier efficiency test for vaccine storage

Almost all vaccines are store in temperature ranges 2-8 degree celcius. So we did an efficiency test on peltier to ensure that it can achieve that range of temperature.

Storage temperature : 2 - 8 degrees
Shelf life : 4 to 6 months
One vial contains 20 doses
Dimension of the vial : 15mm X 40mm (approx)
Measurement of potency : White dot on the vial

In a water cooled set up peltier can go upto -2.2 degree in a non-insulated environment. With effective insulation peltier can easily maintain temperature within 2 and 8 degree celcius

Temperature display showing -2.2 degree celcius from water-cooled peltier

4. DISCUSSIONS

4.1 Interview with Anagha Subhedar

What is the storage temperature for polio vaccine?
OPV is a very heat sensitive vaccine having a shelf life of 2 years at a temperature of -20oC, 6 months at 2 to 8oC

How long does it stay at that temperature in the box?
One hour.

What happens if the temperature increases?
The potency of the vaccine reduces.

How do you know if its spoiled?
Every vial has a white dot with which we test the intensity of the stored dose.

How much vaccine is stored ?
1-5 no. of vials are carried. Each vial suffices for 20 doses.

How heavy is the box and How costly is it? Very heavy. It is around 1K

How frequently do you visit door to door to administer the vaccine?
Depends upon the population of the town. Roughly around times a week.

How many ice packs do you use? 4 in each box

How long do you reuse the ice packs? Until they get damaged.

What maintenance does the box requires? Nothing until its damaged. Keeping it clean is important.

Essential points to be considered:

The container should be a frost-free unit and should not freeze the vaccine.

Good air circulation around a vaccine storage unit is essential for proper cooling functions.

Should have enough free space around the vials as they are placed in the center where the temperatures are most stable and effective. (In case of air-cooled chamber)

Should maintain stable temperature without fluctuations.

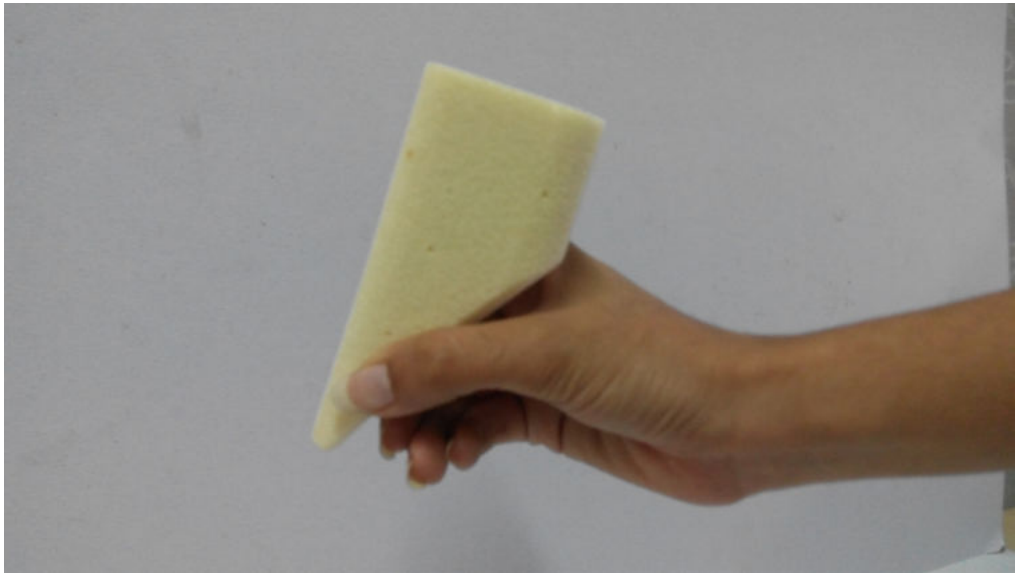
Temperature monitoring is a critical part of good storage and handling practice.

