Study on water from Solar Heater for Domestic Cooking

Ratnik Ramesh Gujjar, Ravi Kumar BN, Dr.LK Sreepathi, Vachan Revankar

Abstract—This article presents an innovative method for domestic cooking using Solar Energy. The technique is based on principles of convection using hot water obtained from evacuated solar tubes. This concept illustrates the feasiablity of readily available hot water to aid in domestic cooking among other uses. Our work deals with the modification, fabrication and performance evaluation of such a heat exchanger unit.

Index Terms— Solar energy, Sustainablility, Green energy, Solar cooking , Alternative Fuel , Thermal Engineering

1 Introduction

Prospects for harnessing solar energy in India are very bright and unlimited. Solar energy has been used for various applications like cooking, drying, lighting, water heating etc. Solar cookers have satisfactorily met it to cook food using solar energy. The present work has been carrying out in line of reducing use of fossil fuels in domestic cooking with little alteration of cooking methods which will reduce cooking cost on a long run. n most of the Cooking activities, LPG is used as a fuel. The Cost of this fuel is rising daily and their contribution to global warming is increasing at a rapid rate and cause adverse environmental effects. Many researchers have worked out the environmental effects of fossil fuels and health effects of inefficient stoves and concluded that use of renewable energy resources should be promoted to reduce the environmental effects. Solar water heaters are commercially available economical gadgets for water heating. Usage of solar heater system reduces the LPG requirement for cooking and also addresses other limitations of solar cooking.

2 Literature Survey

Akhilesh Singh et al., (2017) investigated on indirect solar cooking with steam generation which is also called as community solar cooking. Solar Cookers need to be redesign as per requirement of Indian cooking to enable to adopt solar cookers. They concluded with the Government of India and State Government need to work together for development of Solar thermal application in commercial, Industrial and agricultural applications.

Sunil Indora et al., (2018) discussed on Design, Construction and Operational details of both direct and indirect types of concentrating solar cookers. The end users are apparently satisfied with the use of institutional solar cooking systems and had sufficient motivation to operate and maintain them for about two decades.

N. L Panwar et al., (2012) investigated to provide comprehensive view on standard testing approach of solar cooker and energy analysis approach and economic evaluation of different types of solar cooker. Thermal performance of box type and concentration type solar cookers in both laboratories and actual field conditions also rigorously reviewed and presented in this paper

3 Objectives and Methodology

3.1 Objectives

a) Save the conventional fuel in domestic cooking.
b) Usage of solar energy for cooking as an alternative for LPG.
c) Reduce the cost of cooking by Solar Energy.
d) Provide an Eco-friendly solution for the increasing energy demand of the domestic kitchen in India.

3.2 Methodology

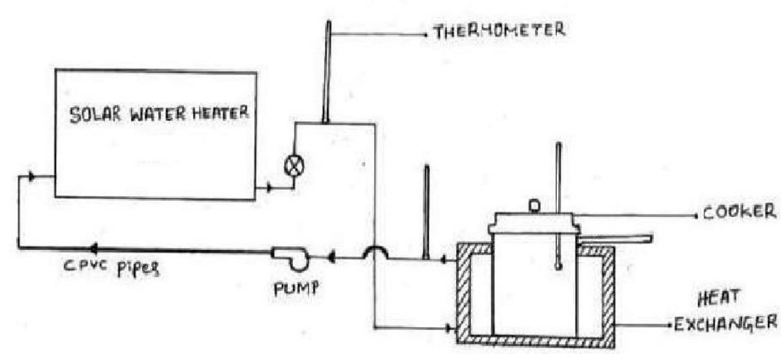

Figure 3.2 Schematic sketch of layout of the project

We have developed a system wherein the hot water from the Evacuated Tube Solar heater is used for the cooking purpose. The hot water from the solar heater enters the heat exchanger unit where the heat of the water is used for cooking and then the cold water is circulated back using Pump. Here convection

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takes place in the heat exchanger unit where in heat is lost to the vessel to cook the food. The outer surface of the cooking unit is completely insulated with Asbestos rope so that the loss is very much minimal to the environment.

4 Design and Fabrication

4.1 Design of Heat Exchanger unit

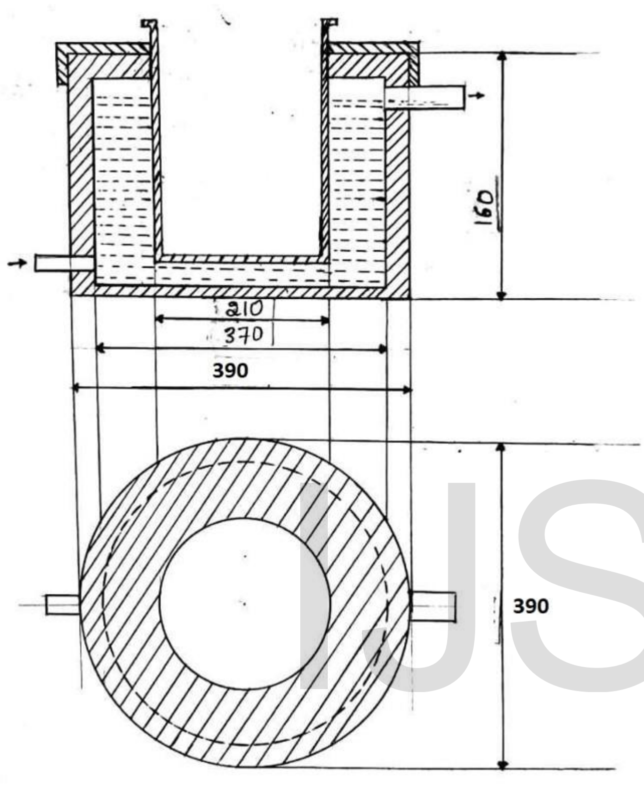

Figure 4.1 Design of Heat Exchanger Unit

We have taken a normal pressure cooker of 4L capacity and developed a heat exachanger for the same. The heat exchanger is the cylindrical frame made of stainless steel. The bottom is flat which allows it to be keep at the live flame for additional heat supply. The stainless-steel material is 3 mm thick.

