Wavelike-fire extinguisher

* *Navid Davar*
* *Corresponding Author:N.davar2014@gmail.com*
Valiasr Research Home, Torbate Heydarieh

Abstract

In this research by simulation and several experiments the parameters which are important to be considered in building a wavelike-fire extinguisher as a new device have been investigated. The most complete hypothesis is based on the phenomenon of vortex or fluid flow. According to this hypothesis, the transmitted audio forms several vortex flows of air with frequency and amplitude, which leads to an increase in the vibrations of oxygen and its removal from the fire environment. By experiments and data analysis, future models are introduced as fire extinguisher too.

Key words

fire extinguisher, acoustic waves, automotive systems

Introduction

There is a lot of fire damages in all over the world, for instance in jungles, cities & … but how can we avoid these damages by extinguishing fire very quickly, from distance? A new plan as fire extinguishers is sound. "DARPA" or America's Defense Advanced Research Projects Agency launched the Instant Fire Suppression (IFS) research program, tasked first with finding out more about the actual nature of fire, and then using this new model, found knowledge to develop novel fire suppression techniques. Instead of chemical reaction, DARPA's main realization was that flames are *cold plasmas*, and thus could be manipulated with physical forces such as electromagnetic radiation and acoustic waves. In this research by simulation and several experiments I have found the parameters are important to be considered in building a wavelike-fire extinguisher as a new device and develop this device by electromagnetic waves; and use it for firefighters. To compare with other fire-extinguishing equipment, it is compact and lightweight which proves its superiority. This scheme can be used in future automotive systems, mechanical equipment, residences or as a supplement to extinguish the fire.

Basic Theories and Hypothesis

Hypothesis 1: Damping Energy of gas fluid will be given as (Eq. 1):

$$\sum E = 0 \Rightarrow E_{sound} = E_{fluid} \Rightarrow E_m \sin^2(kx - \omega t_1) = \frac{1}{2} k' s^2 \qquad (1)$$

and coefficient of oscillation for gas fluid (Eq. 2) is:

$$k' = m\omega^2 = \rho V \omega^2 = 4\pi^2 f^2 \rho V \qquad (2)$$

Energy and power of sound wave (Eq. 3 & 4) are, respectively:

$$E = \int P.t = 2tA\pi f \Delta p_m s_m \sin^2(kx - \omega t) \qquad (3)$$

$$P = \frac{A(\Delta p_m)^2}{\rho v} \sin^2(kx - \omega t) \qquad (4)$$

K	number of wave
K'	coefficient of oscillation
ρ	density of gas fluid (in condition of fire)
V	volume of gas
Δp_m	maximum pressure difference
s_m	maximum displacement of sound wave
A	surface of gas
F	frequency of sound wave
T	time of extinguishing fire
λ	wave length

the frequency can be found as (Eq. 5 & 6):

$$E_m \sin^2(kx-\omega t_1) = 2\pi^2 f^2 \rho V s^2 \Rightarrow 2tA\pi f \Delta p_m s_m \sin^2(kx-\omega t) = 2\pi^2 f^2 \rho V s^2 \Rightarrow t\Delta p_m = 3.14 f s_m \Rightarrow 1.7584 f = t * 289845.4871 * \frac{6.28}{\lambda} \Rightarrow \quad (5)$$

$$f = 579690.9742 * \frac{t}{\lambda} \quad \Leftrightarrow \quad t = H\ (even\ number) \quad (6)$$

Hypothesis 2:

Vortex formation (air flow) with specific frequency is the most complete hypothesis. According to this hypothesis, the transmitted audio forms several vortex flows of air (as the ring) with frequency and amplitude, which leads to an increase in the vibrations of oxygen and its removal from the fire environment. The frequency will respond at a specific interval and depending on the characteristics of the wave, the time for the shutdown of the fire is different.

Velocity of the ring as a function of distance (Eq. 7) is:

$$V = Vo\, e^{-cx} \quad (7)$$

Velocity of the ring as a function of time (Eq.8):

$$V = \frac{Vo}{(1 + Voct)} \quad (8)$$

Radius of the vortex ring (Eq. 9) is:

$$R = \sqrt[3]{\frac{3Ro^L}{4\gamma}} \quad (9)$$

And distance traveled by the ring in time t (Eq. 10) is:

$$X(t) = \frac{1}{c}\ln(Voct+1) \quad (10)$$

so energy of a ring (Eq. 11) will be:

$$E = \frac{1}{2}\rho r^2 R A' \qquad A' = \ln\left(\frac{8R}{a}\right) - \alpha \qquad \alpha = 2.05 \quad (11)$$

Where the parameters are:

L , T	stoke length and stoke time
Vp = L/T	mean velocity of sound source
L/Do = Vp T/ Do	dimensionless formation time
L/Do = 4	formation number
Do , Ro	diameter and radius of the pipe
V	kinematic viscosity of the fluid
γ	eccentricity of the air
K	Bessel added mass factor
Cdc	measured drag coefficient on a ring

Experimental setup, tools and Results

The instruments were used in our setup are included as signal generator, power supply, amplifier, pipes, aperture, subwoofer and fuel (Fig. 1). ANSYS, CATIA, MATLAB, and Proteus Professional were software for data analysis. Multi meter, Oscilloscope, dB meter and ruler were measuring tools.

