

# Comparison Analysis of Flame Sources, Loss Quantities and Atmospheric Conditions of Kerosene and Gas in Domestic and Industrial Heating Processes

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**Abstract:** Gas and kerosene are the two major sources of fuel used at home and industrial cooking. The process of optimizing these resources poses great challenge to industrial cooking and heating. This work examined whether gas and kerosene are rapidly exhausted when heat is applied at high temperature to heating cylinder and stove respectively. At the end, reliable and efficient conditions that optimize heating process are proffered. It was also observed that the rate of decrease in the substances used while cooking depends on the quantity of heat applied at various temperatures. In both domestic and industrial heating processes, there is a major concern of the appropriate fuel source and atmospheric conditions to be adopted. This research work presented the costs and effects of adopting a particular method. It is obvious that there is a particular cost and benefit attached to each method. This work analyzed them to enable a concise and suitable choice of heating process. At the end, there was clear indication that gas sustains cooking than kerosene when heat is applied.

**Keywords:** Industrial Cooking, Temperature, Orthogonal Comparison, Loss Quantity, Atmospheric Conditions

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## 1. Introduction

Industrial and domestic cooking is predominantly done with cooking gas and kerosene. These substances undergo series of serious purification before they are used as source of fuel. It is not enough to enhance cooking without the presence of light, which converts mechanical energy to heat and light energy. In another development, cooking takes place ineffectively without the presence of an enhanced air. It is among the essential factors that enhance the constant lightening and production of desired heating flame. Though air contains 73 percent nitrogen, 21 percent oxygen, 0.03 percent carbon dioxide and 0.01 percent inert gases [1], the most critical element is oxygen because light needs it to enhance constant production of flame and heat. Effective industrial heating takes place when all the required environmental and atmospheric conditions necessary to boost flames are considered.

According to Brownian motion gas molecules undergo

random motion [2]. If heat is applied to gas, its kinetic energy is increased and transferring heat environment through exothermic reaction. The rate which gas molecules move in a container is affected by the amount of heat applied to it. The tendency of gas molecules to spread fast, release heat to its environment due to their molecular kinetic energy and the distance created by the molecules makes it preferable in industrial and domestic cooking. In the other hand, we have kerosene as a source of energy in stoves. And this source needs to be transported from the trunk of the stove to the burner through wool [3]. Wools have the capacity of assimilating liquids gradually from trough to crest. It does not burn concurrently in absence of kerosene because the presence of kerosene makes it lighter to flame well. Wools drain the kerosene gradually to the top where combustion takes place and sustain a free constant flame with the aid of air. As the wool burns its size is reduced vertically resulting to the idea of increasing the wool by adjusting or tuning the stove jack.

The size of the wool determines the amount of kerosene

convey to the crest [4]. Wool of 2mm by 5cm transfers a little quantity of kerosene decreasing the quantity of flame produced while wool of 4mm by 5cm produces more flame and heat. As wool brings kerosene to stove acme, the kerosene molecules heat and evaporate which in turn reduces the quantity in the container. At normal circumstance, especially in a hot weather condition the rate by which kerosene evaporates varies from the evaporation that takes place in water and gasoline. Evaporation in kerosene is not often noticeable, because of its molecular nature. During the process of heating, kerosene loses molecules to the environment [5]. The quality of flame produced depends on purity level of kerosene and size of the wool. Red-like flames are undesirable due to black smoke it produces. This is mostly as a result of combustion wool undergo with the purified substance containing thin paraffin and alkane hydrocarbon called kerosene. It is not all the quantity of flame produced during wool heating is useful. Some are converted to smoke causing black ashes while others are converted to full heat enhancing effective boiling. Kerosene are easily ecstatic because they are not like gas molecules which are always in random motion [6], and are likely to retain its content in a material like wool.

## 2. Methodology

The experiments were conducted and observed at various conditions. In regards to air, flame was introduced to 8 pieces of wood in a ventilated area. The same type and quantity of wood were flame and placed in a blocked area where air

cannot penetrate. A burning burner with 1 litre of kerosene, 12 pieces of wools of 2mm by 5cm were well fixed in the burner and flame under non-ventilated condition. The similar experiment was set in a ventilated area. In two other different set ups, 4mm by 5cm of wool were fixed to the burner and flame with and without ventilation respectively. At this point, the presence of sunlight was introduced to a burner with ventilation having the same materials such as 1 litre of kerosene, 12 wools of 4mm by 5cm. The same set up was made at this point and placed in a cold area where the air is moist.

