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Comprehensive Approach for Flame Extinguishing Using Acoustic Waves

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Abstract: The need of fireplace extinguishing techniques is significant as fire accidents are catastrophic in nature, ends up in unrecoverable loss. The present fire extinguishing techniques comes with various drawbacks. The requirements for brand spanking new fire extinguishing techniques is significant as fire accidents cause deaths and injuries. The acoustic wave might be one of the potential alternatives as fire extinguishers. The low frequency acoustic waves spilled from a speaker tends to extinguish the flames. The present research aims to develop the portable autonomous system analyzes the effect of various frequency of acoustic waves on flames. If you have got sensitive equipment, like during a computer room or data center, employing a water or a dry chemical device can cause the maximum amount damage as a fire itself. Instead, use an acoustic device. This helps the electronic components to be protected for the damage caused with none replacements of components. Experiments are conducted to test suitable acoustic wave frequency range to extinguish flame and to research the acoustic-flame interaction through observations using portable and innovative approach to reduce the overall cost. Further the research is done out to check the critical parameter such the length to diameter ratio of the vortex tube on velocity, Pressure of waves are discussed. Mobile sensors are accustomed record the information. This prompts the need for fully autonomous systems that can move uncontrolled through various places to detect the levels of dangerous fire accidents, the survivors in the disaster areas, and thus monitor the overall system for future clean and green societies.

Keywords: Acoustic, Autonomous System, Extinguisher, Fire, Frequency, Pressure

I. INTRODUCTION

The incontrovertible fact that everyone knows that fireplace incorporates a great influence on all living spaces in modern society. This type of fireside is necessary for mankind, but it damages people by fire. There are tens of thousands of fires once a year in our country, and thousands of individuals are killed and many billions of lives are damaged once a year. Although fire could be a necessary necessity for mankind, it can come as a disastrous threat to mankind. There are various causes of fireside and materials that cause fire also are various. Fire extinguishing equipment is usually used for water spraying, foam fire extinguishing, powder fire extinguishing, greenhouse emission extinguishing, and halogen compound extinguishing. It is very inappropriate to use general fire-fighting equipment. These places can lose their original function due to existing fire extinguishing materials, and there's a good risk of economic loss. Firefighting and rescue activity is taken into account the risky mission. They're a perfect target for robot technology to stay away firefighters from danger. Moreover, it makes possible to rescue way more victims. Some fire departments have already developed and deployed firefighting and rescue robots [1]. However, the performance of the robots isn't enough they're considered and examines following points of view: "size and weight", "cost and performance" & "Availability of resources to extinguish the fire". A robot may be a mechanical and virtual intelligent agent that may perform tasks automatically or with guidance, typically by voice. Present extinguisher contains different chemicals, depending upon their application [2]. Generally, they're pressurized with Nitrogen or carbonic acid gas (CO2), when this pressure released a blaze will extinguish the hearth, as we all know there are many such firefighting agents like water, potassium acid carbonate, evaporating fluorocarbons etc. Also, of these resources are limited during the time of extinguishing fire. Despite such quite behavior of fireplace, there's an opportunity of extinguishing it by sound. If we discuss the procedure of spreading fire, with enough amount of fuel and oxygen and constituent fire is caused, the very first constituent from any source ignites the fuel in presence of oxygen. As a summary, we will say that fireplace is formed to spread by heating elements [3]. This particular task is completed by sound and fire is easily extinguished with none risk to human life and hazard to nature.

In this system, a wireless communication is employed to acknowledge human input and is converted as data. This data is further processed and accustomed control the robot. Using this method perform several studies on control style variants for robots. Results show that it's indeed possible to find out to efficiently manipulate real-world objects with only data (presence of flame) as an impression mechanism [6]. The results provide strong evidence that the further development of

voice-controlled robotics are successful. Also the system performance are increases, reduction of size and weight is feasible and satisfies condition of resources availability efficiently.

