https://dx.doi.org/10.22161/ijaers.77.57 ISSN: 2349-6495(P) | 2456-1908(O)

A study on Sound Wave Fire Extinguisher with cooling rate

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Abstract**—** *Since the Industrial Revolution, human progress has grown quickly and the structures have become skyscrapered and their inside has gotten muddled. Another blaze concealment technique is expected to stifle or forestall fire in different situations because of the difference in putting out fires condition. The Sori Sound Engineering Research Institute (SSERI) applied a special acoustic lens to the Sound Extinguisher to focus the sound energy. The wind speed of the sound beam was estimated, when the converse stage sound was provided to the sound beam, the wind speed was lost and the sound level was decreased by around 20 dB. The characteristics of a sound beam formed by a special acoustic lens and how efficiently a sound beam transmits sound energy through experiments is investigated. Sound Fire Extinguisher utilizes acoustic focal point to limit the constriction of sound vitality and move vitality to the objective point. It can forestall blaze by bringing down surrounding temperature even before fire. In this examination, we tested to check whether the Sound Fire Extinguisher could forestall fire by bringing down the surrounding temperature. Test results show that when the Sound Fire Extinguisher sound part of a similar breeze speed is provided, the warmed silverware is cooled by 10 ~ 20% quicker than the breeze speed of 2m/s. These outcomes show that the Sound Fire Extinguisher can be utilized to forestall blaze, since the sound segment of the Sound Fire Extinguisher itself advances the encompassing warm dissemination to cool rapidly.*

Keywords**—Acoustic Lens, Cooling, Sound Beam, Sound Component, Sound Energy.**

I. INTRODUCTION

As structures become skyscraperized, bigger, and complex, fire can prompt enormous fire. Regardless of these adjustments in the putting out fires condition, the smother technique to date stays being used of substance responses by fire quenching specialists. Another quench technique is expected to conquer the difference in putting out fires condition [1-3]. Sound Fire Extinguisher has been effectively explored as a choice to conquer the changing putting out fires condition. Sound Fire Extinguisher is a fire douser that smothers the fire by utilizing sound qualities. It is relied upon to be another putting out fires innovation that can defeat the constraint of existing fire douser that relies just upon compound response. Sound Fire Extinguisher was first discharged by US Defense Advanced Research Projects Agency (DARPA) and George Mason University students.The Sound Fire Extinguisher, which they discharged just because, is difficult to use in the putting out fires field in light of the fact that the sound vitality spreads as far as possible and doesn't convey enough vitality to the flamesIn the Sori Sound Engineering Research Institute (SSERI), an exceptional acoustic focal point was applied to improve the impediments of the recently discharged Sound Fire Extinguisher to center sound vitality forward. A unique acoustic focal point created by SSERI gathers and reverberates the sound and alters the course of the reverberation sound vitality to the front. The sound shaft that happens during the way toward unifying the sound vitality frames a breeze speed because of the transmission of an enormous sound vitality [4-6]. Sound Fire Extinguisher smothers fire by utilizing a sound part that isn't water or dousing specialist, so it can limit the harm of different gear, for example, data media transmission framework and can be completely utilized as a preventive even before blaze happens. Specifically, by applying an acoustic focal point to the Sound Fire Extinguisher, the sound part is collimated aside to annihilate it, consequently upgrading the extinguishable effectiveness and amplifying different impacts of the sound.In this paper, we looked at the cooling pace of the sharp edge and Sound Fire Extinguisher to check if the sound segment of Sound Fire

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Extinguisher can forestall blaze by bringing down surrounding temperature before fire happens.

Fig. 1: Sound Fire Extinguisher from SSERI

II. MATERIALS AND METHODS

2.1 Related Terms and Theory

Combustion refers to a strong oxidation reaction in which a substance generates a rapid chemical reaction with oxygen to generate heat and light. Three factors are essential for this fire to be generated and maintained, which is called the 'third element of combustion'. The three elements of combustion are defined below, and if none of them is present, they are not burned.