In other cases, four different gas cylinders of 6kg content each were placed in ventilated, sunlight, cold, non-ventilated areas respectively and set aflame. After that, a burner of 6 litres of kerosene, 12 pieces of thread wools of 4mm by 5cm was set on flame where there is ventilation, cold, hot air and without ventilation and observed in different set ups according to their atmospheric conditions. Here, a burning stove burner of 30 ml of kerosene, 12 wools of 4mm by 5cm each was set under sunlight and observed. After that, a stove filled with same amount and size of wool but 1 litre of kerosene was increased times three and placed in a ventilated area. Furthermore, the same materials were placed in a ventilated area, but the jack was turned to the highest level. At the end, a cylinder filled with 6 litres of kerosene with wool of 4mm by 5cm was set in a ventilated area. A stove with fuse 6kg of gas molecules and wool of 4mm by 5cm was placed in a ventilated atmospheric condition. The entire arrangement was presented in Table 1.

*Table 1. Presentation of Experimental Conditions.*

Method	Materials	Conditions Required
1	8 pieces of wood, light.	In presence of air/ ventilation.
2	8 pieces of wood, light.	Absence of air/ no ventilation.
3	Stove, 1 litre of kerosene, 12 wools of any seize, light.	Absence of air/ no ventilation.
4	Stove, 1 litre of kerosene, 12 wools of any size, light.	Presence of air/ventilation.
5	Stove, 1 litre of kerosene with 12 wools of 4mm by 5cm, light.	No ventilation.
6	Stove, 1 litre of kerosene, with 12 wools of 4mm by 5cm, light.	Ventilation.
7	Stove, 1 litre of kerosene, with 12 wools of 4mm by 5cm, light.	Sunlight.
8	Stove, 1 litre of kerosene with 12 wools of 4mm by 5cm, light.	Cold
9	Gas cylinder, 6kg of gas molecules, light	No ventilation
10	Gas cylinder, 6kg of gas molecules, light	Presence of air
11	Gas cylinder, 6kg of gas molecules, light.	Sunlight/hot area.
12	Gas cylinder, 6kg of gas molecules, light..	Cold area.
13	Stove, 6 litres of kerosene, 12 wools of 4mm by 5cm, light.	Presence of air.
14	Stove, 6 litres of fuel, wool of 4mm by 5cm, light.	Cold.
15	Stove, 6 litres of fuel, wool of 4mm by 5cm, light.	Sunlight.
16	Stove, 6 litres of pure water, wool of 4mm by 5cm, light.	Ventilation.
17	Stove, 30ml of kerosene s	Sunlight/hot area.
18	Stove, 1 litre of kerosene, 12 wools of 4mm by 5cm (turning the jack 3 times), light.	Ventilation.
19	Stove, 1 litre of kerosene, 12 wools of 4mm by 5cm (turning the jack to the highest), light.	Ventilation.
20	Cylinder, 6 litres of kerosene, wool of 4mm by 5cm, light.	Ventilation.
21	Stove, 6kg of gas content, pipe/channel, light.	Ventilation.

## 3. Result and Discussion

In the grounds of this study, presence of air makes woods to burn faster affirming that oxygen supports combustion and the rate in which flame increase is high, producing big

amount of heat [7]. It was discovered that the high amount of air resulted to the high rate of combustion in a ventilated case. In absence of air, huge amount of heat was produced causing the blue flame unstable, and it generate much smoke, which is choking when inhaled. This type flame does not enhance cooking, rather it negatively affect industrial heating

and cooking. In a ventilated experimental set up, quantity of the flame increased, the heat generated is higher than that of 2mm by 5cm wools and blue flame was produced. The degree in which food boils here is higher with less smoke [8]. When 4mm by 5cm wools was used, it produced non-blue flame. This experiment delays cooking, but maintains conducive state of health and atmosphere.