II. PROPOSED SYSTEM

The acoustic fire extinguisher robot operates as per the command received by wireless communication through ZigBee. The PIC 16F677 microcontroller is integrated with the system which makes it possible to control the locomotion of the robot vehicle via the wireless communication. The controlling device is also any computer or laptop /tablet having a Proteus 8 professional application. The controlling system provides a decent interactive GUI that produces it easy for the user to manage the robot. The receiver end reads these commands and interprets them as controlling the robotic vehicle. The user sends commands to the microcontroller through wireless communication to motion the vehicle in forward, backward, right and left directions also used to a generation of the sound which is employed to extinguish the fire. After receiving the commands, the microcontroller then operates the motors to motion the robot in four directions and reach the fire location and blow the sound through the speaker to extinguish a fireplace. The output of the sound is concentrated flaming by using conical shape tube. Due to this conical shape, fire can extinguish early than other fire extinguishing agent without damaging the environment. The communication between transmitter and receiver is distributed as serial communication data. The microcontroller program is intended to control the motor through a motor driver IC as per the commands sent by the user. The status of the operation is shown on the LCD for information robot is figure correctly. The LCD also displays the temperature value, percentage of gas composition, identify and detects the piezo or sound material, and also the number of humidity. The figure1 shows about the proposed system to extinguish the fire using the acoustic waves.

III. IMPLEMENTATION

The block diagram that specify the method of the signal generation and also different stages. The image of the diagram constructed is shown in Figure. 1. The locomotion of acoustic fire extinguisher robot controlled by ZigBee. The PIC 16F677 microcontroller with a set of sensors as temperature sensor, humidity and gas sensors to monitor the environment. The controlling devices of the whole system is a PIC 16F677 microcontroller. The input delivery by the ZigBee module from user is fed as input to the controller and controller acts accordingly on the DC motor for movement of the robot and acoustic wave generation for extinguishing the fire. The robot in the project can be moved in all the four directions. In achieving the task the controller is loaded with small device 'C' complier (SDCC) using USBASP adaptor. In second part of the figure describes about the woofer setup and PIC microcontroller setup where PIC microcontroller controls the chassis of the robotic vehicle and woofer setup will generate the frequency and through the vortex cannon to extinguish the flames.

