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An Experimental insight into the effect of Acoustic on Smoldering Combustion

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Abstract—*Fire starts with smoldering before transforming into the flames which necessitates the need to fundamentally understand the smoldering. Almost all of the combustion processes are accompanied by sound which significantly affects its progression. The Thermo acoustic interactions are likely to alter the forward heat transfer with varying symmetry and sound wave frequency. The maximum acoustic effect is noted to vary with the sound source distance from the ignition front however, the acoustic effect coupled with external heat source is an aspect yet to be explored. The present work represents a practical case where combustion phenomenon is accompanied with external heating. The work attempts to gain physical insight into heterogeneous nature of acoustic thermal energy interaction in presence of an external heat source and related implication on smoldering. An experimental setup was upraised and experiments were carried out on incense sticks with systematic variation of sound frequency, distance between the fuel and sound source, symmetry of the sound source with the fuel and in presence of external heat source. The sound waves were impinged onto the reaction front from diametrically opposite directions and related sound source symmetry. Results indicate that sound significantly affects smoldering and may lead to flaming combustion. The work is motivated by the need to have better fire safety with faster transition into flaming results in less production of toxic products (gases) minimizing hazards. The results can be effectively applied to terrestrial and space applications.*

1. INTRODUCTION

Smoldering is a fundamental combustion problem involving heterogeneous chemical reactions and the transport of heat, mass and momentum in the gas and solid phases. The fundamental difference between smoldering and flaming combustion is that, in the former, the oxidation reaction and the heat release occur on the solid surface of the fuel or porous matrix and, in the latter, these occur in the gas phase surrounding the fuel. The characteristic temperature, spread rate and heat released during smoldering are low compared to those in the flaming combustion of a solid.

Figure 1: Smoldering combustion

Typical values in smoldering at ambient conditions are around 500-700 °C for the peak temperature and 6-12 kJ/g for the average heat of combustion; typical values during flaming are around 1500-1800 °C and 16-30 kJ/g respectively. Because of these characteristics, smoldering propagates at low velocities, approximately two orders of magnitude lower than the velocity of typical flame-spread (figure 1). Significantly higher temperatures and higher heats of combustion can be expected in technological application of smoldering combustion in porous media with forced flows at high pressure (like in-situ combustion for oil extraction or coal gasification)since these reproduce nearly adiabatic conditions and provide large oxygen supplies. Because of its low temperature, smoldering is characteristically an incomplete oxidation reaction and thus emits a mixture of toxic, asphyxiant and irritant gases and particulates at a higher yield than flaming fires. It favors CO_2 to CO ratios around unity (as opposed to ratios around 10 in flaming combustion), so CO is an important toxic factor in smoldering fires. [4]

In a reverse smoldering, the oxygen reaches the reaction zone by moving through the unburnt fuel and the degradation zone whereas, heat is transported from the burning to the unburnt region. The heat transfer is primarily by conduction and radiation and the opposed air movement prevents heat transfer by convection. In a forward smoldering fire, the air moves in the same direction as the smoldering reaction zone. As a result, forward heat transfer is assisted and thus oxidation of the fuel continues until all the fuel is consumed. Thus, enhanced pre-heating of the unburnt fuel causes the ignition front to accelerate.[11] Sound is transmitted through gases, plasma, and liquid as longitudinal waves, also called compression waves. It requires a medium to propagate. Through solids, however, it can be transmitted as both longitudinal waves and transverse waves. Longitudinal sound waves are waves of alternating pressure deviations from the equilibrium pressure, causing local regions of compression and rarefaction, while transverse waves (in solids) are waves of alternating shear stress at right angle to the direction of propagation. The energy carried by an oscillating sound wave converts back and forth between the potential energy of the extra compression (in case of longitudinal waves) or lateral displacement strain (in case of transverse waves) of the matter, and the kinetic energy of the displacement velocity of particles of the medium. [7]

The regression rate is only a function of of forward heat transfer. So for regression to change the forward heat transfer must change the forward heat transfer preheats the unburnt fuel. Under a selected condition the increase in forward heat transfer gets influenced by the addition of additional energy owing to the parametric gradients. The properties of ignition front, the localized temperature and velocity fields remain same. Acoustics under some conditions results in gradient changes which brings positive energy transfer which means the localized temperature fields get altered to provide more heat feedback. That occurs owing to sound wave generating intense compression or rarefaction which is again a conditional phenomenon. The energy loss to the environment also varies as:

$$h=g+ts$$

where,

'h' refers to enthalpy, 'g' refers to gibbs free energy, 'ts' refers to energy from atmosphere. It is important to note that the 'ts' varies with the presence of an acoustics source which results in varying 'h' value.

Smoldering fires diversity has associated several aspects not understood by the fire safety community viz., smoldering decomposition under varying conditions and influences. This has necessitated research efforts motivated by the need to have better combustion and improved fire safety by understanding of the governing mechanisms under diverse conditions. One of the fire inhibition method is through use of an external influence to eliminate spread. A spreading flame interaction with an external sound source have been comprehensively explored however, smoldering spread response to an external sound is an aspect yet to be investigated thoroughly. Acoustics is likely to alter the localized field around ignition front thus affecting pyrolysis of fuel resulting in reformed smoldering spreading rates. The extent of change is very likely to vary with the key controlling parameters viz., sound frequency, surface orientation, and source distance. The increase or decrease of regression rate can have significant effects and applications in engineering background. Present work, experimentally explores the implications of acoustic effects on smoldering spread in view of prevention and efficient utilization.[11,4] The specific objectives of the study are:

a) To study acoustic effect on the smoldering combustion.
b) To examine the role of key controlling parameters.

