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Innovative Method of Heat Conservation in Domestic Gas Stove

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Abstract: An energy need of every nation has been growing by leaps and bounds and to meet these demands newer and newer sources such as non conventional renewable sources of energy have been harnessed. Problem every nation facing is that; rate of production of energy is lesser than the rate of consumption. The natural sources of energy such as petroleum, coal, natural gas etc. are depleting and alternate fuels are being found spending lot of money. In such a situation, it becomes necessary - for the proper and effective use of available natural resources. One of such small measures is the use of pressure cooker for cooking; saving considerable amount of energy. Energy conservation in cooking is an important area for scientific investigation. To minimize the fuel usage in a longer run and also the time required for cooking is assessed. To make the best use of possible opportunities, it is important to consider the form of commercial process as early as during laboratory development to ensure it to be suitable for application in the intended continuous form. Improvements to insulation can cut energy consumption greatly, making a space cheaper and economical. This paper reports on energy conservation during domestic cooking via different cases as reported.

Keywords: Heat, Energy conservation, Efficiency, Domestic cooking.

I. INTRODUCTION

Energy is the driving force for the universe. Energy is a quantitative property of a system which may be kinetic, potential or in other form. The primary factors affecting energy consumption include:(i) the production and transport efficiency of fuel sources (electricity, natural gas, wood, etc.); (ii) the appliance (or end-use) efficiency; and (iii) the behaviour of the consumer during cooking. Regarding appliance efficiencies, some improvements are plausible and policies should be directed towards reducing or alleviating stand-by energy consumption in new products [1].Several energy conservation methods are developed such as reduction of losses of energy at transmission and distribution stages and also at consumption stages. Though energy saving devices such as CFL tubes, high octane fuels, Turbochargers, common rail direct injections in I.C engines, etc. would not show direct benefit several such devices and processes would help in reduction of power generation; saving energy.In a domestic pressure cooking; heat energy from gas is used to generate steam inside a closed and pressurized vessel to have effective fast cooking of food. Major portion of thermal energy is used in actual cooking process and is presumed some amount of heat energy is lost to the surrounding.It is analysed that a considerable percentage of energy goes waste in the domestic heating system via the wastage of energy due to the dispersion of flue gases which carry considerable amount of heat energy; heat losses through the heat conduction from the cooking Pan's wall to the environment; Improper adjustment of the flame; Enthalpy losses through the exhaust steam and so on[2].

II. OBJECTIVE

Any work done, has an objective; differentiating from others. The present work focuses on -

To know whether cooker is absorbing energy to the best of its capability.

Check portion of total gas energy liberated is actually going into cooking or lost to the surrounding atmosphere.

Analyze the above data & assess which type of cooker is thermally efficient i.e., from the 3 cases reported in the methodology.

Conduct experiment to assess the above and make thermal mapping to study the thermal dissipations of energy Make one thermal insulation shell to conserve thermal energy and study its efficiency.

To check the heat transfer and losses in conduction, convection and radiation collectively.

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III. METHODOLOGY

In cooking, typically there is a heating element (such as a fire), a heat transfer medium (oil, water, air, a pan, etc.), and the food itself. Flame consists of three temperature zones as shown in figure 1. Nearer to the tip of the burner is the coldest zone while the tip of the flame is considered to be the hottest zone while the intermediate temperature zone lies in between these two zones. As a result; improper positioning of the cooker over the flame, instead of the hottest zone the conduction might be occurring from the coldest zone of the flame. To avoid this loss; flame of the burner is studied and the most suitable position for the cooker is suggested.

Fig.1 Flame showing zones

The area through which heat conduction takes place is the bottom of the cooker; while the metallic walls of the cooker transfers the energy from the cooker to escape to the environment, which is an energy loss [3]. To prevent this loss; insulation could be made on the walls of the cooker, but it would be an obstacle to the conduction of heat from the flue gases accumulated around the cooker to water and finally the insulation was made externally to the walls of the shell; so that neither the flue gases nor the walls of the cooker could make its energy to escape.

Experiments were carried out with the following three cases: Alluminium cooker without casing; Alluminium cooker with base electroplated with cooper of 300microns; Alluminium cooker with casing (clay) and copper plated.

Equipments used for various measurements in the study.

