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DESIGN, CONSTRUCTION AND PERFORMANCE EVALUATION OF A TWO SELF-IGNITED GAS COOKER

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ABSTRACT

The gas cooker is a cooking appliance available in several forms: the single face burner, the multi-face burner, the manually ignited cooker and the self-ignited cooker. The gas used is natural gas, propane, butane, liquefied petroleum gas or other flammable gas as a fuel source. The objective of this work is to design and construct a two self-ignited gas cooker with good working efficiency using available materials.

The design, construction and performance evaluation of a two self-ignited gas cooker requires using locally available materials such as a stainless steel plate (for the cooking surface), regulator, gas cylinder, hose, clips, burners, hobs, gas etc. The gas cooker is with gas rings and a cook top for cooking with gas. The gas cooker also contains a heating element that transforms fuel or electricity into heat. For the design of this project, Auto-cad 3D drawing was use.

For this study, four different observations were taken for two different types of gas cooker burners. A reading was taken for each type of burners in a single burning condition Cold Start Test and the other is to observe the time taken to boil a certain amount of rice. However, the method adopted on obtaining this condition is subjective (i.e. visual inspection on flame was carried out when the knob was tuned). Optimum burning condition can also be obtained by objective methodology and for this it is essential to measure the boiling temperature with high capacity thermometers.

The efficiencies of the two different burners of the double gas cooker was calculated and was found to be 50-93% for optimum burning condition. The efficiency of the given burner is not constant. Those values could vary on the basis of surrounding conditions and quality of the gas cooker. The high value of efficiency could be obtained in optimum burning condition in field however this value is normally lower than the value obtained in controlled laboratory condition. The efficiency of gas cookers depends on: 1. Environmental conditions such as wind, temperature and pressure. 2. Burner size of cooker and size of bottom face of cooking vessel.

KEYWORDS: Gas Cooker, Self-Ignited Cooker, Burner, Gas, Performance Evaluation

INTRODUCTION

A gas cooker is a range with gas rings and a cook top for cooking with gas. The gas ring is a burner consisting of a circular metal pipe with several small holes through which gas can escape to be burned. The gas cooker also contains a heating element that transforms fuel or electricity into heat. It is a cooking appliance available in several forms: the single face burner, the multi-face burner, the manually ignited cooker and the self-ignited cooker. The self-ignited cooker can also be of a single faced burner or of a multi-faced burner. Either type though, works with a self-ignition device. The gas used is natural gas, propane, butane, liquefied petroleum gas or other flammable gas as a fuel source. The essence of using a self-ignited gas cooker during cooking is the comfort it gives, safety, ease of use and because of the high rate of heat it generates. The gas stoves tend to great economy, as they are not lit till the moment wanted, then only the quality required, and may be put out the moment it is done with". James patented a gas cooker in Northampton, England in the year 1826 and opened a gas cooker factory in 1836. His invention was marketed by the firm Smith & Philips from 1828 (Utoft and Thompson, 2006).

The gas cooker is considered as an effective cooking appliance due to the above importance. Over the years, several cooking appliances have been invented and used for cooking. All of these cooking appliances require heat and as such derive heat through various means. The most common and ancient cooking appliance is the use of firewood. A bunch of dry wood is put together and a means of igniting the wood with fire is required. However, in a self-ignited gas cooker, firewood is not needed neither is there the need for a manual ignition. A major improvement in fuel technology came with the advent of gas. The first gas cooker was developed as early as the 1820s, but these remained isolated experiments. An important figure in the early acceptance of this new technology was Alexis Soyer, the renowned chef at the Reform Club in London. From 1841, he converted his kitchen to consume piped gas, arguing that gas was cheaper overall because the supply could be turned off when the cooker was not in use. James Sharp patented a gas cooker in Northampton, England in 1826 and opened a gas cooker factory in 1836. His invention was marketed by the firm Smith & Philips from 1828, (Snodgrass, 2004). In this project, the twin auto-ignition cooker is used as a key study.

