INFRASONIC BLAZE DOUSER

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Abstract: The traditional fire extinguishers, such as chemical foam or water are used successfully but pose threat by severely damaging indoor equipment. The need of fire extinguisher technique is vital as fire accidents are catastrophic on nature and lead to unrecoverable loss. Hence the goal of this project is to use acoustic sound waves to extinguish a flame instead of traditional fire extinguishing methods. Acoustic sound waves can be one of the potential alternatives to extinguish a flame, as they use low frequency infrasonic sound waves to quench the flame by lowering its temperature by contacting vibration energy from low frequency sound. Frequencies used will be under 100 Hz to disperse the oxygen molecules and extinguish the flame. The following project can be used in non-typical applications like Spacecrafts and International Space Stations (ISS). This infrasonic fire extinguisher offers the cleanest and least destructive way to put out flame.

Index Terms - fire extinguisher, blaze, douse, fire, infrasonic.

I. INTRODUCTION

Fire is a rapid combination of oxygen and other materials that generates heat and light. It is composed of glowing particles of burning material and luminous gases. In order for fire to sustain, a combustible substance must be present, the temperature must be high enough to cause combustion, and enough oxygen must be present to sustain rapid combustion. The reaction releases the energy as heat and light. For fire to exist there are three main components that it must possess which are oxygen, heat and fuel. If it is denied any one of these components, then its ceases to exist.

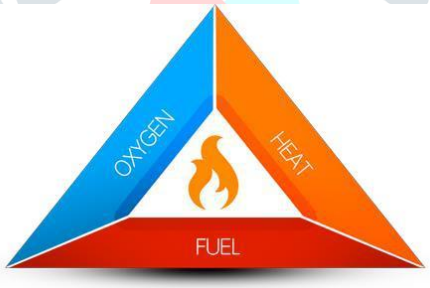

Figure 1: The fire triangle

1.1 The Fire Triangle: Fuel

Fuel for fire can be any kind of combustible material, such as paper, oil, woods, gases, fabrics, liquid, plastics, and rubbers. Fuel is often characterized by its moisture content, size, shape, quality and the pattern in which it spreads. Moisture content plays an important role here as it determines how easily it will burn.

1.2 The Fire Triangle: Heat

The heat source is responsible for the ignition or to start fire. It can be generated by a cigarette, electrical current or portable heater. Heat is a necessity to maintain fire and it also enables them to spread by drying out and preheating nearby fuel and warming the surrounding air.

1.3 The Fire Triangle: Oxygen

Air approximately consists 21 percent of oxygen. Most fires only require 16 percent. Oxygen aids the chemical processes that occur during fire. The process is known as oxidation. When fuel burns and reacts with oxygen from the surrounding air, it releases heat and generates combustion products such as gas, smoke and light [1].

Although conventional fire extinguishers are ideal for use in warehouses, factory environments and other areas where there are considerable advantages offered by their effectiveness and multi-purpose application, but the disadvantages of their residual properties that pose threat to the equipment cannot be ignored. The downside to it is that they leave a very fine powdery residue that will disburse on discharge over a wide area and settles into every nook and cranny, making the clean-up process of small fires

extremely problematic. The powder residue often cause damage to sensitive electronic equipment such as circuit boards, computers, production machinery etc., the extinguishing agent contains ammonium phosphate which can undergo hydrolysis to form phosphoric acid, which is extremely corrosive to ferrous metal and alloys, and may also attack some plastics, rubber and coatings. Each particle of this powder will cause potential damage to machinery and must therefore be removed during the clean-up process as soon as possible.

This is where a sound-based fire extinguisher comes into the picture, an acoustic wave fire extinguisher would douse the flame and protect the equipment from further damage caused by the fire. The extinguishing device developed is intended for typical residential and commercial use. However, it can also have non-typical applications such as in a spacecrafts and aircrafts. This project utilizes the scientific principle of physics and the engineering aspects of electronics to successfully suppress a flame.