1. Temperature measurement probe
   a. Surface temperature thermocouple
   b. Flue gas temperature thermocouple
   c. Flame temperature thermocouple
2. Digital indicator instrument for temperature measurement
3. Clay casing
4. Gas stove
5. LPG cylinder
6. Weight pan
7. Flow meter
8. Pressure gauge
9. Pressure Cooker

Aluminum cooker without casing

Aluminium cooker with base electroplated

Alluminium cooker with clay casing and base electroplated

Using the Boy's gas calorimeter experiment was carried out to find the calorific value of gas.

Fig.2 Casing used as a ducting for flue gas, made of clay

Assumptions made during the experimentation:

- The readings have been taken at 1st press/release knob.
- The cooker has been analyzed into 3 major parts namely - hollow cylinder; base plate (surface) and top plate (surface).
- Heat transfer is uni-direction.

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- Concentration was on convection and radiation loss reduction by casing.
- A flow rate of 0.75 LPM was taken as standard for experiments and for calculations as it was found to be the optimum size of the flame (i.e. approx. 70% of the base of cooker)

IV. Results And Discussion

Case -1

Aluminium cooker without casing (η = 55.83%)

Heat Transfer	Hollow Cylinder	Top surface	Bottom Surface
Conduction in Watts 'W'	127.82×10^3	10.3×10^3	136.5×10^3
Convection in Watts 'W'	21.52	5.75	
Radiation loss in Watts 'W'	65.36	16.47	

Table 1

Case -2

Aluminium cooker with base electroplated (η = 59.1%)

Heat Transfer	Hollow Cylinder	Top surface	Bottom Surface
Conduction in Watts 'W'	127.82×10^3	10.3×10^3	152.8×10^3
Convection in Watts 'W'	21.52	5.75	
Radiation loss in Watts 'W'	65.36	16.47	

Table 2

Case -3

Alluminium cooker with clay casing and base electroplated (η = 60.59%)

Heat Transfer	Hollow Cylinder	Top surface	Bottom Surface
Conduction in Watts 'W'	137.64×10^3	10.3×10^3	150.2×10^3
Convection in Watts 'W'	7.13	5.75	
Radiation loss in Watts 'W'	20.82	16.47	

Table 3

Volume flow rate = 0.6 LPM

Calorific value of LPG, $C_v = 39396$ MJ/m^3

Supplied heat from gas = m x C_v …m = flow rate in m^3/s

$= 1 \times 10^{-5} \times 39396 \times 10^6$

= 393.9 KW ~ 400 KW

Time taken by aluminium vessel without casing = 6min 14sec; Time taken by copper plated vessel = 5min 54sec and Time taken by aluminium vessel with casing and electroplated = 5min 51sec.

Figure 3 shows thermal map of temperature distribution at equal distances away from the source. (The unit equal distance is taken as 1cm).It is seen that the flame temperature recorded at 3cm from the center is at a high of 680º Celsius. It gradually reduces to ambient temperature as the distance moves away. It is also evident from the map above that there are high temperature flue gases exiting from the circumferential region of the vessel. Attempt has been made to make use of this high temperature flue gas whichotherwise would have lost to the surrounding atmosphere.

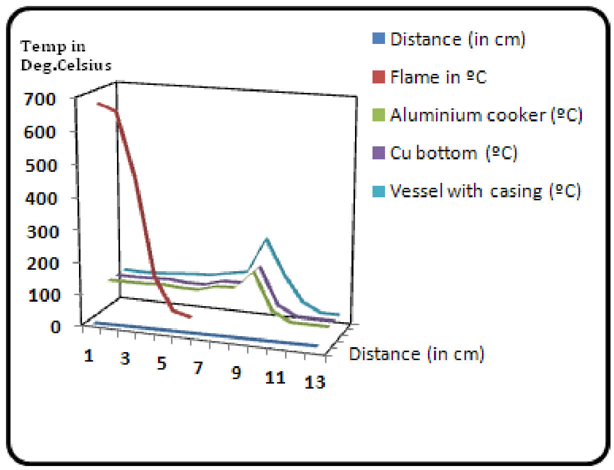

Fig.3 Thermal Mapping of Temperature distribution

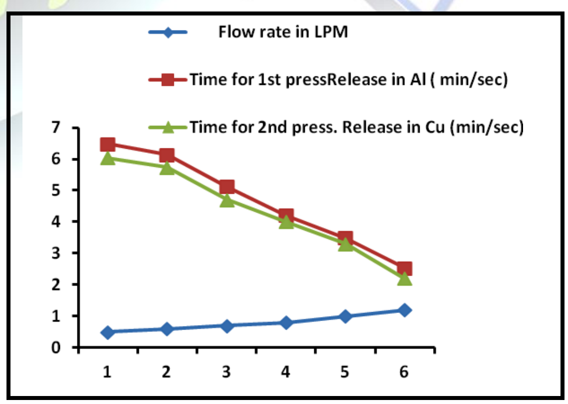

Fig.4 Graph of Flow rate vs Time

From the above graph it is evident that as the flow rate increases the cooking time is faster. But when the flow

