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Get Wet Spring 2018
ATLS 5151-001: Flow Visualization
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Context + Purpose

This video was created for the "Get Wet" Assignment to illustrate the effect of a soldering iron's concentrated heat on solder wire. For this first large assignment I wanted to stretch people's perception of flow and fluidity by using molten metal as an unusual source of flow dynamics. The intent is to show both the beauty of liquified metal and to explore the ways that this can be shown through video. Though Technology, Arts, and Media (TAM) is a major within the School of Engineering at University of Colorado Boulder, I focused on the flow from a more artistic perspective because photography and motion-graphics are my general area of expertise.

Flow Apparatus and Materials

The flow apparatus[Fig 1] was a simple set-up of a Canon EOS SL1 DSLR with a f/1.8 50mm fixed lens put 14" in front of a 5"x7" metal plate (of unknown composition). I set a very shallow depth of focus (f/1.8) on the middle of the plate and used a piece of Blu-tack to set the focus on the camera.[Fig 2] I also used a Sparkfun "Heaterizer XL3000" heat gun to heat the metal plate to try and keep the solder liquid for longer, but the heat may have been too indirect and/or inconsistent to be significant.

For the solder itself, I used Rosin core leaded solder wire (63% Tin, 37% Lead) with 2.0% flux. I think this would be more helpful a description if the solder wire was branded and the flux chemistry defined online, but as you can see[fig.3], the wire is unbranded. I tried a reverse image search of just the wire with my hand removed, but was unable to find its source and thus the chemistry of this particular rosin flux is unknown.

Description of Flow Phenomena

A brief explanation of solder and flux

"Solder" is metal that is easy to melt through concentrated heat, heat which can be provided through a pointed "soldering iron". As science writer Chris Woodford describes on his science education site, "Explain that Stuff", when you have a situation where you are trying to create a stable electrical connection, you often need to solder wires together to make sure the flow is not disrupted by changing resistance.[1] Metal, however, does not often melt at low temperatures. In order to have meltable metal, we combine soft metals (or in the case of most solders, multiple metals in an alloy [this alloy was 67% Tin and 37% lead]) with a chemical compound called a flux that keeps the metal from heavily oxidizing as it melts. When metal oxidizes, It is interacting with the air instead of the metal, and so the way that it bonds to itself and its surroundings changes, and it can interfere with the use of the metal as an electrical connector.[2] Flux reduces that oxidation and the offset of the chemical reaction between the flux and the oxidizing metal creates plumes of white smoke.

Description of the Flow and Flow Forces
Through heating the solid soldering wire alloy with the soldering iron, we melt the alloy from a solid to a liquid. Through melting, we can observe the changes in form caused by a phase shift between solid and liquid. Additionally the flux provides the opportunity to see the gaseous flow of the flux-oxidation interaction. It appears to me that the flux-flow is laminar in nature because the edges of the flow are smooth, but I am not a flow expert, despite being in this class. In terms of the metal, the phase shift from solid to liquid changes the way the metal appears from a piece of wire to a ball[Fig. 4]. It would make sense that, as the flux is impeding the oxidation and thus the adhesion between the metal and the air, that cohesion would increase and a droplet caused by surface tension would present itself, but this is for me an a guess based off of my results, not my own scientific findings or literature. Additionally, the fact the metal stays a droplet once it cools could be caused by uneven cooling. The surface cools enough to keep the shape, and the inside becomes less liquid as heat is removed.

Improvements

I received a large amount of feedback, some of it contradicting, but general themes for how to improve this visualization are outlined below:

- Increase the frame rate.
    - My frame rate was 23.98 frames per second, it should have been 60 or higher. Several people recommended a high speed camera and I agree that it could be very useful for this visualization.
- Focus more on the solder
    - My soldering iron was more the focus of the video than the solder itself, and the slow frame rate made many viewers feel distracted from the flow. Some were confused about how this was a flow visualization, and though I feel that it meets the criteria for flow vis, zooming in and really focusing on the phase shift and flux flow is essential to getting that across.
- Use more solder
    - I used far too little solder! More is better and easier to see.