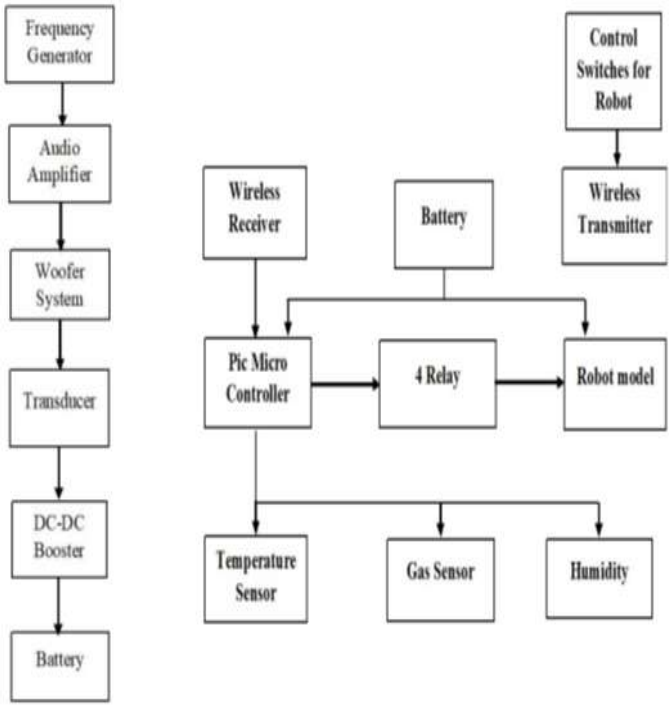


Figure 1. Block Diagram

IV. MATERIALS

The block diagram that specify the method of the signal generation and also different stages. The image of the diagram constructed is shown in Figure. 1. The locomotion of acoustic fire extinguisher robot controlled by ZigBee. The PIC 16F677 microcontroller with a set of sensors as temperature sensor, humidity and gas sensors to monitor the environment. The controlling devices of the whole system is a PIC 16F677 microcontroller. The input delivery by the ZigBee module from user is fed as input to the controller and controller acts accordingly on the DC motor for movement of the robot and acoustic wave generation for extinguishing the fire. The robot in the project can be moved in all the four directions. In achieving the task the controller is loaded with small device 'C' complier (SDCC) using USBASP adaptor. In figure2 describes about the woofer setup and PIC microcontroller setup where PIC microcontroller controls the chassis of the robotic vehicle and woofer setup will generate the frequency and through the vortex cannon to extinguish the flames.

A.PIC MICROCONTROLLER

PIC microcontroller is that the first RISC based microcontroller fabricated in CMOS (complementary metal oxide semiconductor) that uses separate bus for instruction and data allowing simultaneous access of program and data memory .It has a wide operating voltage of 2.0-5.5 volts where the implementation of the work becomes easier. The performance of the PIC becomes very faster because of the RISC architecture. When compared to other microcontrollers, power consumption is very less and the programming is very easy for the controls of the robotic vehicle.

B.GAS SENSOR

MQ-2 gas sensor is supposed with sensitive material of SnO2, which with lower conductivity in clean air. When the target combustible gas exists, the sensor's conductivity is higher. Signal conditioning circuit is employed to convert the change of conductivity to correspond signal with the input gas concentration. MQ2 gas sensor works on 5V DC and draws around 800mW. It can detect LPG, Smoke, Alcohol, Propane, Hydrogen, Methane and Carbon Monoxide concentrations anywhere from 200 to 10000ppm. Thus the percentage of various gas composition present in the environment can be easily obtained.

C.TEMPERATURE SENSOR

The LM35 device encompasses a bonus over linear temperature sensors calibrated in Kelvin, because the user isn't required to subtract an oversized constant voltage from the output to urge convenient Centigrade scaling. Its minimum and maximum input voltage is 35V and -2V respectively .Typically 5V. It can measure the temperature ranging from -55degree Celsius to 150degree Celsius. The output voltage is directly proportional to temperature which will sense the current temperature at the environment.

D. ACOUSTIC GENERATOR

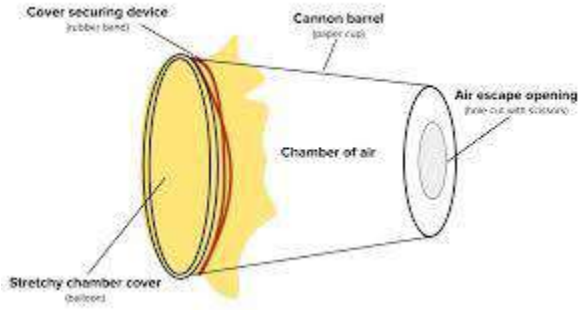
An Acoustic Generator is a woofer, or a complete loudspeaker, which is dedicated to the production of pitched audio frequencies known as bass. The typical frequency range for a subwoofer is about 20–60 Hz for consumer products below 100 Hz for professional live sound and below 80 Hz in THX-approved systems. Subwoofers are intended to augment the low frequency range of loudspeakers covering higher frequency bands.

E. ZIGBEE

ZigBee communication is specially built for control and sensor networks on IEEE 802.15.4 standard for wireless personal area networks (WPANs), and it is the product from ZigBee alliance. This communication standard defines physical and Media Access Control (MAC) layers to handle many devices at low-data rates. These ZigBee's WPANs operate at 868 MHz, 902-928MHz and 2.4 GHz frequencies. The date rate of 250 kbps is best suited for periodic as well as intermediate two way transmission of data between sensors and controllers.

F. ACOUSTIC GENERATOR

The Vortex Cannon could be a piece of weaponry that releases doughnut-shaped air vortices. The vortices are able to disturb papers or blow out candles after travelling several distance. It's a plastic landscaping trim made up sort of a plastic funnel for the output energy. It's designed with 1 1/2"*3" PVC Adapter and with duct tapes to eject the output for laying aside the flames.