Under the condition of no air, a non-blue coloured flame was produced, and a lot of heat was observed. In the presence of sunlight, blue flame was produced. The utensil heated faster and the quantity of the kerosene decreased gradually than the set up in absence of sunlight. Placing the stove under a cool condition, the blue flame was produced, conducting less smoke [9]. The utensil heated faster and approaches the rate of the set up under sunlight condition. In the absence of air, unstable blue flame was produced, and the smell remained dominant in that area. In presence of oxygen, stable blue flame was produced and the smell was not easily perceived. The rate of heat generated is high [10].

Placing the cylinder under sunlight/hot area, gas molecules were set in a great motion and a higher blue flame was produced. The 6kg of gas molecules are highly affected by the great motion caused by the additional heat, sourced by sunlight. Blue light was produced. Smell was perceived [11]. The gas movement was not as high as result in the presence

of ventilation, food substances tends to boil not fast as we have result when oxygen was introduced. Under a cool condition, the wools burned faster, yellow light was produced, which has a great tendency of exploding while sunlight condition makes yellow light produced with tendency to explode faster than result in cold condition [12]. The 30ml of kerosene remained 29.3ml after 5 hours; it was observed that quantity loss quantity was 0.7ml. In other words, 0.7ml was lost under sunlight within 5 hours showing the rate of evaporation. In the event of 10 hours, the amount of kerosene to be evaporated is  $10/5 \times 0.7 = 1.4\text{ml}$ . When the jack was increase 3 times, blue flame was produced, enhancing less smoke. Cooking utensil boiled gradually without staining the back of the pot. High flame was produced in ventilated condition, which has yellow colour mixed with blue. The cooking utensil boils more than the normal case, but the utensil was highly stained with black smokes. Changing the content in cylinder to kerosene with wool produced blue flame but the rate in which the food boiled was slow [13]. When the content of stove was changed to gas and placed outside the house, constant flame was not retained, rather the gas reacted to the light by exploding and some gases escaped immediately due to the openings.

**Table 2.** Presentation of Observations and Inferences.

Method	Observation	Inference
1	Wood burns faster increasing the Heat.	Air supports combustion
2	Heat generated, Unstable Flame.	Reduction in combustion
3	Insufficient flame produced, smoke, Heat.	No ventilation
4	Hard to generate light, little kerosene conveyed	Oxygen supports combustion
5	Flame size increased, much heat generated plus blue flame.	Ventilation Contributes to heating
6	4mm by 5cm wool produces a non-blue flame.	No Ventilation
7	Blue flame, less smoke, rapid heating and decrease in kerosene.	Sunlight/Hot Area
8	Blue flame, less flame light plus increased heating.	Cool
9	Blue flame plus dominant smell.	No Ventilation
10	Blue flame plus mere smell with increased heat and flame.	Ventilation
11	Better blue flame with great motion and much heat	Sunlight/Hot Area.
12	Blue flame, increased in motion faster cooking.	.....
13	Occurrence of method 12 result.	
14	Wools burned faster with yellow flame and explosive tendency.	Cool Area.
15	Yellow light, more explosive than method 14.	Sunlight.
16	Loss of 0.7ml within 5 hours, greater evaporation.	Sunlight enhances evaporation
17	Blue flame with little Smoke, gradual burning without stain.	Having The Jack Turned 3times.
18	High mixture of yellow and blue flame plus smokes and stains.	In Presence Of Air.
19	Black smoke with slow heating	Gas heats faster than kerosene
20	Loss of heat, gas molecule explosion and lack of constant flame	Excessive exposure affects heating

**Table 3.** Data Representation.

Method S/N	Method	No of Stove	Wool size (mm:cm)	Wool No	Jack Turn Decree	No of wood (L: W) each	Seize of wood (cm)
1		-	-	-	-	8	5:2
2		-	-	-	-	8	5:2
3		1	2:5	12	1440	-	-
4		1	4:5	12	1440	-	-
5		1	4:5	12	1440	-	-
6		1	4:5	12	1440	-	-
7		1	4:5	12	1440	-	-
8		1	0	-	-	-	-
9		-	0	-	-	-	-
10		-	0	-	-	-	-

Method S/N Method	No of Stove	Wool size (mm:cm)	Wool No	Jack Turn Decree	No of wood (L: W) each	Seize of wood (cm)
11	-	0	-	-	-	-
12	-	4:5	12	1440	-	-
13	-	4:5	12	1440	-	-
14	1	4:5	12	1440	-	-
15	1	4:5	12	1440	-	-
16	1	4:5	12	1440	-	-
17	1	4:5	12	1440	-	-
18	1	4:5	12	1080	-	-
19	1	4:5	12	1400	-	-
20	0	-	-	-	-	-
21	1	4:5	1	720	-	-

Table 3. Continued.

