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Design of Fire Extinguisher Robot Based on Low-Frequency Acoustic Waves

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ABSTRACT: The main motivation of this system is to eliminate fire disasters using sound. The need of fire extinguishing techniques is vital as fire accidents are catastrophic in nature, leads to unrecoverable loss. The present existing techniques are not eco-friendly. Sound wave could be one of the potential alternatives as fire extinguishers. The low frequency acoustic waves spilled from a speaker tend to extinguish the flames. The present research aims to develop the portable fire extinguisher study and analyzes the effect of different frequency of sound wave on flames. Experiments are conducted to study suitable sound wave frequency range to extinguish flame and to analyze the acoustic-flame interaction through observations from camera. So the purposed system deals with fire _without effecting any other system around it and avoid all messy chemical, therefore resulting in an electronic- extinguisher.

KEYWORDS:Low frequency acoustic waves, portable fire extinguisher, acoustic-flame interaction, electronicextinguisher.

I. INTRODUCTION

Sound wave was found to be one of the alternatives in creating new method in flame extinguishing technology. There are some aspects of the combustion that can be affected by sound wave. The flame Air-Fuel Ratio at the boundaries which is at the lowest lean limit of the combustionoffuelscanbeaffectedbysoundwavebychangingthevelocityofitsmedium (air). Furthermore, the changes in air velocity changes will also be able to affect the flow rate of the fuel around the heat source as well as increasing the convective heat transfer of the heat source and reducing the average temperature of the flame. These effects are similar to flame blow-offcharacteristics.



Fig.1.The physiology of sound

The pressure fluctuations due to the sound wave propagation will cause a significant changeintemperatureprofileneartheflame.Highpressuretolowpressureandviceversawill cause immediate change on the temperature according to the



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first law of thermodynamic. The combination actions of fluctuating temperature, pressure and air-fuel ratio to the flame will affect the flame behaviour under the regulated sound wave environment. A pressure perturbation is known to have influence on the burning rate of a material and cause combustion instabilities, which could eventually lead to flame extinction (Hood and Frendi) [8].

Contrariwise, ultrasonic frequency proves to have an effect in chemical kinetics of reactions (Ultrasound in Organic Chemistry). High frequency excitation on a reaction will be able to enhance the combustion as well as delaying and perturbing the chemical reaction which depends on the affected bonding for every specific chemical compound on certain frequencies. However, ultrasonic application for flame suppressor has not been investigated due to the results of previous experiment that shows the optimum frequency was at 60 Hz.

II. RELATED WORK

The maximum reduction of losses arising from conducting firefighting operations, both at the rot emergency level, and at the level of permanent fire-fighting equipment also requires the use of modern and "clean" technologies [10-13] for the return of the plant and the environment[14] after a failure to fully functioning at maximum short time. Therefore, special attention was paid to technologies such as efficient use mist [13] Wetting agents [11] [12] or acoustic waves [15-16] that are the subject of a publication. Law and Axelbaum [17] verified experiments theoretical assumptions that stretch flame property resulting mainly from the operation of vortices turbo significantly affect its aerodynamic distortion, leading to its extinction. Studies on the combustion processes show that in some circumstances it may be smooth non-continuously. Unstable burning was observed in age devices such as industrial burners, any smokers jet engines, jet engines in and missiles, with significant oscillating flow parameters [17-18].

III. METHODOLOGY

The development of a fire extinguisher is initiated with the basic design approach shown in fig. 2. The key components includes a tone generator (ATmega2560), generates the audio signal. The tone generator is interfaced with the subwoofer, which converts the low frequency waves into sound waves these waves are amplified using amplifier. The generated sound waves are made to travel to the vortex tube. Subwoofer along with the vortex cannon is designed to produce extremely low frequencies is used to manipulate the sound waves. The waves are further tuned in a frequency generator until they extinguish thefire.



Fig. 2. Block Diagram of Proposed System.



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Fig. 3. The circuit diagram of Proposed System for Sound wave fire extinguisher robot.

IV. EXPERIMENTAL RESULTS

1. The effect of frequency on pressure, sound and acoustic velocity.

Sound wave significantly effects on the fire extinguishers process. To evaluate the impact of sound waves on the fire, the fire was exposed varied frequency of sound waves from 0 Hz, 10 Hz, 30 Hz, 35 Hz, and 40Hz. Figure 4.1, 4.2 and 4.3 shows variation of pressure, sound and acoustic velocity for varied frequency.





Fig. 4. (b)



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Fig. 4. (a) Variation of Pressure with Frequency, (b) Variation of Sound with Frequency, (c) Variation of Acoustic velocity with Frequency.

The Sound travels in waves, which are simply variations of pressure in a medium. The energy from vibrating objects, such as speaker membranes, moves from particle to particle in the air in a repeating pattern of high- and low-pressure zones that is perceived as sound. It is found that the effective range was between 30 and 40 hertz, within the range of human hearing.

2. 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 50 and 100mm.





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Fig. 5. (c)

Fig. 5. (a) Effect of vortex geometry on pressure, (b) Effect of vortex geometry on acoustic velocity, (c) Effect of vortex geometry on sound.

From the result it is found the length of 300 mm and diameter of 100 shows the optimum pressure, velocity and sound for fire extinguisher.



Fig. 6. Testing images of fire extinguisher.



V. HARDWARE SETUP

Fig. 7. Hardware Setup



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VI. CONCLUSION

The idea of extinguishing fire with sound is a novel one, and has many possible applications in today's world. The technology is based on the way sound waves displace oxygen as they move through physical space-oxygen that fire feeds on. The lower frequencies 30 to 60 hertz seemed to be so-called "Goldilocks zone" at which the waves were able to effectively keep the oxygen from the flames long enough to suffocate them. The developed prototype consists of the sound frequency generator by a controller, a amplifier, and a collimator made out of a cardboard tube with a hole at the end, to focus the waves in a specific direction. The low frequency acoustic waves spilled from a speaker tend to extinguish the flames. So the purposed system deals with fire without effecting any other system around it and avoid all messy chemical, therefore resulting in an electronic-extinguisher. Experiments are conducted to study suitable sound wave frequency range to extinguish flame and to analyze the acoustic- flame interaction through observations using portable and innovative approach to reduce the overall cost.

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