Charge from your Coffee

Experimenting with Thermo-Electric Coolers

November 2017

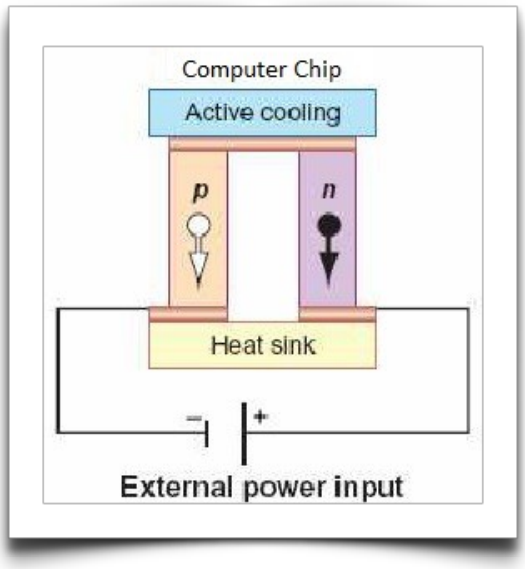
TO CREATE A MOBILE PHONE CHARGER USING HEAT FROM A COFFEE CUP
FOR THE SCIENCE FAIR OF THE CATHEDRAL SCHOOL.

Aditya Advani
Campion School, Mumbai, India
adityaadvani.com | aditya2advani@gmail.com

The Concept

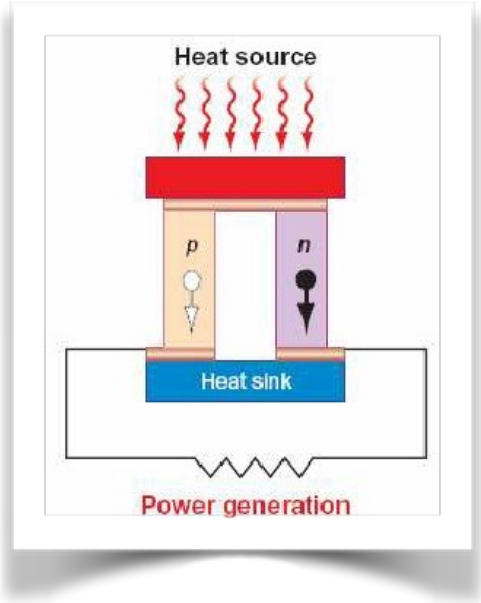
Understanding Thermoelectric effect: Thermoelectric effect is a phenomenon where a) temperature difference gives rise to an electric potential (Seebeck Effect) b) an electric potential creates a temperature difference (Peltier Effect).

Thermoelectric Cooler (TEC): Thermoelectric coolers are "Solid State Heat Pumps" which work on the basis of Peltier Effect. When a



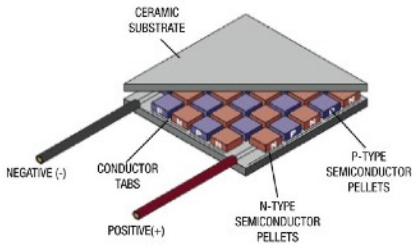
Voltage is applied to the free ends of two dissimilar elements, a temperature difference is created. These devices are primarily used to cool computer chips.

Thermoelectric Generator (TEG): Thermoelectric Generators are "Solid State Heat Engines" which work on the basis of Seebeck Effect. That is when a temperature is applied across a thermoelectric material, an Electric potential is generated leading which



can used a source of electrical power.

As mentioned earlier Thermoelectric Coolers (TECs) are used in PCs to quickly distribute heat from the CPU chips to the heat sink. A voltage is fed to the thermocouple to make the side in contact with the CPU chip cooler. So the concept was to use the difference in temperature of the cold and hot sides of thermocouple to generate enough voltage and current. Since I could not find any cheap source for Thermo-



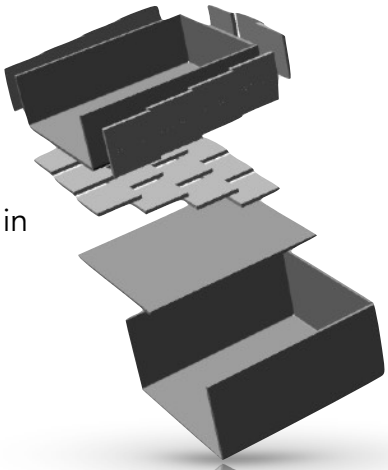
electric generators I thought why not try to use a Thermo-electric Cooler (see image) instead.

After all the Peltier Effect and Seebeck Effect are just an inverse of each other.

To charge a mobile phone requires 5VDC and 1Amp of current so this was my target. I realised that given the limited space and heat sinks I could get my hands on I would not be able to produce 5W of power directly from TECs. I hence decided to look for a circuit that could convert a smaller voltage to 5VDC. The most common one was one that required a minimum of 1VDC to make 5VDC.