Gas cooker today use two basic types of ignition sources, standing pilot and electric. A cooker with a standing pilot has a small, continuously burning gas flame (called a pilot light) under the cook top. The flame is between the front and back burners. When the cooker is turned on, this flame lights the gas flowing out of the burners. The advantage of the standing pilot system is that it is simple and completely independent of any outside power source. Electric ignition cooker use electric sparks to ignite the surface burners. This is the "clicking sound" audible just before the burner actually lights. The sparks are initiated by turning the gas burner knob to a position typically labeled "LITE" or by pressing the 'ignition' button. Once the burner lights, the knob is turned further to modulate the flame size.

Auto reignition is an elegant refinement; the user need not know or understand the wait-then-turn sequence. They simply turn the burner knob to the desired flame size and the sparking is turned off automatically when the flame lights. Auto reignition also provides a safety feature: the flame will be automatically reignited if the flame goes out while the gas is still on--for example by a gust of wind. If the power fails, surface burners must be manually match-lit. Electric ignition for cookers uses a "hot surface" or "glow bar" igniter. Basically it is a heating element that heats up to gas's ignition temperature. A sensor detects when the glow bar is hot enough and opens the gas valve. Normally a burner plays an important role in any combustion system. Since proper efficient modifications of a burner often leads to an efficient combustion and possibility to produce less pollutant formation. Its consumption in domestic cooking is increasing every year at the rate of approximately 10 %.(Pankaj and Salim, 2011). Nearly all atmospheric (venturi) burners have a gas orifice that is accurately fixed in the burner throat providing air intake. The hole in the orifice is very small to provide the correct gas flow and to provide sufficient velocity to ensure there is suction (vacuum) available for the correct air inspiration. (Pantangi et al, 2007).

The Liquefied Petroleum Gas (LPG), which is a multi-purpose fuel that is clean, safe and energy efficient is most preferably used. LPG is a clean and environmentally friendly source of energy and in order to protect the environment, LPG should be made accessible to all households as substitute to wood and biomass in many developing countries

(Chikwendu, 2011). In a conventional burner, LPG and air are required to be mixed before combustion in the throat of the burner where reactions occur. There is a single flame zone. Burner work on the principle called the venture-effect. It says that as a gas passes through a pipe that narrows or widens, the velocity and pressure of the gas vary. When pipe is narrows, the flow of gas is more rapidly. When the gas flows faster through the narrow sections the pressure decreases.

However, gas cookers can present potentially hazardous problems if poorly installed or maintained. Although modern cookers usually come with excellent safety features, they still occasionally leak poisonous, flammable or explosive fumes. Extinguished pilot lights can release carbon monoxide (CO) into your home environment. CO is a colorless, odorless gas that can lead to sudden illness and even death. A way to avoid this hazard is by investing in a carbon monoxide detector. Having the gas cooker checked once a year by a qualified service technician to ensure the appliance isn’t leaking any gas fumes that can cause explosions or fires. (Carson, 2013)

The objective of this work is to design, construct and performance evaluation of a self-ignited gas cooker in order to improve its efficiency, to generate scientific data that define the conditions that leads to either a higher efficiency or lower efficiency burner and to support practical recommendations for attaining a better efficiency gas cooker.

MATERIAL AND METHOD

A self-ignited gas cooker was designed with an auto-igniter. The gas cooker has preferably, a stainless steel surface (to prevent corrosion), burners and a gas source. The auto-ignition is to lit the gas cooker burner with flame and this flame with the aid of a gas source is used for cooking. The gas cooker has two knobs which controls the two burners. This knob when turned on makes a clicking sound, and then creates a spark which lit the burner with flame. It also releases a required amount of gas into the burner to aid the continuous lit of flame until the knob is turned off. The materials to be used will be gotten locally.

Material Selection

The materials to be used for the fabrication of an auto ignition gas cooker will be sourced locally. The aim is to produce the machine at the lowest possible cost, increase its economic efficiency and make it available to the end users.

The factors considered in the selection of materials are the following:

- Availability of the material.
- Mechanical property (strength, durability, corrosion resistance).
- Cost.

Materials

The materials used are stainless steel plate (for the cooking surface), regulator, gas cylinder, hose, clips, burners, knobs, gas and igniter.