V. THEORY/CALCULATION

PID (Proportional–Integral–Derivative) – Motion of the robot is controlled. A proportional–integral–derivative controller (PID controller or three-term controller) is a control loop mechanism employing feedback that is widely used in industrial control systems and a variety of other applications requiring continuously modulated control.

As the name suggests, PID algorithm consists of three basic coefficients; proportional, integral and derivative which are varied to get optimal response.

Proportional – The error is multiplied by a gain. The higher is the gain, the faster is the response. However, very high gain cause instability. Thus the robot gain will be increased for its control motion in order to increase the efficiency.

Integral – Is used to remove steady- state error. However, integral action increases the overshoot and reduces system ability. So the error can be eliminated from the robot easily.

Derivative – Is used to improve the transient response by reducing overshoot.

Three parameters are X, Y, ɵ

Start – X

End – Y

Rotational – ɵ

Where X, Y gives the horizontal and vertical movements about the robotic vehicle for its directional controls and ɵ gives the tangential value about the robot. It describes about its accurate longitudinal latitudinal position of the object and desires to put off the flame beyond any kind of obstacles.

The PID formula weights the proportional term by a factor of P, the integral term by a factor of **P/TI**, and the derivative term by a factor of **P.TD** where P is the controller gain

TI is the integral time

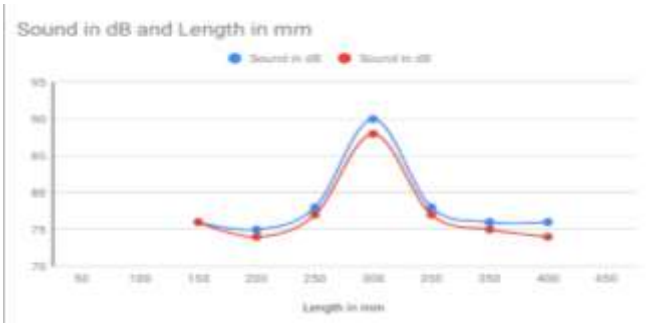
TD is the Heading and Subheading derivative time.

Firstly the info are initialized for PID where the simulation is completed supported the sampling. Next all the collected samples are going to be updated to perform the PID values to urge PID output. The info are going to be tried to add up with necessary details and output are going to be obtained as a listing. If the output is fully processed it draws the info from setter and provides the output and it it's not completed yet, the steps are going to be processed until we get the output. These controllers are applicable to many control problems, and often perform satisfactorily without any improvements or even turning. It is widely in the process industry, automation system process dynamics and in particular the loop dead time.

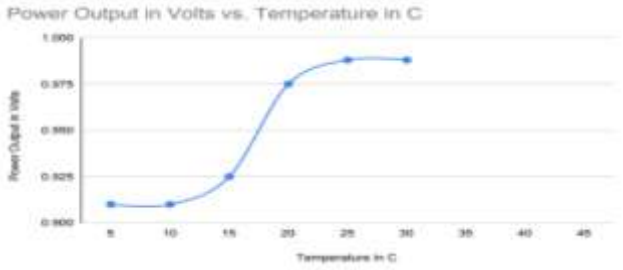
VI. FIGURES, TABLES AND GRAPHS

Optimization of acoustic generator

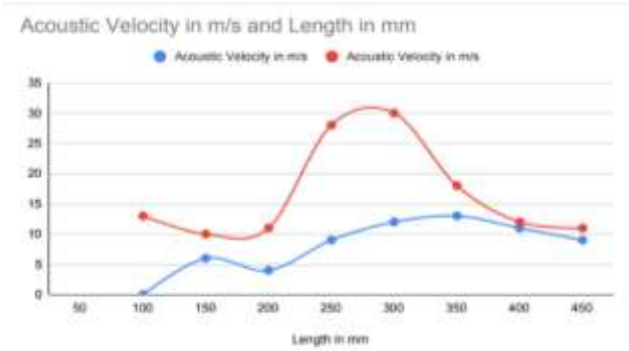
In the present research a shot has been made to analyze the effect of the geometry of the vortex to optimize the critical parameter like pressure, sound and therefore the acoustic velocity. The graphs shows the variation of pressure, velocity and sound for diverse length from 100 to 400 mm and varied diameter of 50 and 100mm.