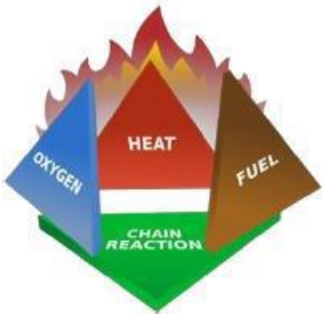

Fig. 2: A flame tetrahedron

Fuel (combustible material): It is a substance that can be dehydrated in fire, divided into solid fuel, liquid fuel, and gaseous fuel. In addition, the characteristics of burning depend upon the composition of the fuel.

Heat (ignition source): In order for the substance to ignite, it must have very high heat, and the amount of heat must be moderate. The size of warmth required for combustion is split into ignition point, flash point, and combustion point.

Ignition point: The minimum temperature at which the fuel starts burning.Flash point: The temperature at which the fuel burns when the fuel is turned on. Burning point: Temperature at which fire continues to empty when fuel is burning.

Oxygen (air): The material must be supplied with oxygen to take heat. Most liquids are difficult to ignite when the oxygen content in the air is reduced to 15% or less.[7]

2.2 Sound Wave

Sound wave could be one of the potential alternatives in putting off flames. The acoustic pressure and air velocity produced from a speaker is that the main theory wont to explain how sound waves put off flames. A simulation of acoustic wave was administered to review behavior acoustic wave propagation within the collimator and surrounding environment. Experiments were then conducted to review suitable acoustic 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) [8]. From the primary a part of results, using a standard collimator, it had been found that acoustic wave can only extinguish gas fuel type flames at 91 Hz. Sound wave was found to be one among the alternatives in creating new method in flame extinguishing technology. There are some aspects of the combustion which will be suffering from acoustic wave . The flame Air-Fuel Ratio at the boundaries which is at the lowest lean limit of the combustion of fuels can be affected by sound wave by changing the velocity of its medium (air) [9]. Furthermore, the changes in air velocity changes also will be ready to affect the flow of the fuel round 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-off characteristics.

2.3 Sound Fire Extinguisher's Sound Component Collimation by Acoustic Lens

Hardware Required

- 300 Watt Speakers
- 250 Watt Amplifier
- Collimator
- Power supply unit
- High speed camera

The principle behind the extinguisher is simple: as they are mechanical pressure waves that cause vibrations in the medium in which they travel, sound waves have the potential to manipulate both burning material and the oxygen that surrounds it. If the sound could be used to

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separate the two, the fire would be starved of oxygen and, accordingly, would be snuffed out. The work could potentially be applied to swarm robotics where the device would be attached to a drone to be used in situations such as large forest fires or urban blazes, thereby improving safety for firefighters.

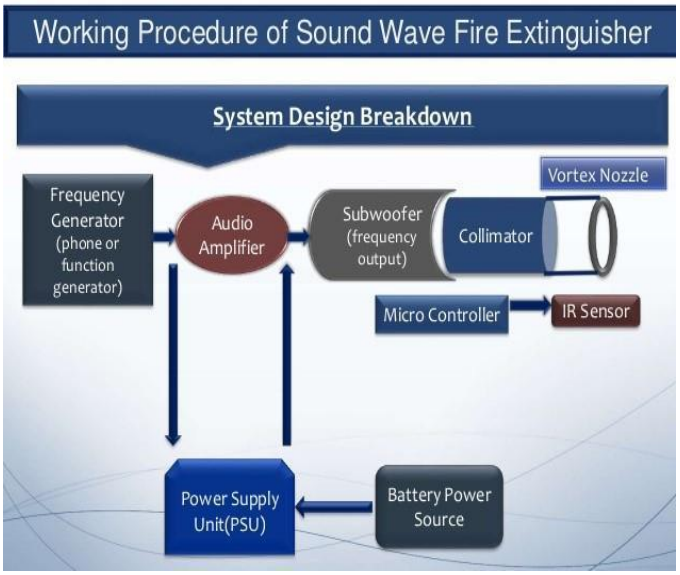

Fig 3: Block diagram

2.3.1Acoustic Lens

An acoustic lens is a device that focuses or collimates sound energy. Generally , sound emits an equivalent energy altogether directions, therefore the propagated form becomes spherical. Therefore, when the propagation distance is doubled, the propagation area is quadrupled and therefore the propgated energy is reduced to 1/4. An acoustic lens is placed on the trail of sound propagation to focus sound energy. Sounds are refracted at the interface of various mediums like other sorts of waves. When an acoustic lens with radius of curvature R is installed ahead of the oscillator, the distance F at which the sound is concentrated are often approximated as shown in equation (1) is a schematic of an acoustic lens

