Solder Drop

By: Sam Brown

With this experiment I wanted to capture something people don't often see. I thought that the fluid flow of a metal would be something few people have seen. Along with this I was interested in the dynamics of molten solids. What intrigued me about this idea was the choice of materials. The choice of metal can significantly alter the experiment results because of material properties such as density, and melting point. Steel for instance has a very high melting point so getting it hot enough to behave as a liquid capable of flowing freely becomes very challenging. Solder on the other hand has a very low melting point and getting it to a liquid state is much more achievable. Density of the material is also a factor to consider. Solder is very dense sitting at 8.60 g/cc. Where aluminum is less dense sitting at a density of 2.60 g/cc. After careful consideration I believed solder would be the best material for the job.

In order to control the flow of molten solder, I created the following apparatus shown in **Figure 1**. This apparatus is designed to create consistent drops of solder onto the non-painted tin can. **Figure 1** depicts a stack of cinder blocks supporting a cantilevered piece of wood that then attaches to a steel bar. This way the heat is suspended away from flammable materials yet is still well insulated. A paint can lid is then placed on top of the cantilevered steel bar. This lid has a 4mm hole drilled into it to allow for liquid solder to drip slowly through. The steel bar also has a hole to allow the solder to continue its path. Once this is set up I lit the torch and mounted it on the structure to begin the heating process a shown below.

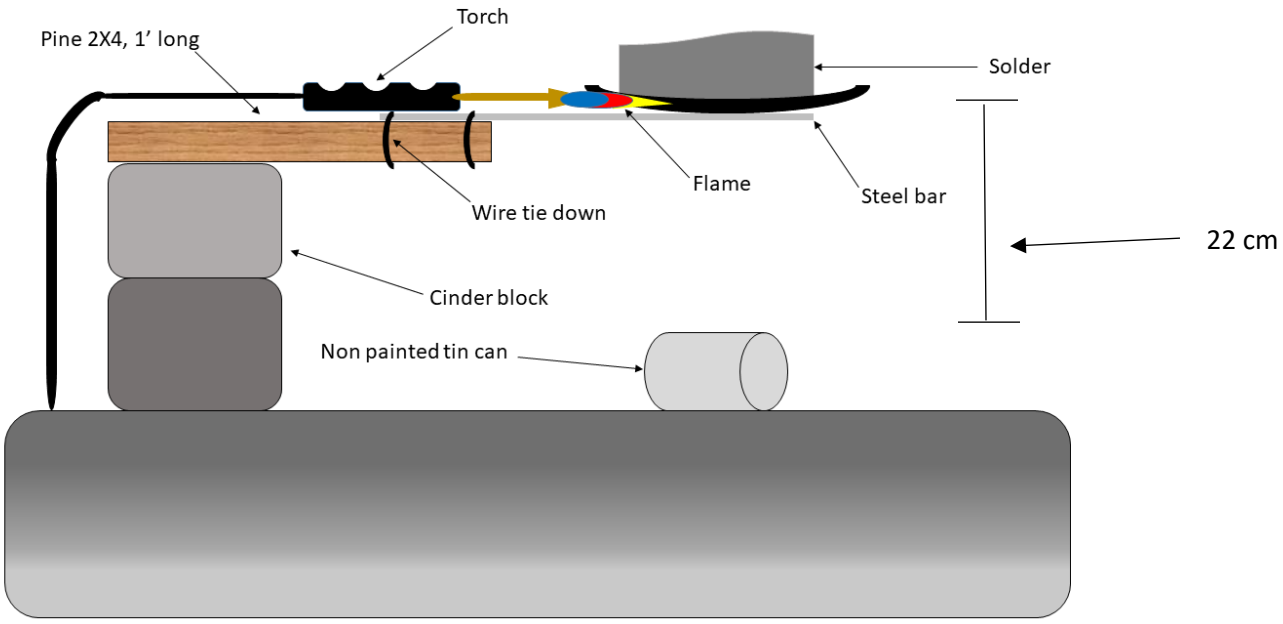

Figure 1: Solder drop apparatus

Using the above fluid set up, the solder was heated until it was in liquid form where it will simply flow through the hole in the paint can lid and fall a distance of 0.22 m before making contact with the metal cylinder. I chose 0.22m strategically because any further would result in too dispersed of splatter and any closer would lack excitement. At 0.22m there is enough height for the droplet to pick up speed and impact the cylinder in an exciting way. The fluid was moving quite quickly. Its motion started from rest and was only subjected to gravitational forces. The final velocity before impact is calculated below.

$$v^2 = v_0 + 2(g)(x)$$

$$g = 9.8x = .22m; \qquad v_0 = 0; \qquad g = 9.8\frac{m}{s}$$

$$v = 2.08\frac{m}{s}$$

At a speed of 2.08 $\frac{m}{s}$ it makes for a beautiful splatter with lots of reaction forces vaulting it back upward. The fact that the solder is so dense also allows for a significant impact. Because the fluid is moving so quickly it was difficult to prevent motion blur. A high speed camera would have come in handy during this experiment.

To capture this image I was making use of sunlight reflecting off of the liquid solder. To create a clear image, without any distractions, I made use of a black steel plate to make the liquid solder really pop. Because the fluid is moving so quickly I waited until the lighting conditions outside were at its brightest. This allowed me to increase the shutter speed in order to reduce extreme motion blur. However I was unable to completely remove all motion blur from the image.

For this photo I was using a Nikon D40X equipped with an 18-55 mm lens. To best capture this image I was about six inches away from the impacting solder. I would recommend protective gear as the solder can splatter onto your skin at this distance. To absorb the most light possible my aperture was set to F/5.3. This allowed me to use a shutter speed of $\frac{1}{100}$ (s). The focal length for this image was 40mm and my focus distance was 0.28m. I would have liked to use a higher shutter speed however lighting provided limitations. Lastly my ISO was set to 100. After playing and tuning all of these factors I settled on the setting listed above. After the image was taken I used Darktable to edit my photo. I cropped the image tighter and played with the saturation of the image. I found this allowed for a crisp image. Below show pre edited and post edited, respectively.

In summary I think the image does what I set out to do, which was to show how liquid metals behave as they fall through the air and impact something. I think the image could be more effective with reduced image blur. To accomplish this I would require a higher shutter speed and better lighting conditions. This image also has distracting details in the background. The black piece of steel that I used for the background isn't positioned in a way that blocks the ground effectively. Despite this image having lots of motion blur I think it is very beautiful. It shows the chaotic nature of impacting molten solder, which until this experiment I haven't observed before. The metallic colors are also gorgeous. I also appreciate how the final moments of the liquid state of the solder will be forever solidified to allow for up close inspection. If I were to recreate this image I would use a smaller hole to slow the drip of solder to a more predictable rate.