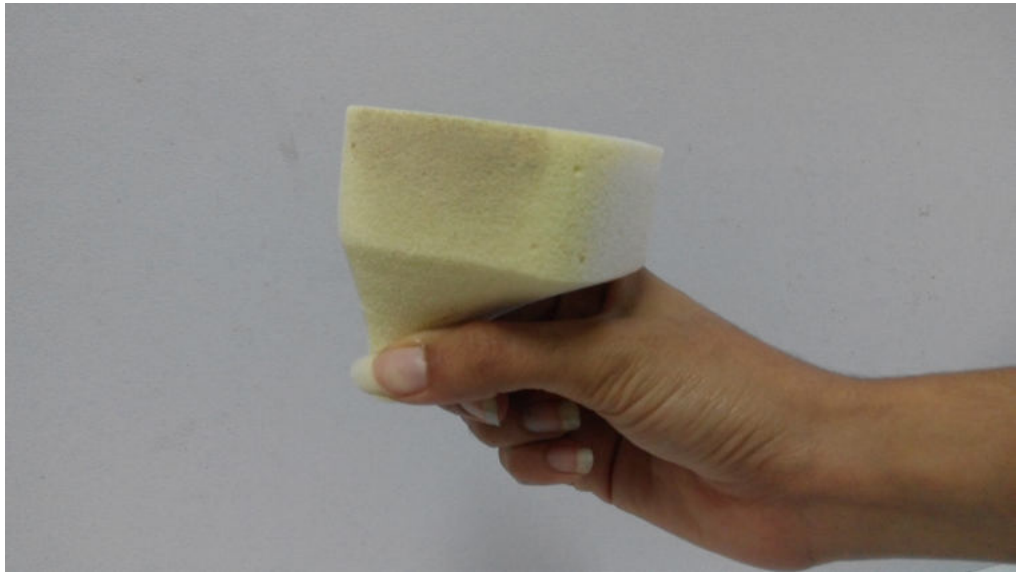
4.2 Interview with Dr. Ainapure

Ideal temp for consuming milk for infants : 30-40 degree Celsius
Breast milk is given upto 1-2 years
Babies can be fed with cow milk minimum after 8 months
Cow's milk is better than any formula milk
Maximum travel time is around 15 hrs. During this time milk powder is convenient.
Breast milk/Cerelac/mashed bananas serve the purpose

Heating chamber may result in high complexity
Cleaning and keeping the container sterile is very important for babies
Making a cooler for storage is more useful
Heating may not be necessary
The scope is very limited
Cost will play a huge role

