Automated Traffic Signal Snow Removal System

Team 65

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***Abstract* - This paper describes the use of a heating element in order to keep snow from building up on the surface of an LED traffic signal. This product provides an easy way of improving existing LED traffic signals and it can be easily mounted to them. It provides enough heat to keep the surface clear during the harsh winters of the northern regions around the world. The device will melt snow in no longer than 10 minutes. The materials for the device are cost efficient and should be easily installed/uninstalled.**

I. INTRODUCTION

After the invention of cars, the traffic signals were created. Traffic signals needed to command the flow of traffic since it had become a problem in bigger cities. First traffic signals used gas to power them. Then, they converted into electricity powered. Throughout the years the traffic signal had used halogen bulbs to emit the light. Therefore, the use of those bulbs became a problem to cities since it used high amounts of energy. Why was it a problem now? The problem arose since the car population around the globe increased exponentially. For this reason, cities had to install multiple traffic signals in cities. Therefore, they needed to come up with a solution to control the energy wasted.

The solution was to introduce a new type of bulb/light. The LED lights became the perfect alternative. They were far more potent than incandescent bulbs, and they did not use as much energy. So, after the Energy Policy Act of 2005, traffic signals were mandated to use LEDs.

After the addition of LEDs to traffic signals, a new problem arose. The problem was that LEDs do not emit enough heat to melt the snow at the surface of the lens. Therefore, people tried to solve this arising problem by using deicing chemicals before a storm would hit. The deicing chemicals provide a protective layer to the surface of the light's lens so when the snow hits it, it falls since it can't grip itself to it. But when the snow becomes wet or too heavy, then this deicing chemical does not work as it should. So, there had to be another solution.

The new solution was to create a lens for the traffic signal that could heat itself up when necessary. This is where this project comes into play.

II. MATERIALS AND METHODS

There were two types of heating elements. Both types will be applied to a 1/16 in thick sheet glass. The first type is a heating wire that is fused into the glass. The second is an ITO film that is applied to the top of the sheet glass. Both will be placed into the heating element container. Inside the container the heating element will be connected to a female connector with a wire.

When designing the heating element container some conditions needed to be considered. The design must be easily replaceable and compact to fit. Due to the location of traffic light's the container must be rugged enough to deal with harsh environments. As such the following design was chosen.

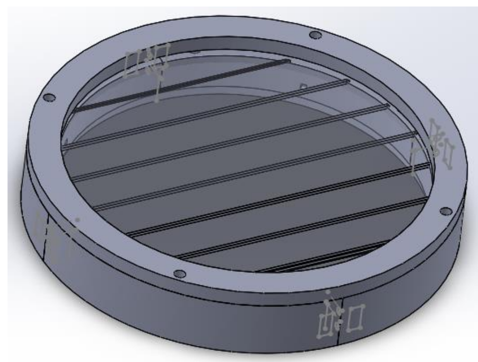

Figure 1: Heating element container

It was decided that the heat element container will be made of aluminum alloy 5052 as that has a high fatigue strength compared to plastic. To improve safety from burns an insulated rubber will be applied between the contact area of the heating element and container. On the bottom edge of the container a thin layer of rubber will be applied to prevent water from entering the system. For proof of concept the container was 3D printed with PLA.

To allow power to run to the heat element a slight modification to the traffic light lid must be made. Some holes are added to the traffic light lid. These holes will allow for the male connectors to be attached. The female connector will be applied to the container of the heating element.

The system is controlled by a microcontroller, in this case an Arduino Uno. The way the system operates is there will be a Temperature Sensor (LM35DZ) mounted on the outside of the traffic light that senses the ambient temperature. If the temperature is below 0 degrees Celsius, it goes to the next phase, otherwise it keeps sensing.

Next, a Photocell (VT43N1) senses light to determine if the lens is covered. If the Photocell senses some light from the LED, then the lens is clear. If it senses a lot of light from the LED, that means the lens is covered because the light reflects off the lens covered in snow back to the Photocell.

