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Thermodynamics and Qualitative comparison of Electric and Liquefied Petroleum Gas Cooking Ranges

Gourav Vivek Kulkarni[1], Priyanka S Koli[2]

[1]B.E. Mechanical Engineering, KLS Gogte Institute of Technology, Belagavi, Karnataka, INDIA
[2]B.E. Electrical and Electronics Engineering, KLS Gogte Institute of Technology, Belagavi, Karnataka, INDIA

Abstract - *Cooking of food is an essential activity which is carried out in daily life. The means and equipment used for cooking matter a lot as far as the quality is concerned. Much importance is given to quality since health cannot be compromised with. Moreover the method needs to be energy efficient, economic and one that yields high performance. Electric and Liquefied Petroleum Gas(LPG) Cooking ranges are used in a wide variety of cooking installations. This paper highlights the basic thermodynamics and the qualitative aspects of each of these installations. The energy and operative requirements will be put forward. Certain improvising measures and practices to optimize the systems are enlisted. The overall idea of switching over to an energy efficient optimized cooking range working solely on electricity by means of well equipped and designed systems forms the basis of the study. This would cut down the demand for hydrocarbon fuels which can be used for applications where found necessary. This would definitely reduce the dependency on hydrocarbon fuels and encourage the use of a common source of energy for all domestic installations.*

Key Words: Electrical, Combustion, Cooking, Combustion, Energy

1. INTRODUCTION

For most of the domestic purposes, the preferred method of cooking is by means of combustion of certain hydrocarbon gases like Butane(C_4H_{10}) released at high pressure and utilizing the heat obtained thereby. However owing to a considerable amount of study, these systems do not come out to be much energy efficient. This paves way for the formulation of a much more energy efficient method to carry out the process of cooking food. Thus instead of using the routine hydrocarbon filled cylinders, we can switch to electric cooking ranges like coils or induction sets. Thus the design of a much more energy efficient electrically powered cooking range is what comes out to be one of the much feasible solutions to mitigate the high demand of hydrocarbon fuel. This can lead to reduction in the energy crisis and bring certain balance in the ratio of supply to demand. With this the electrical power generation methods can be optimized and the direct use of hydrocarbon fuels can be easily reduced so that they may used for applications where necessary.

2. Literature Review

In order to come up with the concept of a new optimized system for cooking functions, following literature review was conducted and the points studied thereby have been mentioned as follows

In the research carried out by Iman Mansouri et al.[1] , feasibility study was initially carried out with respect to the implementation of new and efficient methods in the field of domestic use of energy. Environmental attitudes, beliefs and behaviors were the chief areas of study. It was observed that the people under study were ready to acquire the knowledge of environmental impact and change their approach towards the utilization of energy. It was stated that by changing the behavior of the consumers, there can be excellent saving in energy. A certain minimum efficiency was proposed to be decided so that systems with lesser efficiencies shall not be used which can contribute towards sustainable development. Environmental impacts of use of energy were proposed to be analyzed periodically and to reduce the ill-effects of the same over a period of time.

The work of Omar R Masera et al.[2] reflects the effects of energy utilization on the health of the occupants. The means towards development are stated to be Technology innovation, Market development, continuous monitoring and evaluation of systems and processes.

The research carried out by Qier An et al.[3] deals with the study of energy efficiency and exergy efficiency of household energy utilization in China. The study was intended to demonstrate the energy conversion process and certain related performance parameters. As a result of the study, considering a certain study space as defined in the original work, the exergy efficiency values in space heating, cooking and hot water sector were found to be lesser than the energy efficiency values. This shows that the fuels have to be utilized in larger quantities to keep the systems working.

As a result of the literature review, it was observed that conventional methods of using hydrocarbon or any other type of fuels yield less efficient energy conversion systems. In the present world scenario where we are interested to have highly efficient systems, the proposition of an optimized electrical system is of utmost importance. In this system, all domestic activities including cooking, space heating, water heating and so on can be carried out such that discreet energy consumption can be reduced to consumption of a single source of energy like electricity for household purposes.

3. Basics of Combustion

Combustion is the process of release of high intensity energy from a combustible substance due to the burning of a certain fuel. Thus it becomes of utmost importance to understand that to carry out a combustion process successfully; the three conditions of combustion namely combustible substances, fuel and presence of oxygen must be satisfied to the optimum. This condition itself is known as the combustion triangle.

Even if any one of the conditions is not satisfied, either the combustion does not take place at all or it results into a highly inefficient process that liberates minimal useful energy. The concept of Calorific value plays a vital role in the study of combustion of fuels. Basically, the calorific value of a fuel is the energy released on complete combustion of unit mass of a fuel in the presence of excess of air or oxygen. Thus it can be inferred that more the calorific value, more will be the energy released in the form of heat.

4. Thermodynamics of Liquefied Petroleum Gas Cooking Ranges

The basic principal of working of a liquefied petroleum gas cooking range is the combustion of the high pressure discharged mixture of hydrocarbon gases at atmospheric pressure at the burner and carrying out the cooking process by the heat liberated thereby.

Liquefied Petroleum Gas(LPG) constitutes of Butane(C_4H_{10}), Ethane(C_2H_6) and Ethyl mercaptan propane(C_2H_5SH) also called ethanethiol which is liquefied by compressing it and is filled into cylinders. On discharging, due to difference in pressures, the liquefied gas changes to gaseous state and is ignited by means of a spark arrangement at the burner.