No of cylinder	Quan. of fuel	Quan. of kerosene	Quan. of H2O	Quan. of gas	Turn of the cylinder decree
-	-	-	-	-	-
-	-	-	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	-	-	6	720
-	-	-	-	6	720
-	-	-	-	6	720
-	-	-	-	6	720
-	-	6	-	-	-
-	-	-	-	-	-
-	6	-	-	-	-
-	6	-	6	-	-
-	-	0.3	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
-	-	1	-	-	-
1	-	6	-	-	-
-	-	0	-	6	720

The average time per litre taken for the different atmospheric conditions by randomly assigned cooking fuels with no prior experience of the boiling time of these fuel mechanisms after the same amount of water and instructions was observed and recorded. The primary interest here was to

compare several different methods of boiling water. The cooking methods give varied boiling times. The experimental set up was carried out with 1 litre of water and the boiling time was recorded in minutes at different experimental set up shown below

Table 4. Flame Sources and Atmospheric Conditions (in Minutes).

	Ventilation	Non-Ventilation	Sunlight	Cold air	$T_i$	$\bar{x}_i$	$\bar{d}_i$
Fire wood	25	38	16	32	111	27.75	-1.1875
Kerosene stove	30	40	35	31	136	34	5.0625
Electric stove	28	33	30	32	123	30.75	1.8125
Gas cooker	15	30	20	28	93	23.25	-5.6875
$T_j$	98	141	101	123	463	↓	↓
$\bar{x}_j$	24.5	35.25	25.25	30.75	→	115.75	↓
$\bar{d}_j$	-4.4375	6.3125	-3.6875	1.8125	→		0.0000

The primary interest here is to state the model, estimate the mean effect of each composition and to ascertain at 95 percent level of confidence if there is any significance difference in the boiling methods.

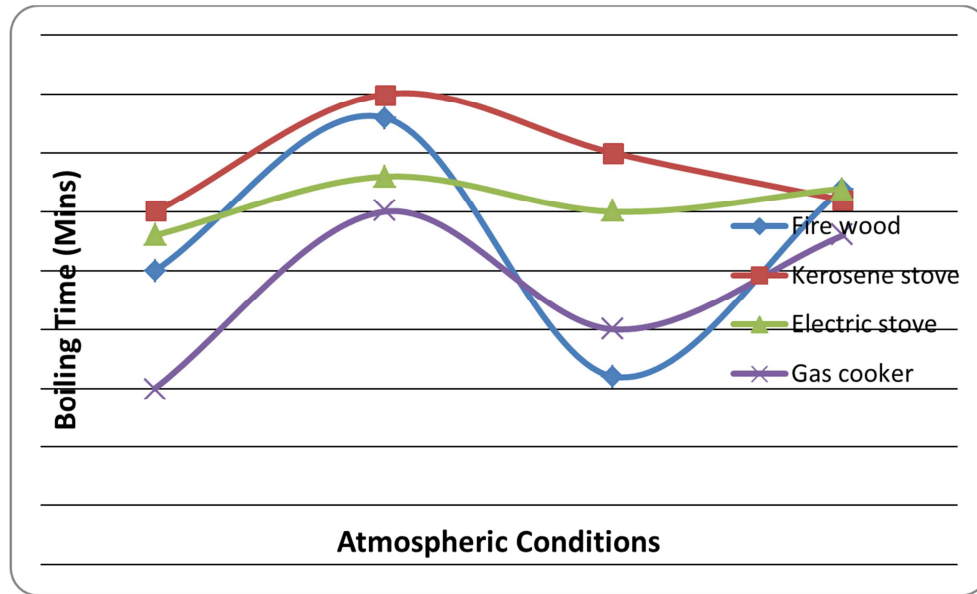


Figure 1. Flame Sources and Boiling Time.