This has a water inlet valve at the bottom and the water outlet valve at the top. The hot water circulates around the cooking vessel and goes out through the outlet valve. These valves are made from threaded clamps which are connected to the house pipes. This unit is completely insulated from the surface using asbestos so that there is no loss of heat to the environment. This has thermocouples at different junctions so as to keep an eye on the temperature.

4.2 Fabrication of Heat Exchanger Unit

The heat exchanger unit consists of different parts like outer

Figure 4.2 Fabricated Heat Exchanger Unit

body, top covering plate and rubber sealing material to avoid any leakage of water. Outer body and top covering plate were made with stainless steel material. The thickness of material is of high gauge was used to withstand high pressures to avoid any variations during normal working conditions. In order to avoid leakage of water and overflow, a rubber sealant of thickness 3 mm was sandwiched between the top covering plate and the outer body and fastened using bolt and nuts.

The outer body of the heat exchanger unit has two openings, one for inlet and another for outlet of hot water which is coming from solar water heater and they are positioned at opposite sides of the heat exchanger unit, one at the top and another at the bottom and they are attached with PVC clamps with threads and rubber seals to avoid any leakage of water. The outer body of the heat exchanger unit is fully wound with asbestos rope to avoid loss of heat to the environment.

The flowrate is limited to 9L/min since increasing flowrate beyond it, the water starts spilling out from Top plate which is a limitation of the unit.

The Critical Radius of Insulation is given by R_c =k/H
Where k of asbestos is 0.08W/mK and H of air is 5 W/m²k
Thus R_c = 0.08/5 = 0.016m
Hence radius of insulation is 16mm and we have taken 10mm each side.

Power Capacity of the pump is given by P = Q x D x g x H
Where Q is flow rate =9l/min =0.00015m^3/sec
D is density =1000Kg/m^3
G is acceleration due to gravity =9.81 m^2/sec
H is head of 45 feet that is 13.8m (2 storey Building)
P = 0.00015 x 1000 x 9.81 x 13.8 =20W
Hence a 20W Pump is needed to circulate the water.

5 Results and Discussion

We allowed the hot water from the solar heater to flow through the Heat Exchanger unit and observed the temperature of the surface of the cooker at different time interval.
After the Experimentation, the following results were obtained. Table 5.1 shows the tabular column of temperature v/s time on surface of Cooker and figure 5.1 shows the graph of Temperature vs. time on surface of cooker.

Table 5.1 Temperature on surface of cooker vs Time

Time (in min)	Temperature (in C)	Time (in min)	Temperature (in C)
0	20	35	35
5	22.5	40	37
10	25	45	40
15	27	50	50
20	32	55	58
25	33	60	59
30	34	65	59

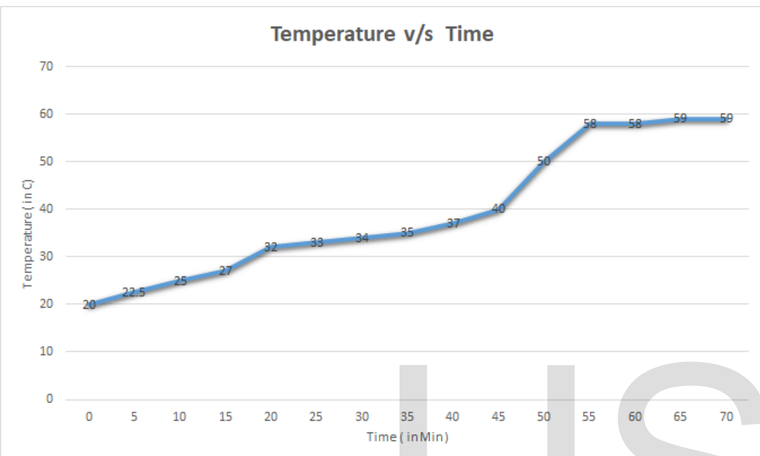

Fig. 5.1 Graph of Temperature on surface of cooker vs Time

Initially the temperature of cooker was 20^{o}C which after 60 minutes increased to 59^{o}C and didn't increase further as the Thermal equilibrium was reached at this point.

We know that,
Q = M× Cp × ∂temp/∂time

M = Mass of water = 12kg
Cp = 4.187 KJ/kg C
∂temp/∂time = slope of the graph =0.0262

Q = M× Cp × ∂temp/∂time
Q = 12 × 4.187 × 0.0262
Q = 1.3189 KW

From the experiments and calculations, it was observed that the proposed unit has heat transfer rate to of 1.3189 KW. Hence it was concluded that it saves up to 1.3189 KW of energy that was used from LPG

6 Conclusion

The heat exchanger unit is fabricated according to the design requirement for the Cooker selected thus pump is selected accordingly.Further these specifications of pump and the heat exchanger will change according to head and coker selected. From the experiments and calculations, it was shown that the fabricated unit has heat transfer rate of 1.3189 KW.

Hence, we can conclude that it saves up to 1.3189 KW of energy that was used from LPG thus saving the cost occurred from Convectional Cooking.

7 References

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