Materials, Fittings and Components

Materials, fittings and components used in any gas installation shall be suitable for use with the:

- Type of gas being conveyed;

- The pressure to which they may be subjected under both operating and fault conditions
- The environment in which they are installed.

Cooker Construction

The other major factor, which affects the efficiency of the Cooker, is the constructional feature of the cooker. Gas cookers are found in the market in different shape and constructional features. The constructional features of the Gas cookers which affects the efficiency are:

- Burner types (orientations of holes, shape and size of holes, burner size)
- Space between burner and the other vessel supporting mechanism
- Air control mechanism and optimization on burning etc.

Stainless steel was used in the fabrication of the body of the cooker. This sheet was cut from a roll of sheet, bent and joined together by welding. The other parts, like the igniter, burner, gas rod and knobs is then attached to the welded frame using mainly bolt and nut. The knobs were attached to exterior front side of the cooker and then, the cooker was sprayed with blue color.

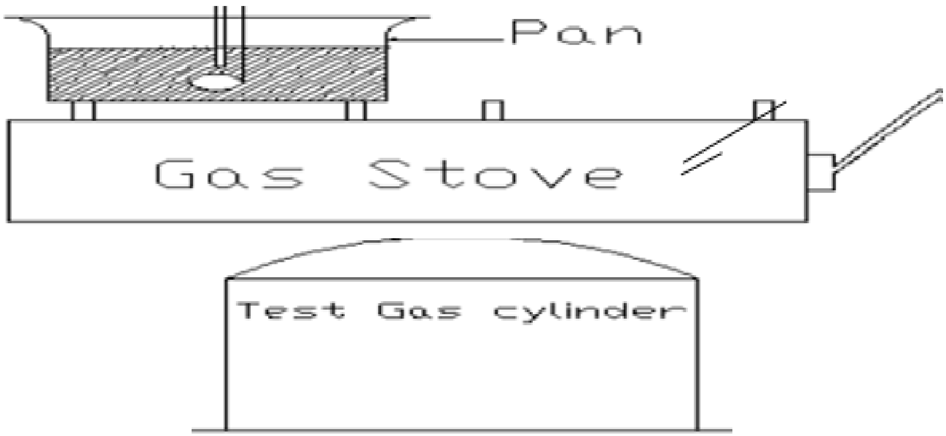

Figure 1: Schematic Diagram of a Gas Cooker with Cylinder

RESULTS AND DISUSSIONS

For this study, four different observations were taken for two different types of gas cooker burners. A reading was taken for each type of burners in a single burning condition Cold Start Test and the other is to observe the time taken to boil a certain amount of rice. The Cold Start Test which is also called High Power Phase which is done at Optimum air burning condition. Optimum air burning condition can be defined as the burning of gas cooker stove at which the burner gives the complete blue flame for same inflow of gas. However, the method adopted on obtaining this condition is subjective i.e. visual inspection on flame was carried out when the knob was tuned. Optimum burning condition can also be obtained by objective methodology and for this it is essential to measure the boiling temperature with high capacity thermometer i.e Thermocouple thermometer.

At high Power Phase, the stove is at ambient temperature. The quantity of fuel to boil a measured quantity of water in a standard pot is measured. Then, the boiled water is replaced with a fresh pot of ambient temperature water to perform the second phase. The hot-start high power phase is conducted after the first phase while the stove is still hot. The protocol is the same except that the stove is hot and a certain amount of rice is made to boil while the time taken is measured accordingly.