Figures and Further Information

Figure 1: Experiment Setup

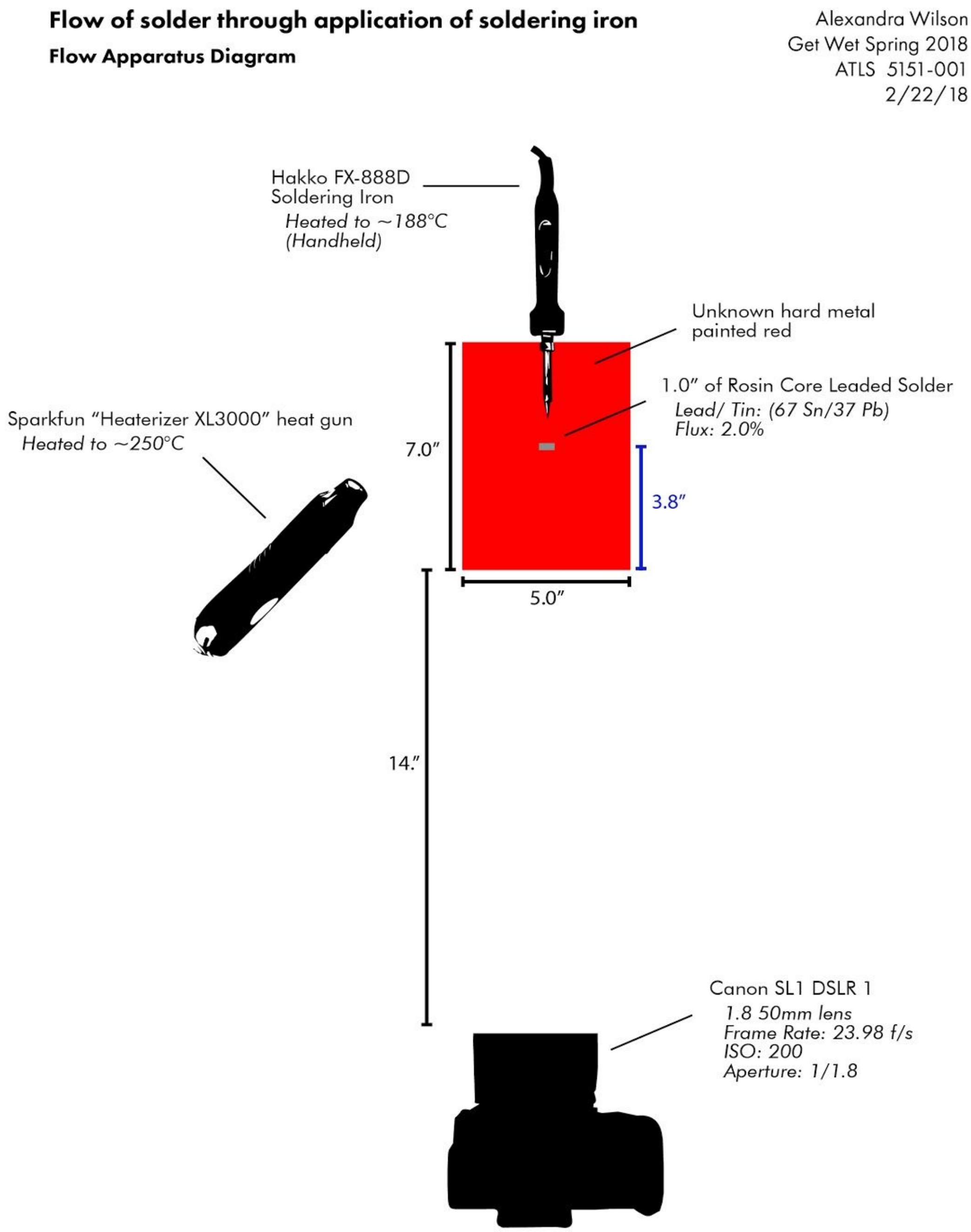

Figure 2: Blu-Tack for focus

Figure 3: Solder wire used

Figure 4: Droplet of cooled solder

Research References

[1] Woodford, Chris. (2009) Welding and soldering. Retrieved from http://www.explainthatstuff.com/weldingsoldering.html. [Accessed 2/21/18]

[2] What is Flux? | Soldering

Howcast Video on Youtube with narrator professor Jeff Koskulics from Stevens Institute of Technology

Equipment References

Sparkfun Heaterizer XL3000 Datasheet and Instructions

https://cdn.sparkfun.com/datasheets/Tools/Heaterizer-Instructions-02.pdf

Hakko FX888D Soldering Station data sheet:

https://cdn.sparkfun.com/datasheets/Tools/fx888d.pdf

Soldering Wire General Reference Datasheet (may not be completely accurate to the solder wire I used, but the chemical composition of the alloy sans flux is the same, so melting point should be preserved):

http://www.farnell.com/datasheets/315929.pdf