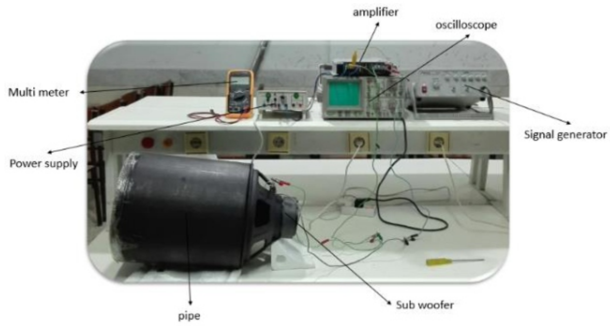
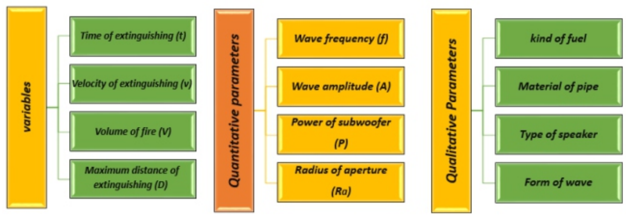


Fig 1: Experimental Setup

Variables, qualitative and quantitative parameters are separately clarified in table (2).

Table 2: Different parameters in this investigation



In constant volume of fire, length of the pipe, radius of aperture, power of woofer with oil as fuel and changing the frequency, time of extinguishing in different distances are calculated and the relation are shown as (Fig. 2 & 3).

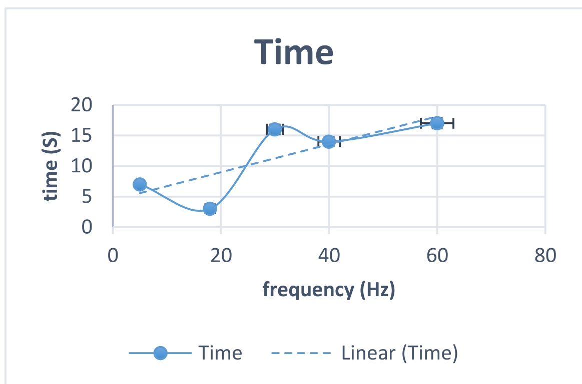


Fig. 2: Time vs frequency

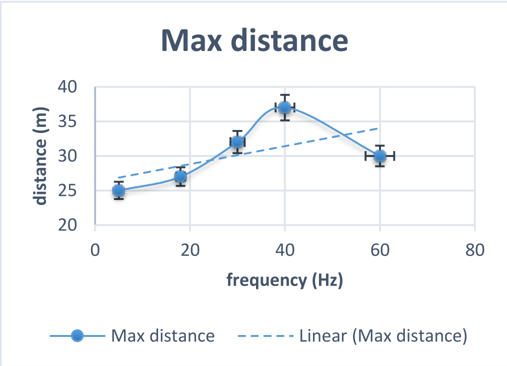


Fig. 3: Distance vs frequency

Radius of aperture, the amplitude and power of speaker are parameters have been investigated too (Fig. 4 -7).