Table 1: Observation Sheet A

Observation		SI Unit
Experiment date and time	Date 6/03/2015	Time:14:00
Burner Sample ID	Thermocool	
Air control Condition	Optimum Burning	
Environmental Temperature (Tamb)	26	^{0}C
Volume of Water (VI)	1.5	Liter
Initial weight of vessel + water (WI)	1.36	Kg
Initial temperature of water (Ti)	31	^{0}C
Boiling Temperature of Water (Tb)	92.5	^{0}C
Time required for boiling water (t)	11	Minutes

Table 2: Observation Sheet B

Observation		Si Unit
Experiment date and time	Date 6/03/2015	Time:14:20
Burner Sample ID	Oster	
Air control Condition	Optimum Burning	
Environmental Temperature (Tamb)	26	^{0}C
Volume of Water (VI)	1.5	Liter
Initial weight of vessel + water (WI)	1.36	Kg
Initial temperature of water (Ti)	31	^{0}C
Boiling Temperature of Water (Tb)	95.5	^{0}C
Time required for boiling water (t)	9	Minutes

Table 3: Observation Sheet C

Observation		SI Unit
Experiment date and time	Date 6/03/2015	Time:14:40
Burner Sample ID	Thermocool	
Air control Condition	Optimum Burning	
Environmental Temperature (Tamb)	26	^{0}C
Volume of Water (VI)	1.5	Liter
Initial weight of vessel + water (WI)	1.36	Kg
Initial temperature of water (Ti)	31	^{0}C
Boiling Temperature of Water (Tb)	94.5	^{0}C
Time required for boiling water (t)	10	Minutes

Table 4: Observation Sheet D

Observation		SI Unit
Experiment date and time	Date 6/03/2015	Time:15:00
Burner Sample ID	Oster	
Air control Condition	Optimum Burning	
Environmental Temperature (Tamb)	26	^{0}C
Volume of Water (VI)	1.5	Liter
Initial weight of vessel + water (WI)	1.36	Kg
Initial temperature of water (Ti)	31	^{0}C
Boiling Temperature of Water (Tb)	96.5	^{0}C
Time required for boiling water (t)	8	Minutes

Table 5: Observation Sheet E

Observation		SI Unit
Experiment date and time	Date 6/03/2015	Time:15:20
Burner Sample ID	Thermocool	
Air control Condition	Optimum Burning	
Environmental Temperature (Tamb)	26	^{0}C
Volume of Water (VI)	2.0	Liter
Initial weight of vessel + water (WI)		Kg
Initial temperature of water (Ti)	31	^{0}C
Boiling Temperature of Water (Tb)	94.5	^{0}C
Time required for boiling water (t)	20	Minutes

Table 6: Observation Sheet F

Observation		SI Unit
Experiment date and time	Date 6/03/2015	Time:15:50
Burner Sample ID	Oster	
Air control Condition	Optimum Burning	
Environmental Temperature (Tamb)	26	^{0}C
Volume of Water (VI)	2.0	Liter
Initial weight of vessel + water (WI)		Kg
Initial temperature of water (Ti)	31	^{0}C
Boiling Temperature of Water (Tb)	96.5	^{0}C
Time required for boiling water (t)	16	Minutes

Efficiencies of gas cookers are measured at optimum air burning condition using Q= 2Kg/min. The efficiency of each burner is shown in the table below after running the test.

The equation for the calculation the efficiency of the cooker burners is given as:

Efficiency (∑) $=\frac{Cr}{Q}$ -- (1)

Where Cr$=\frac{VI}{t}$ -- (2)

and Cr = cooking rate, VI = volume of water, T = the time taken to boil, Q = flow rate.

Table 7: Efficiencies of Gas Cooker Burners

Observation ID	Burner ID	Air Control Condition	Overall Efficiency %
Observation A	Thermocool	Optimum	68%
Observation B	Oster	Optimum	83%
Observation C	Thermocool	Optimum	75%
Observation D	Oster	Optimum	93%
Observation E	Thermocool	Optimum	50%
Observation F	Oster	Optimum	63%

