Team Number: THS203

School Name: Taos High School

Area of Science: Engineering

Project Title: Tune the Fire

Problem Definition:

In 2004, firefighters responded to a four-alarm two story warehouse fire in Taos, New Mexico. Upon entering the second story of the warehouse, two firefighters were quickly overcome by flames. One firefighter attempted to escape the flames by exiting through the stairwell but the stairwell then collapsed. The other firefighter then tried to escape the flames by climbing towards the roof. This firefighter was then faced with a decision to either jump off the building or burn to death. Both firemen did survive but deal with health issues for the rest of their life. New technologies can be integrated into firefighting to avoid events like this from happening. Signal generators emit signals at a select frequency. These signals can assist in extinguishing flames in wooden materials. The focus of this project is twofold: first, to determine what ultrasonic frequencies will assist the extinguishing process the most. Second, to model an ultrasonic frequency array that is capable of attaching to a transportation device. This device could then be implemented into firefighting techniques to assist the firefighter in escaping fire entrapment.

Problem Solution:

I have experimented with this problem in a real laboratory setting. The experimental procedure used was

Tuning Fork and Bunsen Burner Test

1. Light Bunsen Burner, turn off lights.
2. Place Bunsen Burner within enclosure with denoted lines and mounted ruler to prevent air from manipulation the flame and to be able to record flame movement.
3. Tap tuning forks of various increasing frequencies against the desk with the same amount of force to produce consistent sound waves.
4. Move tuning fork within 3 cm of the top and bottom of the flame, observe any potential movement during duration of sound emission from the fork, or for 1 minute.
5. Repeat steps with all tuning forks
6. Extinguish flame, analyze data

Other Fuels and Tuning Forks

1. Place other fuel items within clamp.
2. Ignite using Bunsen Burner.
3. Place clamp apparatus within enclosure to prevent air from manipulating the flame.
4. Tap tuning forks of various increasing frequencies against the desk with the same amount of force to produce consistent sounds waves.

5. Move tuning fork within 3 cm of the top and bottom of the flame, observe any potential movement during duration of sound emission from the fork, or for 1 minute.
6. Repeat steps with all tuning forks.
7. Extinguish flame (if necessary), analyze data.

Frequency Trials

1) Place electrode within conductance bridge measuring apparatus.
2) Calculate Frequency using inductance (micro Henry) and capacitance (farads).
3) Tune Frequency generators to calculated frequency
4) Place leads on either side of flame within 3 cm of flame of each object within clam apparatus, observe flame behavior for nearly matched electrodes in 2 and 4 electrode arrays.
5) Observe flame behavior at differing increasing frequency levels. Measure flame movement and behavior during trials, measure weight and size of fuel source before and after trials.

To further investigate this issue on a larger scale requires a computer model that visually expresses the impact of ultrasonic frequency signals on wood-based materials. The model will use the best preforming array as a base for the computer model. The model will have a 2 electrode, or a parabolic array that emits a signal with a 100kHz frequency. Amplitude of the wave will vary. The wood source in the model will have a series of graphs which display the pressure of the fire, the mass of the fuel source, and the temperature of the fire. The sound waves' impact will be expressed by the variations in the graphs of the fuel source. A visual decrease in flame height and a change in flame color will also represent the effectiveness of the fire suppression array. Overall, the computer model will express the effects of the suppression array on a larger scale than what was tested in the experiment.

Progress to Date:

Currently, the data from the lab experimentation has been analyzed. It has been determined that 100 kHz is the most effective signal frequency. Through research it has also been determined that higher amplitude of the wave will prove more effective. Research also suggest that a parabolic copper array will direct the waves more efficiently than the two electrode system. The early visual stages of the model have been constructed. The turtles in Netlogo have been set so that each period for the wave is a turtle and the fuel source is also a turtle. To expand on the model, the wave turtles need to decrease the temperature and pressure attributes of the fuel source turtle. This way the data is accurately represented.

Expected Results:

Following the optimization of the model, it will be able to accurately represent the effectiveness of the suppression array with the differences in the wave behavior. The sliders in the program will change the features of the wave. The graphs will display the accurate amount of mass that the fire consumed, the pressure of the fire, and the temperature of the fire. Following research

and running the model. The results from the model could be used to optimize the construction of the fire suppression array. A prototype could be implemented into further real life experimentation and then be integrated into firefighting techniques. The system could allow the firefighters to do their job more safely and effectively.

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