The final phase is when the heating element (ITO Film) heats up melting all the snow/ice. The circuit is shown in figure 2 below.

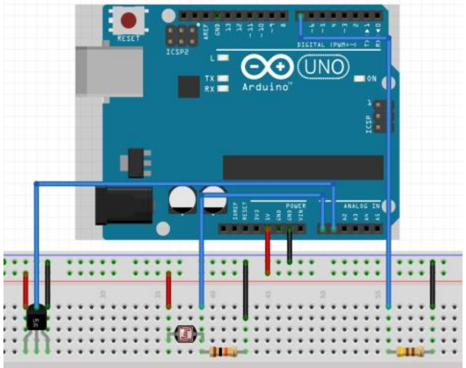

Figure 2: Circuit on Breadboard

III. RESULTS

While following heat transfer laws, the ITO film was tested having different areas in order to come up with an idea of the heat generated which could be produced. Since this film is conductive, the surface area plays a big role to know how much heat we can provide to the system. Therefore, by using the resistivities for each rate of ITO films there is, the resistance could be calculated. Following equation was used to calculate it.

$$R = \frac{Resistivity * Length}{Area}$$

To continue, the next goal was to calculate the power generated by the material. The power was calculated by using the following equation:

$$P = I^2 \, x \, R$$

The film was tested by using a power source and an oscilloscope in order to get the current measurement. The current flow varies per strip of film. Therefore, for the strip of area 1, the current flow was 0.04 A, and for the strip of area 2, the current flow was 0.12 A. Using these known values, the power was able to be calculated.

Rate of Film	Power at A1	Power at A2
99%	0.207	0.829
97%	0.221	0.885
90%	0.224	0.896

Table 1: Power of Strips of Films at different Rates

As Table 1 shows, power does increase when our film has a larger area. The film's power also increases as the rate of the film increases. Therefore, the last step was to find out how much the surface would heat up. According to some derivation of the energy transfer equation, the temperature of the surface was able to be solved by using the following equation.

$$T_s = \frac{\dot{q}}{2 \, h \, A_s} + T_a$$

To further explain the equation, $\dot{q}$ is the power generated by film, h is the heat transfer coefficient of glass, A_s is the surface area of film, T is temperature, and subscripts s and a mean surface and ambient, respectively.

It was discovered that the surface temperatures of the films increase as the ambient temperature increases. Also, the film rated at 90% has the highest of all.

Another study done on the heating element was to use different types of snow to see how the heating element will behave. Therefore, the thermal conductivities of air to ice. Also, the ambient temperature was of -10 ºC which is a temperature below the average temperature of states such as Illinois. The power used was of 100 W. This power was measured to be the most attainable for our system. Therefore, Graph 1 shows the surface temperature vs the thermal conductivity. Power used was of 100 W.

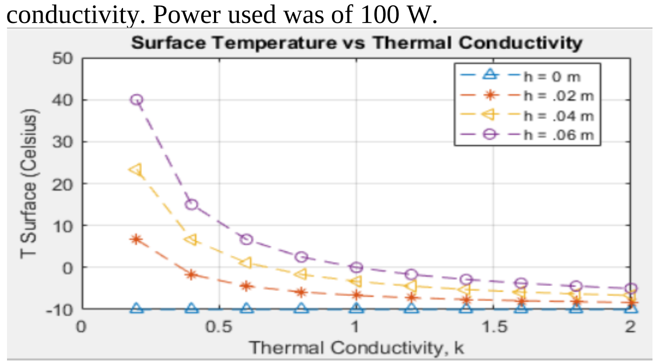

Figure 3: Surface temperature vs. thermal conductivity.

IV. CONCLUSION

In conclusion, this system is a great idea for LED traffic signals. The heating element used will help improve visibility of light and will use a low amount of energy since it is activated only when necessary. Also, it has the capability of being installed easily, and being uninstalled easily. This further improves the efficiency of it. Furthermore, it does need more work to be done.

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