$$R = F.(1 - \frac{1}{n}) \text{.....(1)}$$

R : Radius of curvature of acoustic lens

F : Distance to focus

n : Sound velocity ratio between medium1(acoustic lens) and medium2

The fluid momentum (Navier-Stokes) equation and continuity equations are abridged to get the acoustic wave equation via the following assumptions, i.e. the fluid is compressible (density changes due to pressure variations) and there is no mean flow of the fluid [10].

The acoustic wave equation is given by:

$$\nabla \cdot \left(\frac{1}{\rho}\nabla p\right) - \frac{1}{\rho c^2}\frac{\partial^2 p}{\partial t^2} + \nabla \cdot \left[\frac{4\mu}{3\rho}\nabla\left(\frac{1}{\rho c^2}\frac{\partial p}{\partial t}\right)\right] = -\frac{\partial}{\partial t}\left(\frac{Q}{\rho}\right) + \nabla \cdot \left[\frac{4\mu}{3\rho}\nabla\left(\frac{Q}{\rho}\right)\right] \text{.....(2)}$$

Where:

c=speed of sound($\sqrt{\frac{k}{\rho}}$) in fluid motion

ρ = mean fluid density

k = bulk modulus of fluid

μ = dynamic viscosity

p = acoustic pressure

Q = mass source in the continuity equation

t = time

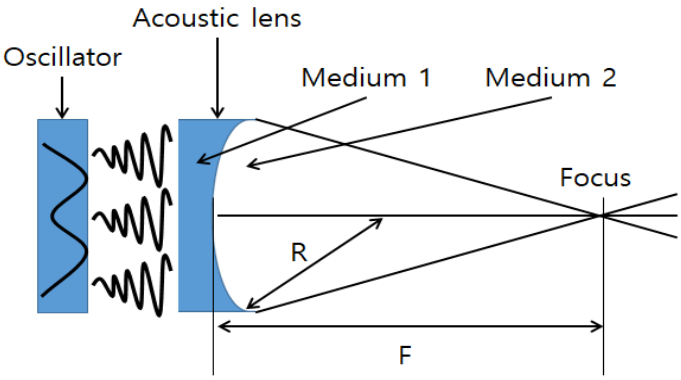

Fig 4 : Schematic of Acoustic Lens

2.3.2. Sound Component :

The point where the sound energy is concentrated through the acoustic lens is named focus. When a sound source is placed at the focus of an acoustic lens, the sound wave passing through the lens becomes a plane wave that transfers energy to a certain area. Sound extinguisher uses a special acoustic lens to collimate a sound component in order that it propagates as a plane wave. Thus, within the case of a Sound extinguisher , the sound passing through the acoustic lens minimizes attenuation and may transfer energy to the flame. Generally, in the sound field, the wind speed is not formed because the low density part and the high part of the medium particle repeatedly change and the wave is transmitted. However, Sound extinguisher uses acoustic lens to collimate the sound energy, therefore the variation of medium particle density becomes very large and wind speed is made.The portable Sound Fire Extinguisher used in the experiment has a wind speed of about 10m/s at a distance of 10cm [11-14].

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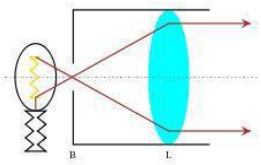

