Design and Fabrication of Acoustic Fire Extinguisher

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Abstract: This paper highlights fire extinguishing techniques used in today's world which are having economic and ecological disadvantages. Fire accidents very hazardous and can cause a great loss of life and property, so a new fire extinguishing technique is designed. This paper compromises on design and fabrication of acoustic fire extinguisher. In this sound waves are used as it is efficient alternative in extinguishing flames. The main concept of this paper is to show that acoustic pressure and the air velocity produced from a speaker can extinguish flames. This paper highlights on the behavior of different sound frequencies in the collimator and surrounding environment. Experimental study and testing is done for different sound frequencies on which the extinguisher works smoothly. Different kind of fuels are tested with different sound frequency. The collimator which is used is converged which increases the air velocity. The air fuel ratio at the flame boundary is disturbed because of the variation of pressure and high air velocity which leads to extinguishing of flames. During conduction of the experiments the suitable range of sound frequency to extinguish flame was found to be between 30 to 50 Hz. However, in the experiment flame used in the testing were relatively of thinner boundary.

Index Terms **– Extinguishing, Sound, Acoustic pressure, High velocity, Air-Fuel ratio.**

I. INTRODUCTION

The control of fire by early humans was a turning point in the cultural aspect of human evolution. Fire provided a source of warmth, protection, improvement on hunting and a method for cooking food. These cultural advancements allowed for human geographic dispersal, cultural innovations, and changes to diet and behavior. Additionally, creating fire allowed the expansion of human activity to proceed into the dark and colder hours of the evening.

Fire accidents are catastrophic in nature and leads to unrecoverable loss. The conventional fire extinguishing techniques have various drawbacks which includes existing techniques are not eco-friendly. This research aims to develop a portable fire extinguisher and to analyze the effect of different frequency range on flames. Every year approximately 3,600 deaths and 18,600 injuries occur [1].

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1.1 Flames

Flame is a chemical process that releases energy through light or heat. It is an exothermic reaction in which solid, liquid or gas fuels undergoes rapid oxidation. When an exothermic chemical reaction occurs, fuel and an oxidizing agent are heated above a certain temperature by releasing additional heat energy. There are different classes of fire; Class A fires are associated with ordinary combustible such as wood, paper, cloth, trash and plastics. Class B fires are associated in flammable liquids such as gasoline, petroleum oil and paint. Class B fires do not include fires involving cooking oils and grease. Class C fires involves in electrical equipment such as motors, transformers and other appliances. Class D fires are the fires in combustible metals such as potassium, aluminum and magnesium [2].

1.2 Fuel

Fuel is combustible material which is used to begin the process of combustion. Fuels can be solid, liquid or gas, the material will burn when in the vapor phase. This means that a combustible gas phase must exist in order for fire to begin. When a material is heated, at a certain temperature known as flash point a gas phase is achieved in order to exert a vapor pressure that can ignite in air to support the combustion.

1.3 Sound

Sound waves was found to be one of the conventional alternatives in creating new method of flame extinguishing. The air fuel ratio at the boundary of the flame of lowest lean limit which is affected by sound waves, the velocity of the medium (air) is changed by sound waves. The change in air velocity change is the flow rate around the fuel by increase convective heat transfer. The current research aims to study and analyze the effect of different frequency of sound waves on flames.

II. PROBLEMSTATEMENT

The conventional fire fighting techniques have many drawbacks, such as toxic to humans and leaves residue (for dry chemical-based fire extinguisher). For water-based fire extinguishing techniques also have drawbacks, as they freeze in cold climate and conducts electricity, using sound waves with certain frequency as a fire extinguisher will have advantages as they are not leaving any residue and toxic material behind as byproducts.

III. EXPERIMENTALSETUP

3.1 Description of the components

Subwoofer: A Subwoofer is a woofer which produces pitched audio frequency known as bass. the typical frequency range for a subwoofer is about 20-60Hz for consumer products below 100Hz for professional life sounds and below 80Hz for THX approved systems. The Subwoofer are powered by external amplifier. Figure 3.1 shows a 440 watts subwoofer [1].

Figure 3.1: Sub-woofer 440 watts

Collimator/Vortex:Acollimatorisadevicethatbasicallynarrowsabeamofparticlesorwaves,whichmeanstocausethedirection of motion to become more aligned in a specific direction. Figure 3.2 shows a nozzle type pvc pipe collimator, Collimator is used because it reduces intensity by blocking incoming radiation and improves radiation[2].

Figure 3.2: Collimator or vortex

Signal Generator: A signal generator is an electronic audio acoustic equipment commonly associated with a telephone system which is used to generate high and low frequency signals. in each case, electrically generated audio pulses are sent to specific components [3]. Figure 3.3 shows, D-trek DT-2062 platinum 2400W amplifier is used.