The loss quantity for kerosene and gas were respectively recorded at different atmospheric conditions measured in mililitre.

Table 5. Correlation of Loss Quantity between Gas and Kerosene.

Source	Ventilation	Non-Ventilation	Sunlight	Cold air	Correlation Kerosene	Gas
Kerosene	0.45	0.65	0.70	0.60	1	0.926
Gas	0.12	0.30	0.50	0.35	0.926	1

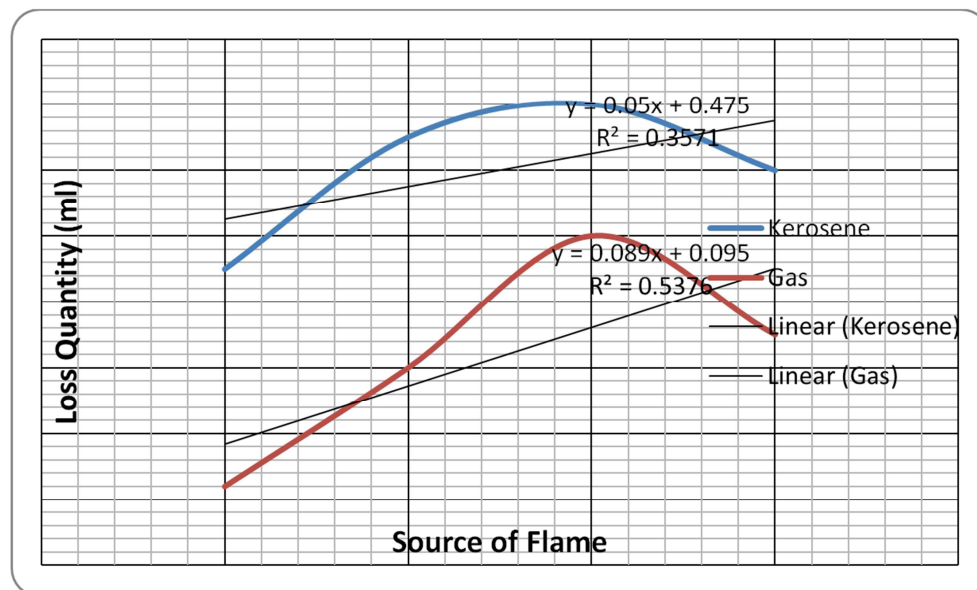


Figure 2. Comparison of Loss Quantity.

Though there is significant relationship existing between the use of gas and kerosene in heating and boiling process across the atmospheric conditions such as ventilation, sunlight, cold air and non-ventilation, it is worthy to not that they are not at exact level [14]. The analysis shows that there existed 95.3 percent relationship in the loss quantity of the two substances. In other words, one has more loss quantity than the other at a given atmospheric condition. In a general

case, kerosene is 4.7 percent loss quantity greater than gas.

The model is  $X_{ij} = t_i + b_j + e_{ij}; i, j = 1, \dots, 4$  where  $X_{ij}$  is the boiling time in minutes of experimental condition obtained from the  $j$ th source of fuel,  $t_i$  is the mean effect of the fuel composition,  $b_j$  is the mean effect of the atmospheric condition while  $e_{ij}$  is the random error associated with  $X_{ij}$ . The analysis of variance was done and recorded.

**Table 6.** Analysis of Variance.

SSV	DF	SS	MS	F-cal	F-tab
SSt	3	250.6875	83.5625	4.03115578	3.86
SSb	3	305.688	101.8958	4.91557789	3.86
SSe	9	186.563	20.72917		
SST	15	742.938			

Since 4.03 is greater than 3.86, there is enough evidence that the boiling time varies among the four fuel sources. Similarly, since 4.92 is greater than 3.86, we also have enough evidence that the boiling atmospheric condition to atmospheric condition.