II. WORKING PRINCIPLE

There are mechanical pressure waves that cause vibrations in the medium that they travel in, causing sound waves which have the potential to manipulate both the burning material and oxygen that surrounds it. Here sound is used to separate the two, the fire is starved of oxygen and, accordingly, is snuffed out. Sound waves being a kind of pressure waves remove oxygen from air molecules, given that oxygen is the main fuel for the fire. The impact of different frequencies of sound on small fires was explored through thorough experimental analysis. While ultra- high frequencies (ultra-sonic frequency waves) and high-pitched tones were ineffective on flames, it was found that lower, bass frequencies – between 25 and 50 Hz – produced the desired extinguishing effect. The prototype consists of a subwoofer amplifier and collimator to focus the sound. Therefore, deep bass tunes of hip hop, dub, dubstep, or grime would also work on flames

III. EASE OF USE

As compared to the conventional fire extinguisher this prototype is much lighter and user friendly. The wiring has been done with utmost care so that when the time arises there are no loose connections from the circuit end. The user simply has to connect their phone to generate the optimum frequency. As mentioned before, this prototype works well for all kinds of fire so in case of fire breaking out in important equipments we can save the equipment without causing any further damage to it or the surrounding environment as it does not leave any residue.

IV. EQUIPMENTS

4.1 Subwoofer:

A subwoofer is a woofer that allows electrical signal to be converted into sound waves, which is dedicated to the reproduction of low-pitched audio frequencies or the concept that we know as bass and sub-bass. Typical the frequency range found on a subwoofer is about 20–200 Hz for consumer products. We are using a subwoofer of diameter 12 inch. Peak power :800W. This is a dual coil subwoofer that means it has two coils with separate input ports. Each coil has a input impedance of 2 ohm which makes total input impedance of 4 ohms.

Figure 2: Speaker

4.2 Audio amplifier:

An audio amplifier circuit is used to amplify the input audio signal i.e. to increase amplitude level of an input signal. There are different class of Audio Amplifiers. We are using a 2.1 Channel Class D Audio Amplifier because we have 2 coils. In this type of amplifier, the switches are either fully on or fully off, significantly reducing the power losses in the output devices. Efficiencies of 90-95% are possible. The audio signal modulates a PWM carrier signal which further drives the output devices, with the last stage being a low pass filter to remove the high frequency PWM carrier frequency. The TPA3116D2 is a stereo efficient, digital amplifier power stage for driving speakers up to 100 W with an effective resistance of 2 Ω in individual channels. The TPA3116D2 can even run 2 × 30 W / 8 Ω without heat sink on a dual layer PCB. If even higher power is needed the TPA3116D2

does 2x50 W / 4 Ω with a small heatsink attached to its top side Power PAD. This device shares the same footprint enabling a single PCB to be used across different power levels.

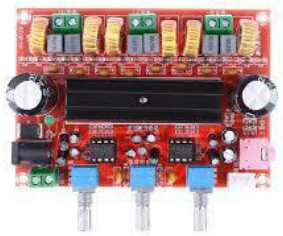

Figure 3: Audio Amplifier

4.3 SMPS (Switching Mode Power Supply):

Converting electrical power from one form to another form with necessary characteristics is called switch mode power supply.

This power supply is used to attain regulated DC output voltage from the DC input voltage or unregulated AC.

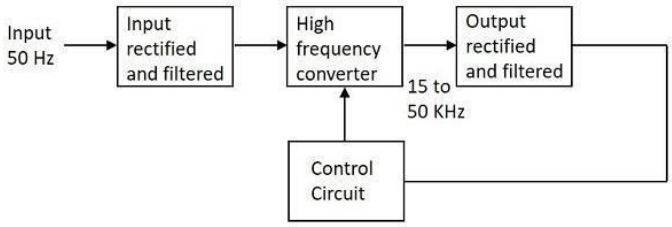

Figure 4: SMPS block diagram

4.4 Vortex Cannon

It is a Cylinder-Shaped Equipment used to Increase the directivity & Pressure of Sound. Without Vortex cannon, the sound pressure needed to extinguish fire is 140-150 dB which is very difficult to achieve but with Vortex cannon only 80-90dB Sound Pressure is Required. The Range of Vortex Cannon is 1-1.5 meter. Hight of Vortex cannon is 150cm & diameter of output Circle is 12inches

