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Design and Experimentation of Heat Shields for Commercial Cooking Stoves

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***Abstract* - Community cooking and religious events are very common in India as we are a culture forward society. As these events are very common, catering services remain employed year-round. The major issue that we have observed is the cheap and inefficient stove that is used by these caterers. We found that the burner used was cheaply made never cleaned and the frame provides no insulation whatsoever causing the heat from the burner to be wasted. This causes excessive use of fuel this causes the rise in the cost of food as well has contributing to other major issues like pollution and national waste of a non-renewable resource and excess emission of greenhouse gases.**

***Index Terms* - Heat Shields, Cooking Stoves, Heat Transfer, Efficiency**

I.OBJECTIVE

The objective of our project is to develop a cheap effective and universal fitting heat shield which can be used with any commercial stove. It will boost the efficiency reducing fuel consumption and reducing cost to the food caterer along with reducing pollution. The heat shield should not melt or distort under regular use during cooking. To ensure that the performance should not degrade for at least a month of regular use. To keep the cost of manufacturing should be as low as possible. We used commonly available materials to construct the shield like Mild Steel and Ceramic Wool.

II. EXPERIMENTAL SETUP

The experimental setup for testing consists of following components:

1. Aluminum vessel of 10 L capacity.
2. Normal commercial stove.
3. Gas cylinder connection.
4. Weighing machine.
5. Dimple glass thermometer.
6. Stopwatch
7. Temperature Probe
8. Materials required for the heat shield.
   a) Mild steel plate of thickness 1 mm.
   b) Ceramic wool covering.

The stove is placed on level ground and the Gas Cylinder in placed on the weighing machine. It is ensured that the line connection for the LPG cylinder to the stove is safe and leak-proof.

III.PROCEDURE

1. Firstly, the vessel is marked with a 2 lit. and 7lit mark.
2. Then the normal tap water is poured in the vessel up to the 7lit mark.
3. The vessel filled with water is then placed on the commercial stoves and heated.
4. Water is heated to the boiling temperature of that particular day which was calculated with the atmospheric pr. in mm of Hg and specific gravity of mercury.
5. The temperature is simultaneous measured with the help of thermometer and once the temperature gets constant the weight of water vessel and cylinder is noted down with the help of weighing machine and stopwatch ids started.
6. Then the water is constant evaporated until it reaches to the 2lit marks.
7. At this stage again the mass of water and gas cylinder of measured and time is noted from the stopwatch.

8. Same procedure is repeated for 4 more time by varying the flame from minimum to maximum.
9. With the help of these values the heat loss percentage of the commercial stove is calculated which is given in the below sample calculations.
10. After installation of heat shield same procedure in followed and values are taken of the comparison.
11. Then graphs are made for easy comparison and data interpretation.

IV. OBSERVATIONS

After conducting the experiment at 3 different fuel consumption levels the efficiencies were calculated for each case as displayed by the graph below.

It is clear from the graph that the efficiency of the stove increases with increase in fuel consumption. It is also observed that the effectively of the shield is highest at low fuel consumption scenarios. It is observed that the average efficiency gain due to the shield is 3.65% across all scenarios.

V. SAMPLE CALCULATIONS

To calculate the boiling temperature:

atmospheric pr. in mm of Hg*specific gravity of mercury*specific gravity/10^5

=0.733*13.6*9.81$10^5$

=99.97 C

Mass of vessel = 2.360kg

Initial mass of water,m_{wi}=9.110kg

Final mass of water after boiling,m_{wf}=4.470kg

Total mass of eater evaporated,

m_{fe} = 9.110-4.470

=4.64kg (with vessel)

Time required to boil the water

t = 66.50 min, 3990s

Rate of water evaporate, m_f=m_{fi}/t

=4.64/3990

=1.163*10^{-3}kg/s

Latent heat of vaporization,

h_{fg}=2256.9kj/kg

t_{sat}= 100 C

Rate of heat required for evaporation of water,

Q_w= $m_f \times h_{fg}$

=1.163*$10^{-3} \times 2256.9$

= 2.624Kj/s

Mass of cylinder at the start of evaporation,m_{ci}=23.440kg

Mass of cylinder after evaporation,m_{cf}=23.070kg

Mass of LPG supplied to water for evaporation i s m_f= 23.440-23.070

=0.370kg

Rate of heat supplied by LPG ,

Q_f=$m_f \times CV$/t

=0.370$\times$ 46.1 $\times 10^3$/3990

=4.27 KJ/s

Heat lost to the surrounding due to convention and radiation:

$Q_{lost} = Q_f - Q_w$

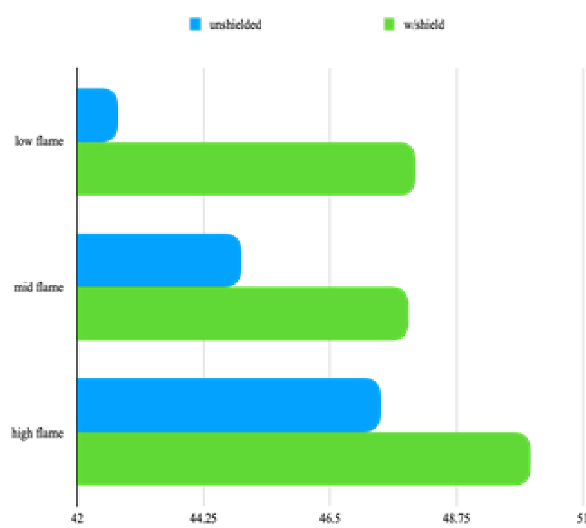
=1.646KJ/s

Percentage of heat lost = $\frac{Q_{lost}}{Q_f}$

=1.6/4.27

=38.54%

VI. EFFICIENCY GRAPH



VII. CONCLUSION

The aim of this project was to create a cheap and effective heat shielding for use by catering services to boost efficiency of the stove which reduces cooking time and reduces fuel consumption.

By the end of the experimentation we found the cost of the shield to be about 300 rupees if it were to be industrially produced. The average efficiency gain by the shield was 3.65%, which may not sound significant but will save a respectable about of fuel over the course of a year.

We estimate the life of this shield to be about 3 years before needing replacement. Overall, we consider our project a success even though further experimentation will result in better efficiency of the heat shield and further increase in savings.

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