2. EXPERIMENTS AND SOLUTION METHODOLOGY

An experimental setup was upraised for the present study comprising of a hard thermocol with angles marked on it and firmly supported on a table. The acoustic effect was generated with a frequency generator software using computer and notable speakers. The experiments were thoroughly carried out in a quiescent room under normal gravity conditions. Marked dark sheets were used for flow visualization to capture the smoke pattern which was digitally video graphed. The solid fuel assembly comprised of dried incense sticks in 6.9 cm × 0.20 cm specification. The incense sticks composition is sawdust (30%), charcoal (30%) and cow dung (38.5%) and incense chemical (1.5%). The fuel strips were marked at regular intervals of 1.0 cm to track the smoldering front propagation with time. Prior to the experimentation, the fuel strip is cut at the top to enable uniform horizontal ignition across the width. Fuel specimen strips are ignited by exposing it to a pilot flame and special care is taken to remove the moisture which can affect ignition and front spread rate. Every experiment was carried out within 10 minutes to bring room atmosphere back to normal. The readings were taken twice for same distance and stopwatch was used to measure the split times across the marks. The regression rate (r) is estimated using linear method as:

$$r = \frac{l_s}{t_{av}} \qquad 1$$

Where, l_s" is length of fuel taken (here, 1.0 cm) and

t_{av}" is the time taken for all three marked distances. From classical theory of ignition spread, assuming unity width of fuel the regression rate (r) is defined by energy balance as:

$$r = \frac{\int q_{net}}{\rho_s \tau_s c_s (T_{surface} - T_a)} \qquad 2$$

Where,

q_{net}" is Net integrated heat transfer per unit time per unit area to the unburnt fuel, C_s " is Solid-phase specific heat, $_s$" is

Solid fuel thickness, "ρ_s" is Solid fuel density, "$T_{surface}$" is the surface temperature, T_a" is Ambient temperature. Ignition is primarily transition from a non-reactive material decomposition to a self-sustained reactive combustion. This transition is owing to an imbalance between the heat production and heat loss which relates to the energy stored in a volume as:

Stored energy change = Energy Production-Energy loss:

$$\rho_s c_s v \frac{dT}{dt} = q_p - q_l \qquad 3$$

The energy production is based on an Arrhenius approximation as:

$$q_p = \Delta H_c v_c C_i A * e^{-\frac{E_a}{RT}} \qquad 4$$

The associated heat energy loss is taken by assuming constant concentration of reactants in the volume (material not consumed prior to ignition) (Ci) indicating a uniform temperature:

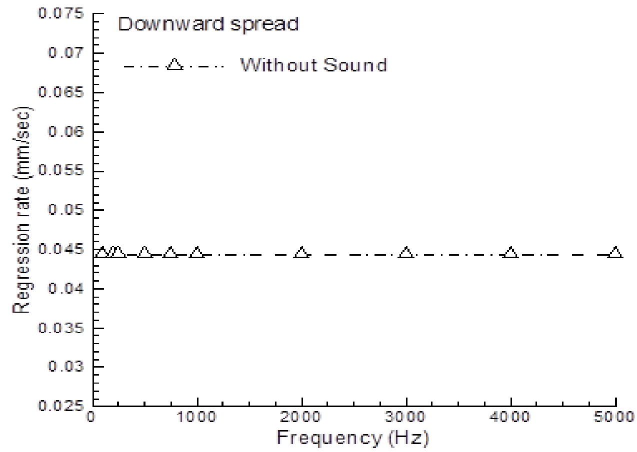
$$q_l = hA(T - T_a) \qquad 5$$

Where,

" q_p " is the Energy production, "q_l " represents Energy loss, "V" is the volume, "T" is the temperature and "t" represents time,ΔH_c" is the heat of combustion, "C_i" represents the Concentration of reactants, "$A*$ " is the Pre-exponential factor, E_a" is the Activation energy, "R" is the Universal gas constant., "h " is the convection factor.

3. WITHOUT EXTERNAL INFLUENCE

A pilot experiment was done to measure the regression rate of the fuel without any external influence. Without external influence the combustion comprises of degradation of the solid fuel in the presence of oxygen leading to the production of heat. The solid fuel is degraded and post combustion consists of form ash which prevents heat loss. A part of thermal energy released in combustion is transferred to the unburnt fuel known as Forward heat transfer. This heat transfer preheats the unburnt fuel and maintains smoldering front propagation. The plot for this experiment is a straight line parallel to the x-axis.(fig 2a)



Without external influence (Figure 2a)

4. ACOUSTIC EFFECT ON DOWNWARD SPREADING SMOLDERING FRONT

The following work is done to study the effect of acoustics on regression rate of smoldering flames. And to examine the effects of governing parameters the work has been experimented in to four segments-

1. The first segment

In the first segments frequency was chosen as the variable parameters keeping all other parameters constant.

The set up

Two speakers of (fig.3,4) were taken and placed in the fashion shown in the figures. The sound sources were kept in a diametric opposite sense making an angle 180 degree between them. The speakers are 40 cm apart from each other with fuel (incense stick) kept exactly between them. Distance between the sound source and the fuel is 20 cm each side.

Keeping this symmetry fixed the frequency was vertical from 100 Hz to 5000 Hz (increment of 1000 from 1000 HZ to 5000 Hz and 250 Hz from 100 Hz to 1000 Hz).Both sound source and the Both sound source and the fuel was mounted on a thermocol stand (base) . The experiment was done for reverse spread. The fuel is then ignited and sound is impinged on to the reaction front from both the speakers.

For this set, sound wave of the following frequencies impinged on the reaction front from diametrically opposite ends –

100Hz 750Hz 3000Hz

250 Hz1000Hz 4000Hz

500Hz 2000Hz 500Hz

And then regression rate of burning fuel was observed. A base reading was taken without any sound.