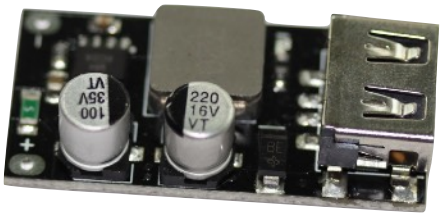
Parts used:

1. 3 Aluminium plates
2. 23 Thermocouples (see sample picture)
3. Thermal glue
4. Voltage amplifier to convert 1VDC to 5VDC with built in USB Port.
5. Ice Pack

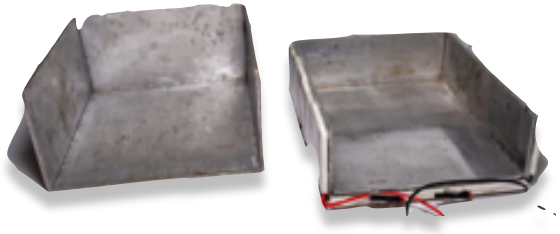


Procedure:

1. The thermocouples would be stuck to aluminium plates. The aluminium plates served 2 functions (a) provide mechanical structure for the individual thermocouples (b) collect all the heat energy from the individual thermocouples.



2. The smallest plate was to be used as an additional support for those TEC elements on the bottom because without this the TEC elements would fall off due to gravity during assembly.



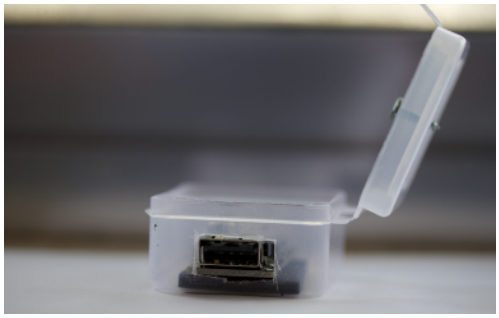
3. Next step was to bend the mid-sized aluminium plate to make a tray like box of 4 sides. The top and front would be open to allow access for the coffee cup.

4. Then using thermal glue I stuck as many TEC elements as I could fit on the bottom and 3 sides of the aluminium tray. The TEC elements on the bottom of the tray were then supported by another small aluminium plate.

5. Once I had the size of this tray with the TEC elements stuck to it, I bent the larger aluminium plate to snugly fit the TEC elements from their open side. This outer tray would be the heat sink for the TEC elements. The fit needed to be as tight as possible so that maximum heat can be transferred.

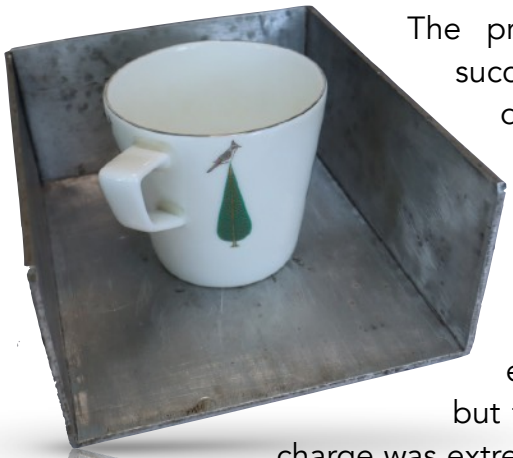
6. I wired the TEC elements in series and measured the output voltage and found that the voltage was still very low. This was because only a small portion of the coffee cup was making contact with the aluminium tray and hence not transferring enough heat to the TEC elements. I needed to create a larger temperature difference between the 2 sides of the TEC element. My grandmother sometimes uses an ice pack for her back pain so I took that ice pack and slipped it under the TEC elements between the outer and inner aluminium trays.

7. I now took fresh voltage readings and found that even after adding the ice pack I could barely get 1VDC using 23 thermocouples, hot coffee cup and ice pack. The biggest issue was that the coffee cups have a small rim at the bottom and hence do not make proper contact with the inner aluminium tray.



8. A voltage converter converted the 1VDC collected from the thermocouples to 5VDC output. The output was connected to a USB Type A port.
9. Provide heat and charge the device through the port.

Conclusion:



The project was successful and did charge the phone being used as an example, but the rate of charge was extremely slow. Using TEGs that could handle wider temperatures without damage instead of TECs, would generate more current and make a faster charger.

Possible Improvements:

a. Replace TECs with TEGs as they can handle wider temperature ranges and hotter temperatures and generate more power.
b. Use an O shape instead of U shape tray for the thermocouples for a direct contact with the side of coffee cup as well and improve heat absorption of heat. My current design only made contact with the bottom of the coffee cup so collected heat from only the bottom of the cup.
c. Add a source of cooling (ice-pack) to the outer tray to increase the temperature difference and produce even more voltage. Initial experiments that I did indicate that as much as 2.5VDC could be produced using an ice-pack to cool the outer plates.