Figure 3.3: D-trek DT-2062 platinum 2400W amplifier.

Working principle: - The concept in this work is based on the principle of physics and engineering aspects of electronics to successfully suppress the flames. it is important to note that the acoustic wave patterns are referred to as longitudinal pressure waves, the waves move back and forth vibrating motion due to which they are able to agitate all molecules away from the fuel of the flame. When the pressure waves are directed towards a source of flame it will decrease the pressure at the source, which in turn will decrease the temperature of the flame. The concept is true based on ideal gas law, which states that pressure time volume is equal to constant 'N'. The substance of gas and 'R' the universal gas constant multiplied by temperature.[PV=NRT].

Working model: The primary acoustic mechanism of suppression of liquid fuels, impart a blow off mechanism. the acoustic wave imparts K.E to the reactants of the flame causing the net velocity of the reactants to be greater than the flame propagation velocity. The flame oscillates about the fuel under acoustic excitation. The flame detaches from the bowl prior to the excitation after approximately 3sec. In the beginning the flame oscillates about the source, shortly after the excitation the flame appears to undergo chaotic mixing in the lifted state. This mixed state represented induced changes in the gradient between fuel and oxidizer. Eventually, the acoustic interaction extinguishes the flame. Figure 3.4 represents the fabricated model and figure 3.5 shows the CAD model of the assembly respectively.