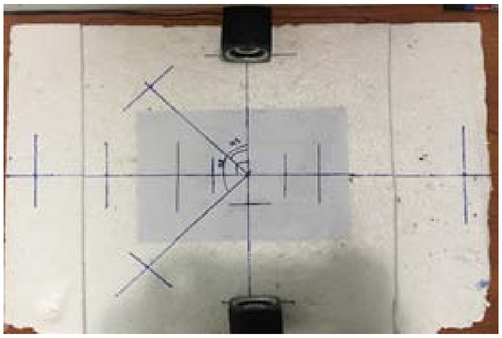


Figure3: diametrically opposite (1)

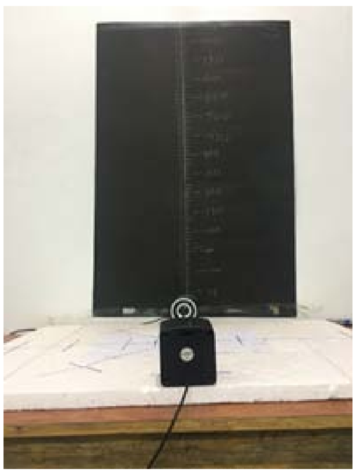


Figure4: diametrically opposite (2)

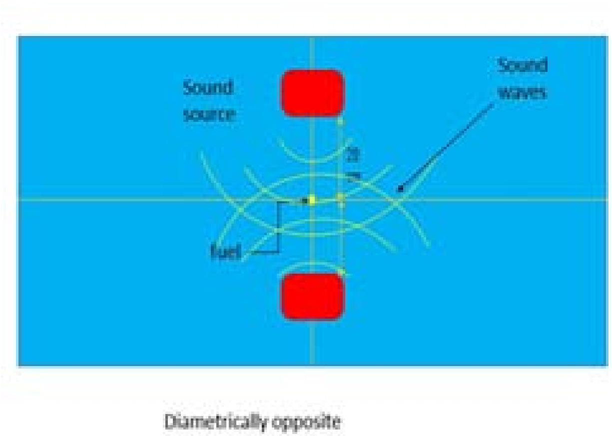


Figure 5: schematic of diametrically opposite configuration

Observation

0.00444 mm/sec --Base no sound.

The lowest regression rate in this set was 0.05789 mm/sec. corresponding to 3000 Hz .with a rise of 30.18% from base The highest regression rate was observed at 250 Hz with regression rate as high as 0.06525mm /sec with 46.9% rise from base .There was a sudden drop for 200 Hz which is about 6.75% drop from 100 Hz .

Regression rate without sound was observe to be 0.044 mm /sec and phenomenally both highest and lowest value show a rise of 46.9% and 30.18% respectively from the base which proves that sound clues effect of regression rate .

The curve rises to a peak at 250 Hz after which there is a drop till 1000 Hz. But values lies within a very close window of 0.05-0.06.After 1000 Hz till 5000 Hz the regression rate becomes insensitive to frequency variation but the regression rates are still higher from the base with 33.924% average rise from base.

Now the plot can be interpreted as follows :

The whole plot is divided into 3 distinct zones:

1) The rise zone where frequency variation (ordinate) results in an increase in regression rate (abscissa).

2) The intermittent zone where the variation in frequency (from 250 to 1000hz) results in a drop of burning rate from 0.065 to 0.060.

3) The insensitive zone where the change in ordinate does not affect the abscissa.

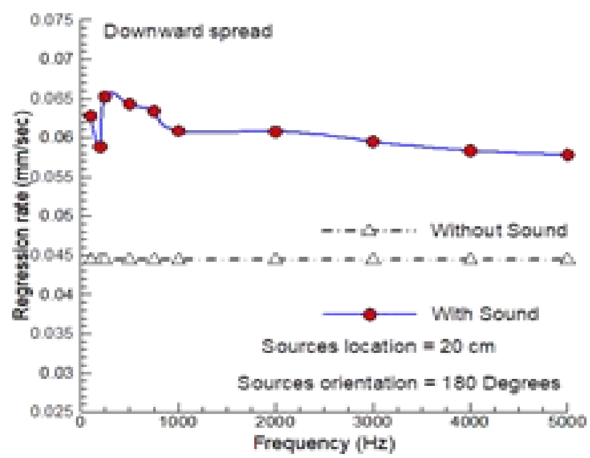


Figure 6: with external source

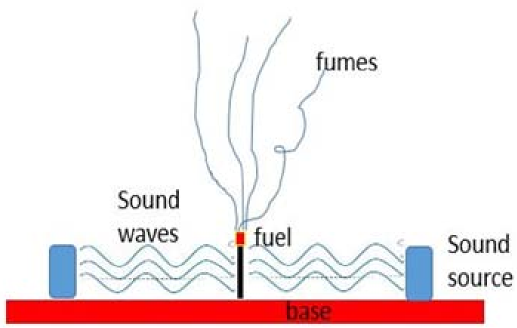


Figure 7: schematic of setup

5. RESULTS:

Regression rate is a function of forward heat transfer. Any change in the forward heat transfer will directly affect the regression rate. Acoustics, here plays the role of this change.

Figure 7a.

The change in the spread rate can be attributed to the energy interactions between the two energies that is sound(mechanical pressure wave) and heat energy which flows due to a temperature gradient. Sound as said earlier is a form of mechanical pressure wave that propagates as compression and rarefaction disturbance through the medium. The compression zone is characterised to have higher temperature and pressure. The rarefaction is an expansion zone which has lower temperature and pressure values.

Now as observed by the experiment, the pressure of sound always shoots up the regression rate hence sound is also a function of forward heat and the pressure of sound will affect any form of combustion.

Between **100hz** and **250hz** there is a hike in regression rate that is from **41.1%** to **46.9%** respectively**(from base reading).** This rise shows that these frequencies have somehow increased the reaction rate i.e. the forward heat transfer. Heat transfer takes place from high temperature to low temperature and the compression zone is characterised to high temperature The reaction zone around it creates a localized field of temperature pressure and convective velocities. Acoustics interferes with the field to change spread rates. The whole phenomenon depends on whether energy is transferred from reaction zone to the pressure wave for which there should be a fall in burning rate or vice versa which will give an increment in the reaction rate.