Comparisons

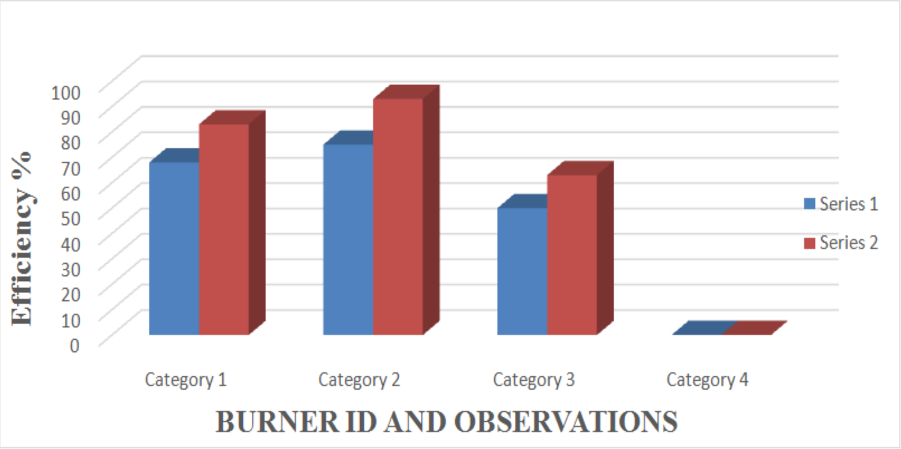

Figure 2

CONCLUSIONS

The efficiencies of the two different burners of the double gas cooker is calculated as per methodology mentioned above is found to be minimum 50% to maximum 93% for optimum burning condition. The efficiency of the given burners is not constant. Those values would vary on the basis of surrounding conditions and quality of the gas cooker. The high value of efficiency could be obtained in optimum burning condition in field however this value is normally lower than the value obtained in controlled laboratory condition. The efficiency of stoves depends upon following conditions:

- Environmental conditions such as wind, temperature and pressure.
- Burner size of cooker and size of bottom face of cooking vessel.

RECOMMENDATIONS

Efficiency measurement of double gas cooker under operation in different part of the country should be carried out as soon as possible and after analyzing the result necessary actions should be taken so that the gas cooker could be used effectively as possible. It is observed from the test carrier out that, to determine the efficiency of a gas cooker, the burner of the cooker cannot be over looked. Since the burner is so important, is it is only appropriate that improvements be made on it.

The number of holes and rods attached to the burner has a great effect on the efficiency of the cooker. To have a gas cooker with maximum efficiency, the rod connecting the burner to the gas pipe should be single as this will allow for maximum pressure to be released to the burner. The number of holes are very important also because, the more the number of holes, the more the flame. The gas cooker is a safe, cheap and efficient kitchen equipment which is good for every house hold.