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rate is increased above 1.2LPM there is incomplete combustion of gas. But as the flow rate is increased there is lot of wastage of energy. So it is evident that though by increasing the flow rate time taken for cooking may be less, but the energy loss increases. Hence it is very much necessary to cook with optimum flow rate to conserve energy.

The experiment was conducted with open lid and 500ml of water. From the graph it is seen that with the electroplating of only 300 microns of copper at the bottom of the cooker approximately 30-40sec can be saved. So if the whole of the bottom off the cooker is changed to copper the heat absorption capacity of the cooker can be increased to a very high extent.

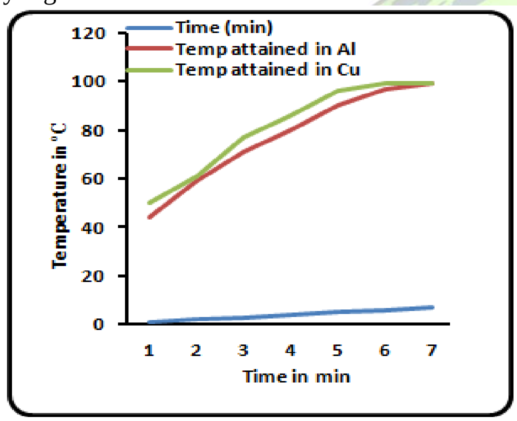

Fig.5 Graph of Temperature vs time

IV. CONCLUSION

Theoretical estimates showed the heat losses in gas stove cooking to an extent of 44.17%.The bottom of cooker electroplated which helped in increasing the thermal absorption capacity also increases the efficiency by an extent of 3.27% and saving 7878 KJ of energy for one time cooking. One insulation material viz. clay tried by a simple molding process showed encouraging results by increasing the heat absorption capacity between 2 – 5% with insulation barriers. Experiments done within the limited time frame and cost restrictions showed an increase in thermal efficiency. Always care should be taken to maintain diameter of the flame (intensity of flame) up to 70% approximately of the base of the cooker to improve performance.

V. SCOPE FOR FUTURE WORK

A study has been made on various aspects of heat transfer in domestic cooking, and certain scientific methods are proposed for effective utilization of energy. 2nd law of thermodynamics states “all the heat supplied cannot be converted into useful work” and a perpetual machine of second kind does not practically exist. However there is always scope for optimization and improvement to be made in current systems. The objective of this project being, to increase thermal efficiency in order to ensure maximum heat transfer. This has been achieved by electroplating copper on the base of the cooker with clay casing; as the thermal conductivity of copper is high compared to aluminum and its alloys. Significant improvements in these experiments are:

Though Cu has high thermal conductivity; presence of Aluminum below it doesn’t show drastic improvements. Firstly though large amount of heat is being liberated from the LPG fueled flame; only a part of it is transmitted, through, to the base of the cooker. The amount of heat transmission depends on the thermal conductivity of the material of the cooker. The base of the cooker is electroplated with a layer of copper of 200/100 microns.
This has proved to be effective to a certain extent.
For further improvements in results:
The whole base of the cooker can be replaced with copper based plate.

1. Side walls of the cooker can be electroplated with copper of 200 microns.
2. Cook wear should always be clean, free from suite deposition and other organic impurities. As these impurities hinder effective heat transmission.
3. Use of advanced insulating materials such as composites, to provide proper ducting for the high temperature flue gases so that they interact effectively with the body of the cooker before releasing to the atmosphere.
4. The insulating and ducting structure could be enhanced with composite reinforcement.
5. The insulating material could be made lighter in weight by providing webs and hollow structures and provisions implemented for better material handling.

All the suggestions and improvements if implemented would definitely yield better results and would help conserve useful energy which otherwise would be accounted as heat losses.

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