Extinguish Fire By Means of Sound Waves

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Abstract- *The current fire extinguishing comes with various drawbacks. The need for new fire extinguishing techniques is vital as fire accidents cause deaths and injuries. Sound wave could be one of the potential alternative in putting off flames. The acoustic pressure and air velocity produced from a speaker is the main theory used to explain how sound waves put off flames. This research aims study and analyze the effect of different frequency of sound wave on flames. A experiment of sound wave was carried out to study behavior acoustic wave propagation in the nozzle and surrounding environment. Experiments were then conducted to study suitable sound wave frequency range to extinguish flame and to analyze the acoustic-flame interaction through observations from camera. Three different sources of flames were used to with three different state of fuel (solid, liquid and gas). From the first part of results, using an ordinary nozzle, it was found that sound wave can only extinguish gas fuel type flames at 45 Hz. However, in the second part of the experiment, the sound wave manage to extinguish all flames of different fuel types, with the converged nozzle design. This mainly is due to the converged nozzle gives a higher air velocity output as compared to an ordinary nozzle design, which was verified through simulation result. The combination of varying high and low pressure and coupled with high flow air velocity, which in then causes disturbances in air-fuel ratio at the flame boundary (leading to thinning of flame boundary), is one of the possible explanation leading to flame extinction. In both experiment, the frequency range needed suppress the flames was found to be, between 40 to 50 Hz. However, in both experiments the flame boundary used was relatively small as compared real fire accidents due to safety consideration. Nevertheless, this sound wave based fire suppression technology could be used to combat early stages of fire accidents.*

Keywords- Fire Extinguisher, Sound waves, Sound fire extinguisher, Acoustic waves, Fire.

I. INTRODUCTION

Fire extinguishers are trying to eradicate one of the elements in the pyramid (a flame tetrahedron) in order to eliminate the flame. Firefighting in an enclosed space has always been a problem, other than the accessibility for the fire fighter to access the place, accessing the water, carbon dioxide (CO2) or other fire extinguisher technology to the closed space is a major challenge. A compact, independent and reliable fire extinguisher is required in order to overcome this problem. Space station and submarine are the main examples of the application that highly required new fire extinguisher technology that will be able to be used in a confined and very limited space.

Fire manipulation using sound was not a new technique. The interactions between sound and flames was first reported by John Leconte in 1858, who noted flames within an orchestral respond to beats within music. A German physicist, Heinrich Rubens in the 1900s, showed the technique using a section of pipe with holes perforated along the top. One end was sealed off with a sound speaker connected; the other sealed off and attached with a gas supply. Subsequently, igniting the gas leaking from one of the openings and varying the sound frequency being emitted, the height of the flames could be manipulated, this effect is called Rubens tube.

II. METHODOLOGY AND PROBLEM STATEMENT

A. Problem Statement

Current method of firefighting using has significant drawbacks such as toxic to humans and leaves residue (for dry chemical base fire extinguisher) while water base fire extinguishing techniques freezes in cold climates and conduct electricity. Using sound wave with certain frequency as a fire extinguisher will have significant advantages such as leaving no residues and non-toxic.

B. Methodology

Previous experiment done by previous researchers from DARPA was stated that the optimum sound frequency for fire extinction is 60 Hz. This experiment will be focusing on the observation in the frequency range of 35 – 200 Hz (human hearing frequency) in order to confirm the results from previous research.

There are different types of flame that is going to be tested, solid, gas, and liquid fuels, of which each is a single representatives for each thermodynamic state of a material.

The fuels are: wood, methane and gasoline. A nozzle will be used to modify the intensity and direction of the sound wave in the experiments. Nozzle will increase the intensity of the sound wave to a single point which will provide better results in suppressing the flame.

III. DESCRIPTION OF COMPONENTS

1) Subwoofer- A 600W subwoofer with 8 inch diameter is used to produce the low frequency sound as an output which is used to extinguish fire. The typical frequency range for a subwoofer is about 20–60 Hz for consumer products below 100 Hz for professional live sound, and below 80 Hz in THX-approved systems. Subwoofers are intended to augment the low frequency range of loudspeakers covering higher frequency bands.

2) 2)Vortex Cannon (Nozzle): The woofer is further connected to the convergent type nozzle or vortex cannon. An air vortex cannon works primarily by applying force quickly and efficiently to air molecules contained in a semi-enclosed space. The rapid escape of the air molecules forms a stream, or jet, of air that flows straight out of the cannon. When a jet of air escapes the opening of air vortex cannon into the still air outside, it forms a stable donut-shaped gaseous projectile. This flying gas donut is called a toroidal vortex or vortex ring, hence the name air vortex cannon. A toroidal vortex is caused by the friction of the jet of air with the edges of the cannon's opening and the slow moving air outside the air cannon.

3) Tone Generator: A tone generator of 12V, 12Amp is connected after the SMPS which can create a low frequency tone. The tone generator is basically comprises of a cell phone by which we used the software for tone generation and a audio receiver which is the intermediate between the cell phone and the Amplifier. The audio receiver receives the audio signals from the cell phone and then pass to the amplifier connected to it.