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APPENDIX

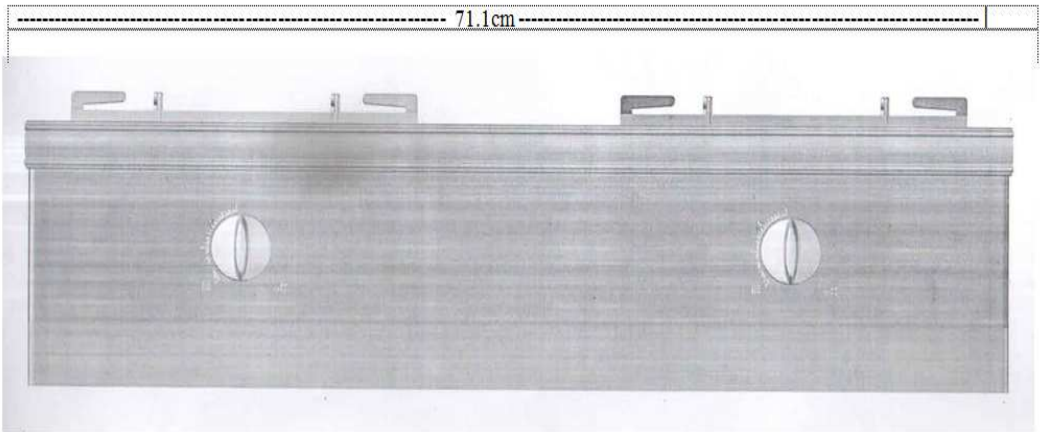

Figure 3

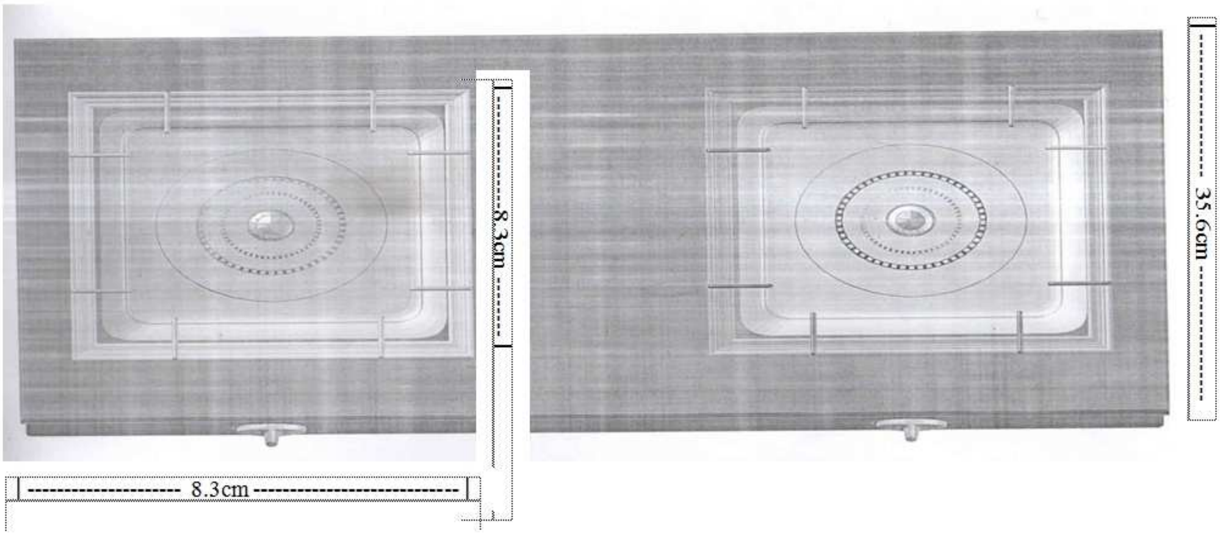

Figure 4

Top view of Twin self-ignited gas cooker AutoCAD 3D model

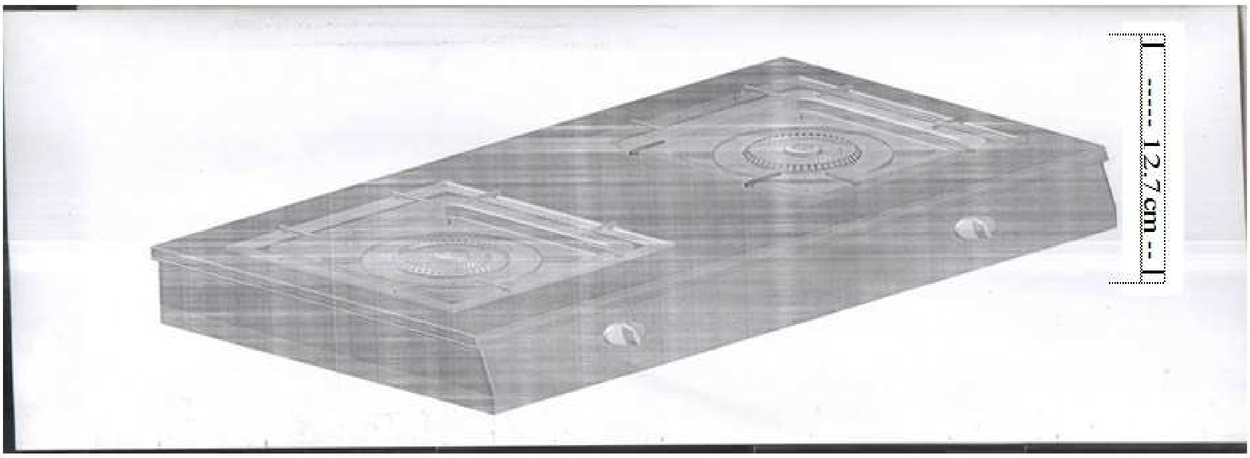

Figure 5

Isometric view of Twin self-ignited gas cooker AUTOCAD 3D model

Figure 6

Running of the test in the laboratory before painting the cooker.

Figure 7

Self Ignited Gas Cooker