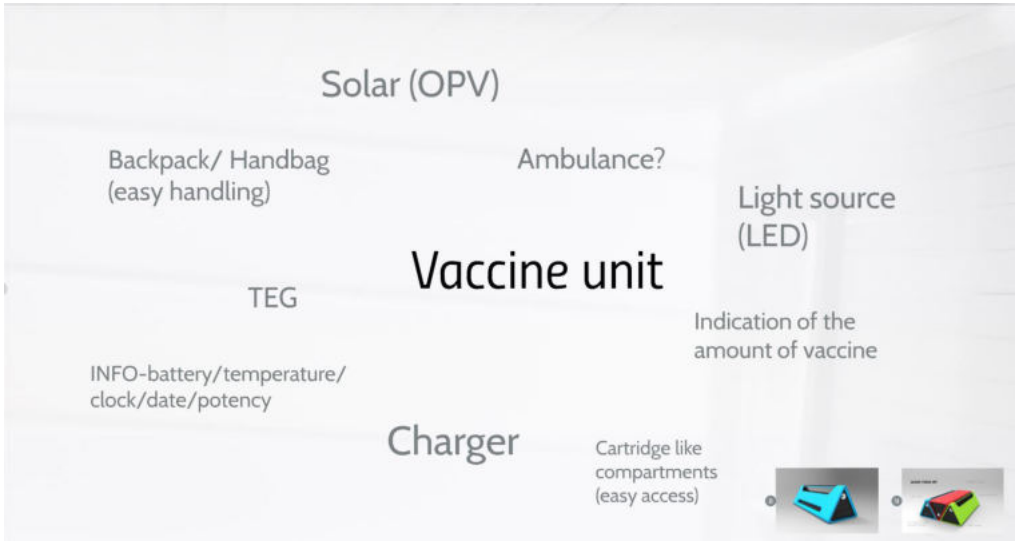
5. Form Study



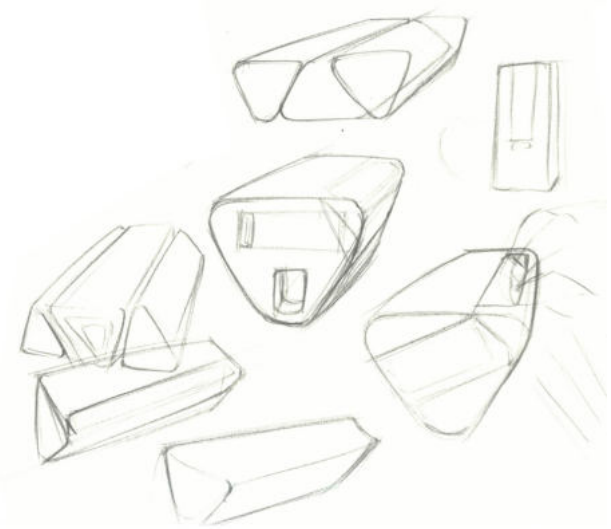


6. Initial Concepts

6.1 All in one concept for polio vaccine



This concept is an all in one vaccine carrier, where you can carry vaccine use a built in LED flashlight and a USB charging port. It also have display which says the temperature inside and time. It can dispense the vials from the side opening. The unique triangulas shape improves stackability.



6.2 Injectable vaccine carrier

This concept have a heatsink in the form of vaccine holder. Peltier , battery and circuitary are placed under the heat sink. The holes in heatsink ensures effective contact area for polio vials. the vial is placed inside the holes made inside heatsink

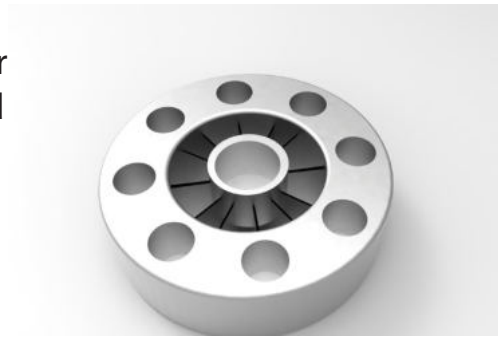
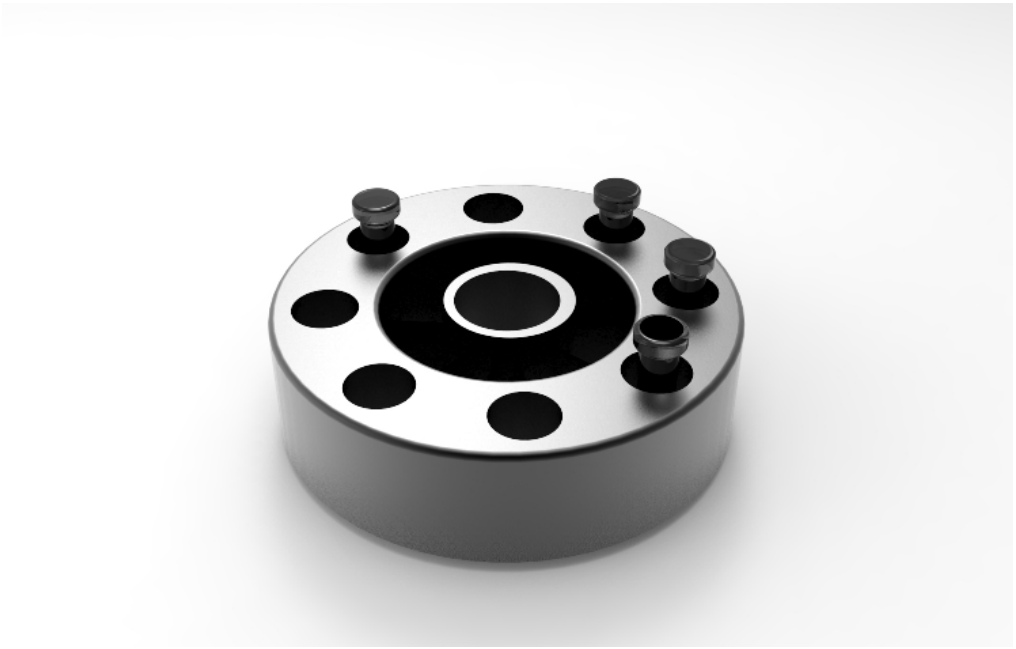
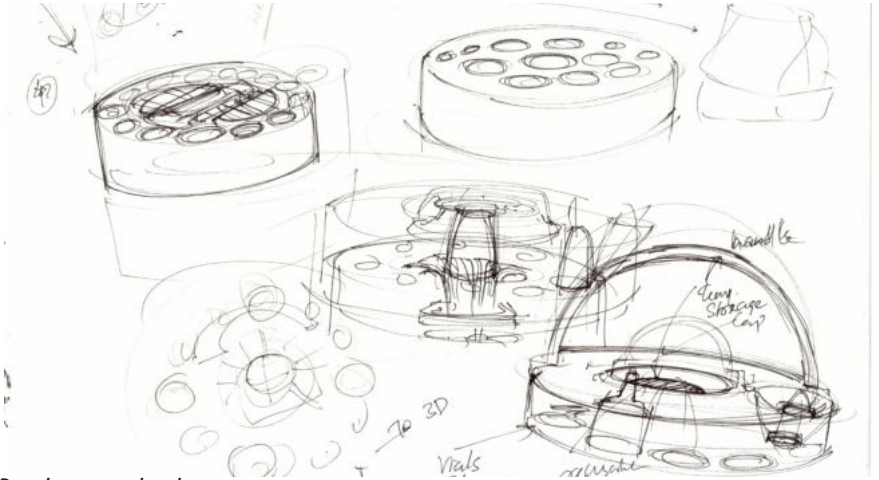