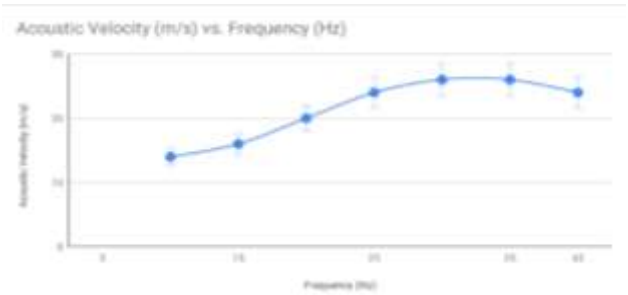
Graph 1. Effect of Vortex geometry on Sound



Graph 2. Power output and temperature



Graph 3. Variation of Vortex Geometry on Acoustic Velocity with Frequency



Graph 4. Effect of Vortex Geometry on Acoustic with Frequency

The research has also revealed the effects of important parameters such as the length to diameter ratio of the vortex tube on the acoustic velocity and pressure of waves which has also been used in this experiment [5]. Experimentally, the geometry of the vortex tube was optimized considering important parameters. The chosen variations were 100 to 400 mm for length and 50 to 100 mm for diameter. It was found that the length of 300 mm and diameter of 100 mm show the optimum pressure, velocity and sound for extinguishing fires. The Figure 5 and figure 6 illustrates the effect of variation of vortex tube on the acoustic velocity and variation of output power versus temperature.

The effect of vortex geometry on 50mm and 100mm length for the acoustic velocity. The light blue lines depicts the 100mm for diameter and dark blue depicts the 50mm for diameter in shown in the figure 7 .The acoustic 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, 10Hz, 30 Hz, 35 Hz, and 40Hz. The figure 8 demonstrates the various frequency input on the vortex tube on acoustic waves.

The numerical table value is shown as below:

Table1 1. EFFECT ON ACOUSTIC GENERATOR ON SOUND FOR 50mm DIAMETER

Length in Millimeter (50mm Diameter)	Sound in Decibels(db)
100	74
200	77
300	85
350	78
400	76

Table 2. EFFECT ON ACOUSTIC GENERATOR GEOMETRY ON SOUND FOR 100mm DIAMETER

Length in Millimeter (100mm Diameter)	Sound in Decibels(db)
100	77
200	78
300	90
350	81
400	76

Table 3.EFFECT OF TEMPERATURE FOR THE POWER ON THE OUTPUT

Temperature in Celsius	Power Output in Volts
10	0.938
20	0.939
30	0.945
40	0.944

Table 4.EFFECT ON ACOUSTIC GENERATOR GEOMETRY ON ACOUSTIC VELOCITY FOR 50mm DIAMETER

Length in Millimeter (50mm Diameter)	Acoustic Velocity in meter per second
100	0
150	11
200	12
260	11
270	12
350	13
400	10

Table 5.EFFECT ON ACOUSTIC GENERATOR GEOMETRY ON ACOUSTIC VELOCITY FOR 100mm DIAMETER

Length in Millimeter (100mm Diameter)	Acoustic Velocity in meter per second
100	12
200	14
250	28
270	27
360	20
400	11

Table1 6. EFFECT ON ACOUSTIC GENERATOR ON ACOUSTIC WITH FREQUENCY

Frequency in Hertz	Acoustic Velocity in meter per second
10	14
20	20
30	25
35	27
40	25

The Extinguisher that store the sound energy in the battery and use that sound energy which will put off the flame. The acoustic signal are boosted using the DC-DC booster. To evaluate the results, fire was exposed to various sound frequencies: 0Hz, 10Hz, 30Hz, 35Hz and 40 Hz. Variation of pressure, sound and acoustic velocity were evaluated with respect to the above chosen frequencies. Sound travels in the form of waves, which are fluctuations of pressure in the medium. The energy from vibrating objects moves from one particle to the next one in air in a pattern of varying pressure regions that is received as sound. In figure 3 shows the woofer setup connected with the frequency generator where we can tune the frequencies according to the output.