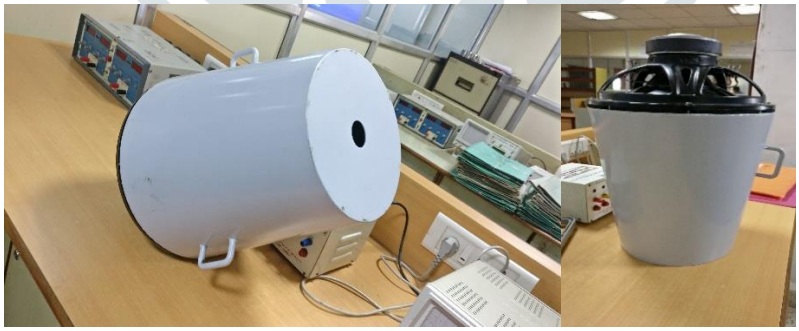

Figure 5: Vortex cannon

4.4 Battery

Instead of converting the AC supply to DC with the help of a SMPS we can directly use a 12v 5A Battery to provide the DC supply. SMPS was initially used for experimental purposes, as using the battery repeatedly would drain it eventually. With the addition of a battery we also make the prototype portable and flexible to use.

Figure 6: DC Battery

V. IMPLEMENTATION

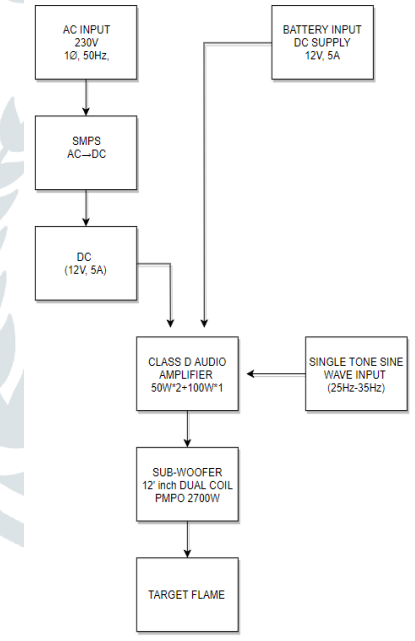

Figure 7: Implementation flowchart

For this, we can either use a DC input of 12v, 5A which is then directly given to the audio amplifier or a AC single phase supply as shown in figure 5.For the DC connection we require a battery which provides a constant DC supply of 12V, 5A to the audio amplifier. The first block of AC connection is AC supply which is a 230V supply, this voltage supply is rectified and stepped down with the help of a SMPS (switching mode power supply) to a 12V, 5A DC supply which is provided to the amplifier.

A sine wave input signal is fed to this amplifier with a tone generator, which generates sinusoidal signals of low frequency of about 30 Hz- 100Hz. Here we make use of low frequency electrical sine waves, which are needed to be a single tone frequency because only single frequency signal is capable of generating the larger vibrations than other multiple tone frequency. The sound frequency installed must have the capacity to vibrate the fire molecules in a vibrating pattern such that they should not recombine with fuel to burn in presence of oxygen

The third block is an audio power amplifier (TPA3116D2) that reproduces high-power electronic audio signals. This amplifier is a three channel amplifier i.e. left channel, right channel and the subwoofer channel. The amplifier amplifies the single tone sinusoidal signals from the generator and supplies them to a subwoofer (12inch dual coil) which directs this mechanical sound waves to the focusing vortex canon. The vortex canon is a wide collimator used to direct the waves on a target. The vortex canon is pointed out on the fire which helps in extinguishing the flame.[4]

An audio power amplifier (or power amp) is an electronic amplifier that reproduces low-power electronic audio signals. It amplifies the single tone signals from the generator and sends them to the focusing guide to direct these waves on the flame.