Diagram showing exploded view

The order of arrangement is fan, heatsink, circuit, peltier chip, heatsink vials, outer cover(from the bottom)



Vials placed inside heatsink



Development sketches

7. Vacci-can for polio vaccine storage

Concept 1

The concept shown here, named as Vacci-Can, has 3 layers. Where 4 vials one top of another are contained in a silicon skin ice pack. This assembly is then isulated with a PU Foam. the outer shell is a metal can, to have long life and asthetic metallic finish.

The Ice pack have peltier attched to the surface of it and is accompanied by a heat sink to take away the heat of the gel pack. the concept is such designed that the vials can be taken out from top and pressed again in from bottom. the gel pack is made of the sillicom material, which allows to have tacking property with the skin of the vial. Thus the vial is press fitted in the ice pack. The top inner edge of the ice pack has a onverged edge which snaps to the neck of the vaccine vial and locks in the vial in its position. However with small force, the vial can be pulled out.

Concept 2

This concept has same layers as the previous one. The 4 vials are stacked one on top of another. These Vials are stacked in a silicon skinned ice gel pack (shown in blue). The ice pack has peltier [TEC] attched to its one face. It takes away heat from the ice pack and cools it down. The heat from the peltier is then taken aways by a heatsink. A fan is provided to have forced convection of the air over the heats sink. This concept shows 4 peltiers inline, for 4 vials stacked one on top of another. This whole assembly is sealed in an insulation. Insulation can be PU ,foam for its light weight and cost friendly-ness. The heat sink part is exposed to atmosphere by an opening on the rear side of the product. The whole assembly is covered with a high quality HDPE skin. This skin is glossy, it protects product from shocks and environmental variables. The top part of vial is projecting out to administer the dose. The skin has a display showing temp of the vials and the battery status.

The cap of this concept, as shown in the render is transperent and has some features in it. Most important feature of the cap is the Vial Opener on the top of the cap. The cap opening of the vial can be done directly with the product cap where one have to invert Vacci-Can cap oper Vial seal. The Rotating dics can be rotated to move in the jaws which then exerts pressure on the vial seal resulting in opening the seal of the vial. The opened seal then is ejected out of the vacci-can cap by a spring provided in the cap.
Another function of the vacci-can cap is finger mark slot. An opening is provided on side of the vaccican cap which allows to press in the finger of the kid to have a marking. Inside the slot a felt tip is provioded wich applies ink on the finger. Thus the cap performs 2 additional fuctions in process of the Vaccination.

