Review of Thermal Efficiency of Cooking Pot And Performance Analysis of Different Cooking Pots

Purushottam Kadam[1], Prof. Dr. J.P.Shete[2]
Department of Mechanical Engineering
[1, 2] Vishwakarma Institute of Technology, Pune

Abstract-*Nowadays, an enormous amount of energy is wasted in different forms and we need to harnessing energy. Lot of people are cooking with liquefied petroleum gas (LPG).In LPG cooking large amount of energy wasted during the cooking process. Therefore, conservation of energy is prominent in fast growing economies. This review paper mainly focused on ongoing research of energy conservation and determination of thermal efficiency of cooking pots during cooking process. The goal of this study is to understand the overall performance of the pots, rate of heating influenced by the heating source, rate of heating influenced by the material compositions of cooking pots.*

Keywords-Water Boiling Test, Heating time, Thermal efficiency, Conservation of energy.

I. INTRODUCTION

Cooking is an inevitable part of daily life for many reasons such as to reduce food-borne illnesses, and to enhance taste, texture, digestibility. Pots and utensils used for cooking and food preparation typically work on LPG gas, coal, biomass, or electric stoves. LPG gas is the most used energy source. Kitchens are one of the places where deals with this phenomenon daily in cookware application. This leads us to two considerations: thermal diffusivity and reactivity. Thermal diffusivity determines how fast the pan will heat up. Several studies about energy efficiency in cooking pots have focused primarily on the stove type and the type of fuel used. They studied the heat transfer characteristics of different sauce pans on various cooktops such as electric coil, natural gas and induction cooktops and identified the most appropriate sauce pan for each cooktops. Differences in cooking efficiencies are due to differences in heating principles and cook top wattage, pan size and shape, composition, base thickness and mass [2]. The cooking efficiency is determined based on various parameters such as loading weight, loading height and mass of water added into the pot. The carbon emissions during cooking process is measured at different power levels [3]. The analysis of temperature distribution is done with two different structures of cooking utensils and compare the insulated and non insulated cooking utensils[4].The comparison of heat transfer efficiency of flat bottom surface and rounded bottom surface of cooking pots. The rounded bottom pot have higher heat transfer efficiency than flat bottom cooking pot [5]. The combustion efficiency of stoves using biomass as a fuel in rural areas without access to an electrical interconnection system or natural gas network. They created a baseline for calculating greenhouse gas emissions, particulate matter emissions, and combustion efficiency and proposed an efficient operating range according to the power and dimensionless criteria [6-8].

II. EXPERIMENTAL METHODS

1. Water boiling test.

Water boiling test is conducted for calculating thermal efficiency of cooking pot.

The following experimental procedure is employed during test:

1. Initially measure the weight of the cooking pot without water.
2. Add some amount of water in the pot.
3. Measure the weight of pot with water.
4. Measure the initial temperature of water.
5. Turn on the LPG stove.
6. Start the test by putting the pot on stove and begin to record the time.
7. Record the water temperature by thermometer.
8. Record the time when the water reaches the boiling point temperature.
9. After reaching boiling point temperature turn off the lpg stove.
10. Remove the pot from the stove.
11. Finally measure the weight of the pot with the water.

Fig. 1. Experimental setup

II. EMISSION TEST

Emission test is performed for measuring the carbon emissions during the cooking process from LPG burner.

The following experimental procedure is employed during test:

1. Initially gas is admitted at inlet pressure of 2.943KN/ m^2.
2. Cooking pot with water is mounted on the burner and gas is allowed to preheat for 5 minutes.
3. Remove the pot and place collecting hood over the stove burner for collecting the emissions from burner.
4. Start the readings of emissions with the help of exhaust gas analyzer at different power levels.

The emission test setup and exhaust gas analyzer is shown in fig 2 & 3.

Fig. 2. Emission test setup

Fig. 3. Exhaust gas analyzer

III. MATHEMATICAL FORMULAE

1. Mass flow rate

   Mass flow rate M is

   $M = m / T$

   Where, m = Mass of gas in the cylinder in Kg.

   T = Time for cooking in sec.
2. Heat energy required to boil water per sec

   $Q_i = M_f * CV$

   Where,

   M_f = Mass flow rate of gas in Kg/s

   CV =Calorific value of LPG gas in KJ/Kg (46100KJ/Kg).
3. Heat absorbed by the water

$Q_a = m_w * Cp * (T_f - T_i)$

Where,

m_w = Mass of water in Kg.

C_p = Specific heat of water in KJ/KgK.

= 4.187 KJ/KgK

T_i = Initial temperature of water

T_f = Final temperature of water
4. Thermal efficiency of cooking pot

   It is the ratio of energy entering into the cooking pot to the energy supply from the source to the cooking pot.

$$\eta_{th} = \frac{m_w * C_p * (T_f - T_i) + m_{w,evap} * h_{fg}}{M_f * CV}$$

where,

m_w = Mass of water in Kg.

C_p = Specific heat of water in KJ/KgK.

= 4.187 KJ/KgK.

T_i = Initial temperature of water.

T_f = Final temperature of water.

$m_{w,evap}$ = Mass of water evaporated in Kg.

h_{fg} = Specific latent heat of water in KJ/Kg.

M_f = Mass flow rate of LPG gas in Kg /sec.

CV= Calorific value of LPG gas in KJ/Kg.

IV.THE EFFECTS OF DIFFERENT PARAMETERS ON EFFICIENCY

1. **Loading height:** It is the distance between the bottom surface of cook pot and stove burner head.
   It can be seen that when loading height is less then the thermal efficiency of cooking pot is less because of the incomplete combustion due to which the heat generated and heat transferred to the pot is to be in less amount.

2. **Loading weight :** It is the amount of water added into the cooking pot.
   It is observed that as the loading weight increases the thermal efficiency increases. The heat absorbed by the water is increased at lateral surface of pot due to which thermal efficiency increases.

3. **Pot diameter :** It is observed that the thermal efficiency increases with increase in pot diameter.
   The heat transferred to the pot is more due to the large surface area.

4. **Ratio of pot diameter to flame diameter :** It is observed that at lower ratios, thermal efficiency of pot increases with increase in ratio of pot diameter to flame diameter. This result is due to large heat transfer surface. The interaction between pot bottom surface and hot gases from burner has increased. This leads to more heat absorption of pot bottom surface. Therefore, high thermal efficiency is obtained.

5. **Ratio of pot height to pot diameter :** It is observed that the thermal efficiency decreases with increasing the rario of pot height to pot diameter. This result is due to separation of boundary layers on side walls of cooking pot.

6. **Bottom surface design :** It is observed that the pots with concave surface have lower efficiency and pots with bulgy or flat surfaces have higher efficiency than the concave surfaces. This is due to the bulgy surfaces attract more hot gases to the bottom surface of cooking pot.

V.CONCLUSIONS

This paper presents the new methodology to determine and enhance the thermal efficiency of cooking pots with water boiling test. The consumption of LPG gas is maintained by developing the different types of cookwares. Thermal efficiency of cooking pot is mainly depends on the working principles of heating source, pot size and shape, composition, base thickness, amount of water added in the pot and variation in wattage of heating source. The induction cooktop have higher thermal efficiency than electrical and natural gas cooktops. This study shows that the more consumption of LPG gas causes the air pollution in developing countries. The best way to eradicate this problem is to use the microwave oven or induction cooktop.

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