Waste heat recovery from porous LPG gas burner used for cooking

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Abstract - *Generally in cooking devices three modes of heat transfer takes place (conduction, convection and radiation). Heat is transferred to the utensils mainly due to conduction and convection. A considerable amount of heat in the form of radiation is dissipated to the surroundings. The purpose of this project is to recover this waste heat. Surface radiation without participating media is considered in this study. Hence, copper coil is used to absorb the radiant heat and transfer it to water which run through the coil. This low temperature recovery water can be used for cooking or to keep the food hot packed or other similar low grade heat applications.[1]*

Key Words: Waste Heat Recovery system, Waste Heat Energy, Heat losses, Enthalpy losses, Exhaust System, Financial Impact.

1. INTRODUCTION

In applications involving heat, fuel combustion or chemical reactions, certain amount of energy which does not participate or contribute to the overall efficiency of the system is dumped into environment. This particular energy maybe termed as waste heat. The strategy of recovering this heat or energy depends on the temperature range the waste heat gas comes under and the cost involved in that. The energy lost in waste gases cannot be recovered fully, however much of the heat could be recovered. Many processes, especially in industrial applications, produce large amounts of excess heat i.e., heat beyond what can be efficiently used in the process. Waste heat is heat, which is generated in a process by way of fuel combustion or chemical reaction, and then ―dumped‖ into the environment even though it could still be reused for some useful and economic purpose. The essential quality of heat is not the amount but rather its value.[2] The strategy of how to recover this heat depends in part on the temperature of the waste heat gases and the economics involved. Large quantity of hot flue gases is generated from gas burner during cooking. If some of this waste heat could be recovered, a considerable amount of primary fuel could be saved. The energy lost in waste gases cannot be fully recovered. However, much of the heat could be recovered and loss minimized by adopting a particular method. In India, majority of the house uses the circular porous closed type inverted cup gas top Liquefied Petroleum Gas burners for cooking because of its compactness, low cost and easy to handle. In this type of LPG gas burner, 65% of heat is effectively utilized for cooking whereas, 35% of heat is lost through various forms.[4]

1.1 OBJECTIVES

The Objectives of “Waste heat recovery from porous LPG gas burner” are as follows:

- To recover considerable amount of heat which is dissipated to the surrounding in the form of radiation during cooking.
- To increase the cooking efficiency.
- To utilize the recovered radiant heat which was lost to the surrounding for any desirable purpose.
- To increase the combustion efficiency and trying to provide maximum heat to the cooking vessel.
- To reduce the thermal pollution caused due to radiant heat loss from LPG gas burner to the surrounding.

2. CFD ANALYSIS

The CFD analysis of proposed waste heat recovery system is as shown in figure below.

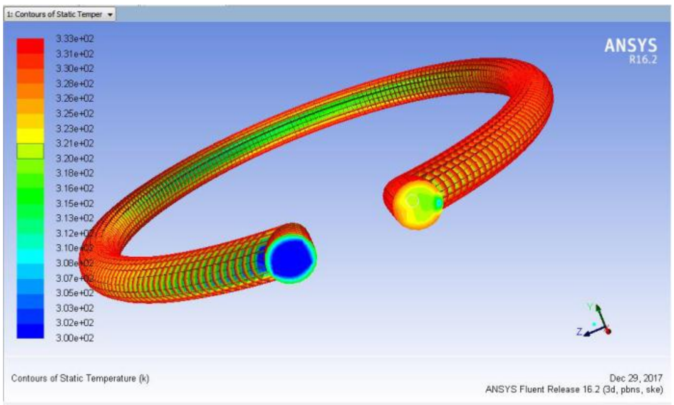


Figure- CFD analysis of WHR system

Result of CFD analysis is as follows:

INPUT PARAMETERS

Diameter of copper tube=10 mm

Radius of copper tube wound=13 cm

Temperature of water at inlet=302 degree Kelvin

Surface temperature of copper tube=60 degree Celsius

Flow rate of water=0.0045kg/sec

OUTPUT PARAMETER

Temperature of water at tube outlet=321 degree Kelvin

Net increase in temperature of water=19 degree Kelvin

3 EXPERIMANTAION

For the experimentation, copper coil is used as material/medium to absorb the radiant heat loss around the gas burner and transfer it to water. The copper coil is wounded around the burner in such way that it does not affect the proper function of the burner and the specification is described in Table 1 and the Figure 2 displays the installed experimental setup. Since radiation is a surface phenomenon, the proximity is chosen by trial and error method by placing vessels of different bottom size.

Table Design specifications of the WHR system

Coil diameter	13cm
No of turns	3
Burner radius	4.1cm
Coil radius from centre of burner	6.5cm

Figure Actual Setup of the Experimentation

4. CALCULATIONS

(A) Cooking Efficiency without copper coil

Energy gained by HPP= mw*cp*(t2-t1)

= 2*4.186*(86.1-27.5)

= 490.59 KJ (E1)

Energy gained by vessel = mv*cpv*(tv2-tv1)

= 0.578*0.51*(45.3-31.5)

= 4.06 KJ (E2)

Energy gained by low power phase = mvp*Latent heat of boiling water

= 0.15*2660

= 399KJ (E3)