Concept 3

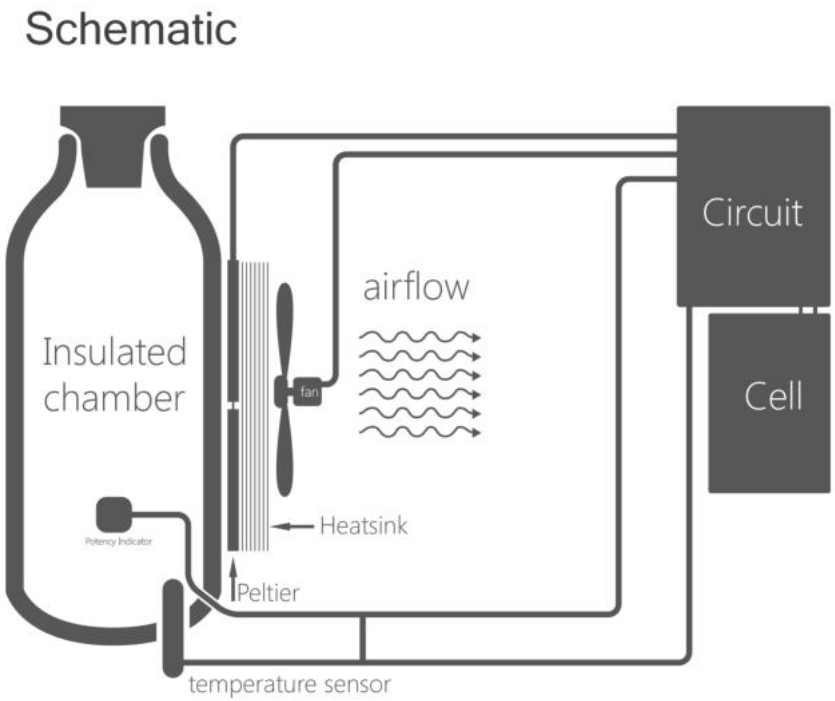
The concept shown here in the render is same as the pervious two with different form. The form here is more playful and is having all the same components inside. The details are shown in the render here. The four vials stacked vertically are jacked in a ice pack filled with a ice pack gel. The ice pack is then skinned with a HDPE thin skin and is protecting the ice pack from loosing its shape and loosing the heat. The peltier assembly is attached to the ice pack and the heat sink is having a fan to cool the heat sink. the fasn allows to have forced circulation of the air over the heat sink allowing faster and reliable cooling of the heat sink allowing more faster cooling of the ice pack. The fan has to suck air from atmosphere so there is an opening provided in the outer skin of the vaccican. The outer skin of the vacci-can is made from the HDPE and has enough space left around the ice pack to fill the isulating foam to insulate the product from gaining heat from the surrounding. On the base we have the space for the battery and the circuit. Both the battery and the circuit will be in the disc form with hole in middle. the bottom of the vacci-can have a rubber bush wich can be opened to push a vial in when vial is empty.

The cap of the vacci-can have same features as the previous one with additional one cover from inside to isulate it better.

from feedback we came to know thatb this form needs more seriousness and has to be worked upon for the improvement of the form and the product friendly-ness. Therefore we started exploring more forms for the bottle as well as the detailing was dome for the cap opener with a working acrylic laser cut working model.