Figure 2: Acoustic Generator system.

After the hardware part concluded the simulation are done by the software which is PROTEUS 8 PROFESSIONAL., by the setup for the reading information and that is given in figure3below

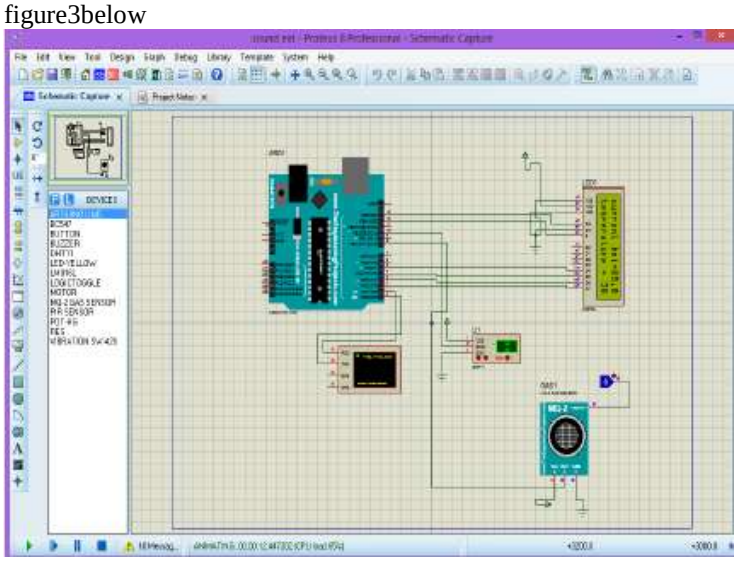


Figure 3. Simulation setup

Then the results are displayed and recorded. Especially the temperature value are get the input values as the 0 and 1. If the value 0 then the temperature is Normal**,** if the value 1 then the temperature will an alert.

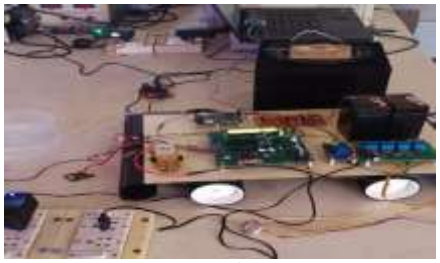


Figure 4: Side view of the Extinguisher

Figure 5: Front view of the Extinguisher

Figure 6: Pictures that put off the flames

VII. CONCULSION

The idea of Sound fire extinguisher Robot controlled by user potentially is an alternate to traditional fire extinguishers. It is programmed to alternate the frequency supported a width of the flame. So it is possibly used for a bigger area. Without risking human life or limb, robots can replace humans in some hazardous duty service [6] . Robots can add every kind of polluted environments, chemical similarly as nuclear. They will add environments so hazardous that an unprotected human would quickly die. The experiment of this study could

be a meaningful result which confirms that the fireplace extinguishing element of the fireplace extinguisher is transmitted well to the flame by penetrating the contents which are contained within the robotic vehicle, though it's somewhat different from traditional method [7]. It's hoped that sound fire extinguishers are actively researched and utilized in environments where existing fire extinguishing systems are difficult to use. For the future purpose a booster are often attached to the vehicle to create it a strong extinguisher. For security purposes, authentication for accessing the robot may be done. A piston aerosol bomb be used which uses the concept of formation of mist as a heat absorbing ability to scale back heat [8]. The vehicle are often mounted with a thermal camera in order that auto detecting of warmth areas is created possible and live images of the incident are often seen through a wireless camera. GPS enabling are often done in order that the vehicle are often controlled from a distant place and also the communication range can also be increased by using XbeePRO.

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