Further there may arise a question pertaining to the fact that although methane has much better calorific value, what is the very purpose to use butane since it would be more energy efficient to use methane. But the fact that the storage and operating conditions of methane require a lot of care to be practiced which is quite difficult in case of domestic use due to the lack of knowledge and awareness of people regarding this subject. Thus for the purpose of safety, butane is used as a primary constituent of liquefied petroleum gas.

The flame thus obtained on combustion of the liquefied petroleum gas is without soot and is efficient enough to heat the vessels to carry out the cooking. Precisely designed devices called regulators avoid the leakage of the gas to the atmosphere. Since this gas is highly explosive, the cylinders are designed such that any impact to the outer body of the cylinder should not affect the internal gas storage cylinder and cause any mishaps thereby.

The combustion efficiency of a liquefied petroleum gas is defined as the ratio of the amount of heat released during combustion to the heating value of the fuel. The heating value is further classified as higher or lower heating value. Higher heating value is considered when the complete heat liberated in the process is efficiently used by condensation on the combustion gases and the Lower heating value is the one that is obtained when the combustion gases leave the site of combustion immediately after performing it.

It has been found that the thermal efficiency of an LPG stove with a regular cast iron burner is 48% [4]. This itself paves the way towards research in the field of finding an alternate source of energy that can be more efficient and can contribute towards sustainable development.

5. Electric Cooking Ranges

Electric Cooking Ranges work on the principle of dissipation of heat from a high resistance when suitable current flows through it across the given voltage. This equipment can be optimized by using more energy efficient resistors that would consume lesser heat and dissipate a large amount of the heat produced by them to the cook top or the base of the cooking range. Since the principle involved does not require any specific skills for operation, safety can be assured of and much knowledge is not required to carry out cooking on this equipment.

If properly grounded, these systems can prove to be much safer than the traditional liquefied petroleum gas cooking ranges. The chances of short circuits can be made minimum if proper insulation and grounding with steady current input is provided.

Since the energy used in this method is electrical energy, better conversion of energy due to resistance into heat can be noticed thus making the systems more energy efficient than the LPG cooking ranges. Accounting for losses such as material defect loss, hysteresis loss, variable power factor and so on the efficiency of electric based cooking ranges is found to be in the range of 74% to 77% [5]. Thus it can be clearly understood that electrical energy can be used for high end efficient energy conversion applications. The next section deals with the concept of an optimized electric system which can prove to be more energy efficient than the existing energy systems.

6. Concept of optimized Electric Cooking Ranges

Further it has been proposed that the electrical energy supplied to homes can be itself used for the purpose of cooking instead of opting for additional use of hydrocarbon gases.

From the thermodynamics point of view, this type of system would be much more feasible and energy efficient. Since the electric current is constantly flowing through the conductors of the domestic wiring system, it has got a certain value of entropy associated with it. Due to this itself, if a system draws the same current it would require lesser energy to overcome its own inertial forces. But the same case if considered with gas cooking ranges, comparatively larger amount of energy would be required to first increase the entropy of the system to overcome the inertial forces first and then to start and

stabilize the system for continual operation. This can lead to better of utilization of energy since electric coking ranges get heated faster and reach the optimum cooking temperature with lesser energy input as compared to LPG ranges that require combustion of certain fuel to reach the suitable cooking temperature.

Whilst other factors such as operating costs are concerned, an all electrical system would cost quite less in the long run as compared to a combination of electrical lighting system and a hydrocarbon fuel combustion system for the purpose of cooking. This would reduce the demand for extra financial requirement of the monthly expenditure.

7. Advantages of optimized Electric Cooking Ranges

1. It rules out the need for different energy sources and serves the required purpose with a single energy source.
2. The overall cost of electrical systems for cooking is much lesser as compared to the LPG cooking ranges.
3. Once the energy supply to the electric cooking range is cut off, the resistance coils remain hot for a considerable amount of time by which we can plan and save the electrical energy by periodically switching off the energy source.
4. There is no risk of fire due to an open flame. The system can be made fireproof by providing proper grounding.
5. Considering the safety point of view the electrical systems prove to be much safer than the conventional hydrocarbon combustion based systems since there are no chances of leakage.
6. Much knowledge and skill is not necessarily required to operate the electrical systems since they involve simple switching arrangement and are easy to become habitual with.
7. Electricity can be transmitted over large distances efficiently while the diffusion of gases from one point to another is quite a difficult and energy consuming task compared to the electrical transmission.

8. CONCLUSION

Thus the optimized electrical cooking ranges prove to be much more energy efficient, safe and easy to work with. These systems reduce the need of different forms of energy and carry out the operation with a single form of energy. These systems prove to be of utmost use where the availability of hydrocarbon gases is scarce. If all domestic systems are electrically powered, more efforts can be put in to develop a better process of electrical power generation by various methods. This leads to a single input and single output of energy which can reduce the entropy of the system in the long run since lesser energy would be required to overcome inertia of various mechanisms and reach the working temperature of the cooking ranges. Thus is has been recommended to switch over to such high performance energy efficient systems.

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BIOGRAPHIES

Gourav Vivek Kulkarni completed his Bachelor's Degree in Mechanical Engineering in 2017. His areas of interest include Thermal Engineering, Non conventional Energy sources, Computational Fluid Dynamics and Machine Design.

Priyanka S Koli completed her Bachelor's Degree in Electrical and Electronics Engineering in 2017. Her areas of interest include Renewable Energy sources, Power system analysis and technology, Power electronics.