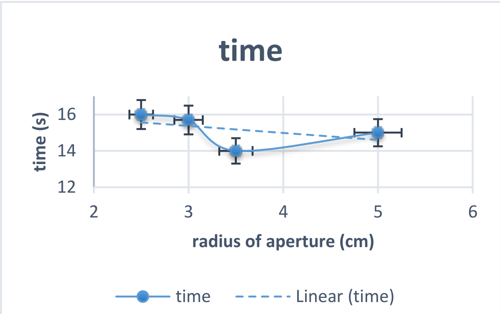


Fig. 4: time vs radius of aperture

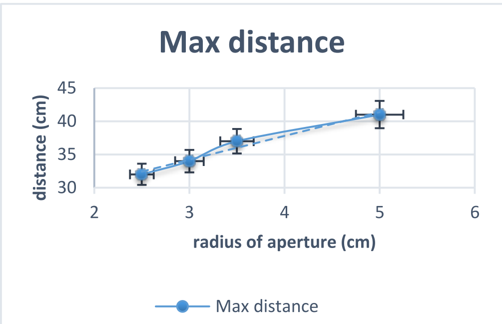


Fig. 5: Distance vs radius of aperture

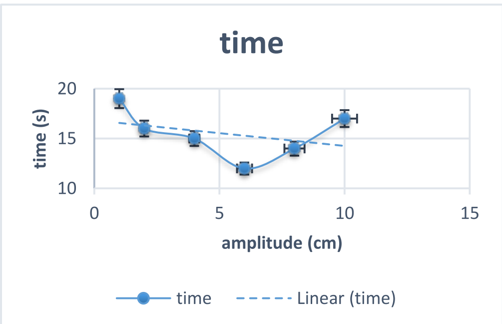


Fig. 6: Time vs amplitude

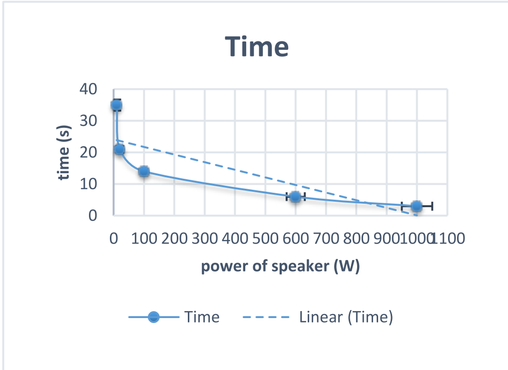


Fig. 7: Time vs power of speaker

Conclusions and Discussion

As the result we found how changing frequency, radius of aperture, amplitude and power of speaker will effect on time and maximum distance of extinguishing.

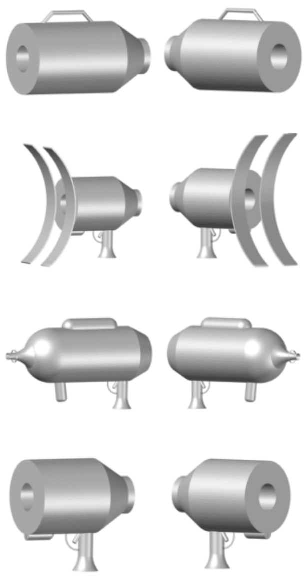
$$t \begin{cases} \propto \frac{1}{A} \\ \propto P \\ \propto f \\ \propto \frac{1}{r} \end{cases} \qquad D \begin{cases} \propto \frac{1}{A} \\ \propto P \\ \propto f \\ \propto r \end{cases}$$

What are the flaws of this model and how we can solve these problems (table 4)?

Table 4: Flaws and solutions

Flaws	Solutions
bad noise	using ultrasonic or electromagnetic waves
Inability to eliminate heat	using liquid nitrogen cool pad or use CO_2 gas instead of a
non-portable	using ion battery instead of power supply and making signal generator which use DC electricity
Heavy weight	using subwoofer made by Ferro-fluid or light materials, and miniaturize the materials

Future Models



Models	Features
Sound wave model	frequency domain (5-60 Hz) _ power of subwoofer (100-1000 watt) _ length of pipe (30 cm)
Electromagnetic wave	frequency domain (very high) – having antenna – control by app(available) – length of pipe(20 cm)
Ultrasonic wave	having horn (acoustic lens) – frequency domain(very high) – cooling pad – length of pipe (30 cm)
Fire extinguisher along (sound wave)	length of pipe (20 cm) – frequency domain (5-60) – control with app – having Wi-Fi and blue tooth – portable – having lithium ion battery

References

1- IAN S. SULLIVAN, JOSEPH J. NIEMELA, ROBERT E. HERSHBERGER, DIOGO BOLSTER AND RUSSELL J. DONNELLY Department of Physics, University of Oregon, Eugene, OR 97403, USA -(Received 2 May 2006 and in revised form 28 April 2008) Auerbach, D. 1988 Some open questions on the flow of circular vortex rings. Fluid Dyn. Res. 2,209–213.

2- Baird, M. H. I., Wairegi, T. & Loo, H. J. 1977 Velocity and momentum of vortex rings in relation to formation parameters. Can. J. Chem. Engng 55, 19–26.Baker, D. J. 1966 A technique for the precise measurement of small fluid velocities. J. Fluid Mech.26, 573–575. Barenghi, C. F., Donnelly, R. J. & Vinen, W. F. 1983 Friction on quantized vortices in helium II.J. Low Temp. Phys. 52, 189–247.

3- Barenghi, C. F., H¨anninen, R. & Tsubota, M. 2006 Anomalous translational velocity of a vortex ring with finite-amplitude Kelvin waves. Phys. Rev. E 74, 046303.

4- Dabiri, J. O. & Gharib, M. 2004 Fluid entrainment by isolated vortex rings. J. Fluid Mech. 511,311–331.

5- Didden, N. 1979 On the formation of vortex rings: rolling-up and production of circulation.J. Appl. Maths Phys. 30, 101–116.

7- Donnelly, R. J. 1991 Quantized Vortices in Helium II . Cambridge University Press.

8-Fetter, A. L. & Donnelly, R. J. 1966 On the equivalence of vortices and current filaments. Phys.Fluids 9, 619–620.

9- Fraenkel, L. E. 1972 Examples of steady vortex rings of small cross-section in an ideal fluid.J. Fluid Mech. 51, 119–135.

10- Fukumoto, Y. & Moffatt, H. K. 2000 Motion and expansion of a viscous vortex ring. J. Fluid