Multiple comparison tests were carried out to find out which boiling method gave the highest contribution to the variation. The mean effect of fuel source and atmospheric conditions were arranged in ascending order of magnitude as

**Table 8.** ANOVA of the Comparisons.

Fuel Source						Atmospheric Condition					
SSV	DF	SS	F-cal	F-tab		SSV	DF	SS	F-cal	F-tab	
[1]	1	40.5	1.953765	5.12	Not Sig	[1]	1	78.125	3.768834	5.12	Not Sig
[2]	1	189.0625	9.120582	5.12	Sig	[2]	1	264.0625	12.73866	5.12	Sig
[3]	1	136.6875	6.593949	5.12	Sig	[3]	1	212.5208	10.25223	5.12	Sig
[4]	1	21.125	1.019097	5.12	Not Sig	[4]	1	200	9.648215	5.12	Sig
Error	9	186.563				Error	9	186.563			

The fuel sources and the atmospheric conditions were respectively checked under four comparisons. Fire wood flame is not significantly different from other sources of fuel [15]. The same case was observed when the minutes used in boiling with cold air are compared to the amount of minutes used in boiling with ventilation. There is a significant difference between the amount of minutes used in boiling water with electric stove and kerosene stove joined together with other sources. Also, the result obtained showed enough discrepancy between the times used when boiling same volume of water with kerosene stove against other sources of fuel. Comparing boiling without ventilation to other atmospheric conditions, there are significant differences [16]. However, the number of times used in boiling water with kerosene stove is significantly different from the number of minutes used in boiling same volume of water using electric stove.

## 4. Conclusion

In Industrial and domestic cooking, it is obvious that combustion and constant lightning take place if air with much content of oxygen is present. Air is an essential component while cooking or burning or doing anything that involves heating. In the absence of air, smoke is been produced and the colour of the flame becomes undesirable. It turns to yellow or mixture of yellow and blue instead of pure blue. Excess smoke effects taste of food after cooking in a non ventilated area. Hot areas or condition and the presence of sunlight make our food to boil fast than in a cold area that has ventilation also. Hot areas or hot weather condition causes evaporation in kerosene in a very little quantity compared to water or fuel. It causes increase in random movement of gas molecules causing higher reduction of gas

$\hat{t}_4 = -5.6875 < \hat{t}_1 = -1.1875 < \hat{t}_3 = 1.8125 < \hat{t}_2 = 5.0625$  and  $\hat{b}_1 = -4.4375 < \hat{b}_3 = -3.6875 < \hat{b}_4 = 1.8125 < \hat{b}_2 = 6.3125$  respectively. The orthogonal linear comparison was set up as

**Table 7.** Orthogonal Comparisons.

Flame Source				Atmospheric Condition			
$\hat{t}_1$	$\hat{t}_2$	$\hat{t}_3$	$\hat{t}_4$	$\hat{b}_1$	$\hat{b}_2$	$\hat{b}_3$	$\hat{b}_4$
1	0	0	-1	-1	0	0	1
-1/2	1/2	1/2	-1/2	-1/2	1/2	-1/2	1/2
-1/3	1	-1/3	-1/3	-1/3	1	-1/3	-1/3
0	1	-1	0	0	1	-1	0

Sum of squares due to the comparisons are calculated using  $SS_{[i]} = \frac{(\sum c_i t_i)^2}{n(\sum c_i)^2}$  and the ANOVA table is presented as

than when placed in a cool ventilated area.

Gases can easily operate or work in a closed system and pressure increases depending on the weather condition or temperature. Gasoline in a cylinder brings about safety in cooking than practicing what was done using kerosene and stove. Kerosene is more convenient, suitable to boil in a stove than in a cylinder. Kerosene is good to use as a source of energy than water which do not conduct flame and fuel which conduct heat, but very dangerous to our health). Whether you are using gas or stove all needs a ventilated area, and the higher the amount of air the higher the light maintain its constant flame, and tends to save from hazardous smoke. It is preferable to cook in a cool ventilated area than to cook in the presence of sunlight or under the penetration of sunlight. Using gas cylinder is good and retains its source than stove.

Finally, the rate of reduction in gas and kerosene is also affected by the intensity/length or temperature or how high the flame and heat is produced. The higher the temperature the higher the level in which the kerosene dry and the higher the gas molecules moves out.

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