4) Amplifier: An amplifier or electronic amplifier is an electronic device that can increase the power of a signal (a time-varying voltage or current). It is a two-port electronic circuit that uses electric power from a power supply to increase the amplitude of a signal applied to its input terminals, producing a proportionally greater amplitude signal at its output. The amount of amplification provided by an amplifier is measured by its gain: the ratio of output voltage, current, or power to input.

5) Switched Mode Power Supply : A switched-mode power supply is an electronic power supply that incorporates a switching regulator to convert electrical power efficiently. Like other power supplies, an SMPS transfers power from a DC or AC source (often mains power) to DC loads, such as a personal computer, while converting voltage and current characteristics. Unlike a linear power supply, the pass transistor of a switching-mode supply continually switches between low-dissipation, full-on and full-off states, and spends very little time in the high dissipation transitions, which minimizes wasted energy. Ideally, a switched-mode power supply dissipates no power. Voltage regulation is achieved by varying the ratio of on-to-off time. In contrast, a linear power supply regulates the output voltage by continually dissipating power in the pass transistor. This higher power conversion efficiency is an important advantage of a switched-mode power supply

IV. WORKING

The working of the extinguisher is made through the deep bass coming through the woofer channeled through nozzle. Whenever we have to extinguish fire or flame we need to put the nozzle opening above the flames and turn on the power supply.

When the power supply is on, the current passes from the main switch to the SMPS(Switched Mode Power Supply). Here the voltage is reduced according to the audio receiver capacity so that to prevent it from damaging & burning due to the overheat caused by the excess current. So the main working of SMPS is to alter the voltage at its output according to the device connected next to it.

After reducing the voltage by SMPS the power is supplied to the audio receiver. The audio receiver is used as a tone generator or say signal provider. Therefore it is the main component that is used to generate the low frequency signals which are used for extinguishing.

For providing the high impact of the deep bass, an Amplifier is used to increase the amplitude of the signals i.e to increased its strength and power at the output of it. Therefore this amplified sound is further made pass to the subwoofer.

Subwoofer is the main component as it is the main device which is specially used for bringing the low frequency signal as a output. The subwoofer provide the bass or low signals according to their specifications and ratings of the power output. The more the power output, the more the low frequency sound can be produced.

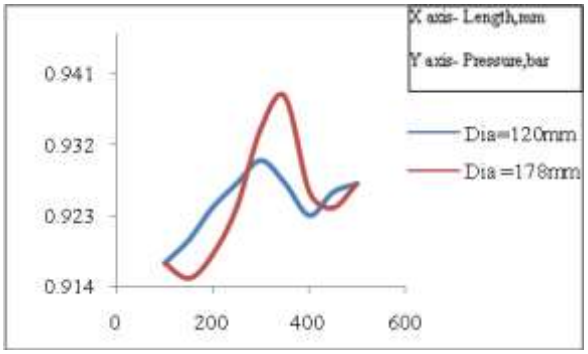
Upto here the main medium is generated which is used for the extinguishing the fire i.e the low frequency sound waves. Now this low frequency generated from the subwoofer is need to put over the flames of the fire, therefore a converging nozzle for say vortex tube is used in front of the subwoofer such that its one end is connected to the output of the subwoofer and other end id free to put over flames. As the nozzle is convergent, the diameter of the woofer end is bigger than the diameter of the free end.

The requirement of the convergent nozzle is needed so the generated low frequency sound waves can provide over the fire with high impact and velocity. As the nozzle is converging in shape when the sound waves are passed via it from the subwoofer, while travelling to towards the end due to the reduction in area inside the nozzle the pressure and the velocity of the waves increased due to which the high velocity waves can be striked over the flames with high impact.

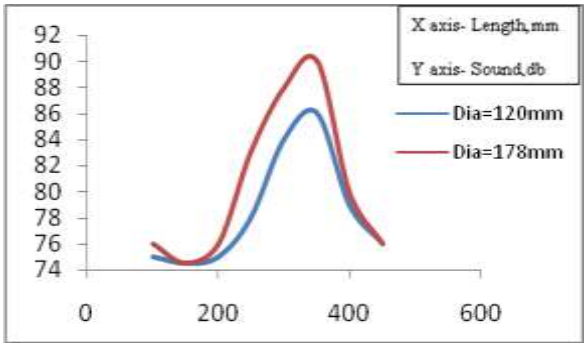
As these highly pressurized and high velocity sound waves strikes to the flames its separates the oxygen from the burning area the flames are reduced and the fire is extinguished to the complete extent.

V. OPTIMIZATION OF VORTEX CANNON

In the present research an attempt has been made to investigate the effect of the geometry of the vortex to optimize the critical parameter such as pressure, sound and the acoustic velocity. Fig shows the variation of pressure, velocity and sound for varied length from 100 to 400 mm and varied diameter of 100 and 200mm.



From the result it is found the length of 356 mm and diameter of 178mm shows the optimum pressure, velocity and sound for fire extinguisher.



VI. CONCLUSION

Based on the experiment result obtained it can be seen that the sound wave can extinguish flames. The frequency range that was able sound wave suppresses the flame is at 45 Hz averagely. This sound wave based fire extinguishing could be used to extinguish initial stage fires.
The table below shows summary of results obtained with this Fire extinguisher

Table : Summary of results with this fire extinguisher

Fuel type	Time taken	Frequency
Solid	4 sec	45 Hz
Liquid	5 sec	45 Hz
Gas	5 sec	45 Hz

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