The increment zone: The rate shoots up to **46%** of the primary value due to the acoustics effect. The reaction front is encountering an intense compression zone probably at the centre of the zone. Since sound has been impinged from two diametrically opposite points, the two sound sources also interfere with each other waves and the result is an intense compression zone at the vicinity of the reaction zone. The temperature of the pressure wave is higher than that of the localized field of the reaction zone. Hence heat “travels” rom the pressure wave to the localized field and add up to the forward heat that gives rise in regression rate. **200** Hz experiences a drop due to the presence of a weak compression zone but this still has a higher temperature than the localized field of the reaction front because the rate is still higher from the base reading which shows that heat is transferred from the wave to the forward spread.

The intermittent zone: the rates fall from **250 Hz** to 1000 Hz which is about **6.69%,** but the range is very small **(from 0.065 to 0.060).** This can be attributed to the fact that the reaction zone encounters a weaker compression or a compression zone near to the rarefaction zone, which is a simple way of telling that for the intermittent zone the heat lost to the wave is more than the transferred heat. But the higher regression rate still proves that heat is flowing from the wave to the localized field of reaction zone.

The insensitive part from 1000hz to 5000hz: The regression rate becomes insensitive of any change in frequency because heat addition becomes equal to the heat lost and that only a fixed amount of energy is passed on to the reaction zone which remains same for all the frequencies between 1000 to 5000hz. But the higher regression rate still proves that heat is still being added to the forward heat transfer.

Periodicity of sound: The acoustic energy is periodic in nature. Sound traversing through a medium is a periodic wave function. It is a train of identical wave pulses which repeat after a fixed distance or after an interval.

Whereas heat transfer is a non-periodic process, it is a function of direction; hence regression of fuel is non-periodic in nature; i.e. the burning of fuel does not follow a specific trend without any specific condition. The following as well as the preceding experiments tell about the dominance of any one form of energy “Acoustic” or “Heat”. It is to be noted that if the burning of a fuel starts to follow a specific trend , it is a clear implication that Acoustic energy is dominant.

6. VARIATION OF SYMMETRY:

In this segment the symmetry of sound sources has been changed. It is kept as a variable keeping all other parameters fixed. The change of symmetry has been done on all the frequencies from preceding segment. (fig.8-11)

In the following segment the symmetry of the sound sources has been varied with respect to the fuel keeping the source distance fixed at 20cm. Sound is now impinged on the reaction front from different symmetries depicted in the figures above. The symmetries are 45 90 135 and 180. The speakers are arranged respectively. The symmetry variation has been done on 100,250,500,750,1000,2000,3000,4000,5000Hz and the respective trend were observed.

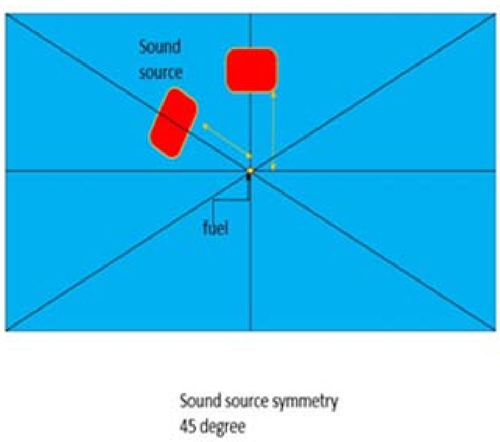


Figure 8:45° symmetry

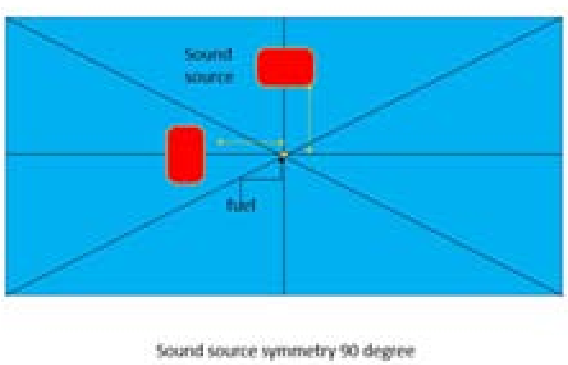


Figure 9: 90° symmetry

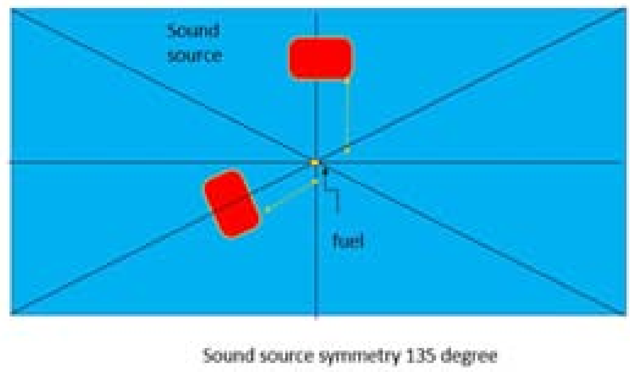


Figure 10: 135° symmetry

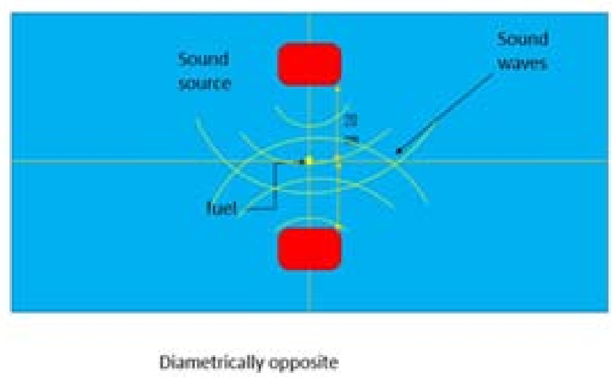


Figure 11: 180° symmetry

Observation (lower frequency zone):

When sound sources are at 45 with respect to the fuel, the highest rate is observed at 750Hz i.e. **0.06249(40.71% rise from base reading)** and the lowest rate is observed for 1000hz i.e. **0.053761(21.08% rise from the base reading).** The slope of the graph remains nearly constant in the frequency range between 100 to 500hz but the slope increases suddenly at 750hz after which there is a drop again till 1000hz. Fig.16

