Seth Dry – Team Third Report

MCEN 5151 November 3rd, 2025

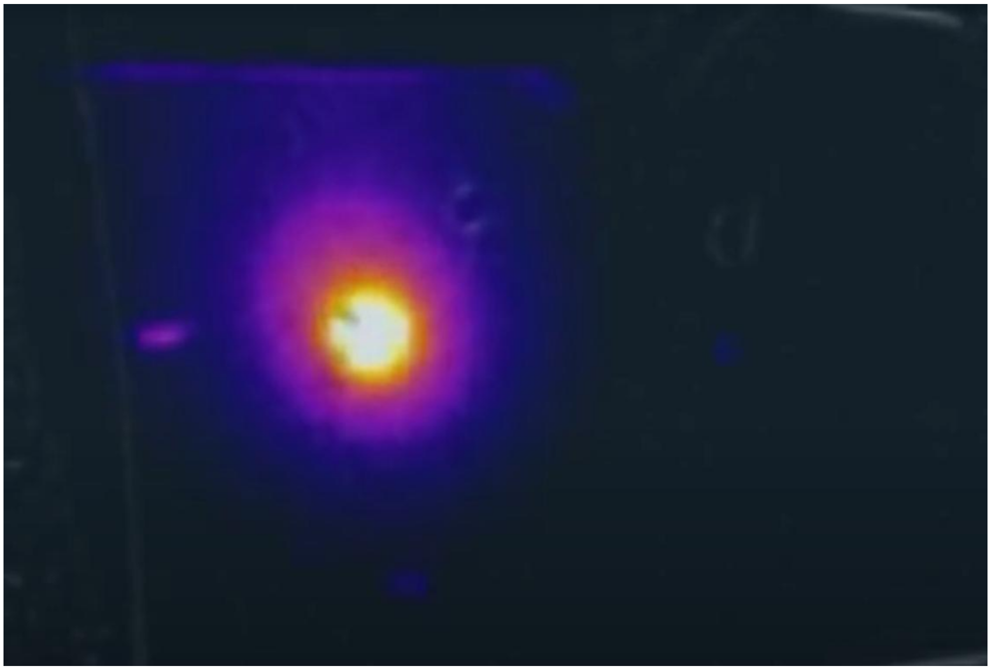

Figure 1- Steady State Temperature, Frame from Original Video

For my team third assignment I worked with my groupmates Haiying Peng and Iker Acha to record the heating and cooling of a metal plate using a thermal imaging camera. Our intent was to capture the temperature distribution as the plate heated and cooled, so that the heat flow to and from the plate could be visualized. We thought that this would be a novel “flow” phenomenon to capture, and an interesting application of the thermal camera. The final video was successful in showing the heat flow from the source, provided by a butane torch, into the surrounding plate, as well as the cooling of the plate once the torch was removed. The resulting visualization is also quite aesthetically interesting, and the symmetry of the flow phenomenon and the color gradings chosen create an interesting artistic work.

This visualization shows both heat flow via conduction and demonstrates the effects of convective and radiative cooling. Watching the video, we can see the initial stage of heat flow from the main heat source, until it reaches an equilibrium or steady state. The happens as the heat being dissipated from the plate via conduction, convection and radiation to the air is equal to the heat flowing from the source at some radius away from the source.

Analysis of this heat flow can be done using the methods described in [1] and [2] where the temperature distributed can be modeled as:

$$T(r) = \frac{T_1 - T_2}{ln(r_1/r_2)} ln(\frac{r}{r_2}) + T_2$$

This distribution holds for the steady state condition seen about halfway through the video. Where T1 is the temperature of the heat source, and r1 is the radius of this source, in the case of this experiment this is the area being heated by the blowtorch. T2 and r2 correspond the ambient temperature of the plate and the radius at which this temperature is seen from the heat source. r is the distance away from the heat source from its center. The approximate values of T1 and T2 as measured by the thermal camera are approximately 415 F and 77 F respectively. Measuring the nozzle of the blow torch we can approximate r1 as 1/8th of an inch. Using pixel correlation, we can determine r2 at steady state as about 2.5 inches. Plugging these values into the equation above we can generate the plot shown in figure 2 of the steady state temperature as a function of radius.