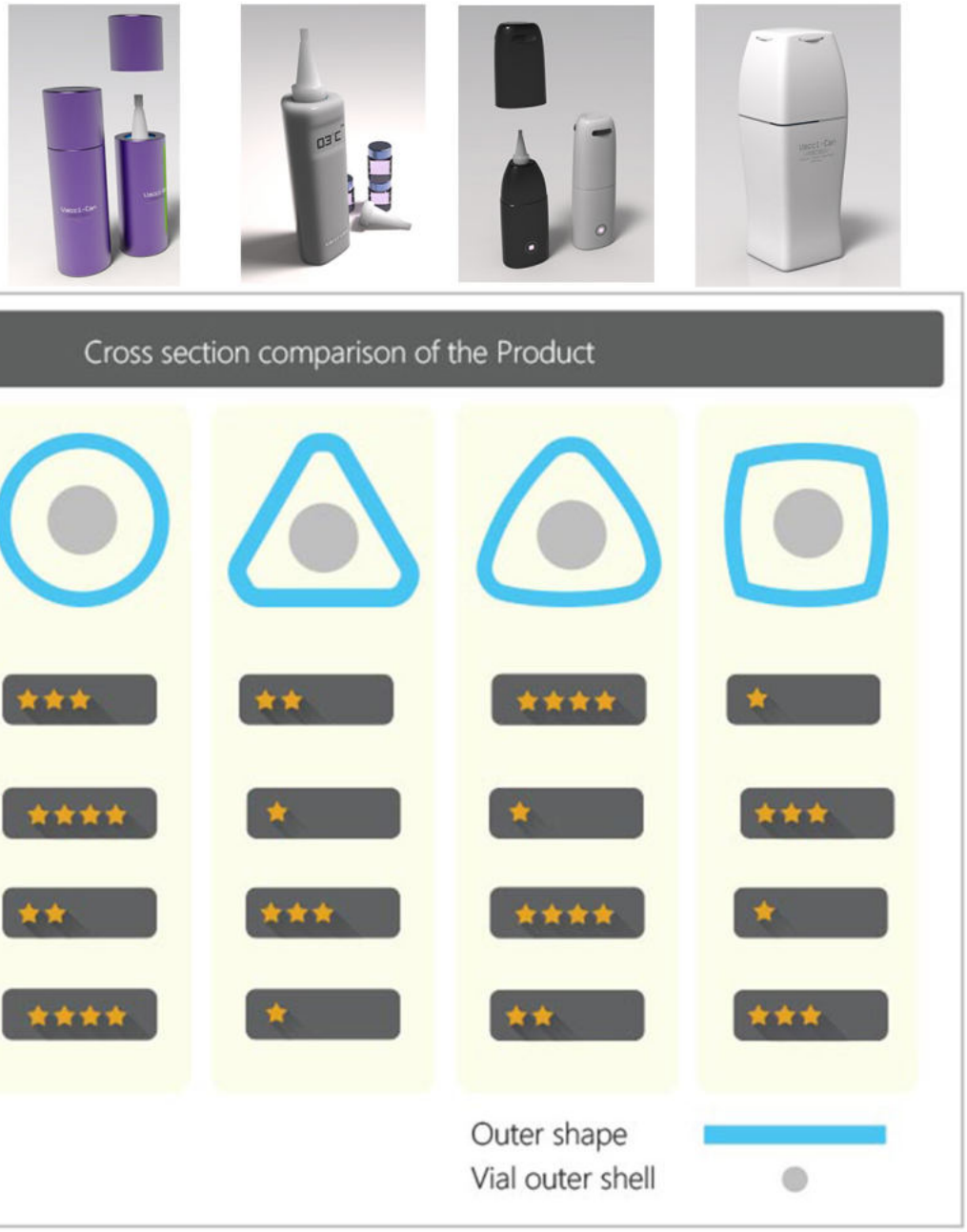
Concept 4

The one here is just a modified version of the previous iteration of the form. This concept of the vacci-can does not feature any display unlike other concepts. We had a look at the conventional ways of the conveying or checking the potency of the vial. We found that there is a white dot inside a circle on the graphics on the vial which changes its color when while temperature is changed. Thus taking inspiration from such simple graphics we designed a simmilar minimal indicator which will indicate the condition of vial vy just color or intensity of the LED. As shown in the render we can se a white dot LED in a circle which can be easily noticed and can be read as the intesity variation in elation to potency of the vial. The LED will get the input from the temp sensor and the circuit will vary the intensity of the LED and hence saving lot of power compared to the display.



VII. Conclusion

We compared each prototype based on four criteria



End