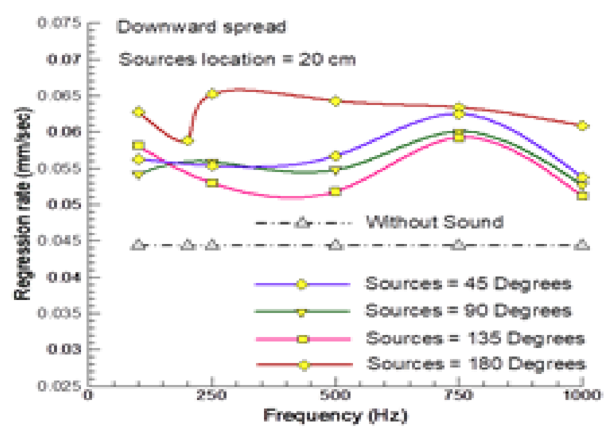
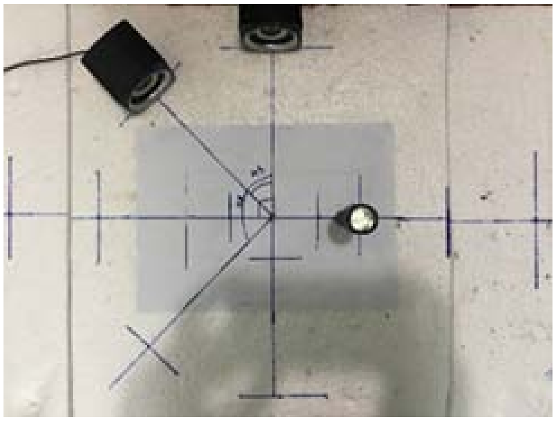


Figure 12: with variation in symmetry of external sound source

Set up for 45° sound source symmetry

Figure 13a&b: 45° symmetry

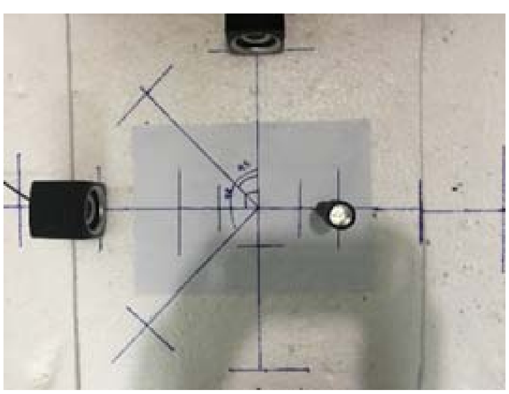


13(a)

13(b)

Set up for 90°sound source symmetry

Figure 14a&b: 90° symmetry

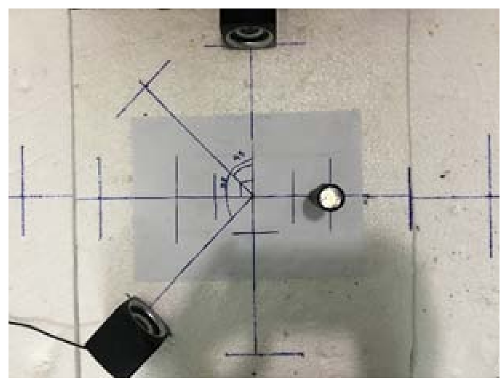


14(a)

14(b)

Setup for 135° sound source symmetry

Figure 15a&b: 135° symmetry



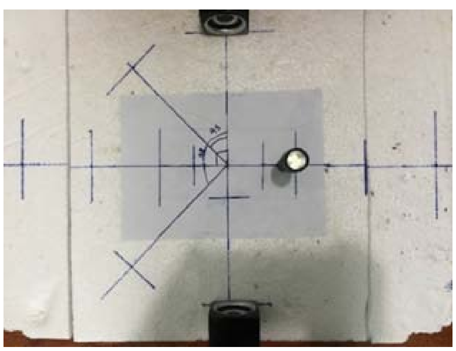
15(a)

15(b)

Set up for 180° sound source symmetry

Figure 16a&b: 180° symmetry

16(a)



16(b)

7. RESULT

The change in symmetry of the sound sources changes the regression rate as sound from different symmetries affect the forward heat differently.

45° symmetry: As mentioned earlier sound interacts with the external localised field of the reaction zone and changed the forward heat transfer. The drastic rise of the regression rate at **750Hz (40.76%)** interprets that the reaction zone has encountered an intense compression zone with high temperature and pressure higher than that of the localised field. Due to heat was transferred from the wave to the field adding to the forward heat transfer. The sound wave from both speakers interacts to give an intense compression zone at the vicinity of the reaction zone.

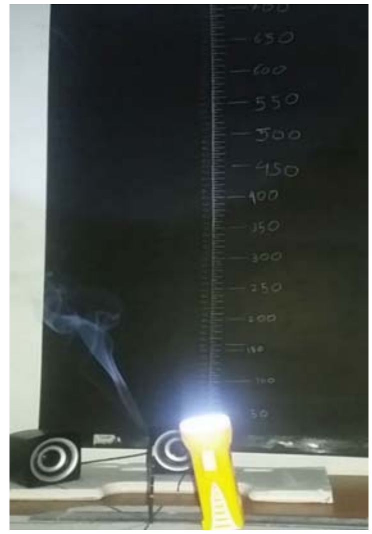


Figure 19a: 45° symmetry

90° symmetry:

The sound source for this experiment is kept at 90° and at a distance of 20cm with respect to the fuel. The regression rate at 90° follows a similar trend as 45° with highest rate at **750Hz(0.060057, 26% rise from base**) and lowest at **1000Hz(0.052649, 15.67% rise from base)**. Rest follows the same trend as 45°.

Figure 17b :90° symmetry

135° symmetry:

The trend is same as 45° and 90° with highest regression rate at 750Hz (**0.05925, 33.4% rise from base)** and lowest at 1000Hz (**0.05115, 15.20% rise from the base)**.