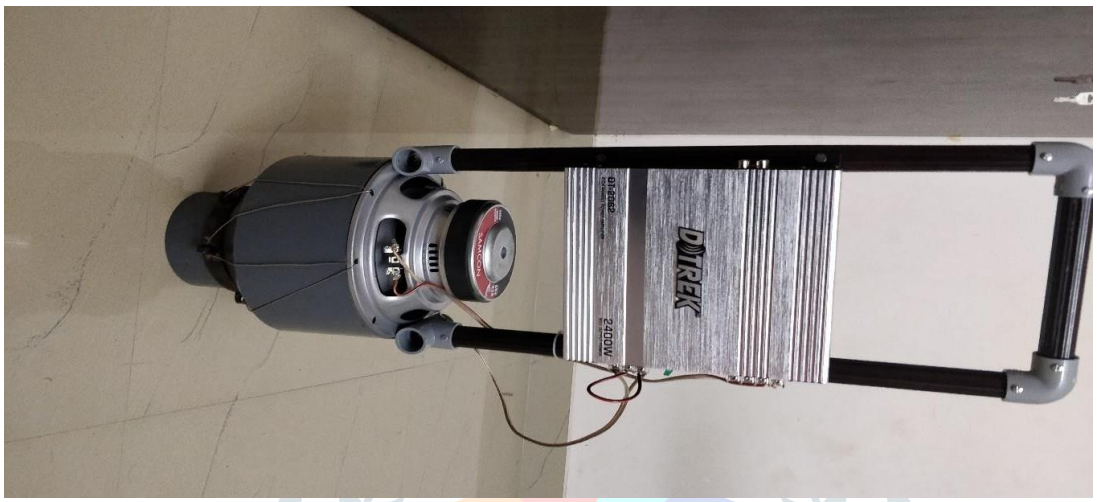

Figure 3.4: Experimental model

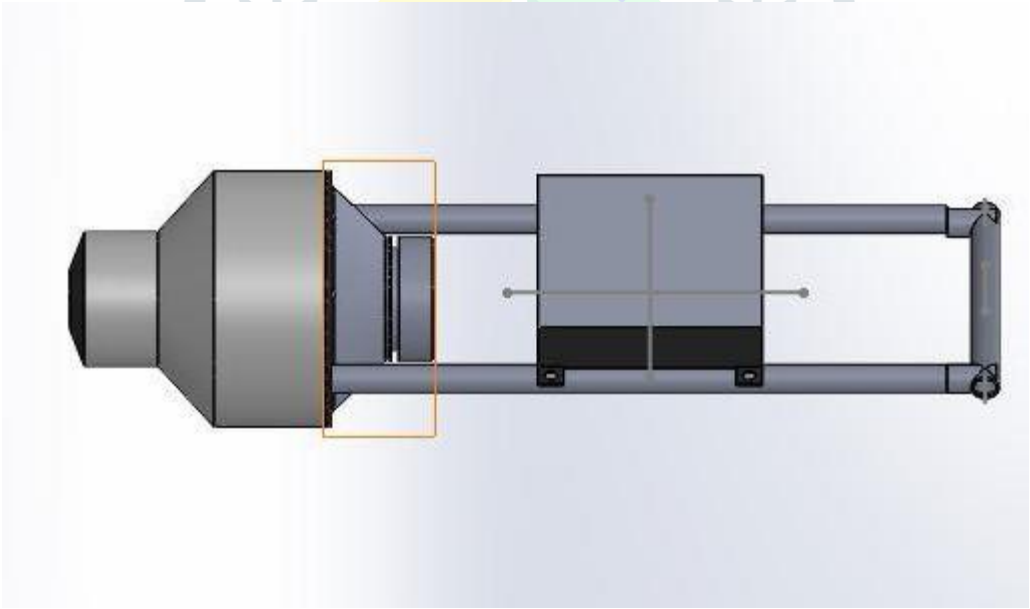

Figure 3.5: CAD model

IV. RESULTS ANDDISCUSSION

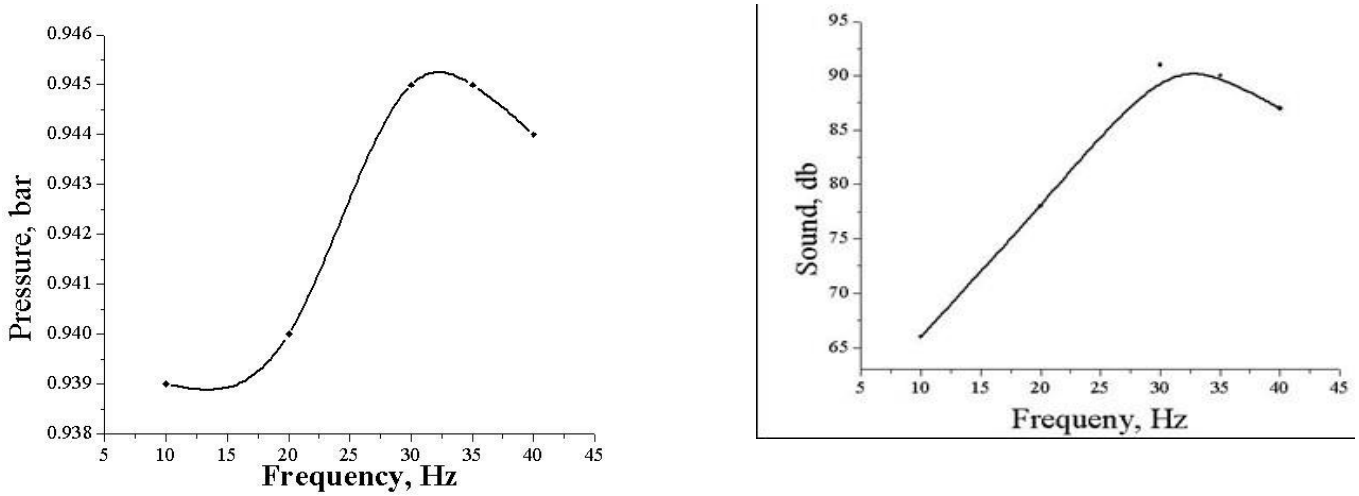

Figure 4.1: Variation of Pressure and Sound with Frequency

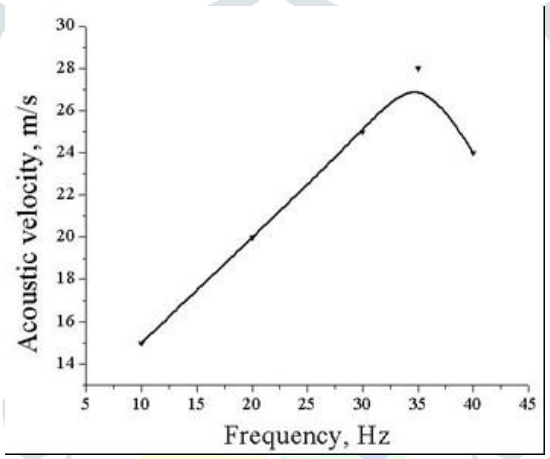

Fig 4.2: Variation of acoustic velocity with frequency

Discussions:

The above graph (figure4.1and4.2) shows the frequency changed in the collimator or the vortex with respect pressure and velocity or sound in db. The graph shows that the most suitable range for extinguishing the flames is when frequency is in between 35to45 Hz as the graph escalates to the maximum peak between this frequency ranges and starts to drop after this frequency. Which shows that the air velocity is maximum when the frequency range in between 35 to 45Hz.

V. CONCLUSION

From Figure 4.1and 4.2 it is observed than an optimum frequency of 40Hz and an operating distance of Two feet successfully suppresses a natural kerosene flame in 2.2 sec.

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