I hope to reverse-engineer my philosophy of engineering design with a story.

Every so often when boredom strikes, I try to occupy myself with design tasks. This past summer, I had been entertaining the idea of overclocking my computer to tap into that extra processing power before I purchased a new one. Sources online suggest using advanced cooling systems to prolong the life of overclocked central processing units (CPUs), so I had the idea of making my own homemade liquid cooler. To tackle this project, I first gathered information on current designs of liquid coolers and on what principles they are founded. I gained an understanding of heat sources, sinks, radiators, and more (this was before I had taken Thermodynamics). Then, I started surveying my own inventory because one of my goals was to minimize costs. Luckily, living among 3 siblings with similar interests in computers, we frequently purchased computers with the "Buy One, Get One Free" deals. Over time, we had amassed a few old computers and their carbon copies: these computers had the same CPUs, video cards, power supplies, and, perhaps most importantly, heat sinks. Here are some design features of the liquid cooler:

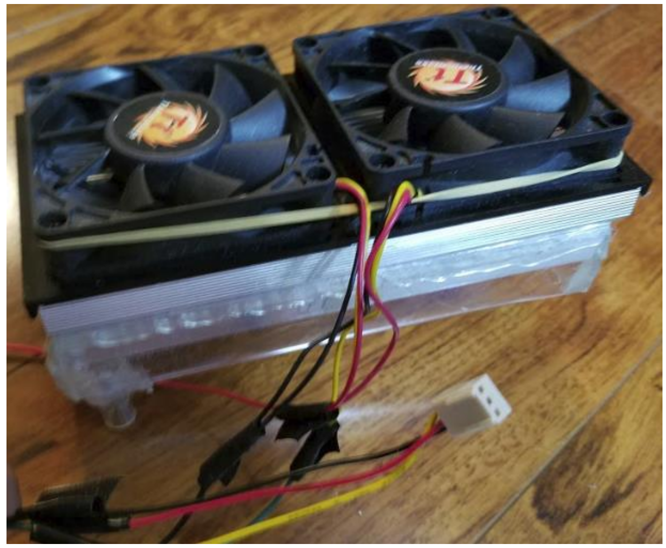

Figure 1. Image of radiator for liquid cooler. The fans' wires were cut and soldered in parallel at locations marked by the electrical tape. A rubber band held the fans loosely together. Adhesive glue and plastic enclose the circulation system.

- 2 CPU heatsinks were scavenged from old computers and hot-glued together to act as a radiator. If my understanding of thermodynamics is correct, this radiator would be roughly twice as efficient dissipating heat as a single heatsink would be in steady-state conditions.
- The fans mounted on the heatsinks are soldered in parallel (Figure 1) and can attach to the motherboard. I soldered them in parallel so both fans would receive their recommended 12V but consume four times as much power.
- The CPU water block (Figure 2) is made from a smaller heatsink found on the motherboard that was riveted, brazed (somewhat unsuccessfully), and welded (successfully) to two angled aluminum sheet metal pieces. Two holes were drilled in the top for the circulatory system.
- An acrylic plastic housing was heated, shaped, then glued to fit the back end of the radiator. Holes were drilled into this plastic for the circulatory system.
- I had two plastic tubes with different diameters on hand—the smaller one had an outer diameter equal to the inner diameter to the other. I epoxied the larger diameter tubes to

the holes I drilled, using them as a fitting for the circulatory system.

The final piece to this puzzle would be a pump to drive the circulation and I had even brainstormed some ideas. Abbas' old fish tank and its pump were gathering dust in our garage—repurposing the fish tank pump was a viable option because the motor was isolated from the surrounding, using magnets to power the blades. However, the power cord connected to a wall outlet, and I would much rather have the liquid cooler enclosed by the case and supported electrically by the motherboard. I bought a small 12V motor from RadioShack with the intention of 3D printing a housing and blades. However, isolating the motor from water would be difficult. I toyed with the ideas of using rubber rings to prevent leakage past the housing and even considered filling the motor with an oil to keep water out. In the end, I was not confident in the motor's ability to provide enough torque and overcome resistance forces. At this point in the project, however, schoolwork had finally caught up with me and I had purchased a new computer. Much like Abbas' fish tank, the unfinished liquid cooler is on my shelf, collecting dust. I may find the initiative in the future to continue and finish the project.

Figure 2. Top view (held) and bottom view (seen in mirror) of the CPU water block.

But what makes a project finished? To be truthful, I never intended to implement this cooler in my computer. I feared that the liquid would leak from the circulation system and short some electronics, possibly fry some wires, and permanently damage my computer. I was also concerned that, gradually, shear forces due to the circulation of water would eat away at the adhesives and possibly leak several months after its inclusion in the system. Investing in a \$60 - \$100 liquid cooler would have been both safer and more cost efficient if time is included as a factor. So why did I *practice* design?

I used this project to learn valuable metalworking skills such as soldering, brazing, and welding. However, not all projects are designed for the same reason. Understanding the need or problem is an essential part of engineering design. It determines how an engineer perceives failure. For example, extracting low concentrations of RNA at a low purity for PCR wastes a laboratory's resources and time, subsequently slowing down the entire research and publication process. When I failed to braze the metals, it gave me better insight into the effects of oxidation on metal surfaces and how it affects the joining of metals (particularly aluminum). Why we design depends largely on what we want to get out of the product.

In my opinion, what separates design from engineering design is the application of mathematics and principles described by science to predict outcomes. Scientific research often goes hand-in-hand with engineering design. Research is the investigation of the unknown and sometimes results in information that can be used by engineers in design. Similarly, new technological innovations may lead to better methods to conduct science. For instance, aerospace researchers may derive a new formula for drag on a wing, and an aerospace engineer may use that formula and modify the wings on an airplane to modify its drag. Engineers gather and use pertinent information to create designs with predictable outcomes. While designing the radiator and water block, I used measurements to create a circulation system to physically match the CPU lid and radiator.

There exist parameters to determine the quality of a design. What did it set out to accomplish? Did it successfully accomplish this objective? Engineers often use technical methods of determining a design's quality by quantitative measure. For example, Tesla may evaluate their new line of cars based on parameters such as miles it can travel per unit of energy. Often, new designs are held against standards. These old standards might be older versions of the same design or other designs that set out to accomplish the same task in another method. To build upon the example above, Tesla engineers may compare their car to other electric cars designed by a different company or the version that preceded the current. In my design, I would have evaluated the performance of my liquid cooler by measuring temperatures of the CPU.

My interest in engineering stems from my love for problem-solving. Design tasks offer open-ended challenges that often require critical thinking and multidisciplinary skills. In addition, I enjoy learning and academia. Some of the best advice I have ever received is: “it is impossible to learn everything, but it is definitely worth trying.” I design for different reasons from some others, but I use the same methods.

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