Fig 5: Collimator

III. EXPERIMENTS AND RESULTS

Experiments were administered to live the natural process from 100 ℃ by heating chrome steel tableware. The experiment was conducted in three cases: first, the natural process was measured with natural cooling; second, when the blade was blowing; and third, when the sound component of the Sound extinguisher was supplied. so as to match the Blade and Sound extinguisher under an equivalent conditions as possible, the space between the blade and therefore the chrome steel tableware is 50 cm, the space between the sound extinguisher and therefore the refore the stainless tableware is 90 cm and the wind speed reaching the stainless tableware is 2 m/s, respectively. The natural process of the stainless steel tableware was recorded with video using thermal imaging camera and android mobile. The temperature was measured at an equivalent position inside the tableware for every experimental cycle.At the time of the experiment, counting on the experimental environment like the ambient temperature, it's going to affect the speed of cooling the stainless tableware. additionally , measurement errors may occur counting on the situation of the thermal imaging camera. Therefore, so as to match the measured results under an equivalent environmental conditions for every experimental cycle, all the experimental tools were fixed in order that the temperature measurement positions might be an equivalent. Also, in each experimental cycle, one experimental cycle was completed within half-hour to simulate the ambient temperature. The comparison between different experimental cycles is meaningless because the experimental environment including the ambient temperature is different and therefore the temperature measurement position is slightly different. However, within the same experimental cycle, it are often said that the result's comparative measurement under an equivalent condition.

Figure 6 shows the comparison of measured temperature changes when natural cooling, wind of the blade are supplied, and sound components of the Sound extinguisher are supplied. In Figure 6, it took 82 seconds to chill the stainless tableware by natural cooling from 100 °C to 50 °C, and it took 33 seconds when the wind of the blade was supplied. However, when the sound component of Sound extinguisher was supplied, it took 22 seconds and therefore the temperature decreased sooner . However, if the sound component of the Sound extinguisher is supplied to the heated tableware, it'll cool more quickly than when the wind of the blade are supplied. Especially, all of the eight experiments showed that the cooling effect of the Sound Fire Extinguisher's sound components was the simplest . additionally , the results of the entire experiment showed that the sound component of the Sound extinguisher was cooled 10 ~ 20% faster than when the wind of the blade were supplied.

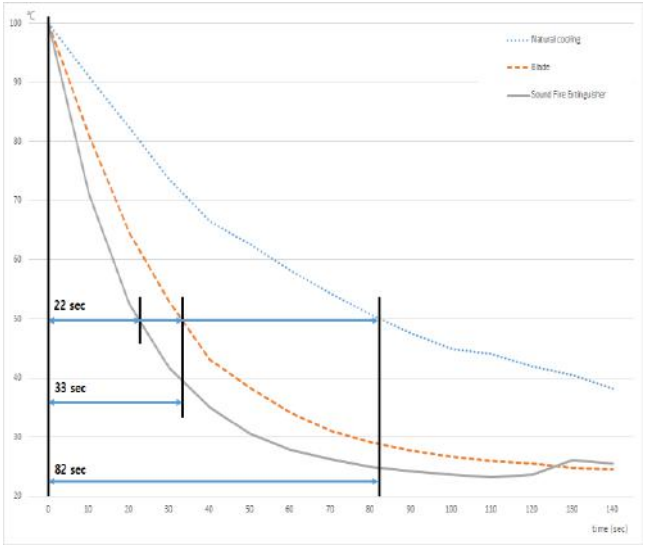

Fig.6: Temperature change measurement result

IV. CONCLUSION

It can not be overcome to overcome the fire fighting environment which was changed only by existing extinguish method which depends only on chemical reaction of fire extinguish agents. Sound Fire Extinguisher, which uses sound characteristics, can be an alternative to overcome a changed fire fighting environment. SSERI has improved its focus on sound energy in flames by applying a special acoustic lens to the existing Sound Fire Extinguisher released by DARPA and George Mason University students.In this study, we tried to verify the cooling effect of Sound extinguisher by comparing with blade. As a result of experiment that the wind speed reaching to the stainless tableware is 2m/s, the Sound Fire Extinguisher's sound component was found to cool the stainless tableware by 10 to 20% faster than when the wind of the blade were supplied. The wind of the blade simply lowers the heat by moving the air around the tableware. On the opposite hand, the sound component of the Sound extinguisher are often said to chill more quickly because it

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dramatically changes the air density round the tableware to promote heat diffusion. These results show that Sound Fire Extinguisher has a high cooling effect even at the same wind speed and can be used for conflagration suppression as well as conflagration prevention. In addition, the Sound Energy Extinguisher's special acoustic lens collimates the sound energy, so we can see that the sound energy is well transmitted to the target point. Sound extinguisher are going to be ready to produce various effects counting on the sound component. Future applications of Sound Fire Extinguisher for various purposes have been studied, and we hope to be able to use Sound Fire Extinguisher in various applications in fire fighting field.

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