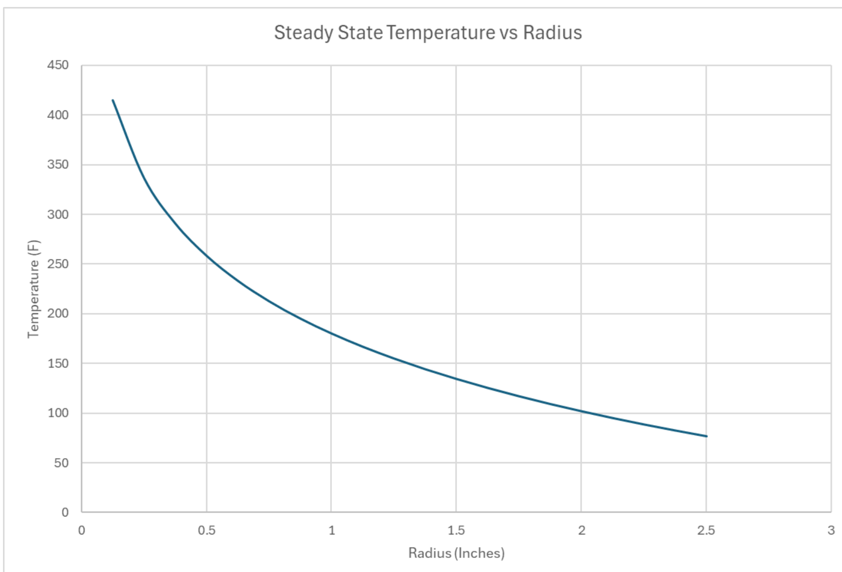

Figure 2 Temperature Distribution Plot

Looking at the original image as shown in figure 3 we can compare the color to the temperature scale on the right side of the image and see that our analysis does roughly match the real-world temperature distribution recorded.

To capture this video, we used a Bernzomatic butane torch, sold for kitchen use, to heat a galvanized steel plate suspended by a photography tripod about 1 ft in front of the thermal camera. This was the minimum focal distance for the camera, and the tripod allowed us to heat the plate safely. The torch also had the ability to lock on, so that no human contact was required through the course of the experiment.

The video was captured using a FLIR E5 Pro thermal imaging camera. The camera itself cannot record video, so we ran the camera into a laptop running FLIR capture, a software provided by the camera company that enabled video recording. Being that these cameras are quite different from ones capturing light in the visual range, many of the normally reported camera settings are not necessarily applicable. The measurement range was manually set using measurements of the torch and background temperature to be between 78.2 and 410 F. This in turn created the color graduations as shown in the video. This setting may be analogous to ISO as it effectively set the gain for the image. The thermal camera does not have a shutter, not aperture in the traditional sense, but the video was recorded at 15 FPS, with the measurement being updated for every frame. The camera allowed for a set focal distance, which was set to 1 ft, which was the approximate distance from the camera to the subject. The only post processing done to the image was to crop it slightly to remove any distracting elements from the frame, such as the company logo and temperature scale.

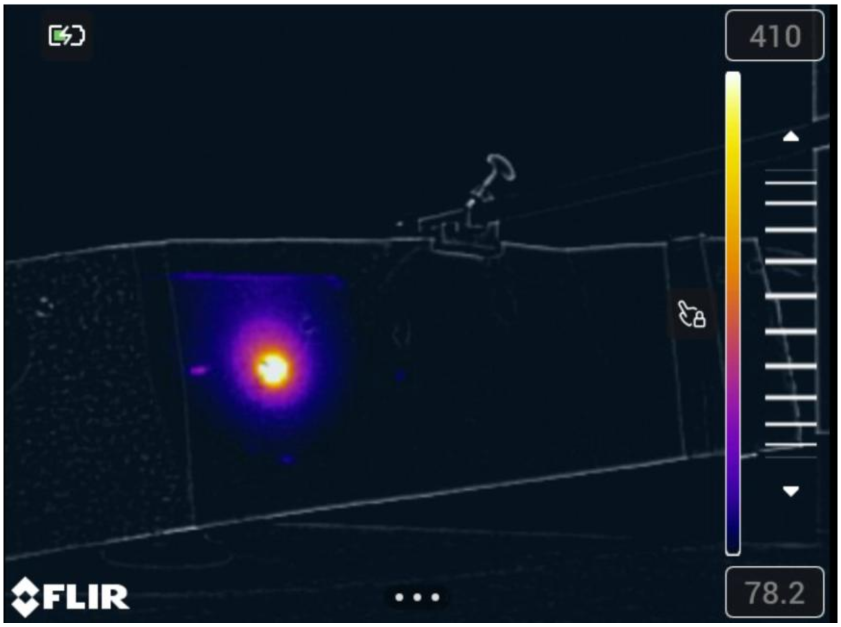

Figure 3 Unedited Frame

The final video, which can be accessed on YouTube at this link. Demonstrates and interesting heat flow concept and condition of a thin plate being heated by a constant heat source. This phenomenon is relevant to many engineering disciplines and this visualization of the heat flow proved a real-world example of a frequently modeled phenomenon. I am very happy with how the final product turned out scientifically, and how the heating and cooling of the plate is shown quite clearly. We can see how the temperature distribution evolves as the plate goes through heating and cooling. This also provided an interesting image aesthetically, it is quite mesmerizing watching the video on repeat as the shown temperature distribution expands and contracts symmetrically, creating a pulsing, rhythmic final visualization.

References

[1] Bergman, Theodore L., et al. *Fundamentals of Heat and Mass Transfer*. Wiley, 2017.

[2] Turns, Stephen R., and Daniel C. Haworth. *An Introduction to Combustion: Concepts and Applications*. McGraw-Hill, 2021.