Figure 17c: 135° symmetry

As mentioned earlier the rates become periodic when the acoustic energy dominates over heat energy released from the reaction zone. The lines of all the symmetries intersect each other at (150,0.056) roughly. These interaction points are the neutral points which suggest at these conditions the heat lost to the environment is same and the amount of acoustic energy added to the forward heat is same. All the points encounter a compression zone as the rates are higher than the base rate.

Observation (Higher frequency zone):

The same symmetry variation experiment was carried out for higher frequencies from 1000Hz-5000Hz. The setup was same as the above experiment. The symmetry of the sound source was varied with respect to the fuel, keeping the source distance fixed at 20cm. Sound was then impinged on to the reaction front from the symmetries shown in figure. The speakers were kept at 45° ,90° and 135° respectively with respect to the fuel. This experiment was now carried out for 2000, 3000, 4000 and 5000Hz and the respective trends were observed.(fig. 18)

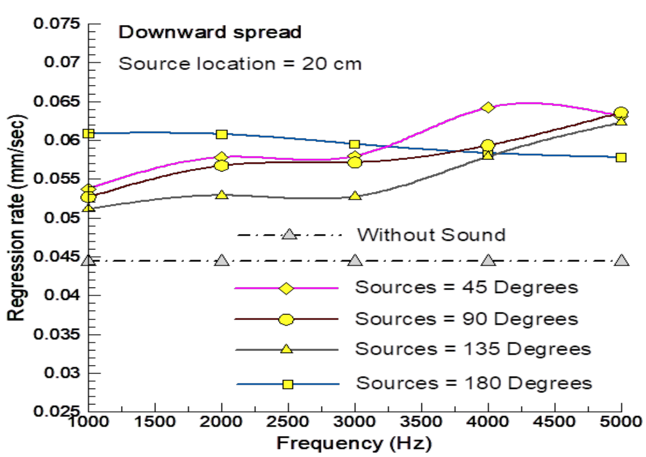


Figure 18: with variation in symmetry of external sound source

45° :

When sound sources are at 45° with respect to the fuel the highest rate is now observed at 4000 Hz (**0.06420) 40.76% rise from base**). The lowest is observed at 1000Hz(**0.053761) with 21.00 rise from base**. There is fall of **16.26%** from highest to the lowest.

Figure 19a: 45° symmetry

90°:

When sound sources are at 90° with respect to fuel the highest regression rate is observed at **5000Hz(0.06359) 43.22% rise from the base** and lowest rate **at 1000 Hz 0.052669 with 18.69% rise from the base**.The intermediate values are following a similar trend as the 45 degree line. There is a drop of **17.12%** from the highest to lowest rate.

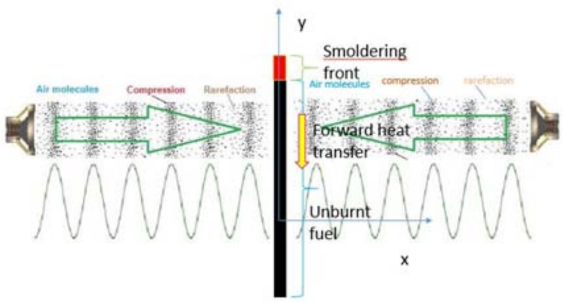


Figure 19b: 90° symmetry

135°:

For a symmetry of 135 degree between the sound source and the fuel the highest rate is observed again at 5000 Hz(**0.062304) with 40.32% rise from te base** and lowest at 1000 Hz(**0.051150) with 15.20% rise from the base**. Intermittent values show a similar trend as 45° symmetry line. The drop between the highest and lowest is **17.9025%.**

Figure 17c:135° symmetry

5.External sound source location effect on downward spreading smoldering front.

The Setup

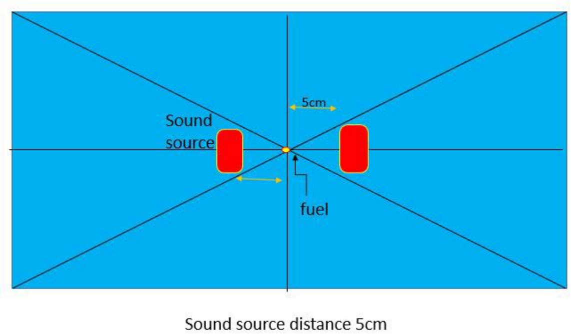
Same setup has been used as in the first segment of the work. The sound source was placed at diametric opposite locations and distance of the locations was varied.Having studied the effect of frequency variation and symmetry variation (sound source) Both the optimum values and corresponding conditions are known.

For this set of experiment frequency (optimum-250 Hz) and symmetry of next sound source (optimum- diametrically opposite) has been fixed and the effect of source distance has been observed. Sound was impinged on the reaction front from diametric opposite locations as shown in the figures above and the distance of sound source location where varied likewise.

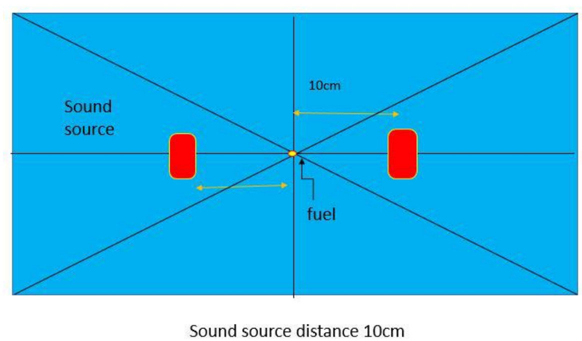
The aim was to observe the regression under conditions where the optimum condition of two parameters were chosen (250 Hz for frequency and 180 degree for symmetry).