Energy consumed= mf *cv

=0.03*44E3

= 1320 KJ

Overall efficiency = (E1 + E2 + E3)/energy consumed

= (490.59+4.06+399)/1320

= 67.7%

(B) Cooking efficiency with copper coil

Energy gained by HPP = mw*cp*(t2-t1)

= 2*4.186*(87.45-29.1)

= 488.50 KJ (Ew1)

Energy gained by vessel = mv*cpv*(tv2-tv1)

= 0.578*.51*(44.2-31.1)

= 3.86 KJ (Ew1)

Energy gained by low power phase = mvp*Latent heat of boiling water

= 0.15*2660

= 399KJ (Ew1)

Energy consumed= mf *cv

=0.03*44E3

= 1320 KJ

Overall efficiency = (Ew1 + Ew2 + Ew3)/energy consumed

= (488.50+3.86+399)/1320

= 67.53%

Hence it is proved that WHR system does not affect the regular cooking system. It means it does not take the heat from burner and recover only radiant heat which was lost to the surroundings.

4.1 HEAT BALANCE SHEET

Table Heat balance sheet

HEAT SUPPLIED			**HEAT UTILIZED**		
Para.	Amt .(KJ)	%	Parameter	Amount (KJ)	%
			Energy gained by HPP	490.59	37.16
Fuel (gas)	132 0	100	Energy gained by LPP	399	30.22
			Energy gained by vessel	4.067	0.3
			Energy gained by water circulated	145.70	11.03
			Radiation and other losses	281.02	21.29
TOTAL	1320 KJ 100		TOTAL	1320 KJ	100

Overall efficiency of the system after employing WHR system= Qutilized /Qsupplied

= (490.59+399+4.067+145.70) / (1320)

= 78.73%

Net increase in efficiency = efficiency after employing WHR system- efficiency before employing WHR system

= 78.73-67.7

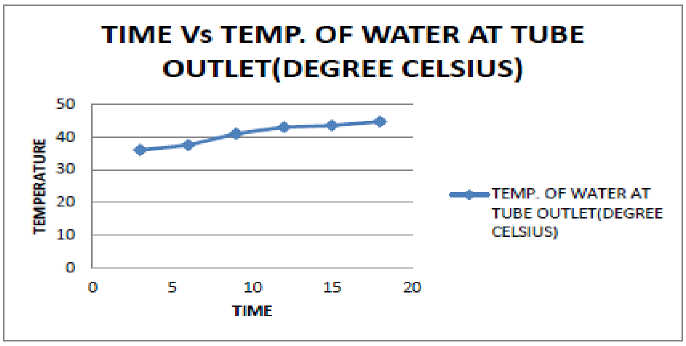
= 11.04%

5. RESULT AND DISCUSSION

Initial temperature of water in storage jar = 29 Degree Celsius

Table -Rise in temperature of water for the flow rate of 400 ml/min

Time Duration (Min)	Temp. of Water in Vessel (Degree Celsius)	Temp. of Water at the Outlet Of Copper Tube (Degree Celsius)
3	49.7	36
6	56	37.5
9	68.4	41
12	79.2	43
15	83	43.5
18	89	44.7



6. FUTURE SCOPE

Average Indian houses have two top brass burners. Hence in future, instead of single burner, two or multi burner can be used in which the copper coil is connected in series and hence higher exit temperature of water can be obtained. In addition to that, instead of three winding of coil, number of windings can be increased which will stall the water for sufficient amount of time, enabling more heat transfer, and different materials can be used to compare the results.

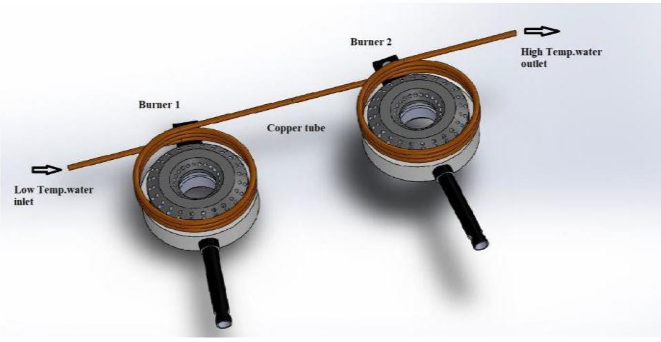


Figure WHR system connected in series (Future scope)

In the future we will try to achieve both heating as well as cooling effect in the same system by using the concept of LPG refrigeration. In domestic cylinder LPG is filled at very high pressure, by using this we can achieve the refrigeration effect without compressor and electricity.

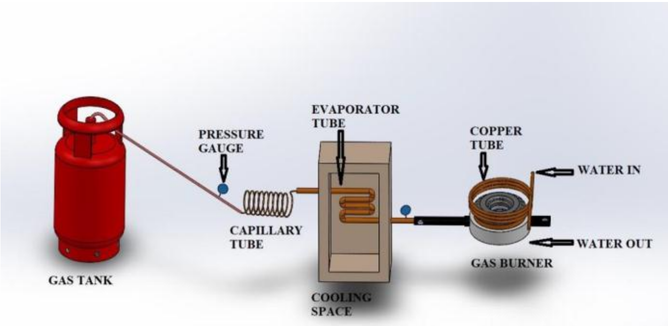


Figure Future scope (both cooling and heating of the water is achieved)

It means, we can achieve the refrigeration effect before burning of the gas and also achieve heating of water by using radiant heat loss.

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BIOGRAPHY

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