VI. RESULTS

6.1 Experimental analysis

In this analysis, we observed the effects of varying frequencies and power levels on the acoustic fire from a particular distance. Specifically, the acoustic frequencies used in the experiment are 25Hz, 30Hz, and 35Hz. During the experiment, it was noticed that the alcohol fire cannot slake if the acoustic frequency is above 100Hz. Furthermore, the output power of signal amplifier is selected to 1060W, 1500W, and 2040W. The flame area of fire to be put off was kept constant. Table 6.1 represents the experiment results under different parametric condition. It can be learned that under these frequencies, the fire can be suppressed with different time.

Sr No	Parameters		Flame Extinction	Flame Extinction time (s)
	Frequency (Hz)	Power (Watts)		
1	25	1060	Extinct	12.2
2	25	1500	Extinct	10.45
3	25	2040	Extinct	10.25
4	30	1060	Extinct	11.73
5	30	1500	Extinct	10.98
6	30	2040	Extinct	8.11
7	35	1060	Extinct	8.63
8	35	1500	Extinct	8.63
9	35	2040	Extinct	3.28

Table 6.1 Frequency and Power parameters for extinction of flame

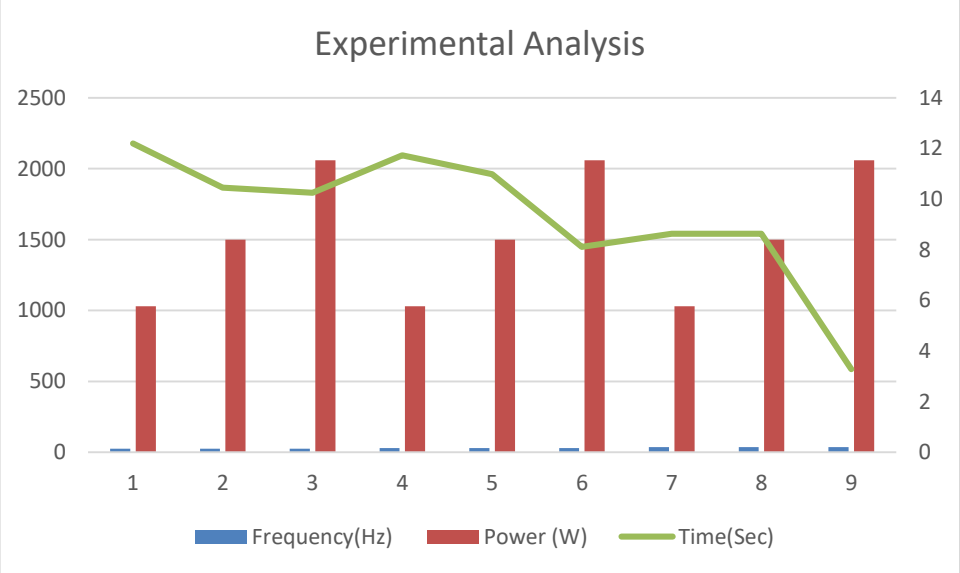

Figure 8: Experimental analysis

6.2 Result

From the above analysis we could observe that flame suppression process was governed by two major factors, acoustic frequency and the acoustic power input. This result shows that the acoustic frequency plays a more important role than the power. From the optimal level, it can be indicated that with the increase of acoustic frequency, the performance of fire suppression is improved. Hence, we can say that the optimum output was acquired at 35Hz frequency at power rating of 2040W.

VII. Conclusion

With knowledge of the resonant behavior of a room or enclosure, the present research aids in incorporating a single (or multiple) speaker within it to achieve acoustic velocities in specific areas of interest. One can generate a specific air velocity using various combinations of pressure and frequency. This technique of suppression would require knowledge of the geometry of the acoustic cavity, so that the optimum placement of the speaker(s) can be achieved, as well as excitation with optimal the resonant frequencies for the room.

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