Figure 18: schematic representing interaction of sound energy with propagating smoldering front

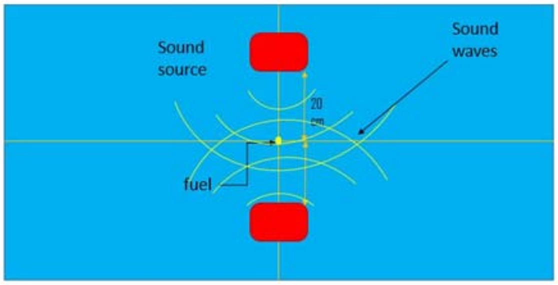
Figure20a,b,c,d,e:varying sound source distance



(a)

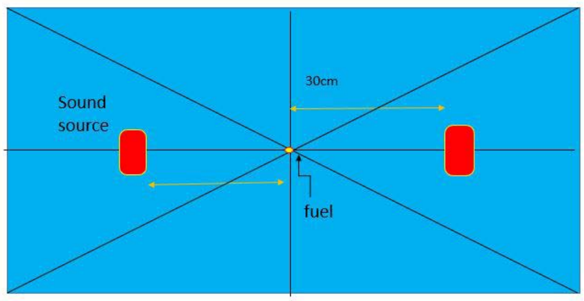


(b)



Diametrically opposite

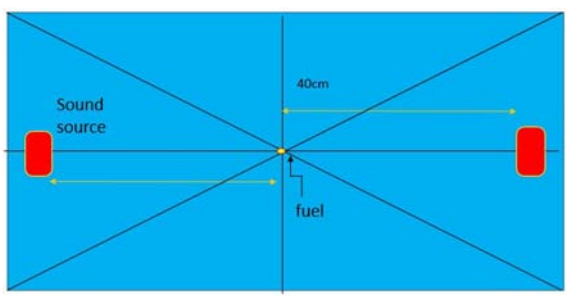
(c)



Sound source distance 30cm

(d)

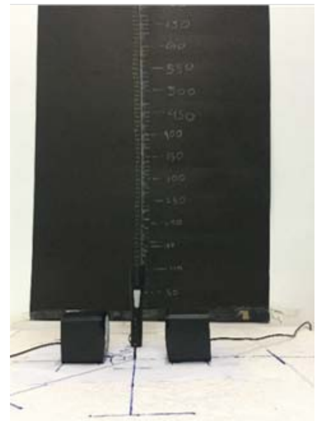
(e)



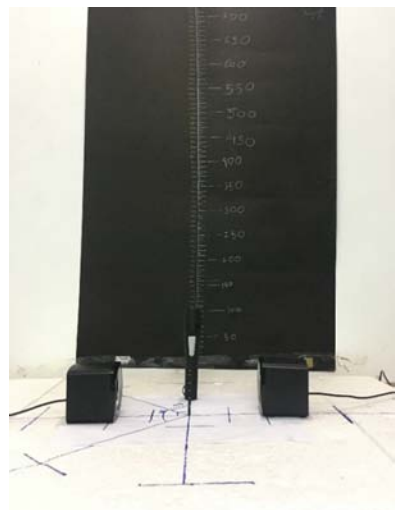
Sound source distance 40cm

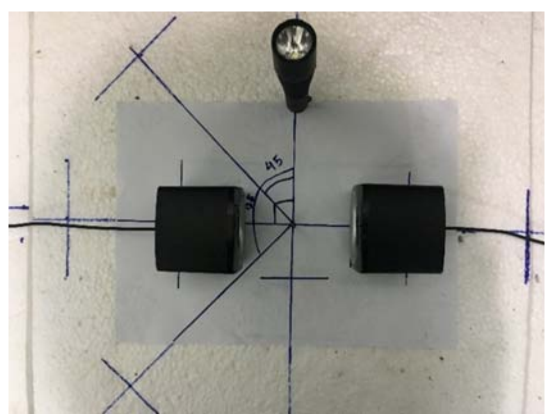
Setup for 5cm source location:

Figure 21a&b



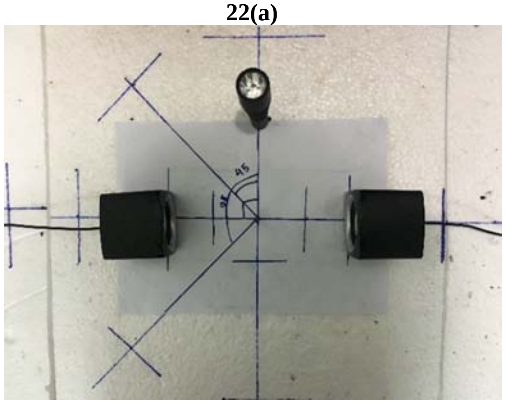
21(a)





21(b)

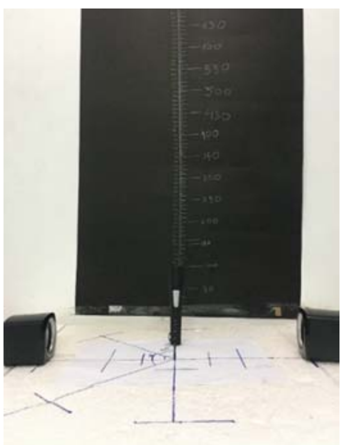
Setup for 10 cm source location
Figure 22a&b
22(a)



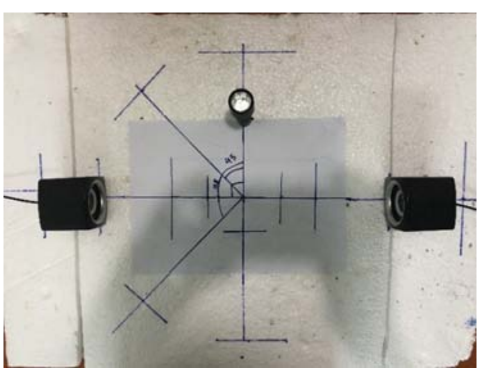
22 (b)

Setup for 30 cm source location

Figure 23a&b



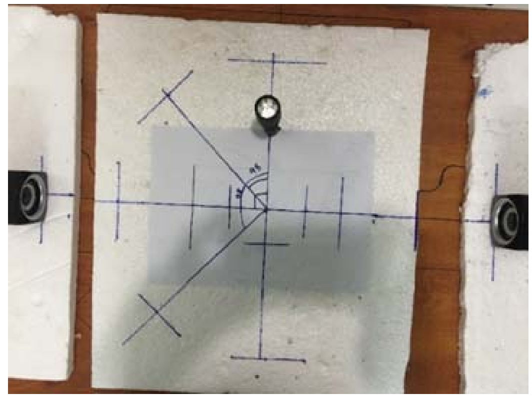
23(a)



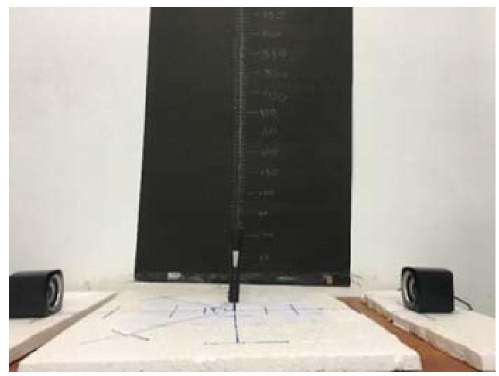
23(b)

Setup for 40 cm source location

Figure 24a&b



24(a)



24(b)

Trends

The highest regression rate was observed at a moderate distance of 20 cm (0.06525) with a rise of 46.95% from the base.

The lowest was observed at a very close distance of 5 cm from the reaction front o.05312 with a rise of 21.12% from the base rate. All other source location had intermediate values.

The plot again can be divided into 2 zones

i) The rise where the reaction rates shoot up to a maximum value from source distance of 15 cm to 20 cm.

ii) The fall where reaction rates fall from the maximum value to the base vaues from source distance beyond 20 cm.

The slope is positive till 20 cm after which the slope becomes negative.

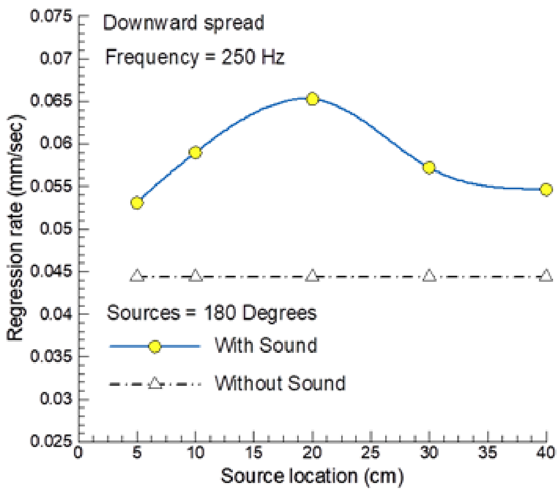


Figure25:with variation in source location

Result:

When the speakers are too close to the reaction zone (5 cm) the sound wave interact with each other and form a weak compression zone. This compression zone interacts with the localized temporary field of the reaction zone and energy is added to the forward heat as the temperature gradient is setup between the localised field and the pressure wave. Since regression rate at this distance rises only by 21.12%(amount of heat added to the forward heat is less) hence the zone encountered is a weak compression zone. Also the loss to the environment is higher at this condition.

As the source distance is increased the waves from both the speakers interact and form a more intensified compression zone which is strongest at 20 cm.

Figure 26: (source distance 5 cm)

Figure 27: (source distance 10 cm)

Figure 28.: (source distance 30 cm)

Figure 29:(source distance 40 cm)

The rates at 10 and 30 cm source distance are almost same. This shows for both case the strength of the compression zone formed is same and same amount of energy is added to the forward heat. Also the drop from 20cm to 30 cm source location can be attributed to the loss of intensity due to increased distance from reaction front The ratio drops further as the distance is increased from 30 to 40 cm. This is caused by 3 effects.

1st- loss of intensity of sound source due to increased distance from the reaction front

2nd- formation of compression zone to transform less energy to the localized field and assist forward heat.

3rd- Increased losses to the environment.

8. CONCLUSION

An experimental exploration was carried out on incense sticks to identify the merits of acoustic effects on smoldering combustion. Reverse smoldering mode was investigated with controlling parameters viz., sound source symmetry for varying frequency and sound source distance for a fixed frequency. The specific conclusions of the study details that:

- Smoldering combustion is severely affected by the presence of external sound sources.
- Formation of strong gradient grounded localized temperature and velocity fields in the immediate vicinity of smoldering controls the relevant energy transfer and consequently the chemical reaction rate decides the acoustic effect outcome under subjected condition.
- The regression rates are relatively high for lower frequencies when sound source symmetry is 180 degrees
- .regression rates For other sound source geometries follow the given order:
  45>90>135.
- The maximum acoustic effect was noted occur at an intermediate sound source location whereas, the minimum effect was evaluated to occur with nearby placement of sound source.
- Two distinct zones were established based on external sound source location indicating no effect (nearby placement) and drastic rise (next to no effect zone) for upward and downward spread. The intensity of compression-rarefaction front interaction with smoldering front varies with source location and primarily controls the energy transfer.

9. APPLICATION OF THE WORK

Almost all combustion processes are accompanied by the presence of sound. The division is external (outside) and internal (produced due to combustion). The low speed combustion experiments are noted to neglect the acoustic effects. Smoldering poses serious hazards on operational engineering systems on earth primarily due to liberation of toxic gases and in space. Utilization of sound for better combustion provides a good discretion. Present work would be very useful for scientific, engineering, practical and functional applications involving smoldering combustion and mitigation on earth and in space. The work offers seamless physical insight into acoustic effects on smoldering combustion being more harmful than the normal combustion with abrupt rise and demands proper attention and prevention. These results can be used in various terrestrial and space applications viz., to design, validate, test engineering systems, smoldering combustion alerts, prevention from expectedly transition to fires, minimizing smoldering damages, hazards, saving life and environmental pollution control. The results can also be applied to the use of hybrid fuels which are marked to have low regression rates. The present work also provides an insight for accelerating the regression rates of hybrid fuels with the use of acoustics.

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